T-4563

EMPLOYMENT IN THE U.S. MINING AND COAL INDUSTRY

by

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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 Master of Science (Mineral Economics).

Golden, Colorado
Date 1/19/95

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ABSTRACT

This thesis examines the demand for employment in the U.S. mining industry and particularly in the coal industry. It examines changes in mining and coal employment, employment by occupation within the industries, and the impact of technology.

An econometric model is developed to predict employment demand based on a set of independent economic variables affecting employment and the amount of labor required. The model is based on economic information related to wages, output, technology, and the value of the output. The model is relatively accurate in producing an out of sample forecast for mining. It is less accurate in predicting employment for the coal industry.

The examination of occupations within the mining and coal industries over a ten-year period reveals a magnitude of change in the occupational mix.

The thesis also examines the importance that technology plays in the mining and coal industries. Technology allows output to increase while labor decreases.

The thesis concludes with an examination of policy

implications about the labor market. The thesis attempts to develop a methodology for predicting the amount of employment and the occupational requirements in a given year. With such information, policy makers would be in a better position to provide adequate labor market information to a unique segment of the labor market.

The U.S. government has to establish a labor market information system which has as its objective the development of an efficient labor supply. The evolution of technology, the changing competitive nature of the firm, and the need for an adequate work force means that the company will have to be more aware of the training needs of its employees in an environment in which the occupational mix is evolving. This must be done in an environment that is reducing the need for labor as technology increases. Labor force entrants have to base their career decision on the future of the industry and the occupation.

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ACKNOWLEDGMENTS

Many students, faculty, and staff members have contributed to my education at the Colorado School of Mines. I am sincerely grateful for their encouragement and support.

Dr. David E. Fletcher has been my mentor, advisor, and friend during the pursuit of this degree. He has given freely of his time in training, educating and coaching me through some unique and challenging times. I am particularly indebted to him for allowing me to view my endeavor from his unique perspective.

Drs. Fletcher, Roderick Eggert, Matthew Hrebar, and John Tilton provided valuable expertise and guidance as I worked through this thesis.

I am particularly indebted to Lu Sepulveda, Ed Miera, Lita Dunham, and the staff at the Bureau of Labor Statistics in Denver and Kansas City for providing the expertise and information necessary to produce this thesis.

There are two individuals who patiently endured more than anyone else in our growth and education. They patiently gave us the advice we did not hear, and watched as we made mistakes. As we made my blunders, they never gave

up on me or my brothers.

Mom and Dad were always there to give us a kind hand or whatever "corrective action" they thought necessary. No doubt raising three boys provided them with many anxious moments.

To my parents I express my love and gratitude for what you did for us.

Chapter 1

INTRODUCTION

This thesis examines labor in the mining and coal industries in the U.S. An econometric model developed for the thesis uses independent variables that influence on the demand for labor. In addition, an examination is made of the occupations, and the change that occurred in the occupational mix from 1983-1993. The information for the occupational analysis was obtained from the Bureau of Labor Statistics (BLS).

The thesis also looks at the impact of technology on the mining and coal mining industries. The thesis concludes with the need for adequate labor market information for the U.S., company, union, and labor market entrant.

The term mining includes all establishments primarily engaged in mining. The term mining is used in the broad sense to include the extraction of minerals occurring naturally: solids, such as coal and ores; liquids, such as crude petroleum and gasses such as natural gas (Office of Management and Budget 1987, 39). Mining also includes quarrying, well operations, milling, and other preparations customarily done at the mine site, or as a part of mining activities. Services performed on a contract or fee basis in the development or operation of mineral properties are classified separately but within this division of mining (Office of Management and Budget 1987, 39).

Coal mining includes establishments engages in producing the anthracite, bituminous, and lignite coal. Mining operations and preparations plants whether or not these plants are operated in conjunction with mine sites are also included. A sub-category under coal mining is called coal mining services. This category covers establishments who are primarily engaged in performing coal mining services on a contract or fee basis. Establishment that have complete responsibility for operating mines for others on a contract or basis are classified according to the product mined.

1.1 Competitive Position of U.S. Mining and Coal Industry

Since the 1980s, coal, natural gas, and nuclear power have provided 87% of the world's growth in energy supplies. Nationally, coal is the basis for 55-58% of all electricity generated today. From a base of 5,204 million short tons (mst) in 1989, world coal consumption will rise to 5,932 mst by the year 2000, and to 6,828 mst by the year 2010 (Merklein 1991, 14). Much of the anticipated increase for coal will be for U.S. coal.

The major factors affecting the U.S. competitive position are regional impacts, mine productivity, technological change, the Clean Air Act, and the consolidation of companies in the mining and coal mining industries.

1.2 Demand for Coal

The demand for U.S. coal in the next two decades will be affected by economic growth, environmental issues, elimination of producer subsidies, and anxiety concerning nuclear issues. Much of the increase in the demand for coal will come from economic growth requirements in developing countries. One barrier to effective international competition for developing countries is the inability to develop the level of production needed, in the absence of continued subsidies, in order to reduce production costs below world markets. This barrier is an advantage to U.S. firms.

Table 1 illustrates coal production, consumption, and year end stocks for 1991-1993.

In 1993, total coal consumption by all sectors increased by approximately 4%. Electric utilities increased their consumption by 4.4% from the previous year.

Table 1. Coal Production, Consumption, and Year End Stocks 1991-1993 (million st.)

YEAR	1991	1992	1993*	PERCENT CHANGE, 1992 to 1993
PRODUCTION	996.0	998.0	947.0	-5.1
CONSUMPTION BY SECTOR				
ELECTRIC UTILITIES	772.3	779.9	814.0	4.4
COKE PLANTS	33.9	32.4	31.6	-2.5
OTHER INDUSTRIAL	75.4	74.0	76.1	2.8
RESIDENTIAL/COMMERCIAL	6.1	6.2	6.7	8.1
TOTAL	887.7	892.5	928.4	4.0
YEAR END STOCKS				
ELECTRIC UTILITIES	158.0	154.0	111.0	-27.9
COKE PLANTS	3.0	3.0	2.0	-33.3
OTHER INDUSTRIAL	7.0	7.0	6.0	-14.3
PRODUCERS/DISTRIBUTORS	33.0	34.0	26.0	-23.5
TOTAL	201.0	198.0	145.0	-26.8
US COAL TRADE				
EXPORTS	109.0	103.0	75.0	-27.2
IMPORTS	3.0	4.0	7.0	75.0
NET EXPORTS	106.0	99.0	68.0	-31.3

Source: Mining Engineering, May 1994

* Consumption and stocks are estimates based on three quarters of historical data and projections for the last quarter.

Note - Due to independent estimates and rounding, total may not equal sum.

Electric utilities accounted for 88% of coal consumed in 1993. This increase by the electric utilities was due to a hot summer which increased the demand for electricity. Electric utility coal consumption was boosted by a decline in net electricity imports from Canada, which was partly replaced by domestic coal fired generation (Pantos 1994, 433).

Even with a favorable economic climate, the demand for coke plants declined in 1993. The slight increase in the demand for pig iron that occurred was satisfied by a drawdown in coke inventories.

Also, coal exports decreased by 27% in 1993. Mainly because of a severe European recession, protectionism and policies in Europe and, successful competition from other major coal-producing countries.

The Energy Information Administration (EIA) has forecast a 10% increase in demand for coal in 1994. This growth will be due to a replenishing of producers and consumer coal stockpile and domestic economic growth. International coal exports are also expected to increase as European economies improve.

Chapter 2

MINING AND COAL INDUSTRY EMPLOYMENT

2.1 Mining Employment

The 1980s experienced recessions and a very long expansionary period, although not all industries in the U.S. enjoyed the prosperity of the recovery. Mining never recovered from the two recessions. It lost an astounding 25% of its employment over the decade. Mining employed 958,000 workers in 1979. Employment dropped to 691,700 in 1989. In 1979, mining had 1.1% of total U.S. employment. In 1989, mining employment had dropped to 0.6% of total U.S. employment.

The fall in U.S. nonfarm payroll employment that occurred in 1990 and 1991 ended in the spring of 1992. Non-farm payroll employment is measured by the establishment survey of the Bureau of Labor Statistics (BLS). Growth in total U.S. employment in 1992 as shown by the household survey was 1.1 million. Job growth in the 1992 expansion was less than in the expansionary years of the 1980s. Mining, on the other hand, experienced substantial losses. By December 1992, mining had approximately 620,000 employees. From the end of 1991 to the end of 1992, mining lost an astronomical 58,300 employees.

2.2 Coal Industry Employment

U.S. economic development relied heavily on coal from the middle of the 19th century to World War I. Coal was used for manufacturing, transportation, and heating homes. After World War I, coal use declined as oil and natural gas use rose. Although coal use recovered during World War II, it declined from 1947 to 1960. After that, its generation of electricity grew enough to more than offset previous years declines.

The U.S. coal industry never employed large numbers of workers. In 1923, it employed 863,000 workers. Of this number, 158,000 workers were employed in anthracite mining. In 1993, total coal industry employment was 105,200. From its high in 1923 to 1993, the coal industry employment decreased by 757,800.

Table 2 lists employment by year in the coal industry from 1983-1993.

In 1977, the coal industry hired many new workers to its aging and retiring workforce. However, technological improvements such as longwall mining soon reduced employment. Because of new environmental regulations and

Table 2. Coal Mining Employment, 1983-1993

YEAR	EMPLOYMENT	PERCENTAGE CHANGE FROM PREVIOUS YEAR
1983	193,500	-----------
1984	195,500	1.0
1985	188,500	-3.6
1986	177,000	-6.1
1987	162,900	-8.0
1988	150,800	-7.4
1989	143,700	-4.7
1990	146,500	1.9
1991	135,500	-7.5
1992	125,500	-7.4
1993	105,200	-16.2

an influx of inexperienced workers, the rising trend in output per man-hour that prevailed from 1949 to 1969 declined between 1970 and 1978 in underground coal mine output per man-hour. Surface mine output per man-hour increases slowed around 1968. Increases in mine output have continued since 1978.

Coal mining employment in the 1980s suffered more than did the other segments of mining. Coal mining lost 115,000 jobs, 46% of its employment. U.S. coal exports and the share of world trade it enjoyed reached its peak in 1981. Coal mining employment also peaked same year. Although coal mining employment was reduced by nearly half over the decade, coal production grew each year from 1985 forward and was at the high point for the decade in 1989 (Plunkert 1990, 6). Productivity grew from technological advancements and the increased use of labor-saving devices such as continuous mining equipment that cuts and loads the coal in one operation. During the period, small and marginal mines which did not have advanced equipment closed.

2.3 Average Workweek and Number of Employee Hours

The average workweek and number of employee hours is an important factor in employment. Average workweek and number of employee hours impact on productivity.

Table 3 shows the average annual rate of change based on least squares regression analysis for the decades 1960, 1970, and 1980 performed on the yearly data by BLS. Although employment in mining and coal mining has been decreasing, the AVERAGE WEEKLY HOURS ALL PERSONS MINING based on the least squares method has been decreasing. For the coal industry, the AVERAGE WEEKLY HOURS ALL PERSONS COAL has been increasing. The hours of employment for mining and coal decreased except for the 1970-80 period when there was an increase in employment.

Table 3. Mining and Coal, Average Annual Rate of Change Based on Least Squares Method: 1960s, 1970s, 1980s

YEAR*	HOURS OF ALL PERSONS MINING (millions)	AVERAGE WEEKLY HOURS ALL PERSONS MINING	HOURS OF ALL PERSONS COAL (millions)	AVERAGE WEEKLY HOURS ALL PERSONS COAL
1960-70	-1	0.4	-1.7	1
1970-80	5.6	0.1	6.3	0.1
1980-90	-5.2	0	-4.8	0.7

Source: Office of Employment Projections, Bureau of Labor Statistics, U.S. Department of Labor

2.4 Labor Shortages/Overages: Causes and Consequences

In the United States, total employment is determined by nontechnological factors. Technology can change the demand for labor in industries. Process innovation can increase labor productivity while reducing the amount of labor required per unit of output.

The supply schedule of labor tells the amount and essentially the type of labor available in the economy under differing economic conditions. The supply schedule of labor is important for several reasons.

1. The government, at least in principle, committed itself to a policy of full employment with the Employment Act of 1946. The supply schedule dictates how many people are willing to work at different wages. Knowing this,

the government can set about attempting to provide an economic climate capable of generating the necessary number of jobs to achieve a full employment economy.

2. Labor requirements of industries change. The demand for skilled labor generally accompanies technological advances. One question that has to concern the government is how to make the reallocation of labor between industries easier. Unemployment and underemployment of labor constitutes a decrease in Gross Domestic Product (GDP) and a decrease in social welfare.

2.5 Reasons Why Occupational Labor Markets Are in Disequilibrium

Occupational labor markets are constantly in disequilibrium. Labor's response to changing demand is slow. The reason for this lack of speed is the time and money it takes to acquire information about labor market conditions. Also, it takes time and money to acquire formal and informal training to change jobs. Some jobs require characteristics for which training cannot be substituted. For example, some occupations require great physical strength. In addition, workers are reluctant to give up jobs that require certain skills, seniority, or require a geographic change for a relatively small salary increase. Finally, unions can act to limit the number of workers in certain occupations.

Even in mining, with its decrease in employment, there are some new entrants with no labor market attachment. In addition, there are some experienced workers who make job changes for various reasons. When the demand for labor is low, employers can use the new entrants and job changers to their advantage to keep wages from rising as rapidly as would have otherwise occurred. Also, conditions which enable unions to get higher wages tend to diminish as employers upgrade technology and change locations when costs dictate. In the long run, based on the theory of competition, the supply curve for occupations in mining may show more elasticity.

2.6 Impact of Technological Change on Employment

Technological change can be defined as change which increases output with the same or lesser amount of input. Technological change can be a new production process, new organizational techniques, new marketing techniques, or new managerial techniques. If it were possible to accurately measure the rates of invention, innovation, and diffusion in the coal industry, it would be much easier to assess the impact of technology on employment.

The demand for employment is a derived demand based on the performance of the economy. Technological change in the resource market affects the demand for the quality and quantity of labor by individual industries.

Technological change is often difficult to predict, and its impact on employment and productivity is generally felt gradually. Although the pace of technological change affects employment and productivity growth, the impact of new technologies also is affected by organizational, institutional, and social factors. A central reason for the complex, gradual character of the employment, productivity, and other economic effects of technological change is that these impacts are felt only through the adoption of new technologies by individuals and firms (Cyert 1987, 24).

New technologies in production processes generally reduce labor and other resource inputs in the production function needed to produce a given amount of output. The reductions of inputs in turn lower the costs of production and employment required for a given level of output. Historically, reductions in labor requirements per unit of output resulting from new technology has beneficial effects on the expansion in total output for the whole economy.

Technological change involves hard adjustments for firms and employees. In a technologically changing economy, employees must develop new skills and may have to seek employment in different industries and geographical locations. Workers can suffer permanent layoffs. Such workers are classified as structurally unemployed. Structural unemployment occurs when labor does not possess skills for existing jobs in the labor market.

Structurally unemployed workers have a larger investment in their existing skills and physical locations. These workers are less likely to find new jobs easily. Structural unemployment is characterized by longer durations of unemployment, and requires larger efforts at retraining, relocation, or infusions of new capital investments for new job creation.

Management must meet the challenge of changing technology by choosing the most efficient technology in a competitive global economy. Such a choice will lower the company costs and contribute to a higher profit margin. This is particularly important for an industry like U.S. mining that has a high labor cost and must compete with countries where the labor cost is low.

One way to get an indication of technological change is with productivity measures. One determination of technological change is the increase in output per unit of labor input. Generally a higher rate of output generates a higher rate of input. This has not been the case for labor in the coal mining industry where increases in labor output has accompanied a decreases in labor input. In the coal industry, technology has increased output per worker while decreasing the demand for labor.

Table 4 shows output per unit hour increasing from 1983 to 1992 for both the mining and coal industry as employment decreased. Table 4 also shows the average rate of change based on least squares methodology for the decades 1960, 1970, 1980. Interestingly, during the 1960s and 1980s, while mining and coal industry employment decreased, output per hour increased. During the 1970s, when employment increased, output per hour decreased.

Change in the ratio of output to the input of labor has been used as a measure of technological change for a long time. The rate of technological change influences labor productivity as does the extent to which capital equipment or other inputs are used as complements to or as substitutes for labor (usually dependent on the relative prices of labor and other inputs). Technological change is not the only factor that influences labor productivity, and labor productivity is not considered to be a totally reliable indicator of technological change. Some of the other

Table 4. Output per Unit of Input and Employment, 1983-1993

YEAR	OUTPUT PER HOUR MINING	OUTPUT PER HOUR COAL	MINING EMPLOYMENT (000)	COAL EMPLOYMENT (000)
1983	72.8	56.5	951.9	193.5
1984	76.4	63.2	965.5	195.5
1985	76.7	64.6	927.6	188.5
1986	84.6	69.4	777.8	177.0
1987	90.1	75.1	718.2	162.9
1988	93.4	83.5	712.6	150.8
1989	93.0	88.4	691.7	143.7
1990	91.4	90.7	709.3	146.5
1991		95.4	688.9	135.5
1992		104.8	630.6	125.5
1993			598.8	105.2
Average annual rate of change based on least squares method				
1960-70	4.7	6.0	-1.4	-2.7
1970-80	-5.0	-2.7	5.5	6.1
1980-90	3.6	7.2	-5.2	-5.4

<u>Source</u>: Office of Employment Projections, Bureau of Labor Statistics, U.S. Department of Labor

factors that influence labor's productivity are economies of scale, percentage of plant capacity used, work stoppages, and managerial ability.

While not shown in this thesis, a second measure of technological change is the increase in joint productivity of labor and capital. This is called total or multifactor productivity growth. Multifactor productivity tries to measure efficiency improvements in inputs which translate into outputs. The increases are said to be due to changes in technology.

2.7 Labor Requirements for the Coal Mining Industry Based on Technological Change

While technological change can create employment, it can also create unemployment. Given its nature, technological change in mining causes more workforce disruption than technological change in other industries. Employees in mining have skills that are not salable in major metropolitan areas, and employment mobility is more limited in mining. Consequently, technological change in mining will increase the demands on the existing system through which workers retrain and acquire job skills.

One technological advance in mining, longwall mining, increased coal production over the years from 11.9 million tons to 131 million tons in 1993. Longwall mining's increased production provides crews with job security. The longwall coal miner knows he operates the most productive underground system possible, and, thus, his company is better placed to win orders for coal sales in a highly competitive industry (Reid 1989, 20). The modern longwall produces 5,000 tons of clean coal a shift compared with 1,000 tons of coal from a continuous miner (Reid 1989, 20).

Chapter 3

EX-POST PROJECTION OF EMPLOYMENT IN MINING AND COAL INDUSTRY

In the United States there is a demand for reliable economic statistics at the national, state, and local level. Often a sample survey is designed to produce reliable statistics for major geographic areas. Because of budget constraints, the survey is spread thinly across the country producing information that is barely reliable area specific data.

Employment in the U.S. economy is projected to grow by almost 25 million over the 15 years from 1990 to 2005. This projected average growth of 1.2% annually about one-half that during the preceding 15-year period, averaging 2.3% annually from 1975 to 1990 (Carey and Franklin 1992, 43).

Employment in the coal mining industry is projected to decline from approximately 148,000 to 113,000 during the 1990-2005 period (Carey and Franklin 1992, 46). Much of the decrease will be related to technological change.

The econometric model developed for this thesis will attempt to predict U.S. demand for employment in mining, and separately in coal mining. With some change, the model could be adapted to state and substate data, and other extractive industries.

3.1 Model

The demand function for employment identifies the significant variables affecting employment and determines the amount of labor demanded. From the demand equation, one can get the demand curve. The demand curve shows the demand for employment relative to some variable, assuming the other variables remain the same.

From the period 1960 to 1992, U.S. mining employment declined by 11.4%. Coal mining employment during the period decreased by 32.3%. The level for employment can decline over time for the following reasons:

1. The demand curve for labor may shift leftward due to higher wages, collusive actions by competitors, government intervention, or certain other factors.

2. Because of decreased economic activity, the demand curve for labor can shift leftward.

3. Another factor that shifts the demand curve leftward is a change in technology.

4. Several other indicators such as substitutes or complements exist that can cause a decrease in demand.

The dependent variables for the study are Employment (E) for mining, and Coal Mining Employment (CME) for coal. Mining has as the independent variables Industry Output as a Percent of Gross Domestic Output (IOGDP), Mining Output divided by the Value of the Industry Output (OYIO), Gross Domestic Output (GDP), a factor for Technology (T), and Mining Annual Wages(C).

For coal, the independent variables are Coal Industry Output as a Percent of Gross Domestic Output (CIOGDP), Coal Mining Industry Output Divided by the Value of the Coal Industry Output (CMOYCIO), Gross Domestic Output (GDP), a factor for Technology (T), and Coal Mining Annual Wages (WC).

The independent variables chosen for the model influence the demand for employment in the industries under study. The independent economic variables selected are considered representative of the factors that influence the demand for employment. For example, GDP influences demand for electricity. The demand for electricity influences the demand for coal. The increased demand for coal impacts on employment. The opposite happens when GDP decreases.

Given the difficult nature in developing an econometric model for predicting employment, no other model was found in a literature review of mining and coal mining. The Office of Projections of the Bureau of Labor Statistics, Research Units of the Mine Safety and Health Administration, and the American Mining Congress were a few of the organizations contacted to determine if such a model might exist. In addition, a review was conducted of the Journal of Economic Literature to find articles relating to employment model for mining.

Current dollars are used when independent variables have dollar values. This was done in order to avoid problems associated with the Producer Price Index, the Consumer Price Index, or other price indexes.

Wage (W) constitutes a cost to the mining and coal industry. Increasing wages translate into a decrease in demand for employment. Industry output as a percentage of current GDP (IOGDP) is used as a measure of industrial activity. As industrial activity changes, there will be a corresponding change for mining and coal industry output. This change will impact on employment. Tonnage divided by current dollar value (OYIO) is a measure of the value of the output. Increased value is expected to give industry an incentive to produce more and hire more employees.

It is felt that the variables GDP, IOGDP, and OYIO are easier to predict for forecasting purposes than using other industry output measures. The same holds for the coal industry.

In the equation for employment in mining, the expected sign for GDP is positive. One would expect there to be a positive correlation between employment and GDP. The sign for IOGDP is expected to be positive since industry output should increase as GDP increases. One would expect employment to be positively correlated with industry output. The anticipated sign for OYIO is positive. If the value of the industry output is going down, employment should also be decreasing. Technology (T) is expected to have a negative sign with respect to employment in mining. With the influx of labor saving devices, output increases while fewer employees would be needed to do the job. Wage (W) is expected to have a negative sign since there is an inverse relationship between the price of labor and the quantity demanded.

The logic for the expected signs in coal mining employment follows the logic for the expected signs for employment in mining.

3.2 Regression Equations

The equations for the study are

$$E = \alpha_0 + \alpha_1 GDP_i + \alpha_2 IOGDP_i - \alpha_3 OYIO_i - \alpha_4 W_i - \alpha_5 T_i + \epsilon_i$$

$$CME = \beta_0 + \beta_1 GDP_i + \beta_2 CIOGDP_i - \beta_3 CMOYCIO_i - \beta_4 WC_i - \beta_5 T_i + \mu_i$$

Table 5 defines the data variables used in the equations.

3.3 Results

Using Ordinary Least Squares (OLS), the coefficients estimated are shown in the following equations. The t-scores are shown below.

$E =$	643.5	$- .01GDP_i$	$+ 67.46IOGDP_i$	$- 28.53OYIO_i$	$+ .0087W_i$	$- 9.56T_i$
	27.15	$- 0.275$	9.082	$- 11.626$	0.913	$- 2.795$

$CME =$	89.398	$+ .001GDP_i$	$+ 173.50CIOGDP_i$	$- .15CMOYCIO_i$	$+ .001WC_i$	$- 2.57T_i$
	5.05	0.19	12.31	$- 0.505$	2.36	$- 2.25$

3.4 Analysis of Regression

The t-test was applied to the individual regression coefficients. The larger in value this t-value is, the greater the likelihood that the estimated regression coefficient is significantly different from zero (Studenmund 1992, 142). The critical t-value (t_c) at a 5% level of

Table 5. Data Variables

VARIABLES	DEFINITION
CIOGDP	Total coal mining output in current dollars as a percentage of GDP in current dollars.
CMOYCIO	Coal mining industry output (CMOY) divided by coal industry output (CIO). This variable is tonnage divided by current dollar value.
E	Employment (E) is the number of persons employed full or part-time in non-farm establishments during a specified payroll period. Employment in the mining in thousands.
GDP	Total market value of all goods and services produced in a calendar year in current dollars.
IOGDP	Industry output as a percentage of current GDP in the same year, computed by the formula ((IO/GDP)*100).
OYIO	Mining output (OY) divided by industry output (IO) is tonnage divided by current dollar value.
T	This is technological change over time. It is meant to represent any change that permits the same level of output to be produced with less input, or enable the former level of inputs to produce a greater output.
W	Wage is the annual wage of workers employed in mining. The annual wage is derived by multiplying (average hourly earnings * 40 hours per week * 52 weeks). Annual wage does not represent total labor costs per hour for the employer because it excludes retroactive payments and irregular bonuses, employee benefits, and the employer's share of payroll taxes. Expressed in current dollars.
WC	The coal mining annual wage is the annual wage of the people employed in the coal mining industry. The computation is the same as that shown for wage (W). Expressed in current dollars.

Source: Bureau of Labor Statistics, U.S. Department of Labor significance and 25 degrees of freedom using a one-sided test is 1.708.

The null hypothesis implies there is no difference between the true value of the population parameter and that which is being hypothesized. The null hypothesis states that there is no positive correlation between the independent variable and the dependent variable. The alternative hypothesis is a statement held true if the null is not true. An analysis of the t-test is shown in Table 6.

The decision rule is to accept the calculated t-value (t_k) if t_k in absolute value is greater than the critical t-value (t_c) as long as the sign of t_k is the same as the alternative hypothesis.

Rejecting the null hypothesis concludes the variable has a positive correlation with the dependent variable. By accepting the null hypothesis, there is no positive correlation with the dependent variable.

Table 7 presents the Ordinary Least Squares (OLS) relevant information concerning the statistical measures used for analyzing the results of the econometric model developed for the study.

The F-test was used to determine the overall fit of the equation. The critical F-value was determined to be 2.60 at the 5% level of significance. From the table above, one can

Table 6. t-test

INDEPENDENT VARIABLE	EXPECTED SIGN	COMPUTED SIGN	CALCULATED t-VALUE (t_K)	CRITICAL t-VALUE (t_C)
MINING EQUATION				
GDP	+	-	-0.275	1.316***
IOGDP	+	+	+9.082	2.485*
OYIO	-	-	-11.626	2.485*
W	-	+	+0.913	1.316***
T	-	-	-2.795	2.795*
COAL INDUSTRY EQUATION				
GDP	+	+	+0.190	1.316***
CIOGDP	+	+	+12.310	2.485*
CMOYCIO	-	-	-0.505	1.316***
WC	-	+	+0.360	1.316***
T	-	-	-2.250	2.060**

Note: *, **, and *** denote statistical significance at the 1%, 5%, and 10% level of significance using the one-sided test with 25 degrees of freedom.

Table 7. Ordinary Least Squares (OLS) Information

DEPENDENT VARIABLE*	R^2	$\bar{R}^2$	STANDARD ERROR OF REGRESSION	DURBIN WATSON	F-TEST
E	0.96	0.952	34.693	1.637	128.161
CME	0.93	0.912	11.191	1.516	66.663

* The dependent variable corresponds to equations referenced earlier.

conclude that the calculated F-test results are well above the F-value. The null hypothesis can be rejected. The equations do indeed have an overall fit.

The coefficient of determination (R^2) was examined. R^2 is a measure commonly used to describe how well the sample regression line fits the observed data. A high value of R^2 means that the sample regression line fits the observations rather well. A value of .96 indicates that 96% of the sample variation of employment can be attributed to the estimated effects of the independent variables. The computed R^2s are satisfactory.

The corrected coefficient of determination (R^2) was also examined. This measure takes into account the number of explanatory variables in relation to the number of observations. The purpose of the corrected coefficient of determination is to facilitate comparisons of "goodness of fit" of several regression equations that may vary with respect to the number of explanatory variables and the number of observations. The corrected coefficients of determination are also satisfactory.

The Durbin-Watson statistic was examined to see if first order serial correlation existed. This was accomplished by examining the residuals of a particular estimation of that equation. A one-sided 95% confidence test was performed for five explanatory variables and 31 observations. The lower and upper limits were $d_l = 1.09$ and $d_u = 1.83$. While the results of the Durbin-Watson test were in the inconclusive range, they bordered the area of no positive serial correlation.

The Cochrane-Orcutt iterative method was used to rid the equations of first order serial correlation. First Order Serial Correlation is a form of serial correlation in which the current observation of the error term is a function of the previous observation of the error term. This is shown in table 8.

The results of the First Order Autocorrelation do not differ significantly from the OLS method used previously. The results of the Durbin-Watson are now slightly greater than the upper limit ($d_u = 1.83$) for the equations with the dependent variables of E, and CME. This means there is no serial correlation.

3.5 Forecasting of Employment for Mining, and the Coal Industry

The data used for the model had 31 observations from from the years 1960 to 1990. The regression equations derived from the model were used to perform an ex-post forecast for the years 1985 to 1990. The new regression

Table 8. First Order Serial Correlation

DEPENDENT VARIABLE*	R^2	$\bar{R}^2$	STANDARD ERROR OF REGRESSION	DURBIN WATSON	F-TEST	RHO
E	.96	.95	34.146	2.02	132.48	0'.2
CME	.93	.92	10.913	1.838	70.38	0.2

* The dependent variable corresponds to the equations

equations with t-statistics below the equation and relevant statistical information for the period 1960 to 1984 follow.

The equation for mining employment follows.

$$E = 409.9 + .023GDP_i + 87.26IOGDP_i - 10.89OYIO_i + .0016W_i - 2.89T_i$$

4.19 0.285 6.608 -1.571 0.124 -0.652

R^2 = .97 F-Test = 136.7 DW = 2.11 SER = 32.58

Table 9 shows the results of the forecast to have been very accurate in predicting the employment for the forecasted years.

The equation for the coal industry follows.

$$CME = 104.69 + .033GDP_i + 163.413CIOGDP_i - .31CMOYCIO_i - .002WC_i - 3.41T_i$$

4.44 0.655 6.338 -.849 -0.317 -2.256

R^2 = .92 F-Test = 43.18 DW = 1.50 SER = 12.71

Although the statistics are adequate, Table 10 shows the predicted values for the coal industry not as good as

Table 9. Mining Forecast

OBSER.	ACTUAL (000)	PREDICTED (000)	RESIDUAL (000)	PERCENT OF ACTUAL	PERCENT DIFFER. FROM 100%
1985	927.00	905.64	21.36	97.7	2.3
1986	777.00	743.47	33.53	95.68	4.32
1987	717.00	718.39	-1.39	100.19	-0.19
1988	713.00	718.44	-5.44	100.76	-0.76
1989	672.00	736.80	-64.80	109.64	-9.64
1990	709.00	726.89	-17.89	102.52	-2.52

those for mining. The predictive capability of the model worked well for the period 1985 to 1987. The years for 1988 to 1990 are not acceptable because of the large difference of the predicted and the actual.

3.6 Model Results

The model attempted to predict the demand for employment in mining and, for the coal industry. With some modification, the model could possibly be used to generate information for state and substate areas.

The statistical information generated showed the model to have high R^2s; corrected coefficients of determination; F-tests; and D-Ws. For a few of the variables, the t-test was a little low.

When the algorithm was applied to the period 1985 to

Table 10. Coal Industry Forecast

OBSERV.	ACTUAL (000)	PREDICTED (000)	RESIDUAL (000)	PERCENT OF ACTUAL	PERCENT DIFFER. FROM 100%
1985	187.00	199.47	-12.47	106.67	-6.67
1986	176.00	190.18	-14.18	108.06	-8.06
1987	162.00	187.22	-25.22	115.57	-15.57
1988	151.00	186.11	-35.11	123.25	-23.25
1989	144.00	188.52	-44.52	130.92	-30.92
1990	147.00	193.22	-46.32	131.51	-31.51

1990, the mining equation was extremely successful in predicting the demand for employment. The difference between actual and predicted ranged from a low of -0.19% to a high of 4.32%. The results for the coal mining industry were not as successful. Overestimation of the predicted pre-employment resulted. Although still providing direction, these predictions would not be as useful for analytical purposes. Further examination of required independent variables would be needed before the model could be used in those industries.

Chapter 4

Occupational Employment in the Mining and Coal Industry

The occupations examined for this study are those directly employed in mining and the coal industry. Other industries which service mining and coal such as the chemical industry and manufacturers of mining equipment are not included in the study.

4.1 Methodology

Since the mid-1960s the Bureau of Labor Statistics has developed industry-occupational matrices. These matrices present the distribution of employment by industry. However, a time series of these matrices was never developed because of concerns that the lack of comparability of the matrix data over time could result in occupational employment trends that would differ from actual trends (Bureau of Labor Statistics 1994). In 1994, BLS developed a national industry-occupation matrix time series in response to data requests from the public.

BLS has developed national industry-occupation matrices on a two-year cycle since the mid-1960s. Before 1972, the

1960 decennial census was used for the matrix. From 1972 to 1980, the 1970 decennial censuses occupational classification was used to build the matrices. However, the OES survey classification changed significantly in 1983 and matrices constructed with OES survey data prior to that date are not comparable with those prepared using Occupational Employment Survey (OES) data collected since 1983 (Bureau of Labor Statistics). Complicating the comparability of data from one period to another is the fact that occupational classification changes and industrial classification changes were instituted in 1972, 1977, and 1987. In addition, occupations covered in OES surveys and in decennial census have changed over time. Lastly, changes have been made in the quality of the data in response to user needs. Consequently, extreme care should be taken when comparing changes in the data over time.

4.2 Development of the National Industry Occupational Matrix, 1983-1993 Time Series Data

The National Industry Occupational Matrix was developed with the following guidelines:

1. The series would be as consistent as possible with the 1992 matrix.

2. The OES survey occupational classification used after 1983 would be used.

3. No data would be presented in the series for either detailed occupations or detailed industries that did not have a comparable definition in every year of the series.

4. A review of the year to year total employment trend for an occupation must be consistent with logical year to year expectations.

5. No cell in the series would have confidential data and no cell would have data suppressed because of confidentiality.

6. The time series would cover only wage and salary workers.

7. Data for industries having fewer than 50,000 workers in 1992 would be collected in all years except those having a distinct occupational staffing pattern that would distort other information into which it was aggregated.

4.3 Data Sources

The following data sources were used in constructing the National Industry-Occupation Employment Matrix:

1. OCCUPATIONAL EMPLOYMENT STATISTICS (OES). The OES survey is a periodic mail survey that covers nonfarm establishments. The survey collects occupational data by industry on employment. The OES survey occurs on a three-year cycle. Three surveys are conducted alternatively for manufacturing, nonmanufacturing, and the balance of nonmanufacturing (Bureau of Labor Statistics 194, 29).

3. POSTAL SERVICE STAFFING PATTERNS. This information was obtained from the Postal Service.

4.4 Comparability of Occupational Data from Year to Year

Occupations that had fewer than 5,000 employees were aggregated into a related occupation. Because of these aggregations of survey occupations, the number of occupations in the matrices constructed from 1986 through 1992 varied from 480 in 1986 to 512 in 1992.

To achieve uniformity over time for the historical series, occupations that were aggregated in the 1986, 1988, and 1990 matrices, but which were presented in the 1992 matrix, were disaggregated in the earlier matrices. However, if an occupation appeared in an earlier matrix but was collapsed in the 1992 matrix, that occupation was collapsed in the historical series. Nevertheless, because the occupational structure of the surveys of the same industry may differ from one survey round to the next, there may be occupational data in an industry cell in some matrices but not in others. The nature of the collection of survey employment data, however, provides for variations in the OES occupational structure from survey round to survey round. An occupation can be dropped from a survey round because of very low employment in the previous survey or an occupation can be added to a survey as a newly emerging occupation.

The 1986 matrix staffing pattern was used as the basis for developing the 1983, 1984, 1985 and 1986 matrices. The 1988 staffing matrix was used to develop the 1987, 1988, staffing patterns. The 1990 matrix was used to develop the 1989 and the 1990 matrices. The 1992 matrix was used to develop the 1991, 1992, and 1993 matrix. Matrices for each year were benchmarked to the latest available industry employment data from the CES survey as of July 1994 when the matrix time series was developed.

Confidentiality of the data had to be taken into consideration. In the industries where occupations were less than 1% of the industry, occupations were collapsed into their residual, or the industry was aggregated to another level.

4.5 Results

Based on the limitations of the data, comparison of occupational changes from year to year is difficult.

Table 11 shows the total employment by major occupational group in the mining and the coal industry. As can be seen from the data, every major occupational group lost substantial amounts of labor from 1983 to 1993. Total employment in all occupations increased by 21% over the 10-year period. Total employment by occupation decreased by 37% for mining, and 45.6% for coal mining. In all major occupational categories listed, coal mining had a greater decrease in employment than mining.

While some of the occupational changes show substantial percentage decreases, the number of people employed in the occupation was very small. Consequently, when looking at

Table 11 Occupations in Mining and Coal Industry, 1983-1993

5 DIGIT CODE AND OCCUPATION		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	% change 1983-1993
00000	Total, all occupations	92586401	96748800	99650501	101552300	104183700	107388700	110058200	111508900	110339900	110746499	112312099	21.30518
00000	Total, all occupations, MINING	951900	965600	927600	777800	718200	712600	691700	709300	688900	630600	598800	-37.0942
10000	Executive, administrative, and managerial	105466	106091	102214	86695	86008	85184	82315	84001	77022	71118	67125	-36.3539
20111	Professional specialty	77544	77616	74481	62690	56270	55781	54178	54811	53554	49695	46664	-39.8226
35000	Technicians and related support	29045	29079	27948	23696	22366	22240	21761	22045	25738	23816	22516	-22.4789
40000	Marketing and sales	16483	16947	16293	12360	9960	10003	9469	9928	8254	7231	7300	-55.7119
50000	Administrative support, including clerical	120038	120976	116640	98011	85072	84474	81994	83604	81942	75426	71838	-40.154
60000	Service	8800	8916	8528	7279	6631	6604	6513	6723	4886	4495	4204	-52.2273
70010	Agriculture, forestry, fishing, and related	1178	1185	1151	1031	629	620	558	568	538	499	471	-60.017
80001	Precision production, craft, and repair	360538	367578	351432	284862	258743	256859	248283	257115	256906	231784	221613	-38.5327
90000	Operators, fabricators, and laborers	232809	237212	228913	201177	192520	190834	186630	190505	180060	166535	157070	-32.5327

5 DIGIT CODE AND OCCUPATION		1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	% change 1983-1993
00000	Total, all occupations	92586401	96748800	99650501	101552300	104183700	107388700	110058200	111508900	110339900	110746499	112312099	21.30518
00000	Total, all occupations, COAL MINING	193500	195500	188500	177000	162900	150800	143700	146500	135500	125500	105200	-45.6331
10000	Executive, administrative, and managerial	14436	14585	14063	13205	13147	12170	11087	11303	9363	8672	7269	-49.6467
20111	Professional specialty	5420	5476	5280	4958	4771	4417	4056	4135	3435	3181	2667	-50.7934
35000	Technicians and related support	1818	1836	1771	1663	1765	1634	1465	1494	1187	1099	922	-49.2849
40000	Marketing and sales	473	477	460	432	677	627	562	573	172	160	134	-71.6702
50000	Administrative support, including clerical	12109	12234	11796	11076	10365	9595	8724	8894	7252	6717	5630	-53.5057
60000	Service	2233	2256	2175	2043	2048	1896	1847	1883	1425	1320	1106	-50.4702
70010	Agriculture, forestry, fishing, and related	380	384	371	348	147	136	118	121	101	94	79	-79.2105
80001	Precision production, craft, and repair	80001	80828	77934	73179	69399	64244	62010	63218	60494	56029	46966	-41.2932
90000	Operators, fabricators, and laborers	76630	77422	74650	70096	60582	56082	53831	54880	52071	48228	40427	-47.2439

Bureau of Labor Statistics, 1994

the percentage decrease one also has to look at the number of people in the occupation. Regardless, while most industries have shown employment increases, mining and coal mining have shown substantial decreases.

Table 12 shows, by year, the percentage of employment by category for that year. In mining, the major occupational category with the highest percentage for any year is craft and repair, and precision production. For 1993, the precision production category accounted for 37.01% of mining employment. The next highest category is operators, fabricators, and laborers accounting for 26.22%. The combined categories account for 63.23% of 1993 mining employment. Administrative support accounted for 12.01% and executive, administrative, and managerial occupations accounted for 11.21%. Together, the two categories accounted for 23.22% of the employment.

A similar scenario exists for coal mining with craft and repair, and precision production occupations accounting for 44.64% of the 1993 employment. Operators, fabricators, and laborers accounted for 38.43% of the occupational employment. Together, the two categories comprised 83.07% hereof coal industry employment. The next largest category was executive, administrative, and managerial had 6.91% of the coal industry employment. For the mining, this category

Table 12 Occupations in Mining and Coal Industry, 1983-1993

5 DIGIT CODE AND OCCUPATION		1983 %	1984 %	1985 %	1986 %	1987 %	1988 %	1989 %	1990 %	1991 %	1992 %	1993 %
00000	Total, all occupations	100	100	100	100	100	100	100	100	100	100	100
00000	Total, all occupations, MINING	100	100	100	100	100	100	100	100	100	100	100
10000	Executive, administrative, and managerial	11.08	10.99	11.02	11.15	11.98	11.95	11.9	11.84	11.18	11.28	11.21
20111	Professional specialty	8.15	8.04	8.03	8.06	7.83	7.83	7.83	7.73	7.77	7.88	7.79
35000	Technicians and related support	3.05	3.01	3.01	3.05	3.11	3.12	3.15	3.11	3.74	3.78	3.76
40000	Marketing and sales	1.73	1.76	1.76	1.59	1.39	1.4	1.37	1.4	1.2	1.15	1.22
50000	Administrative support, including clerical	12.61	12.53	12.57	12.6	11.85	11.85	11.85	11.79	11.89	11.96	12.01
60000	Service	0.92	0.92	0.92	0.94	0.92	0.93	0.94	0.95	0.71	0.71	0.7
70010	Agriculture, forestry, fishing, and related	0.12	0.12	0.12	0.13	0.09	0.09	0.08	0.08	0.08	0.08	0.08
80001	Precision production, craft, and repair	37.88	38.07	37.89	36.62	36.03	36.05	35.89	36.25	37.29	36.76	37.01
90000	Operators, fabricators, and laborers	24.46	24.57	24.68	25.86	26.81	26.78	26.98	26.86	26.14	26.41	26.22

5 DIGIT CODE AND OCCUPATION		1983 %	1984 %	1985 %	1986 %	1987 %	1988 %	1989 %	1990 %	1991 %	1992 %	1993 %
00000	Total, all occupations	100	100	100	100	100	100	100	100	100	100	100
00000	Total, all occupations, COAL MINING	100	100	100	100	100	100	100	100	100	100	100
10000	Executive, administrative, and managerial	7.46	7.46	7.46	7.46	8.07	8.07	7.72	7.72	6.91	6.91	6.91
20111	Professional specialty	2.8	2.8	2.8	2.8	2.93	2.93	2.82	2.82	2.53	2.53	2.53
35000	Technicians and related support	0.94	0.94	0.94	0.94	1.08	1.08	1.02	1.02	0.88	0.88	0.88
40000	Marketing and sales	0.24	0.24	0.24	0.24	0.42	0.42	0.39	0.39	0.13	0.13	0.13
50000	Administrative support, including clerical	6.26	6.26	6.26	6.26	6.36	6.36	6.07	6.07	5.35	5.35	5.35
60000	Service	1.15	1.15	1.15	1.15	1.26	1.26	1.29	1.29	1.05	1.05	1.05
70010	Agriculture, forestry, fishing, and related	0.2	0.2	0.2	0.2	0.09	0.09	0.08	0.08	0.07	0.07	0.07
80001	Precision production, craft, and repair	41.34	41.34	41.34	41.34	42.6	42.6	43.15	43.15	44.64	44.64	44.64
90000	Operators, fabricators, and laborers	39.6	39.6	39.6	39.6	37.19	37.19	37.46	37.46	38.43	38.43	38.43

Bureau of Labor Statistics, 1994

ranked fourth here highest while for coal, it was the third highest. The fourth highest occupational employmentcategory in coal was administrative support at 5.35%.

As a percentage of total occupational employment, the major occupational categories showed surprisingly little percentage change over the 10-year period shown by the data. The percentage composition of total occupational employment over the 10-year period for which the data was available occurred in an industry where total employment by category was decreasing and labor output was increasing. While total employment was decreasing, the percentage of people employed in the occupational groups remained relatively constant. This attests to the impact of increasing technology in an industry becoming more capital intensive.

Appendixes F and G provide a detailed occupational matrices table of employment for 1983-1993 in the mining and coal mining industry by major category and sub-categories. Appendixes H and I provide information by percentage of total employment for the occupational categories from 1983 to 1993.

Chapter 5

POLICY IMPLICATIONS FOR LABOR MARKET

The thesis shows that the employment in mining and the coal industry decreased substantially over a relatively short period of time. The decrease in employment translates into increases in unemployment in the mining and coal industry. The thesis attempts to develop a methodology for predicting the amount of employment and the occupational requirements in a given year. With such information, policy makers would be in a better position to provide adequate labor market information to a unique segment of the labor market.

While employment is a policy issue for the U.S. government, it has implications for the company, union and labor force entrant.

5.1 National

Traditional economic theory of the 1970s, 1980s, and the early 1990s must be reexamined in the light of employment problems peculiar to mining, and to coal mining in particular. Much human resource planning in the past was based on neoclassical economic logic of limited government intervention. Such logic offers little reasoning when applied to the U.S. having an adequately trained labor force capable of maintaining the coal industry's competitive position in a changing global economy. The U.S. government needs to assume an increasing responsibility in planning for an adequate labor force. The government needs to assume a more active role in coordinating programs to provide for a trained labor force which is adequate both in size and ability.

The U.S. government plans to overhaul the labor market information system, having as its objectives the efficient allocation of human resources and a system for career choice which gives individuals an awareness of their own knowledge, skills, resources, abilities, and the alternatives open to them. Interrelated with a policy related to human resources, the government must link its policies on fiscal, monetary, and educational factors.

One such human resource policy is the Job Training Partnership Act (JTPA) of 1982. JTPA is a product of evolution of other human resource policies dating back to the Great Depression. One particular part of the JTPA Act is Title III, Employment and Training Assistance for Dislocated Workers. It provides federal funds to states for the purpose of training and other related employment services for laid-off workers who are unlikely to return to their previous industry or occupation. Workers who become unemployed because of permanent plant closing are also covered. Generally, services provided under Title III are related to job seeking skills training.

5.2 Company

The adoption of technology in mining has caused occupational requirements of the industry to change. In addition, the duties performed by individuals has also changed. Some responsibilities have been eliminated and others added.

The change in job responsibilities performed by the employee increases the requirement that the employer provide training in job-related skills. This does not mean that management change its job-related requirements for entry into a job.

> Management has a number of incentives to encourage the acquisition by workers of the capabilities to perform more tasks, or "multitasking." Coordination is easier when workers can perform a greater variety of activities. Workers also perform better (productivity increases, as does attention to product quality) when they can see the relationship between their job and other jobs, a relationship that becomes clearer when the worker is trained to perform more than one job.

> From the worker's point of view, multiskilling can lead to higher wages or the retention of current wages. Most workers also find multiskilled jobs to be more interesting and challenging than single-skill jobs. Serious disincentives to investment by firms in such training arise from its costs, which may be particularly burdensome for small firms, and the fact that it may be difficult to recover the fruits of their investments in training (Reid 1989, 127).

The evolution of technology and the competitive nature of the firm means that training and retraining will have to be a continuous task for the firm. As has been happening in the coal mining industry, the skill requirements and responsibilities of production workers resemble those of engineers a few years ago. While management and other institutions, including unions, will have to provide the training, the worker will have the responsibility to adapt to changing job requirements.

5.3 Union

Labor unions were formed to provide job security and employment for its members. The strength of the union is in the number of workers in the industry and related industries. Before technology can be adapted to the employees, the union needs some assurance of job security for its members.

These assurances enable management to retain the loyalty among workers who have been retrained at considerable cost to the employer (Reid 1989, 130). Job security and retraining programs are parts of a successful adaption strategy by management and unions. The workers become more highly skilled and the turnover rate decreases.

Unions are also interested in occupational changes because some unions provide training programs. Consequently, these unions need to be cognizant of emerging and disappearing occupations.

5.4 Labor Force Entrants

Changes in technology will raise the level of skills required by labor force entrants. This supports the requirement for continued investment and improvement in the job-related skills of the U.S. work force to support the adoption of new technology to keep the U.S. competitive in world markets.

Technology will not be a limiting factor for people entering the labor force with strong skills in occupations that are in demand. Labor force entrants with strong skills and adequate labor market information will do better than the average in tomorrow's labor market. Labor force entrants need to be aware of requirements for occupations and training available for the occupation.

Chapter 6

CONCLUSIONS

The U.S. mining and coal industry are in unique competitive positions for the following reasons:

1. The U.S. mineral resources are not as rich as in some other parts of the world.
2. The cost of mining is high in the United States.
3. Labor costs are lower in other geographic locations, especially in third world countries.
4. Environmental laws are less stringent or non-existent for producers elsewhere.
5. Mines in third world countries are able to achieve faster start-up time.

Consequently, U.S. companies have had to become more technologically advanced in order to remain competitive. Companies have to utilize labor as efficiently as possible.

In my thesis I have examined the demand for employment in the mining and the coal industry. This examination looked at the decrease in total employment while output per unit of labor has been increasing. Technology impacted on the increased output per unit of labor input.

The second aspect of this thesis is the development of an econometric model to predict the demand for employment in mining and the coal industry. The model is based on independent variables affecting employment and the amount of labor required. The demand function identifies significant variables affecting employment and determines the amount of labor needed.

When the algorithm was applied to the time period from 1985 to 1990, the mining equation was extremely successful in predicting the demand for employment. While still useful, the result for the coal industry was not as successful. Further examination of required independent variables would be needed before the model could be used for the coal industry.

Of importance to any examination of employment is an analysis of the occupations in the industry. Industry-occupational matrices developed by BLS present the distribution of employment by industry. One problem with a time series of these matrices is that the lack of comparability of the matrix data over time could result in occupational employment trends that would differ from actual trends. In 1994, BLS developed a national industry-occupation matrix time series in response to data requests from the public.

This thesis evaluates the time series and shows that occupations in mining and coal have decreased substantially over the last 10 years. Very few occupations in the industries grew. Those that did grow showed inconsequential growth.

On a per year basis, as a percentage of total occupational employment, the major occupational categories showed surprisingly little percentage change over the 10-year period shown by the data. The percentage composition of total occupational employment over the 10-year period for which the data were available occurred in an industry where total employment by category was decreasing and labor output was increasing. While total employment was decreasing, the percentage of people employed in the occupational groups remained relatively constant. This attests to the impact of increasing technology in an industry that has become more capital intensive.

Finally, the thesis attempts to show why U.S. companies, unions, and labor force entrants should find the information important in order to compete successfully in a competitive economy.

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APPENDIXES

APPENDIX A
ORDINARY LEAST SQUARES FOR MINING INDUSTRY

APPENDIX A

DEPENDENT VARIABLE IS E

ORDINARY LEAST SQUARES
SAMPLE RANGE: 1960 - 1984

	COEFFICIENT	STANDARD ERROR	T-SCORE
CONST	409.9457	97.73993	4.194250
IOGDP	87.26352	13.20591	6.607913
GDP	0.019805	0.069452	0.285163
OYIO	-10.88999	6.934055	-1.570508
W	1.55295E-03	0.012546	0.123774
T	-2.894318	4.444811	-0.651167

R-SQUARED	0.972959	MEAN OF DEPEND VAR	754.5600
ADJUSTED R-SQUARED	0.965843	STD DEV DEPEND VAR	176.2867
STD ERR OF REGRESS	32.58026	RESIDUAL SUM	-1.10312E-12
DURBIN WATSON STAT	2.107438	SUM SQUARED RESID	20167.99
F STATISTIC	136.7308		

COVARIANCE MATRIX

CONST, CONST	9553.093	CONST, GDP	2.313188
CONST, IOGDP	-891.1061	CONST, OYIO	-640.2437
CONST, W	-0.216724	CONST, T	-262.6650
GDP, GDP	4.82369E-03	GDP, IOGDP	-0.090124
GDP, IOGDP	-0.098013	GDP, W	-7.58163E-04
GDP, T	-0.030258	IOGDP, IOGDP	174.3961
IOGDP, OYIO	45.41165	IOGDP, W	-0.045805
IOGDP, T	41.53046	OYIO, OYIO	48.08112
OUIO, W	0.013294	OYIO, T	14.96494
W, W	1.57417E-04	W, T	-0.018432
T, T	19.75635		

OUT OF SAMPLE FORECAST: E

OBSERVATION	ACTUAL	PREDICTED	RESIDUAL
1985	927.0000	9015.6464	21.35357
1986	777.0000	743.4745	33.52554
1987	717.0000	718.3969	-1.396891
1988	713.0000	718.4422	-5.442171
1989	692.0000	736.8036	-44.80360
1990	709.0000	726.8879	-17.38793

ROOT MEAN SQUARE ERROR	25.62175
MEAN ABSOLUTE ERROR	20.73495
PERCENT ERROR AT END	2.52298

APPENDIX B
ORDINARY LEAST SQUARES FOR COAL MINING INDUSTRY

APPENDIX B

DEPENDENT VARIABLE IS CME

ORDINARY LEAST SQUARES
SAMPLE RANGE: 1960 - 1984

	COEFFICIENT	STANDARD ERROR	T-SCORE
CONST	4104.6946	23.60067	4.436085
CIOGDP	163.4129	25.78290	6.338036
GDP	0.032530	0.049662	0.655032
CMOYCIO	-0.311515	0.367153	-0.848459
WC	-1.96553E-03	6.19560E-03	-0.317246
T	-3.409191	1.510725	-2.256659

R-SQUARED	0.919112	MEAN OF DEPEND VAR	180.1600
ADJUSTED R-SQUARED	0.897826	STD DEV DEPEND VAR	39.76669
STD ERR OF REGRESS	12.71125	RESIDUAL SUM	1.84741E-13
DURBIN WATSON STAT	1.497762	SUM SQUARED RESID	3069.943
F STATISTIC	43.17897		

COVARIANCE MATRIX

CONST, CONST	556.9915	CONST, GDP	0.518405
CONST, CIOGDP	-227.3785	CONST, CMOYCIO	-7.836319
CONST, WC	-0.060127	CONST, T	-18.55662
GDP, GDP	2.46640E-03	GDP, CIOGDP	0.574021
GDP, CMOYCIO	-3.01036E-03	GDP, WC	-3.03113E-04
GDP, T	-0.042556	CIOGDP, CIOGDP	664.7578
CIOGDP, CMOYCIO	3.920334	CIOGDP, WC	-0.076640
CIOGDP, T	-9.529856	CMOYCIO, CMOYCIO	0.134801
CMOYCIO, WC	3.06457E-04	CMOYCIO, T	0.243130
WC, WC	3.83855E-05	WC, T	4.15536E-03
T, T	2.232289		

OUT OF SAMPLE FORECAST: CME

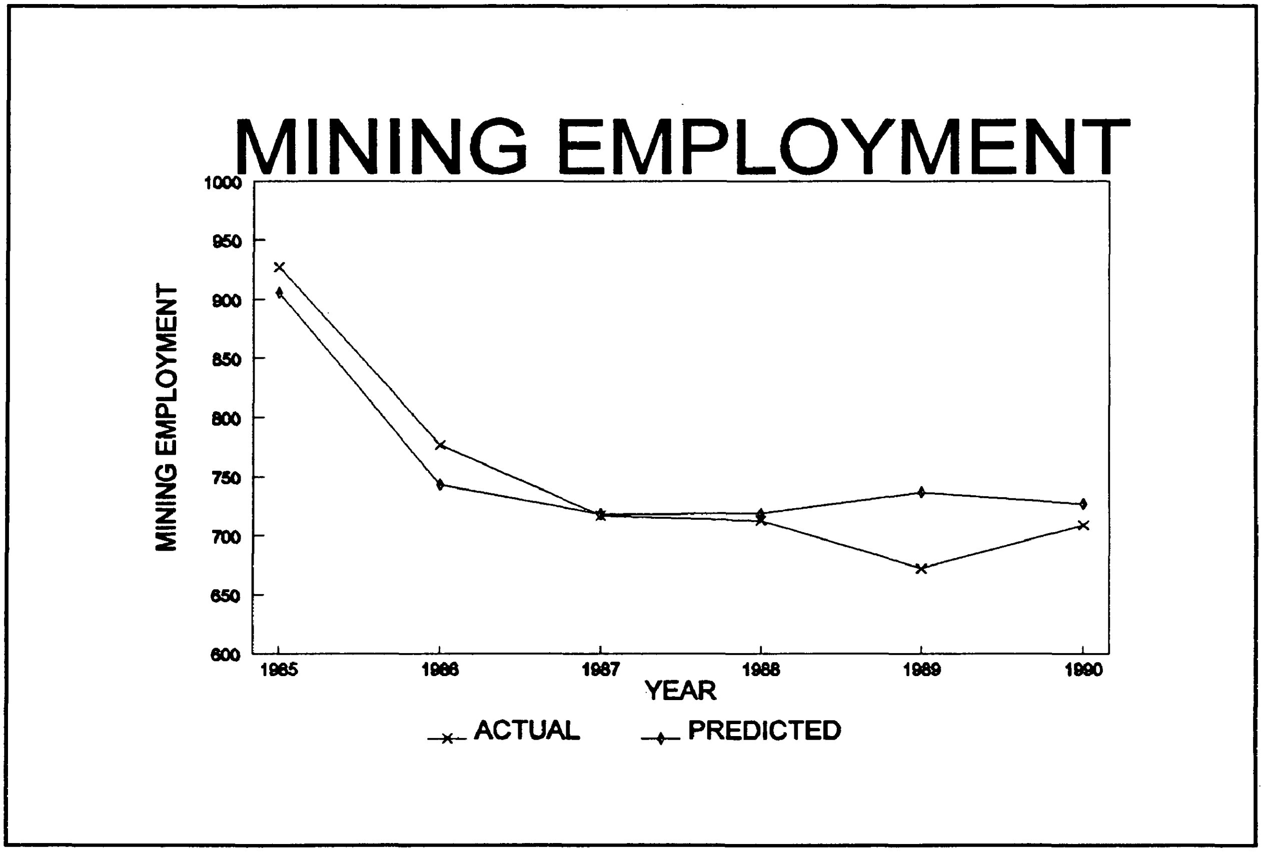
OBSERVATION	ACTUAL	PREDICTED	RESIDUAL
1985	187.0000	199.4699	-12.46989
1986	176.0000	190.1829	-14.18287
1987	162.0000	187.2222	-25.22220
1988	151.0000	186.1099	-35.10987
1989	144.0000	188.5168	-44.51685
1990	147.0000	193.3242	-46.32421

ROOT MEAN SQUARE ERROR	32.54022
MEAN ABSOLUTE ERROR	29.63765
PERCENT ERROR AT END	31.51306

APPENDIX C
GRAPH AND TABLE OF MINING INDUSTRY FORECAST

MINING - FORECAST

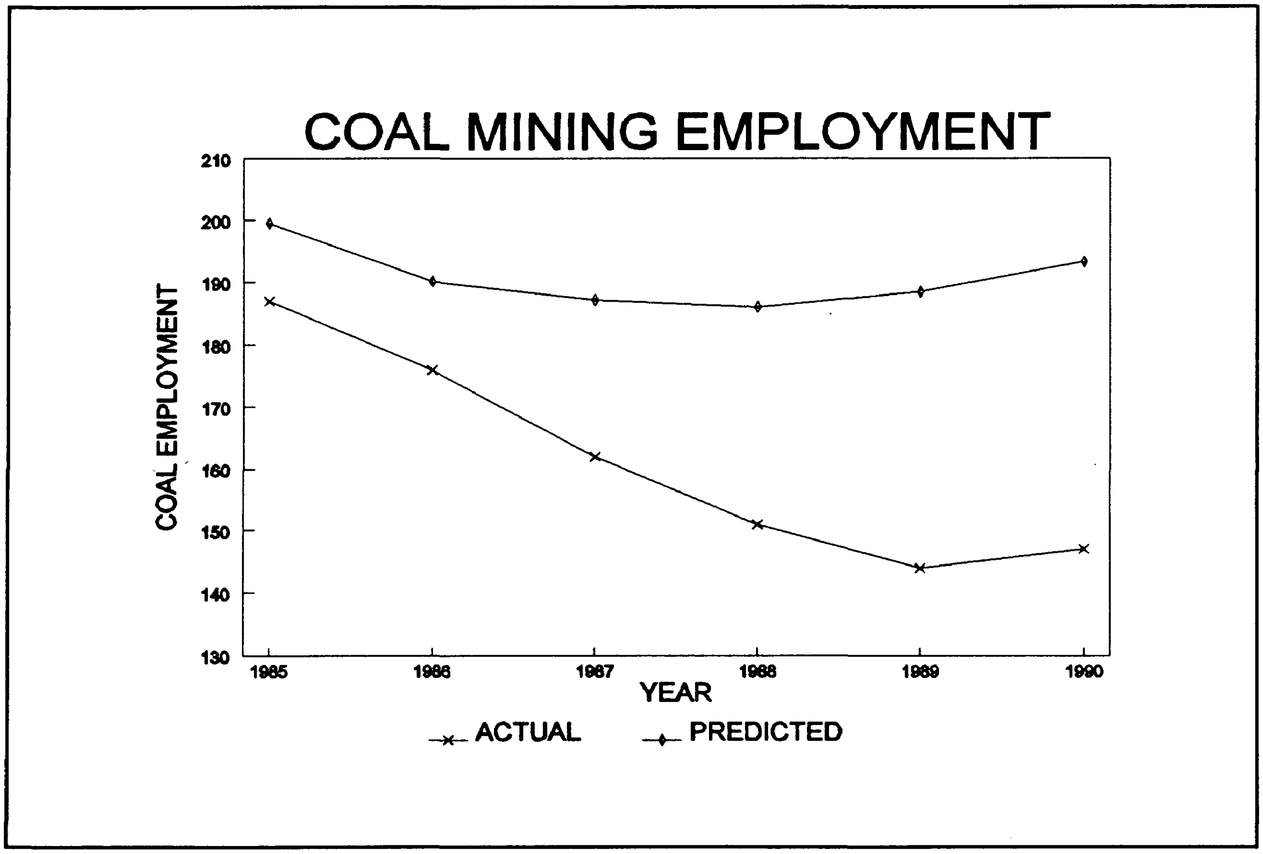
YEAR OBSERV.	ACTUAL (000)	PREDICTED (000)	RESIDUAL (000)	PERCENT DIFFER.	PERCENT DIFFER FROM ACTUAL
1985	927.00	905.64	21.36	97.70	2.30
1986	777.00	743.47	33.53	95.68	4.32
1987	717.00	718.39	-1.39	100.19	-0.19
1988	713.00	718.44	-5.44	100.76	-0.76
1989	672.00	736.80	-64.80	109.64	-9.64
1990	709.00	726.89	-17.89	102.52	-2.52



APPENDIX D
GRAPH AND TABLE OF COAL INDUSTRY FORECAST

COAL MINING - FORECAST

YEAR OBSERV.	ACTUAL (000)	PREDICTED (000)	RESIDUAL (000)	PERCENT DIFFER.	PERCENT DIFFER FROM ACTUAL
1985	187.0	199.47	-12.47	106.67	-6.67
1986	176.00	190.18	-14.18	108.06	-8.06
1987	162.00	187.22	-25.22	115.57	-15.57
1988	151.00	186.11	-35.11	123.25	-23.25
1989	144.00	188.52	-44.52	130.92	-30.92
1990	147.00	193.32	-46.32	131.51	-31.51



APPENDIXES E, F, G, H, I

SEE THESIS POCKET