TECHNOLOGY AND EMPLOYMENT

IN

CANADA'S STEEL INDUSTRY

By

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Abstract

The major emphasis of this paper is to examine technological changes in the steel industry and how these effect employment. The hypothesis is that, "technological changes have contributed significantly to unemployment in the steel industry." The history of the steel industry in Canada is examined. Trends in production, consumption and employment are studied. All are found to be declining in Canada. A regression analysis shows technology to be a significant factor affecting production efficiency in western countries. Data from Canada, Germany, Japan, the United Kingdom, and the United States for the years 1964 to 1982 are used in the regression. More efficient production means lower employment for a given amount of output. The hypothesis is accepted because employment is proven to be lowered as new technology is implemented.

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Introduction

The hypothesis for this research is, "technological changes have contributed significantly to unemployment in the steel industry." This problem is of interest because the steel industry is a major source of jobs in Canada; consequently it is important to know the cause of job loss. If job loss is due to market forces of declining demand then some of these jobs may be regained. If job loss is due to advancements in technology, displaced jobs may never be regained. The purpose of the research is to examine the effect of technological changes in the steel industry on employment in the industry. An analysis will be conducted to determine what effects technological changes have on employment. The analysis will also examine other things such as market forces which affect unemployment in the steel industry. The analysis is intended to show whether technological changes are indeed responsible for a great deal of job loss in the industry or if other factors have a greater impact.

Chapter one will give a historical overview of the steel industry in Canada from its beginning in the 1840's to its rise as a world market competitor in the 1970's. It will outline some of the major influences on the industry, such as Sir John A. Macdonald's National Policy in the 1880's and the great depression of the 1930's.

Chapter two will show some trends which have occurred in the Canadian steel industry during the study period, 1964 to 1982. These will include the general decline in the ratio of employment to output, decreasing consumption of steel, and evidence which suggests the Canadian steel industry is a non-growth industry.

Chapter three will describe the technologies of steel production. These include the open hearth furnace, the basic oxygen furnace, the electric furnace, and continuous casting. The three types of furnaces are different methods of making steel. Continuous casting is a technological improvement to the production process.

Chapter four will deal with data, methods, and analysis. The data section will introduce pertinent dependent and independent variables to the analysis. The methods section will describe regression analysis and why it is used in the research. The analysis section will explain how the analysis was carried out.

The final section will give a brief summary of the findings and a conclusion as to the validity of the hypothesis.

History of the Canadian Steel Industry

Until the mid-nineteenth century the Canadian economy was a staple economy under colonial rule by Britain. The Canadian economy existed to serve Britain. Canada was exploited for its fish, furs, and timber resources.

The first signs of major industrial development appeared in the 1840's. It was at this time that Canada emerged as an industrial democracy and independent nation from a commercial aristocracy and distant imperial rule. Between 1846 and 1849 Canada adopted a free trade policy with the world where it had previously been part of a merchantilist empire (Kilbourn, 1960, p. 8). "Economically and politically Canada was thus cut loose from the privileges and restrictions of empire." (Kilbourn, 1960, p. 9).

During these years the Canadian government improved the canal which brought supplies past the Lachine Rapids to south-west Montreal. Upon completion of this project the government provided industrial sites along the canal with rights to the water power to those who leased them (Kilbourn, 1960, p. 9). Raw materials of coal and iron could easily be landed along the Lachine Canal and shipments of heavy goods taken away. A number of metal factories moved into this area, which included nail and spike, axe, and saw factories (Kilbourn, 1960, p. 10).

Many of these factories enjoyed 100% annual returns on capital during the next twenty years. This would end however with the great world price depression which began in 1873. Sir John A. Macdonald's National Policy helped the industry during 1880's. The National Policy advocated protection. With the introduction of the National policy Canada became a high tariff nation, like the United States and Germany (Swainson, 1971, p. 115). Protection encouraged the growth of industry, including the steel industry, because Canadian industry could be assured of a market for domestically produced goods. Tariffs on foreign goods prevented them from being sold on the Canadian market at low cost. The tariff increases protected up to 35% of steel products during the 1880's (Kilbourn, 1960, p. 16). Another important factor was the expansion of the Canadian market itself. For example the building of branch line railways in the 1880's was vital to the industry (Kilbourn, 1960, p. 16).

It was not until the 1890's that the Canadian iron industry felt the full impact of the world depression. The post-Confederation railway building program was completed in 1885. Competition from foreign manufacturers became more intense. By 1890 the United States had become the major source of competition (Kilbourn, 1960, p.16). Kilbourn (1960, p. 17) notes that, "by the end of the depression, iron and steel products were selling for 58% lower on the average than they had at its beginning in 1873."

The expansion of the Canadian West and Northern Ontario during the early 1900's influenced the development of a new industrial center of gravity in Canada. Rapid growth occurred in Ontario and the sphere of influence edged from Montreal up the St. Lawrence (Kilbourn, 1960, p. 30). In 1899 the Ontario Rolling Mills amalgamated with the Hamilton Blast Furnace Company. This merger linked the two processes of iron-smelting and steel-rolling and the company constructed open hearth furnaces to make steel. This pointed the way to a new method of operation in the steel industry, larger in scale and different in character (Kilbourn, 1960, p. 32). Hamilton became the most industrialized city in Canada and the nation's major iron and steel center.

The Steel Company of Canada (i.e. Stelco) was created in 1910 from the amalgamation of five firms which included the Hamilton Steel and Iron Company, Montreal Rolling Mills, Dominion Wire Manufacturing Company, Canada Bolt and Nut Company, and the Canada Screw Company (Kilbourn, 1960, pp. 72-73). Stelco's bond issue was sold in Britain and its success helped to clear the way for others. Algoma Steel in Sault St. Marie and Dominion Steel in Sydney Nova Scotia, both founded by American capital, issued bonds of similar size in Britain. This marked a significant shift from American ownership and control in the Canadian steel industry to British ownership and Canadian control (Kilbourn, 1960, p. 80).

A serious recession struck the North American economy in 1913. It was particularly severe for heavy industry. With the outbreak of war in Europe the recession turned to depression. Stelco was brought very close to bankruptcy in the fall and winter of 1914-15 (Kilbourn, 1960, pp. 94-95).

There was a general revival of the economy in 1915 which brought increased demand for steel products. European food shortages drove up the world price of wheat. This put new pressure on the steel industry through demands on railways, farm equipment and construction materials. Car manufacturing and ship-building also put new demands on the industry as did the Canadian lumber industry which had a variety of steel needs (Kilbourn, 1960, p. 102).

The great depression of the 1930's hit heavy industries very hard. Open hearths and blast furnaces stood idle for weeks on end in steel towns like Sydney, Hamilton and Sault St. Marie. Canada's steel production shrank to less than 20% of its capacity in 1932. For a period of three months in 1933 no pig iron at all was made in Canada (Kilbourn, 1960, p. 142). "The Steel Company of Canada, operating at one-quarter capacity was better off than its rivals. In 1932 the company produced about forty-five percent of the total Canadian Steel tonnage." (Kilbourn, 1960, p. 142). Its relative success has been attributed to its finishing works. Some of the demand lost from the manufacturers of cars, implements, and railway equipment was made up by continuing demand for lighter steel products because people were driven to repair or rehabilitate obsolete equipment rather than replace it (Kilbourn, 1960, pp. 142-143).

By 1937 the worst was over. Steel production increased as rearmament took place in Europe. In 1939 Canada entered World War Two. She became a principal ally of Britain and Canadian industry was called on to supply the war effort. During the first two years of the war the Canadian steel industry was able to keep pace fairly well with the growing demand for steel. But a shortage soon developed and it became necessary to ration steel by a co-ordinated national plan (Kilbourn, 1960 p. 167).

Growth in the Canadian steel industry during the war was influenced by the American Neutrality Acts which forbade the sale of war materials by the U.S. from 1939 to 1941. In the same period American supplies of raw steel and machine tools were available to Canada. During the first couple of years after Pearl Harbour American industry was still building up its own war supplies. The continued expansion of Canadian industry was even more urgently needed by the Allies. After 1941 Canada held its position as the fourth largest producer of steel among the Allies (Kilbourn, 1960, p. 169). After the war the Canadian steel industry experienced increasing demand in older steel using industries such as railway equipment. There was also an increase in the production of farm machinery as farming became more mechanized (Kilbourn, 1960, p. 215). New steel-using industries grew in Canada in the 1950's. One of the most significant was the petroleum industry. Steel was required for drilling equipment and pipe-lines (Kilbourn, 1960, p. 216).

During the 1950's and 1960's urbanization increased, manufacturing facilities expanded, and infrastructure was built up rapidly. The installation of manufacturing facilities and infrastructure required vast amounts of steel. "Thus the demand for steel increased at an annual rate of 5 to 6 percent from the mid-1950's to the mid-1970's." (Barnett and Schorch, 1983, p.222). Canadian steel companies expanded in response to the increasing demand. Expansion of the industry meant that new modern facilities were introduced at a fairly rapid pace. Barnett and Schorch (1983, p.222) say that these newer, larger, facilities created a more competitive industry in Canada which in turn expanded its competitive position on the world market. "By the late 1960's, Canadian producers had reached competitive parity with the U.S. industry in many product lines" (Barnett and Schorch, 1983, p. 224). During the 1960's some steel products traditionally imported into Canada were produced in Canada by integrated firms. Mini-mills grew in importance during the 1960's. Managerial policy at this time was specialization. Canada's integrated firms did not compete greatly with mini-mill operations in barlike products.

By the 1970's mini-mills accounted for the majority of Canada's merchant bar, wire rod, and light structural production (Barnett and Schorch, 1983, p. 222). There were three major integrated firms at this time; Algoma, Dofasco, and Stelco. Algoma concentrated on structurals, rails, and plates; Dofasco concentrated on narrow flat-rolled and coated products; Stelco produced a range of products (Barnett and Schorch, 1983, p.222).

Trends in Canada's Steel Industry

This section of the paper will illustrate trends which have occurred in Canada's steel industry over the study period. The ratio of employment per tonne of steel produced might be expected to decline over time as new technologies are introduced and the process of steel making becomes more efficient. More steel per unit of employment will be produced under these assumptions. Figure 1 shows the ratio of employment per tonne of steel produced over time for Canada, Germany, Japan, The United Kingdom, and the United States. The expected results of declining employment per unit of output are best characterized by the Japanese example. It shows a high of .0125 in 1964 and a decline to 1973 where it begins to level out and fluctuate between .004 and .005. The Canadian, German and American examples all show a fairly even ratio throughout the period. The Canadian ratio of employment per unit of output fluctuates between .007 and .005. It does show a very slight decline from the high of around .007 in 1964 to 1967 to the low of around .005 from 1979 to 1982. This fluctuation may be attributable to cyclical effects of the economy where there are periods of increased or decreased market action. The German example shows the ratio fluctuating between .002 and .004. The ratio actually increases slightly over the period from 1974 to 1982. The U.S. example shows the ratio fluctuating between .0065 and .0075. The fluctuation is fairly constant with many ridges and troughs but with the 1964 and 1982 ratios very close to .007. The United Kingdom shows a constantly high ratio of employment per unit of output. It fluctuates greatly between .015 and .02 between 1964 and 1979. There is a great increase in the ratio in 1980 to .288. This can be attributed to a national strike in the British steel industry in that year. The ratio drops again by 1981.

As countries become more mature they tend to consume less steel. When a country is growing it is generally in the process of installing large amounts of infrastructure. This affects the domestic consumption of steel because it is used widely in these infrastructural implementations. Its uses include steel reinforcements such as girders, steel rods used in cement structures, pipes used for sewers, natural gas and oil, and water transference. When it reaches maturity most of this infrastructure is in place so the use of steel drops off. Figure 2 shows Canada's consumption of steel for the time period 1964 to 1982. The general trend is increasing consumption from 8.9 million tonnes in 1964 to 15 million tonnes in 1974. This suggests that there was a lot of building going on during the 1960's and early 1970's in Canada. After 1974 there is a sharp decline to 9.4 million tonnes in 1976. After 1976 consumption increases again to 15 million tonnes in 1979 followed by another decline to 9 million tonnes in 1982. The sharp decline after 1974 was probably caused by the recession which occurred during the mid-1970's. Building was slowed down drastically during the recession. With the ensuing recovery building picked up again and consumption increased. There was another recession in the early 1980's but it was not as bad as the one in the 1970's. The recession of the 1980's was not large enough to cause such a severe drop in consumption as that shown in Figure 2. Part of this drop must be attributable to falling demand for domestic consumption of steel due to Canada reaching maturity as an industrial nation.

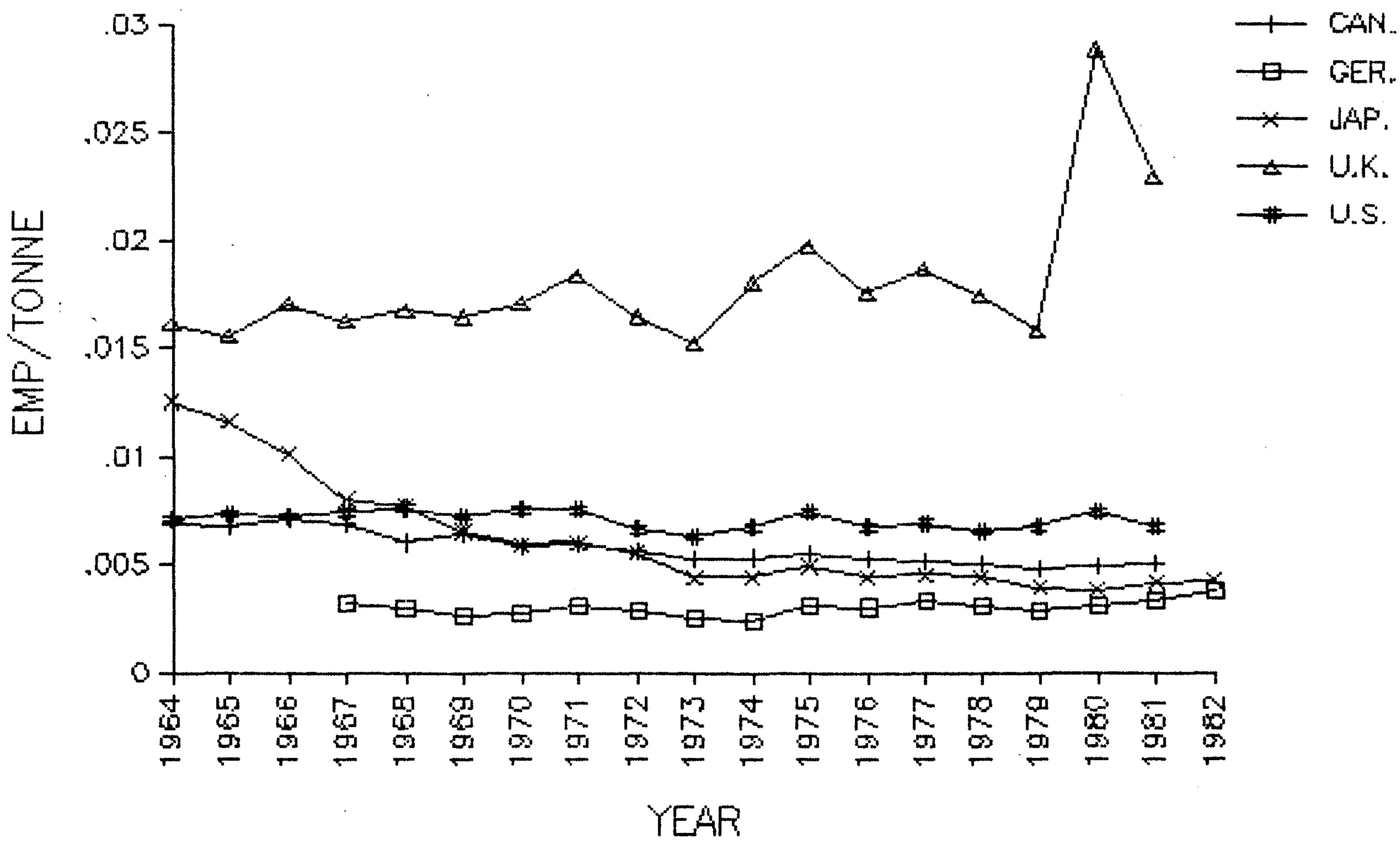
Consumption of steel divided by Gross National Product gives an indicator of the industry's growth potential. The ratio shows the strength of the industry compared to the overall economy. Figure 3 shows that the growth potential for Canada's steel industry is declining. This is also true of the American steel industry. This trend suggests that Canada's steel industry is not a growth industry and probably will not become one in the near future if at all.

Figure 4 shows employment in Canada's steel industry from 1964 to 1984. The general trend is increasing employment in the industry from 56,000 employees in 1964 to 77,000 employees in 1981. Figure 5 shows total industrial employment in Canada. This too is an increasing trend from 1.5 million employees in 1964 to 1.9 million in 1979. Both of these trends show an increase through the 1960's to the 1980's and both show a decline in the 1980's. Figure 6 shows the ratio of steel employment to industrial employment. There is a decline in the ratio from 1966 to 1969 which shows that employment in the steel industry was declining in its share of industrial employment over all. There is a sharp increase in the proportion of steel employment to industrial employment from 1969 to 1970. The trend after 1970 until 1981 was an increasing ratio showing that employment in the steel industry was increasing in its share of industrial employment. There is a noticeable decrease in the mid-1970's. This can be attributable to the recession as it hit heavy industries particularly hard. From 1981 to 1982 there is a substantial decrease in the share of steel employment to industrial employment.

From the trends analyzed here there are a number of things which are revealed about Canada's steel industry. There is a general decline in the ratio of employment to output. This can be attributed to a number of things which include increased efficiency in production (such as improved technology) and decline in demand. Canada's consumption of steel is decreasing. This can be attributed to it becoming a mature industrial country. The steel industry in Canada can also be seen as a slow-growth industry. This means that it will not be expected to grow as fast as the economy in general therefore employment will not be expected to increase substantially in this sector. Employment increases over the time period studied both in total numbers and its share of total industrial employment. There is a decrease in both of these at the end of the period. It can be expected that these decreasing trends will continue to occur, if Canada follows the secular trends observed in the other countries.

Figure 1

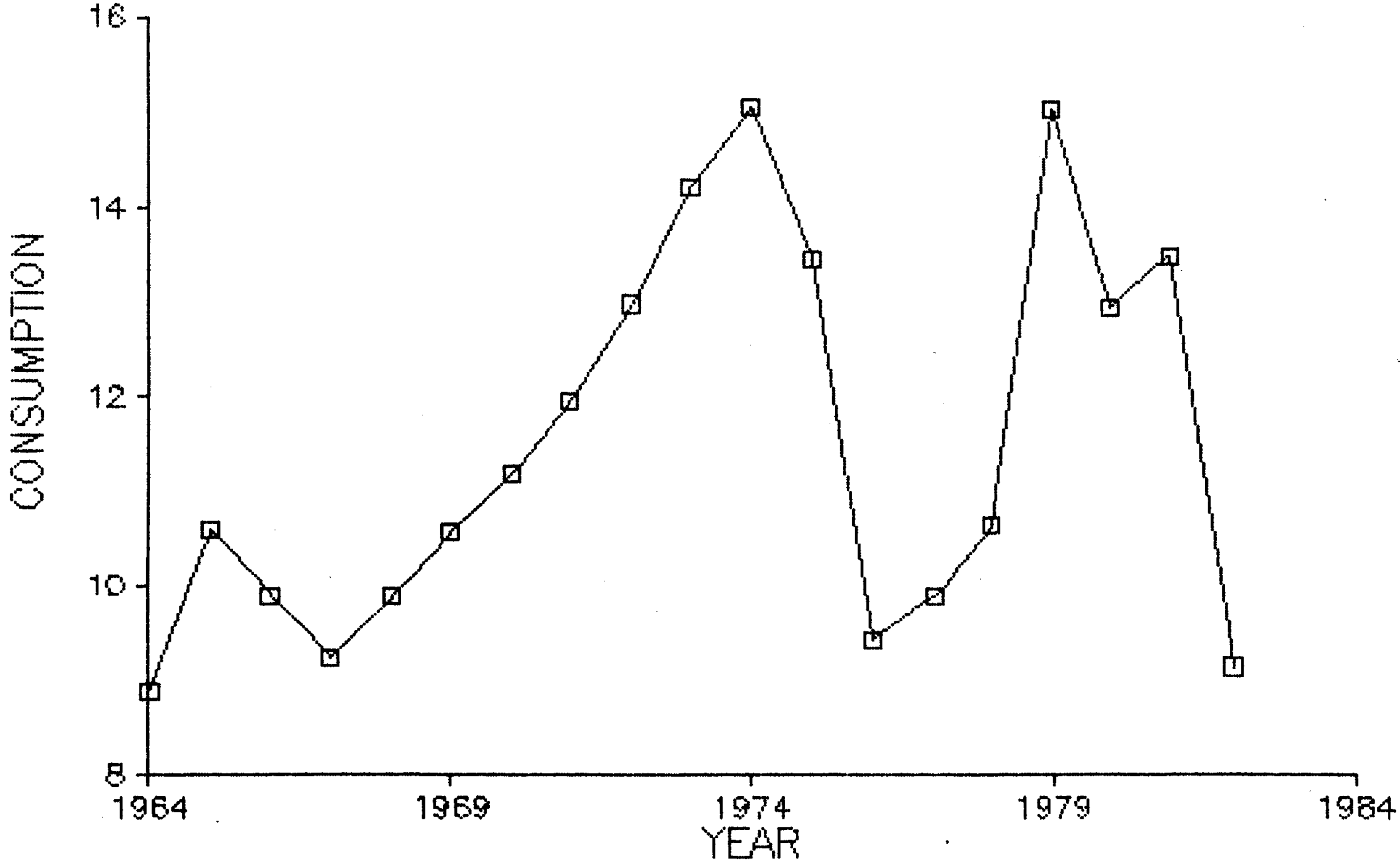
Employment Per Tonne Over Time



Source: See Appendix A

Figure 2

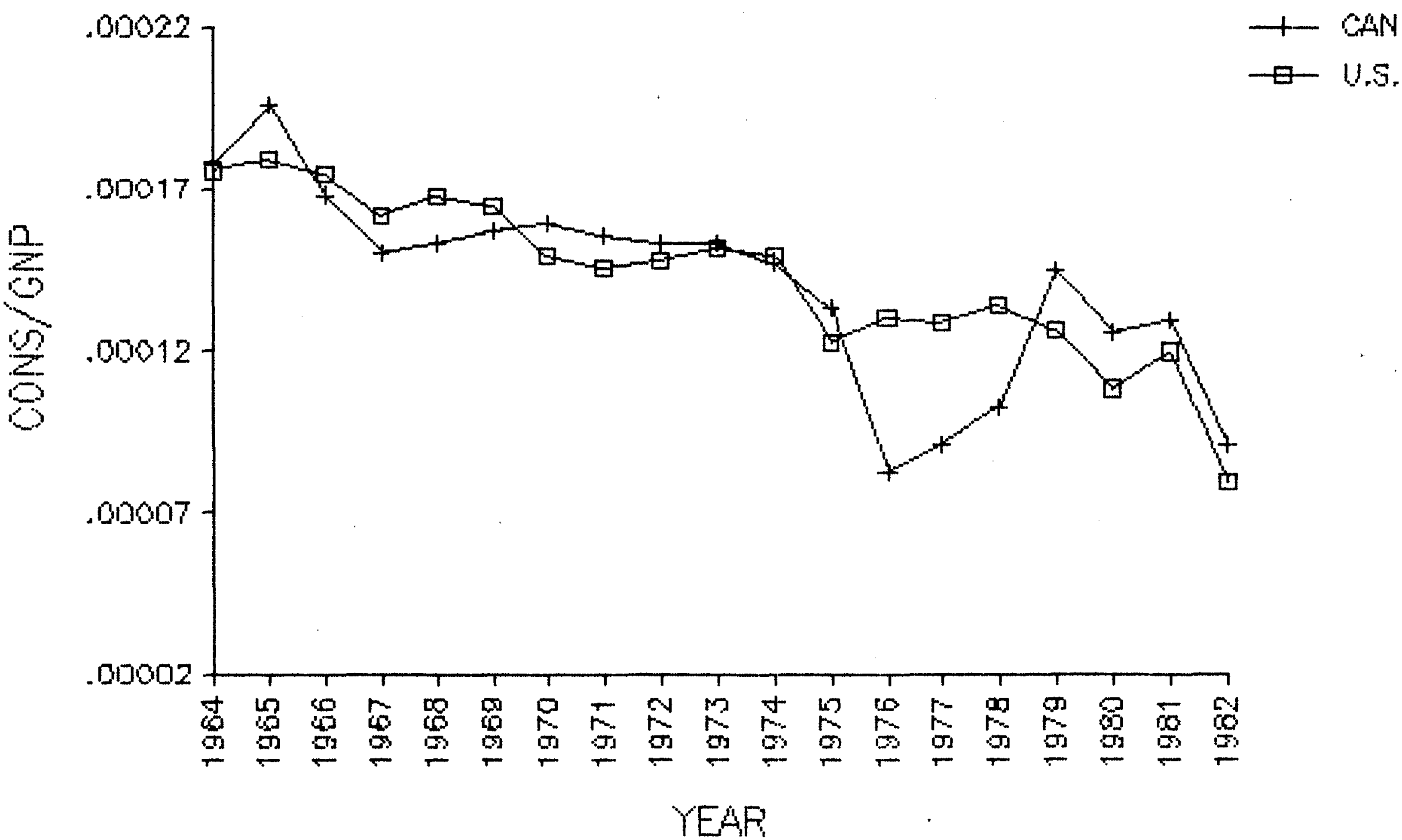
CANADA: Consumption Over Time



Source: See Appendix B

Figure 3

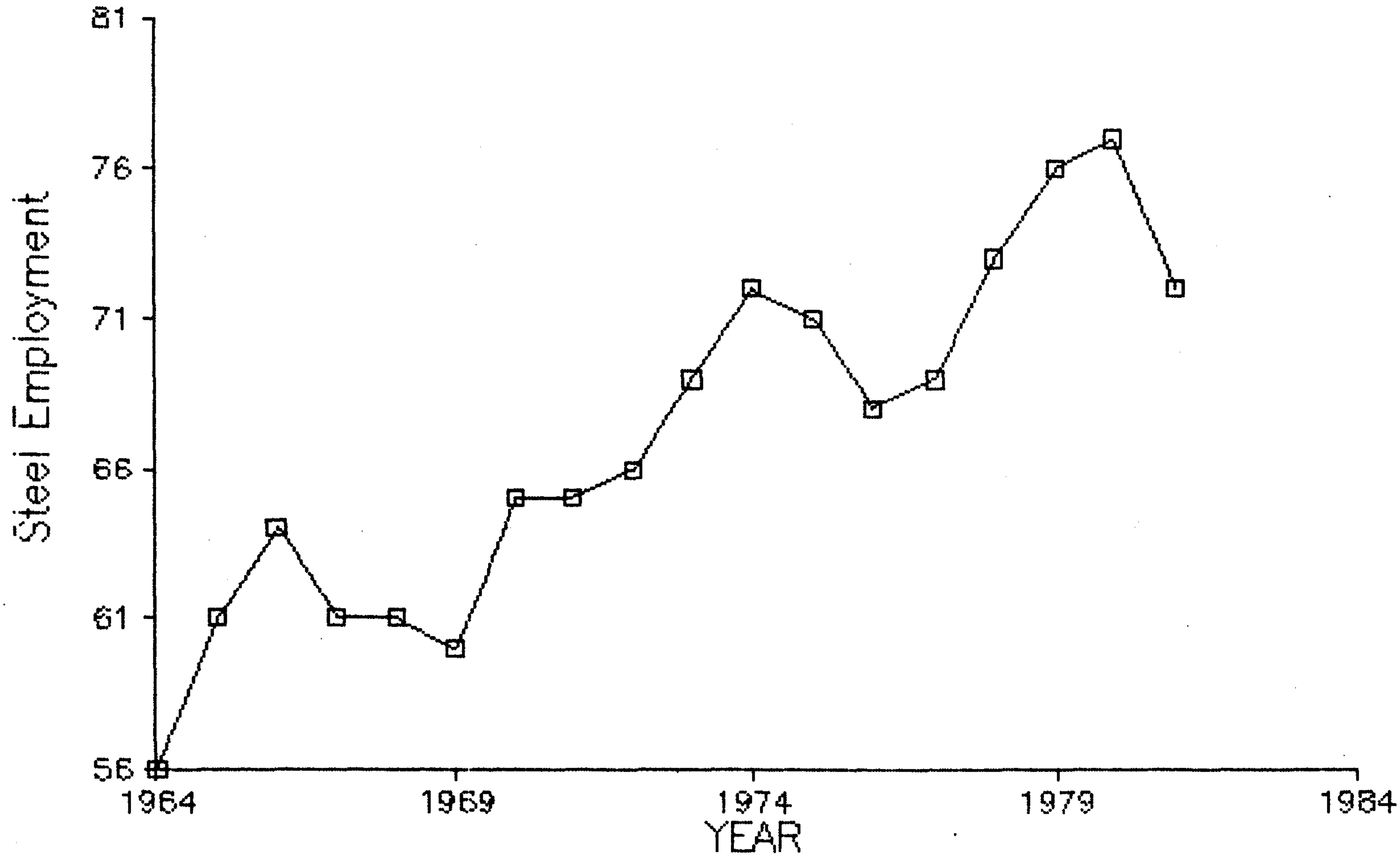
CANADA AND U.S.: CONS/GNP Over Time



Source: See Appendix B

Figure 4

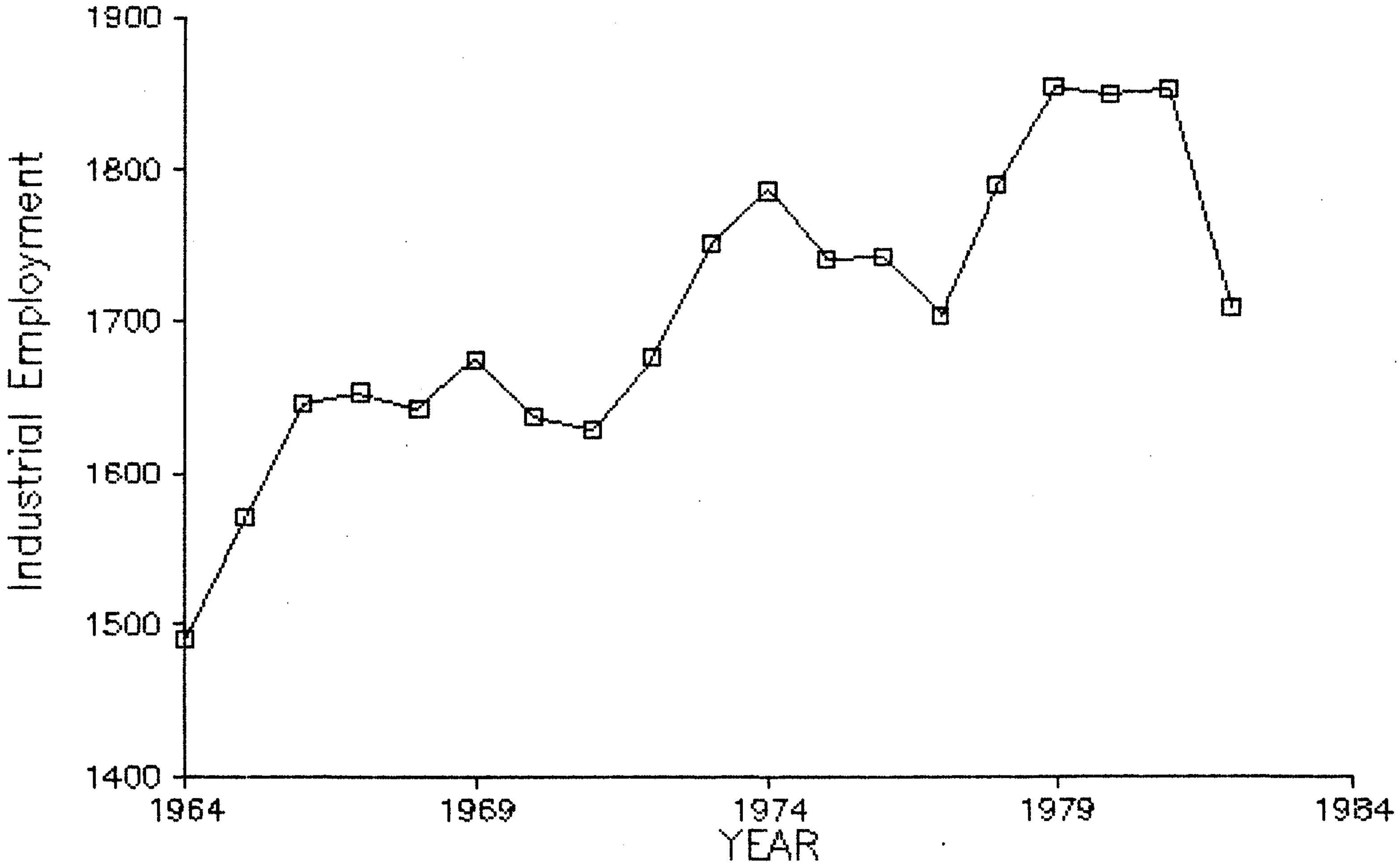
CANADA: Steel Employment Over Time



Source: See Appendix B

Figure 5

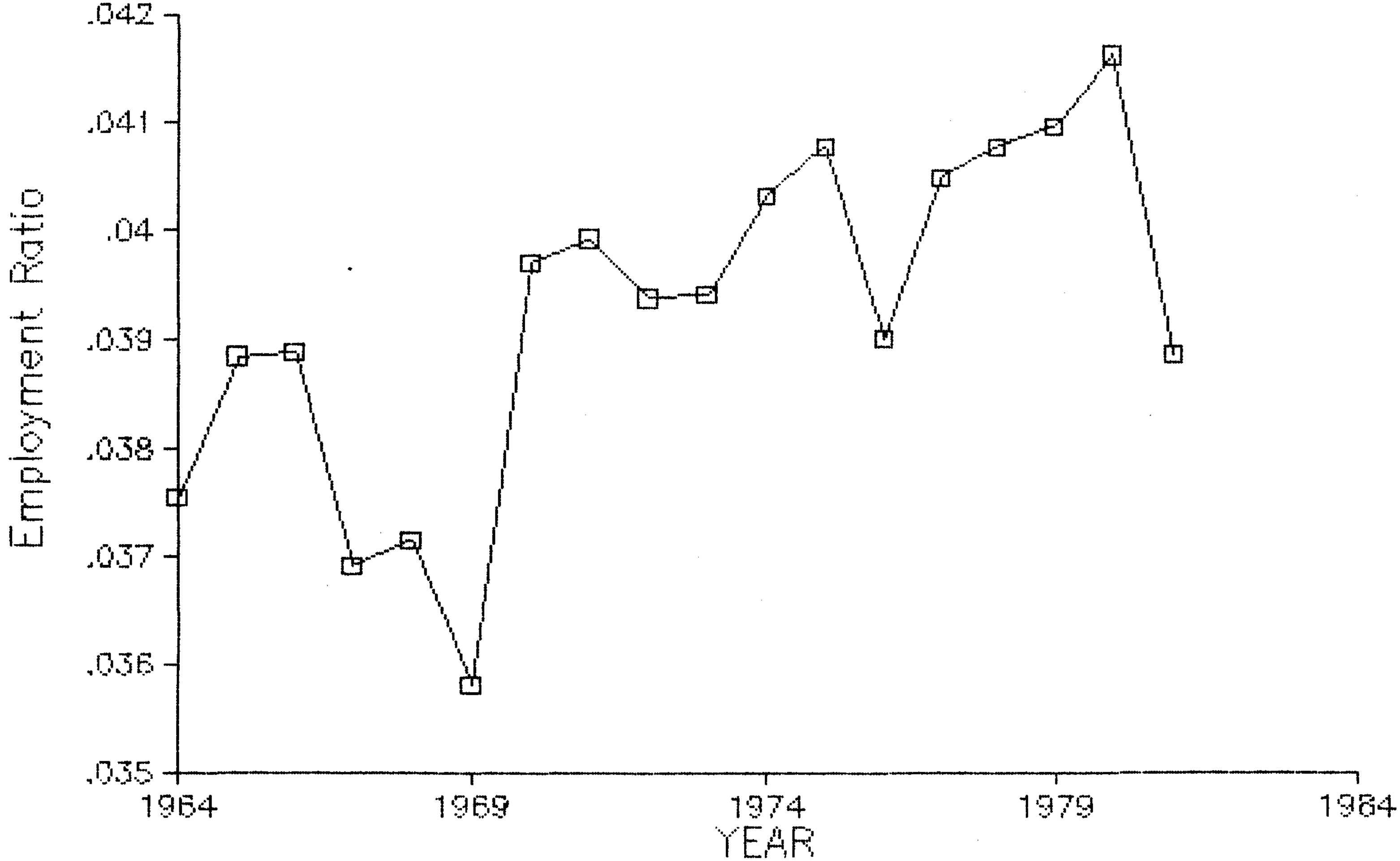
CANADA: Industrial Employment Over Time



Source: See Appendix B

Figure 6

Ratio of Steel to Industrial Employment



Source: See Apperdix B

Technologies of Steel Production

There are various techniques which are used to produce steel from iron. The most commonly used are the open hearth furnace, the basic oxygen furnace, and the electric furnace. These different methods can be compared according to techniques used, differences in inputs and differences in the time required for a complete cycle. Barnett and Schorch (1983, p. 294) note a complete cycle as charging the furnace to tapping the molten steel. This is referred to as heat time.

Open Hearth Furnace

Traditionally the open hearth method of steelmaking has dominated in Canada. The open hearth is a shallow box coated with chemically treated bricks (called refractories) which facilitate desired chemical reactions. Inputs are a varied mix of scrap and molten iron which are mixed with fluxing agents and alloying agents. These inputs are mixed in the open hearth. The furnace is heated by the combustion of natural gas which in turn melts the inputs and fuels the refinement process. In the late 1950's heat times were about twelve hours. Heat times have since been cut by half by the use of oxygen lances similar to those used in basic oxygen furnaces

(Barnett and Schorch, 1983, p. 294).

Basic Oxygen Furnace

The basic oxygen furnace is so named because the furnace is lined with basic refractories and uses oxygen. It is charged mainly with molten iron. A blast of pure oxygen blown on the molten material through an oxygen lance reacts violently with the charge in the furnace. It is able to maintain enough heat in the furnace that the need for external fuel sources are eliminated. The major advantage of the basic oxygen furnace is that the process of steelmaking is much faster than the open hearth method. Heat times in the basic oxygen furnace have been cut to about an hour. The actual refinement of steel takes about twenty minutes (Barnett and Schorch, 1983, pp. 294-295).

Electric Furnace

The electric furnace is an alternative form of steel production. It is generally used to melt down steel scrap, but can also be used to melt solid steel inputs. In the electric furnace inputs are melted by electrodes which are introduced through the cover of the furnace. Heat times vary according to the size of the furnace and the voltage used. These furnaces were traditionally used for the production of specialty steels but since the

1950's have been used for the production of carbon steel as well. Heat times have been reduced from about six hours in the 1960's to one hour in modern furnaces of the 1980's (Barnett and Schorch, 1983, p. 295).

Continuous Casting

Once steel has been produced in the furnace it is tapped into a ladle. Traditionally the molten steel is then poured into ingot molds and allowed to cool. These ingots typically weigh fifteen to twenty tons. Once the ingots have solidified the molds are stripped away. The ingots are then stored until needed. When they are to be used they have to be reheated in "soaking pits" so that their temperature is uniform throughout. Then the process of rolling the ingots into finished products such as generator shafts or structural beams can begin. Normally ingots are first rolled into semi-finished shapes (i.e. primary rolling).

Continuous casting replaces two steps in these traditional steelmaking steps: ingot casting and primary rolling. With continuous casting molten steel is poured directly into a mold, cooling and solidifying as it goes through. It emerges as solid finished shapes. This process is more labor and energy efficient than traditional methods (Barnett and Schorch,1983,pp.295-296).

Data, Methods, and Analysis

This section of the paper will discuss the data and methods used in the analysis, and the analysis itself. The variables which were used in the analysis will be introduced in the data section. The methods section will explain regression analysis and why it is used in this research. The section on analysis will explain how the analysis was carried out.

Data

Data compiled for this research comprises a number of variables pertinent to a regression analysis on employment in the steel industry. The dependent variable is employment per unit of output. The independent variables are those which have an effect on employment per unit of output. These include the methods of steelmaking; open hearth furnace, basic oxygen furnace, and electric furnace. The use of continuous casting in the production process, production and consumption of steel, and wages paid to workers in the steel industry will also effect employment per unit of output.

The open hearth furnace method of steel making is labor and time intensive. Therefore we may expect that steel produced by this method will have a fairly high ratio of employment per tonne of steel produced because of the time factor in the steel making process.

The basic oxygen furnace is a less time intensive method of making steel than the open hearth furnace. Steel produced through this method can be expected to have a lower ratio of employment per tonne of steel produced compared to the open hearth method.

The electric furnace method of steelmaking is highly labor intensive. Steel produced by this method can be expected to have a relatively high ratio of employment per tonne of steel produced.

Continuous casting is more energy efficient and has higher labor productivity than traditional methods of producing steel. Steel produced by this method can be expected to have a relatively low ratio of employment per tonne of steel produced.

The level of steel production has an inherent effect upon employment in the industry. Also, countries which produce a lot of steel can be expected to have lower ratios of employment per tonne of steel produced because they will take advantage of economies of scale and produce steel more efficiently than countries which produce less steel.

High wages will tend to induce incentives for producers to install capital for labor substitution.

Therefore high wages can be expected to coincide with lower ratios of employment per tonne of steel produced.

Data was compiled for these variables for five countries; Canada, Germany, Japan, United Kingdom, and United States. Data was compiled from 1964 to 1982 because these were readily available in the sources. Data prior to and after these dates were not complete enough to use. There were missing values in data for continuous casting for the years 1964 to 1971 in Japan and 1964 to 1974 in the United States. The continuous casting variable was still used in the analysis. If the missing values would cause the variable to be insignificant it would show up in the analysis and the variable would have to be dropped.

Wages were given in domestic currency. These converted to American dollars. The wage variable is average yearly wages per worker in U.S. dollars, taking into account inflation. The inflation rate is based on the U.S. dollar being worth $1.00 in 1967.

Data concerning the technologies of steel production; open hearth, basic oxygen, continuous casting, and electric were obtained from the Organization for Economic Co-operation and Development (OECD) publications called "The Iron and Steel Industry". Data on number of employees and wages were obtained from United Nations publications called the "Industrial Statistics Yearbook". Data on exchange rates were obtained from "International Financial Statistics: Supplement on Exchange Rates" published by the International Monetary Fund (IMF). Data concerning the purchasing power of the U.S. was obtained from U.S. Bureau of Census Publications called "Statistical Abstract of the United States.

Methods

The analysis to be used in this research paper is a multiple linear regression analysis as outlined in Intrilligator (1983, pp. 78-118). In multiple linear regression we assume that there is a causal relationship between the dependent variable (Y) and the independent variable (X's). This linear relationship can be written:

$$Y=\beta_1 X_1 + \beta_2 X_2 + ... + \beta_{k-1} X_{k-1} + \beta_K + u_i$$

where: K-1 represents the independent variables
β_k represents the intercept term
u_i represents the residual term

Necessary assumptions about the error terms (u_i) are:

1) The expected value of u_i is zero. This means that the average value of u_i, which are generally distributed equally between positive and negative, is zero.

2) The variance of u_i is some finite value σ^2 for every i. This is the assumption of homoskedasticity, which means there is no tendency for data to be more

dispersed for some values than others.

3) The error terms (u_i) are independent of one another. This is the assumption of zero covariance. This means that u_i does not depend on u_{i-1}. When this fails there is serial correlation in time series data or spatial auto correlation in cross- sectional data.
The third assumption of the error terms is relavent to the research because of correlation in pooled time-series data. This means that there will be correlation between error terms for the same regions in different years. To get around this problem, dummy variables will be introduced to bring the covariance close to zero.

In this analysis, the dependent variable is employment per tonne of steel produced. The independent variables are the proportion of steel produced by different methods of production; open hearth furnace, basic oxygen furnace, electric furnace, and continuous casting, as well levels of production and consumption of steel, and wages. Regression analysis allows for the examination of the effects of each of these variables on employment per tonne of output holding the other variables constant. For example the regression will show the effect of increasing wages on employment per tonne of steel produced. A negative relationship will suggest that as
wages are increased there will be less employment per

tonne of steel. A positive relationship will suggest that as wages increase there will be more employment per tonne of steel.

Analysis

Initial analysis was done to determine which variables were significant to the regression. It was found, through a series of regressions and correlation analyses, that basic oxygen, electric, continuous casting, production and wages were significant. Open hearth was not significant because it had a high negative correlation with basic oxygen. There appears to be a tradeoff between open hearth and basic oxygen. As open hearth is used less for production of steel basic oxygen takes its place. This can be seen from Table 1. As the percentage of steel produced by the open hearth method decreases the percentage of steel produced by the basic oxygen method increases.

Table 1.

Open Hearth and Basic Oxygen Steel Production, as Percentage of Total, Canada and U.S.

	Canada		United States	
Year	%O.H.	%B.O.F.	%O.H.	%B.O.F.
1964	58.4	30.5	77.2	12.2
1966	53.1	33.4	63.4	25.3
1968	55.0	31.2	50.1	37.1
1970	55.3	29.9	36.5	48.2

1972	39.5	43.9	26.2	56.0
1974	25.2	54.1	24.4	56.0
1976	22.9	61.3	18.3	62.5
1978	20.6	57.1	15.6	60.9
1980	20.7	55.9	11.7	60.4
1982	14.0	61.6	8.2	60.8

(Data from Appendix A)

Because of the high correlation between these two variables the open hearth variable was dropped from the analysis.

Consumption was not significant because it was too highly correlated with production. Table 2 shows that production and consumption of steel is close to being even. Both Canada and the United States examples show that their consumption of steel is very close to the amount of steel they produce.

Table 2

Production and Consumption of Steel (thousands of tonnes), Canada and the United States

	Canada		United States	
Year	Prod.	Cons.	Prod.	Cons.
1964	8284	8668	115282	119245
1966	9075	9882	121656	133331
1968	10210	9881	119261	139395
1970	11200	11200	119309	127320
1972	11868	12975	120876	139941
1974	13591	15058	132196	145129
1976	12970	9430	116122	131144
1978	14728	10650	124314	148255
1980	15684	12939	101456	115591
1982	11762	9133	67656	87275

(Data from Appendix A)

Because of the high correlation between the variables the consumption variable was dropped from the analysis.

In the next step of the analysis, dummy variables were introduced in order to disaggregate for the five countries. When a regression was done using a dummy variable for each country the electric furnace was not significant. Upon further investigation a correlation analysis revealed that the dummy variable for Germany had a high negative correlation with electric and the United Kingdom had a high positive correlation with electric, thus a colinearity between the electric furnace variable and national dummy variables is indicated. To get around this problem dummy variables for aggregate regions; North America (Canada and the United States), Asia (Japan), and Europe (United Kingdom and Germany) were defined. Upon doing this electric regained its significance.

The log linear form of regression is used in this analysis because it makes a better "fit" for the point variables and is more significant. The equation is:

$$\hat{Y} = -11.4 - .147\,X_1 - .369\,X_2 + 1.4\,X_3 - .133\,X_4 + .176\,X_5 + .318\,X_6 + .52\,X_7$$

where: Y = the logarithm of employment/tonne
X_1 = the logarithm of basic oxygen
X_2 = the logarithm of continuous cast
X_3 = the logarithm of electric
X_4 = the logarithm of production
X_5 = the logarithm of wages
X_6 = the logarithm of Asia
X_7 = the logarithm of Europe

with $R^2 = 92\%$
T scores indicate that all coefficients are significantly different from zero at the .05 confidence level.

As mentioned earlier the regression equation provides an indicator of the effect each of the variables will have on employment/tonne. A negative value suggests that as the variable increases the ratio of employment to output will decrease, holding the other variables constant. A positive value suggests that as the variable increases the ratio of employment to output will increase, holding the other variables constant.

The basic oxygen variable is negative this suggests that an increase in the use of the basic oxygen furnace in the steel making process will cause a decrease in the ratio of employment to output. This is consistent with the expected results noted earlier. Because the oxygen furnace is less time intensive than the open hearth furnace for making steel it is much more efficient. More steel can be produced with the same amount of labor because of the time saved with the basic oxygen method. Table 1 shows that the basic oxygen furnace has predominantly replaced the open hearth furnace as a method for producing steel.

The continuous casting variable is negative. This suggests that an increase in the use of continuous casting in the steelmaking process will cause a decrease in the ratio of employment to output. This too fits in with expected results. Because this method is more energy efficient and has higher labor productivity it is more efficient over all. It also replaces steps in the traditional steel making process which means that it is less labor intensive than traditional methods. Continuous casting is not used extensively. Table 3 shows that it occupies a rather low percentage of the total steel production in Canada and other countries.

Table 3

Continuous Casting as Percentage of Total Production, Selected countries

Year	Canada	United Kingdom	United States
1964		0.1	
1966	0.4	0.2	
1968	0.8	0.2	
1970	1.1	0.2	
1972	1.2	0.2	
1974	1.4	0.5	
1976	1.2	1.0	1.1
1978	2.2	1.6	1.4
1980	2.6	2.7	2.0
1982	3.3	3.9	2.7

(Data from Appendix A)

The electric furnace variable is positive. This suggests that an increase in the use of electric furnaces will cause an increase in the ratio of employment to output. This goes along with expected results because this method of producing steel is labor intensive. The greater the amount of steel produced by this method the greater the amount of labor in the production process. The electric furnace of producing steel does not however account for a great percentage of total steel production in Canada. There is a greater emphasis on the electric furnace method in some countries like the United States and the United Kingdom. Table 4 shows that the electric furnace method has remained fairly insignificant in Canada reaching its peak in 1980 at 23.4% and then dropping again in 1982 to 14%. The U.K. and U.S. show an increasing emphasis on the electric furnace. The percentage of total production increases steadily throughout the period to 40.6% of total steel production in 1980 in the U.K., and 31.1% in the U.S. in 1982. The importance of the electric furnace in the U.S. and the U.K. may have to do with stability in the steel industries of these countries. Both have long established and powerful steel industries.

Table 4

Electric Furnace Production as Percentage of Total Production, Selected Countries

Year	Canada	United Kingdom	United States
1964	11.1	11.2	10.0
1966	13.5	13.7	11.1

1968	13.8	16.1	12.8
1970	14.8	19.5	15.3
1972	16.6	19.4	17.8
1974	20.7	23.5	19.6
1976	15.8	30.3	19.2
1978	22.3	35.4	23.5
1980	23.4	40.6	27.9
1982	14.0	31.4	31.3

(Data from Appendix A)

The production variable is negative. This suggests that as production increases the ratio of employment to output will decrease. This goes along with expected results because as countries produce more steel they will tend to become more efficient at doing so.

The wage variable is positive. This suggests that as wages increase the ratio of employment to output will also increase. This is contrary to expected results. Higher wages would be expected to induce producers to install capital for labor substitution. This would decrease the ratio of employment to output. Barnett and Schorch (1983, pp. 66-67) cite employment wages as a major problem in the U.S. steel industry. Table 5 shows the U.S. to have the highest employment costs among these countries. Employment costs have persistently exceeded those of other countries. Barnett and Schorch (1983, pp. 66-67) say that the implications of this labor-cost disadvantage represents a deterioration in the competitiveness of U.S. industry. They go on to say that Japanese productivity is now significantly greater than productivity levels in the U.S. which increases the U.S. disadvantage. Table 5 also shows Canada to have relatively high labor-costs, which suggests it may be facing the same situation of decreased competitiveness as the U.S..

Table 5

Average Yearly Wages in U.S. Dollars, Taking Into Account Inflation (1967= $1.00), Selected Countries

Year	Canada	Germany	Japan	U.K.	U.S.
1964	5777		1639	3478	7912
1966	5994		1892	4484	7988
1968	6289	1646	2304	2548	8100
1970	6918	1709	2763	2902	7857
1972	7997	1879	2616	3430	8869
1974	8531	2023	4270	3830	9202
1976	9192	1859	5438	3719	9507
1978	8064	2198	7667	4311	10069
1980	7510	1966	6744	5461	9182
1982		1222	5648		

(Data from Appendix A)

Conclusions

This section is to give a brief summary of the findings of the research and some conclusions as to the validity of the hypothesis that, "technological changes have contributed significantly to unemployment in the steel industry."

In the first section on trends we determined that Canada's steel industry was a slow-growth industry and employment would not be expected to grow substantially in this sector in the future. We saw that consumption of steel in ratio to GNP is decreasing. This is not expected to change as Canada has become a mature industrial nation. We also saw that employment had been increasing in the steel industry but this trend had recently shifted to declining employment which is expected to continue to occur.

The analysis showed that the more steel produced through the basic oxygen method of steel making would cause a decrease in the ratio of employment to output. The more steel produced through the electric furnace method of steel making would cause an increase in the ratio of employment to output. The basic oxygen method is used far more extensively in Canada than the electric furnace method. The importance of the basic oxygen furnace is also shown by its replacement of the open hearth furnace as the dominant steelmaking method in Canada. The basic oxygen method is less labor and time intensive than the open hearth method.

The analysis also showed that the more steel produced through the continuous casting process the lower will be the ratio of employment to output. The proportion of steel which is continuous cast is constantly increasing in Canada.

Therefore the analysis shows that technological changes in the steel industry do in fact effect employment in the steel industry. The dominant form of steelmaking and the growing form of production process have a negative effect on employment. Employment will be expected to decline in the industry as these technologies are implemented. This is further exacerbated by the declining importance of the industry and the declining consumption of steel. As less steel is consumed domestically the market for Canadian steel declines. Production of steel will decline as the demand drops off. As less is needed to be produced and the technologies of steel production allow for more to be produced by fewer employees the number of employees needed to produce the steel demanded will decrease and this will be translated into layoffs.

The evidence here allows us to accept the hypothesis that, "technological changes have contributed significantly to unemployment in the steel industry". Technological changes and market forces both have a great impact on job loss. It is difficult to say which has the greatest effect, but it is certain that both contribute significantly to job loss. It can be concluded that the employment picture for the steel industry in the future is not promising. The industry is not expected to grow and the market for steel products is not expected to increase substantially in the future. Technological improvements are also expected to limit the employment opportunities of the industry.

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APPENDIX A

"Steel Industry, Statistics"

CANADA

YEAR	EMP/TN	% OH	% BOF	% ELC	% CC	PROD. (MILL. TNS.)	CONS. (MILL. TNS.)	AVG. WAGE (US$
1964	.0068	58.4	30.5	11.1		8.284	8.868	5777
1965	.0067	55	32.2	12.8	.3	9.098	10.601	5937
1966	.0071	53.1	33.4	13.5	.4	9.075	9.882	5994
1967	.0069	53.9	33.1	13	.7	8.795	9.228	6172
1968	.006	55	31.2	13.8	.8	10.21	9.881	6289
1969	.0064	51.2	31.9	16.9	1.2	9.35	10.557	6348
1970	.0058	55.3	29.9	14.8	1.1	11.2	11.2	6918
1971	.0059	52	32.4	15.6	1.1	11.04	11.953	7367
1972	.0056	39.5	43.9	16.6	1.2	11.868	12.975	7997
1973	.0052	31.3	50.4	18.3	1.2	13.386	14.217	8196
1974	.0053	25.2	54.1	20.7	1.4	13.591	15.058	8531
1975	.0055	23.6	56.1	20.3	1.3	13.025	13.448	8316
1976	.0052	22.9	61.3	15.8	1.2	12.97	9.43	9192
1977	.0051	21.3	59	19.7	1.6	13.482	9.889	8676
1978	.005	20.6	57.1	22.3	2.2	14.728	10.65	8064
1979	.0048	20.8	57.5	21.7	2.1	15.855	15.037	7692
1980	.0049	20.7	55.9	23.4	2.6	15.648	12.939	7510
1981	.005	14	60.3	14	3.3	14.387	13.472	7435
1982		14	61.6	14	3.3	11.762	9.133	

SOURCES: IMF, pp. 30-31
OECD, Tables 4, 5 and 21
UN, Tables 3 and 4
United States Bureau of Census, No. 796

GERMANY

YEAR	EMP/TN	% OH	% BOF	% ELC	% CC	PROD. (MILL. TNS.)	CONS. (MILL. TNS.)	AVG. WAGE (US$
1964		45.1	14	8	.2	37.339	34.272	
1965		42.9	19.1	8.5	.2	36.821	33.68	
1966		39	24.5	8.8	.2	35.316	32.318	
1967	.0032	37	31.5	8.5	.4	36.744	30.583	1668
1968	.0029	35.3	37.1	9	.5	41.159	36.501	1646
1969	.0026	29.8	46	9.2	.7	45.316	42.421	1610
1970	.0027	26.2	55.8	9.9	.8	45.041	43.544	1709
1971	.0031	21.2	61.8	10	1	40.313	36.634	1711
1972	.0028	19.1	64.6	10.2	1.4	43.705	41.804	1879
1973	.0025	18.3	67.8	10.4	1.6	49.521	44.492	2164
1974	.0024	17.4	68.8	10.8	1.9	53.232	40.99	2023
1975	.0031	16.7	69.3	12.6	2.4	40.415	38.283	1989
1976	.003	14.3	71.9	12.4	2.8	42.415	41.75	1859
1977	.0033	12.6	74.4	13	3.4	38.985	39.793	1960
1978	.0031	11	74.6	14.5	3.8	41.253	40.053	2198
1979	.0028	9.9	76.1	14	3.9	46.04	36.912	2175
1980	.0031	6.7	78.4	14.9	4.7	42.838	33.783	1966
1981	.0033	3.9	80.2	15.9	5.4	41.61	30.989	1377
1982	.0038	1.5	80.9	17.6	6.2	35.88	26.847	1222

Sources: IMF, pp. 30-31
OECD, Tables 4, 5 and 21
UN, Tables 3 and 4
United States Bureau of Census, No. 796

JAPAN

YEAR	EMP/TN	% OH	% BOF	% ELC	% CC	PROD. (MILL. TNS.)	CONS. (MILL. TNS.)	AVG. WAGE (US$
1964	.0125	34.8	44.2	21		39.799	30.901	1639
1965	.0116	24.7	55	20.3		41.161	28.481	1803
1966	.0101	18.1	62.6	19.3		47.784	37.941	1892
1967	.008	14.5	67.2	18.3		62.154	53.257	2121
1968	.0077	8.1	73.7	18.2		66.839	49.005	2304
1969	.0065	6.4	76.9	16.7		82.166	61.308	2540
1970	.0059	4.1	79.2	16.7		93.322	69.832	2763
1971	.006	2.4	80	17.6		88.557	57.603	3104
1972	.0055	2	79.4	18.6	1.7	96.9	68.719	2616
1973	.0044	1.5	80.5	18	2.1	119.322	86.147	3993
1974	.0044	1.3	80.9	17.8	2.5	117.131	74.37	4270
1975	.0049	1.1	82.5	16.4	3.1	102.314	68.08	5025
1976	.0044	.5	80.9	18.6	3.5	107.399	64.549	5438
1977	.0045	.4	80.5	19.1	4.1	102.405	62.828	6280
1978	.0044		78.1	21.9		102.105	61.507	7667
1979	.0039		76.4	23.6	5.2	111.748	73.209	7285
1980	.0038		75.5	24.5	5.9	111.395	73.442	6744
1981	.0041		75.2	24.8	7.1	101.676	65.445	6668
1982	.0042		73.4	26.6	7.9	99.548	63.733	5648

Sources: IMF, pp. 30-31
OECD, Tables 4, 5 and 21
UN, Tables 3 and 4
United States Bureau of Census, No. 796

UNITED KINGDOM

YEAR	EMP/TN	% OH	% BOF	% ELC	% CC	PROD. (MILL. TNS.)	CONS. (MILL. TNS.)	AVG. WAGE (US$
1964	.0161	70.5	11.7	11.2	.1	26.233	24.35	3478
1965	.0155	63.7	20.5	12.7	.1	27.439	24.221	
1966	.017	59.1	26.4	13.7	.2	24.705	21.724	4484
1967	.0162	57.1	27.8	14.3	.2	24.279	22.118	
1968	.0167	54.9	28.2	16.1	.2	26.277	23.508	2548
1969	.0164	52.8	27.8	18.4	.2	26.846	24.523	
1970	.017	47.2	32.3	19.5	.2	27.782	25.38	2902
1971	.0183	42.1	38.8	18.1	.2	24.174	21.24	3018
1972	.0164	37	42.7	19.4	.2	25.321	22.25	3430
1973	.0152	37.1	47.5	19.9	.3	26.649	25.791	3586
1974	.018	27.6	48.3	23.5	.5	22.426	23.028	3830
1975	.0197	22	50.4	27.6	.9	20.198	20.938	4195
1976	.0175	18.1	51.6	30.3	1	22.274	23.425	3719
1977	.0186	16.1	53.2	30.7	1.3	20.411	20.097	3712
1978	.0174	8.7	55.9	35.4	1.6	20.311	20.025	4311
1979	.0158	5.4	60.1	34.4	1.7	21.464	20.53	4799
1980	.0288		59.3	40.6	2.7	11.277	13.783	5461
1981	.0229		67.6	32.4	3.2	15.573	14.9	3503
1982			65.9	31.4	3.9	13.705	14.197	

Sources: IMF, pp. 30-31
OECD, Tables 4, 5 and 21
UN, Tables 3 and 4
United States Bureau of Census, No. 796

UNITED STATES

YEAR	EMP/TN	% OH	% BOF	% ELC	% CC	PROD. (MILL. TNS.)	CONS. (MILL. TNS.)	AVG. WAGE (US$
1964	.0071	77.2	12.2	10		115.282	119.245	7912
1965	.0073	77.1	17.4	10.5		119.261	129.204	7932
1966	.0072	63.4	25.3	11.1		121.656	133.331	7988
1967	.0074	55.6	32.6	11.6		115.407	128.068	7827
1968	.0076	50.1	37.1	12.8		119.261	139.395	8100
1969	.0072	43.1	42.6	16.7		128.152	139.35	8168
1970	.0075	36.5	48.2	15.3		119.309	127.32	7857
1971	.0075	29.5	53.1	17.4		109.265	129.136	8110
1972	.0066	26.2	56	17.8		120.876	139.941	8869
1973	.0063	26.4	55.2	18.4		136.804	150.844	9111
1974	.0067	24.4	56	19.6		132.196	145.129	9202
1975	.0074	19	61.6	19.4	.9	105.817	117.686	8922
1976	.0067	18.3	62.5	19.2	1.1	116.122	131.144	9507
1977	.0069	16	61.8	22.2	1.2	113.701	135.594	9799
1978	.0065	15.6	60.9	23.5	1.4	124.314	148.255	10069
1979	.0067	14.1	61	24.9	1.7	123.668	140.906	9821
1980	.0074	11.7	60.4	27.9	2	101.456	115.591	9182
1981	.0067	11.1	60.6	28.3	2.2	109.614	129.73	9197
1982		8.2	60.8	31.1	2.7	67.656	84.275	

Sources: OECD, Tables 4, 5 and 21
UN, Tables 3 and 4
United States Bureau of Census, No. 796

APPENDIX B

"Employment and Market Indicators"

	CANADA					UNITED STATES	
YEAR	CONS (MILL TNS)	ADJUSTED GNP (MILLS)	CON/GNP	STL EMP (THOUSANDS)	IND EMP (THOUSANDS)	ADJUSTED GNP (MILLS)	CON/GNP
1964	8.87	50047.44	.00018	56	1491	678956	.00018
1965	10.6	54186.04	.00020	61	1570	720498	.00018
1966	9.88	58853.85	.00017	64	1646	764547	.00017
1967	9.23	61432.93	.00015	61	1653	794000	.00016
1968	9.88	64461.20	.00015	61	1642	830400	.00017
1969	10.6	67263.15	.00016	60	1675	848141	.00016
1970	11.2	70314.03	.00016	65	1637	853980	.00015
1971	12.0	77056.24	.00016	65	1628	888272	.00015
1972	13.0	84931.28	.00015	66	1676	947614	.00015
1973	14.2	92917.12	.00015	69	1751	997152	.00015
1974	15.1	102274.0	.00015	72	1786	972252	.00015
1975	13.4	100961.7	.00013	71	1741	961929	.00012
1976	9.43	114219.1	.00008	68	1743	1008466	.00013
1977	9.89	108847.9	.00009	69	1704	1056818	.00013
1978	10.7	104199.9	.00010	73	1790	1107968	.00013
1979	15.0	104041.5	.00014	76	1855	1114698	.00013
1980	12.9	103342.8	.00013	77	1850	1068592	.00011
1981	13.5	104007.9	.00013	72	1853	1084118	.00012
1982	9.13	100463.9	.00009		1708	1063258	.00008

Sources: Department of Finance: Canada, Table 9
OECD, Table 21
Statistics Canada, Table 1
UN, Table 3
U.S. Bureau of Census, No. 734