THE EFFECTS OF TECHNOLOGY

ON THE LABOUR FORCE OF

DOFASCO INC.

BY

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Abstract

The purpose of this research is to determine how the changing levels of technology at Dofasco Inc. have affected its labour force. This will be approached from the perspective of a production function. An overview of Dofasco's history quickly reveals that the level of technology in its factory is definitely growing. This fact is reflected in the large quantities of new equipment purchased in the company's past.

The production function is utilized through a graphical interpretation of four ratios: the sales/labour; sales/output; output/labour; and capital/labour. These ratios provide and explanation of when, why, and how the technology level at Dofasco changes and the affect these will have on labour.

The company successfully raises the value and quality of its output through value adding processing of the raw steel. This is attained by large capital expenditures on new equipment. The new equipment also has the effect of increasing labour productivity. Translating into a declining need for labour inputs. The exacting specifications needed in steel making are now satisfied through the use of computers and not through an experienced workers judgement.

Acknowledgement

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1.0 Introduction

1.1 Research Rationale

Dofasco Inc., of Hamilton, Ontario (Map 1) has become Canada's largest steel producer. Their dominant product is flat rolled steel and they supply it to a global market. Dofasco has been in business for over seventy-nine years. It has helped to not only drive Hamilton's economy through its contributions to local employment, taxes and stimulation of related development, but also in providing the **Steel City** image.

Surprisingly, given Dofasco's importance, little research has been devoted to understanding how the company has operated and changed. Historical acknowledgement has just started to emerge due to the company's recent seventy-fifth anniversary in 1987. Developing an appreciation of Dofasco's past can provide a possible guide to understanding its future role in our society.

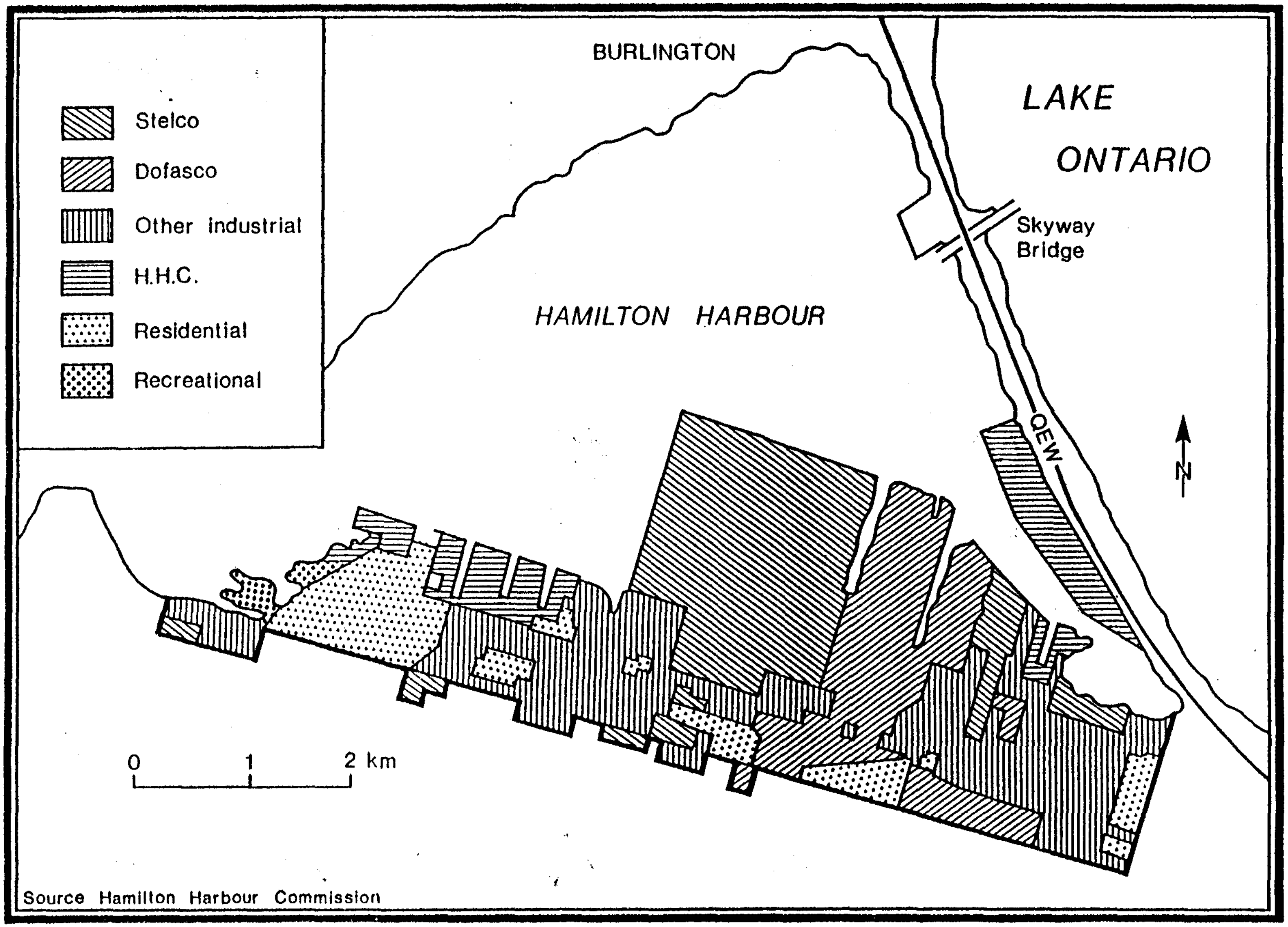
1.2 Research Objective

The objective of this research is to determine how the changing levels of technology at Dofasco Inc. have affected its labour force. One can safely assume that modern technology would invariably lower the need for labour inputs into the production of steel. This is the case and will be shown, but the focus for this research is how and when these new technologies influenced Dofasco.

To achieve such a goal the concept of a production function will be utilized. Central to the production function is the interrelationship between output and the employment of capital and labour. This type of analysis is appropriate because it emphasizes output, which is directly affected by technological changes, and labour, the variable which is being observed.

1.3 Background to Thesis Organization

To properly appreciate what the information obtained through the production function reveals, an understanding of Dofasco's company history is needed. Reference to when major changes in Dofasco's operating circumstances occurred are key factors in the interpretation of the data. The general concepts involved in the steel making process are important for a full comprehension of the reasoning behind the results of the analysis. The equipment which utilizes the technology is a central concept of the analysis and requires a thorough explanation.



Map 1: Hamilton Harbour land use.

2.0 How Steel is Manufactured

2.1 Steel Production Made Simple

The concept behind producing steel is quite simple when all the technical complications and jargon are stripped away from the explanation. Given the three basic inputs iron ore, coal, and limestone, the steel making process can begin. In their proper proportions, these three inputs can be converted into molten iron when exposed to very high temperatures. The coal acts as a fuel to allow for the high temperatures needed to melt the iron ore. The limestone is added to remove the impurities which are naturally found in the iron ore. These impurities are removed from the surface of the fluid ore. In solidified form the molten iron is referred to as pig iron. Historically this was the end of the production process and it was pig iron which was sold to customers. By today's, standards this was a crude, low quality product. To make steel form molten iron, further processing must be performed. The molten iron must be heated again at even higher temperatures with more lime added to remove even more of the impurities. Again, the waste by-product is removed and the output product is molten steel. The molten steel is allowed to cool and solidify.

2.2 The Complexities of Steel Making - Focus on Dofasco

The steel making process today has become far more complex. This is due to the equipment and technology used to accomplish the different stages through which the raw materials proceed before they are ready to be sold as products. The process is not as easy as just extracting the raw materials from in the ground, dumping them into a furnace, heating them up once and then heating them up again and miraculously obtaining a final product ready for the market. In today's steel industry there is a variety of outputs which are processed in different ways. The manner in which the steel is made is not that different between producers. The products which Dofasco produces does not cover the entire spectrum of possible final products but its processing method will be the focus for a closer look at the steel making process.

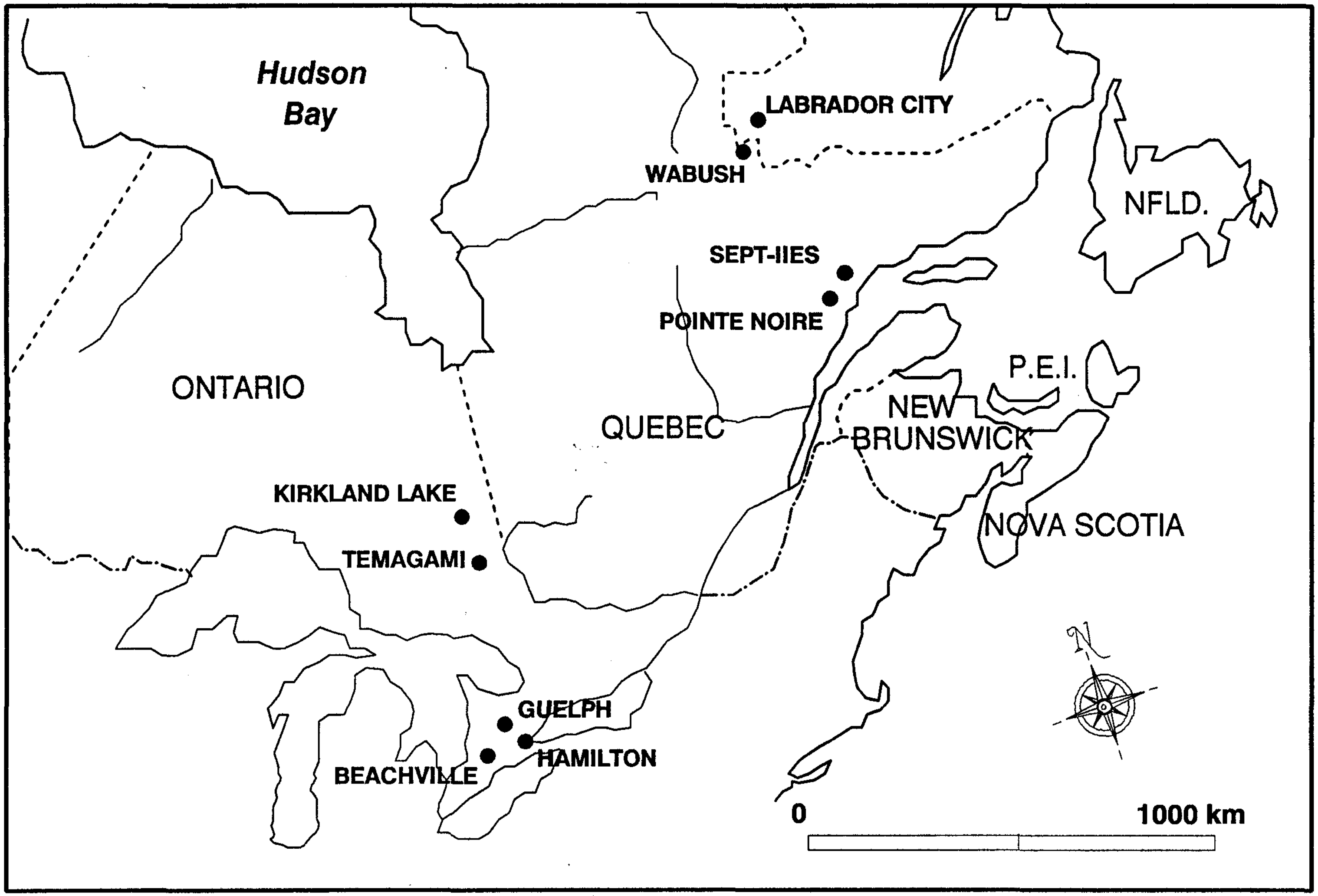
Dofasco receives iron ore and limestone from Canadian mining companies which it directly owns. Coal is purchased from private companies in the United States. Compared to the quantities of iron ore and coal, very little limestone is consumed by the steel making process. Iron ore, from Canadian sources and coal from the United States are usually shipped to Hamilton, via tanker, through Hamilton Harbour, and unloaded onto one of Dofasco's pears. Some iron ore from Canada is brought in by rail during the winter season to maintain inputs when the St. Lawrence Seaway is frozen.

2.3 The Raw Materials

The first input to be considered is the purifying stone, limestone. Limestone is extracted from a quarry in Guelph, Ontario (Map 2) for Dofasco. The limestone is put through a crusher, washed and then screened to obtain small uniform sized stones. To produce lime, the limestone is exposed to high temperatures which drives off the carbon dioxide content present in the stone. Lime, opposed to limestone, has proven to work faster in the blast furnace and the basic oxygen furnace when being used as a flux to remove the impurities from the molten iron and steel. Lime combines chemically with impurities in the metal-producing furnaces and forms into slag, which is removed as a floating waste by-product. It requires approximately 150 pounds (68 kilograms) of lime to produce a ton (1.016 tonnes) of raw steel. Dofasco can produce approximately 4.5 million tons (4.57 million tonnes) of steel in one year, translating into 675 pounds of lime per year.

The second input is iron ore. Dofasco owns several iron ore mines in Canada. Resources are obtained from mines in Temagame and Kirkland Lake, Ontario, along with Wabush and Labrador City, Newfoundland (Map 2). Iron ore is a common material found in the earth's surface. It is mined and brought to Dofasco by tanker ship. The ore goes through a variety of stages before it is put into a blast furnace. Processing plants, located at or near the iron mines crush and filter the ore several times into fine particles. These fine particles are separated from the rocks and made into pellets. Dofasco has these processing plants located in Sept-Iles and Pointe Noire, Quebec (Map 2). Sintering machines located at Dofasco take these pellets and fuse them into quarter-inch (6.1 millimetre) sizes and use them in blast furnaces. For Dofasco to produce its 4.5 million tons (4.57 million tonnes) of steel annually it would need 9 million tons (9.144 million tonnes) of iron ore per year.

The third input needed to produce steel is coal. Dofasco has this resource imported by tanker ship from the United States. Coal is extracted from mines and taken to processing plants. Here the coal is crushed and screened so it can be sorted by size. There are three sizes, slime (which is very fine), fine and coarse. They are washed separately, then combined and transported to Dofasco. The processing continues at Dofasco. The coal is taken to a coke oven battery where it is converted into coke. These ovens heat the coal to temperatures of up to 2400 degrees Fahrenheit (1316 degrees Celsius). Heating at such high temperatures drives off the gases, oils and tar in the coal. After about eighteen hours of cooking, the coke is removed from the ovens, allowed to cool and then it is ready for the blast furnace. Coke is used instead of plain coal as a source of fuel because a higher quality of steel is produced using coke. The gases and tars naturally present in coal create a sticky mass when heated and this adversely affects the quality of the steel. Coke, while it does not have these unwanted substances also retains strength under the weight of the iron ore and lime when it is in the blast furnace. This means that higher



Map 1: The Location of Iron Ore Mines and other Dofasco Resources

temperatures can be achieved in the blast furnace using coke. Dofasco needs 7 million tons (7.11 million tonnes) of coke to produce its total output of steel each year.

2.4 The Blast Furnace

The raw materials, limestone, iron ore and coke are the inputs to the blast furnace. It is a ten-story cylindrical steel vessel, lined with heat-resistant bricks. Once the furnace is lit, it runs continuously until the brick lining wears out and must be replaced. The raw materials are charged into the top of the furnace in their proper proportions. They are exposed to a blast of super-hot air, between 1400 and 2100 degrees Fahrenheit (760-1149 degrees Celsius) which is blown in from the bottom of the furnace. The air burns the coke, which releases heat and gas and removes the oxygen from the iron ore. The ore is now in molten form on the bottom of the furnace with the slag forming on its surface. The molten iron is white-hot as it pours out the bottom of the furnace. It is then taken for further refining in the steel making process or it is poured into shallow moulds where it solidifies into castings and is called pig iron.

2.5 The Basic Oxygen Furnace

At Dofasco the molten iron is taken to one of two basic oxygen furnaces (BOF's) to be made into steel. Oxygen in the fuel used to heat the molten iron. The first step in the process is to charge the BOF with scrap metal and then with molten iron from the blast furnace, which accounts for up to 80% of the charge. A water cooled oxygen lance is then lowered into the BOF and blows high purity oxygen into the mixture at supersonic speed. The oxygen combines with the carbon and other impurities in the liquid thus reducing them and creating molten steel. As in the blast furnace, lime is added to the charge and a layer or slag forms and is removed from the surface of the molten steel. The resulting liquid is poured into a ladle along with a certain amount of alloy additive to get the precise chemistry and then is taken for further processing. One notable modification to the BOF is the Q-BOP. With the Q-BOP the high purity oxygen is blown in form the bottom of the furnace instead of the top. This modification produces and even higher quality of steel than the BOF. Dofasco has adopted this modification in its basic oxygen furnaces.

2.6 The Open Hearth Furnace

This process of steel production is no longer used by Dofasco. It became obsolete with the emergence of the more efficient basic oxygen furnace which makes higher quality steel faster. Open hearth furnaces heats lime, molten iron and a charge of scrap metal to a temperature of approximately 3000 degrees Fahrenheit (1648 degrees Celsius) for five to ten hours. What emerges is molten steel.

2.7 The Electric Furnace

This is another steel producing technique which

Dofasco does not employ. With this method only lime and scrap steel are used as the materials for processing. The furnace is heated using electrodes which produce electric current arcs which in turn melt the scrap steel. This process does not produce large quantities of molten steel thus making it an inappropriate method for a large producer like Dofasco to use.

2.8 Ingot Production

At Dofasco the molten steel is taken to one of two processing locations. The first operation is ingot teeming. The molten steel is poured out of the ladle and into large moulds, or ingot moulds and allowed to solidify. After they have hardened the ingot casting is removed and a steel ingot remains. The ingots must be at a uniform temperature before they can be further processed. This is accomplished by taking them to soaking pits where they are heated to a desired temperature. The reheated ingots are then taken to a roughing mill which is the first stage in shaping the hot steel. Out of the roughing mill comes either blooms, billets or slabs. Blooms being large rectangular blocks, square in cross-section, billets being long rectangular block also square in cross-section, while slabs are flatter and longer pieces of steel. Dofasco specializes in slabs. These two outputs are then taken to further treatment.

2.9 The Continuous Slab Caster

The second processing station which the molten steel can go through is the continuous slab caster. The continuous slab caster is a technological advancement in the steel industry that was developed just recently, and Dofasco has one which can produce 2.17 million tons (2.2 million tonnes) of steel annually. It takes molten steel and shapes it directly into slab form. The molten steel is poured into a mould oscillator which holds the liquid steel until it is hard enough to travel through a series of rollers and shaping equipment. When the slabs emerge from the continuous caster they are cut to desired length by a torch. This form of steel processing is superior to ingot teeming because it is much faster and actually produces a higher quality output. Ingot teeming, ingot soaking and the roughing mill stages are eliminated by the strand caster.

The raw materials have gone through processes which are standard to steel production. Even though most of the output to this point appears the same, they are not. The quality and chemical composition of raw steel which comes out of the basic oxygen furnace can be controlled to a high degree of accuracy. The level of quality will depend on the needs of the consumer who has ordered the steel. The ratio of scrap metal, molten iron, lime flux and alloy charge can be controlled to meet exacting specifications. The output appears the same because it is usually all looks relatively the same at this point. After coming out of the slab caster or the roughing mill the steel continues along several possible production lines.

2.10 Hot and Cold Rolled Steel

The steel in slab form can be taken and shaped into strips, skelps or plates. Skelp being plates of steel that are used for making welded pipe Plates are just flat steel of a desired width. Strips are the main product of Dofosco. Dofasco has two hot strip mills which are capable of rolling ingots and slabs into varying dimensions. The slabs travel through a series of rollers which reduce the thickness of the steel until it is the desired size. All hot rolled steel which is to go through further processing at Dofasco is pickled. A consequence of hot rolling is that the steel sheets carry a surface oxide or scale. Pickling removes this unwanted scale. Dofasco has three continuous pickle lines with an annual capacity of approximately 2.4 million tons (2.44 million tonnes). If further processing is required, the steel will travel to one of the two cold rolling mills.

When the steel is allowed to cool during cold rolling it reduces by 50% or more, thus reducing its flexibility. To process the cold reduced steel further it must go through steps which include annealing and temper rolling. When the steel goes through annealing it becomes soft so that it can be shaped. Cold rolled steel is temper rolled so that a number of coating products can be administered. These coatings include: galvanizing; galvelume; chromium and tin plating. Steel which is galvanized is coated with zinc. Steel which is coated with galvelume, a product developed and patented by Dofasco, has a zinc and aluminum coating. Galvelume steel has proven to be superior to galvanized steel when tested for weathering and corrosion. At the present time Dofasco has one galvelume line which can produce 152,000 tons (154,440 tonnes) annually and 3 galvanizing line which can produce 732,000 tons (743,750 tonnes) annually.

Dofasco sells its products to a wide variety of consumers for a vast array of products including automobiles, household appliances, agricultural equipment, pipes and tubes, industrial and consumer containers and also for railway equipment.

3.0 The Early Iron and Steel Industry in Canada

The birth of the iron and steel industry originated in Montreal, Quebec. The equipment used was crude and the products were very poor in quality. Through time, many firms entered into the industry. Canada's iron and steel industry beginning may have been in Montreal but it has since found a home in Hamilton, Ontario.

3.1 Montreal was the Beginning

An artisan names John Bigelow, in the 1790's was Canada's first metal worker. He opened a small metal shop in St. Laurent, a small suburb of Montreal, and produced nails. They were hammered and shaped out of pieces of iron on an anvil by hand. Production in his small shop was dwarfed by inventions adopted in England and the United States were machines made nails and screws automatically.

When Thomas Bigelow , John's son, took over he expanded the business. Even with expanded production the market was dominated by the large commercial firms abroad. The dominance did stop at a point. Some of the foundries which developed in Montreal were the forerunners of North America in building engines for steam ships.

Canada imported almost all of its manufactured goods from Europe while exporting raw materials. In the late 1840's the British disconnected its direct links with Canada opting for a free trade policy with the world. The Canadian economy soon fell on hardship without the U.K. protection. The once thriving businesses in Montreal wanted to move to the U.S.A. Out of these hard times came the **Reciprocity Treaty** of 1854, making it easier for Canadian good to enter into the U.S.A. Along with an improved water transportation system, by way of the Lachine Canal, Montreal had become the starting point, in 1846, of modern industry in Canada. The emergence of the Canadian railway, in the late 1850's can be credited with causing much of the economic activity. From the wars which followed, heavy demand from the British was put on the Canadian iron industry.

During this time prior to 1850, iron production was marked by very low quality and predominantly manual production techniques. Raw materials were deposited into a blast furnace by hand. The molten iron output would flow into moulds in the factory floor and were cooled by throwing sand on them. "Fire, water power and simple tools in the hands of brawny men" (Heron, p.33, 1988), symbolized the iron factories of this period prior to 1850.

In the late 1860's iron manufacturing was Montreal's most important industry (Kilbourn, 1960). A few large firms dominated the production of iron and steel products. Rolling mills prospered during the railway construction. Steel rails imported from Europe had to rerolled so that they could withstand the harshness of the Canadian climate.

Emerging as a metals manufacturing centre was Hamilton. American industrialists like Charles Wilcox, the first president of the Steel Company of Canada, came to Hamilton in 1880 along with other foreign investors to take advantage of the many benefits found in the town. The tariffs which the federal government imposed protected industry in Canada. The labour force in Hamilton had partially been established due to the flow of European immigrants needing work and the metallurgy based labour pool in the city. Hamilton's geographic location also made it an attractive site for industry because of its access to raw materials and a large market through connections to rail and water transportation (Kilbourn, 1960).

From 1850 up to 1900, the steel industry was in a state of "power transition". Reliance on the archaic use of man-power was passing and the emergence of electric power was coming at the turn of the century. In the mean time steam power was used. It was in this period when the new Open Hearth Furnace was emerging. It brought increased and a better quality output. There was still quite a bit of physical labour put into the steel making process.

Though it is the most calibrated manufacturing location, Hamilton was not the only region which the iron and steel sector was being developed in Canada. Sydney, Nova Scotia and Sault. St. Marie, Ontario were the two other major production sites. The location of the needed raw materials dictated the location of the large steel producers outside of Hamilton.

Nova Scotia Steel, the Steel Company of Canada, Algoma Steel and Dominion Iron and Steel were known as the "Big Four" of Canadian steel production at the beginning of the twentieth century. Other than Stelco, located in Hamilton, these companies had almost direct access to the raw material needed for production but traded this for a strained connection with the iron and steel market.

3.2 The Big Four

3.2.1 Nova Scotia Steel Company Limited

In the late 1880's Nova Scotia Steel was the first company in Canada to produce an ingot of steel. With the purchase of a blast furnace and a battery of coke ovens in 1891 Scotia Steel was the forerunner of the Canadian steel industry. Its isolated location in Ferrona, Nova Scotia had a weak transportation system and this forced the company to move to Sydney, Nova Scotia. The federal government gave Scotia Steel a contract to supply munitions in 1914 for World War I. This boosted the company temporarily. In 1917 the company was taken over by American capitalists who created many problems, culminating with its permanent shut-down during the recession in 1920.

3.2.2 The Steel Company of Canada

The Steel Company of Canada (Stelco), was formed in 1910 through the agglomeration of several finishing mills in the Hamilton Region and from Montreal. Stelco grew slowly, not taking too many chances trying to increase production in large leaps. When the company did expand it was often aimed at integrating the firms production process. This proved to be a beneficial method of growth. Stelco was the only post-World War II success out of the Big Four. A diverse product line close to the major Southern Ontario market was a plus. Stelco's continued success allowed it to expand and until recently, was Canada's largest steel producer.

3.2.3 Algoma Steel Company

Located in Sault Ste. Marie, Ontario, Algoma was a iron producer during the later half of the nineteenth century. Ambitious American management made poor decisions based on a successful method used in the U.S.A., and created difficult times for Algoma. One major mistake, which the federal government bailed them out of, was the purchase of equipment which needed inputs which were not easily available given Algoma's location. The government assistance helped Algoma turn itself around, expanding through the purchase of a blast furnace, making renovations and by vertically integrating its production, but its main product remained rails. A World War munitions contract helped Algoma's business.

3.2.4 The Dominion Iron and Steel Company

The fourth company in the Big Four was The Dominion Iron and Steel Company (Disco). Like Nova Scotia Steel its operations were in Sidney, Nova Scotia. Disco started in 1899 and its specialization was in steel rail and its aim was to supply the booming railway construction. This decision proved to be very lucrative in the short run but was its downfall in later years. Bad management however, dampened the success of Disco and it had to endured a few lean years until the company could diversify and increase its production capabilities. World War I was a prosperous period for Disco. The depression of the 1930's was very damaging to the company's operations. Even though Disco was able to diversify its product lines prior to the War, it was not enough to accommodate the shift in demand for steel from the railway to the automotive industry.

3.3 The History of Dofasco

During these early years Dofasco was only a small independent steel foundry and not fully integrated because it did not have the capacity to produce iron. The company was founded by Clifton W. Sherman, a steel maker from the United States, in 1912. The companies original name was Dominion Steel Castings Company Limited and its original purpose was to supply steel rail for the railway. Dofasco started with one open hearth furnace and was capable of producing 80 tons (81 tonnes) of steel per day using a payroll of one hundred employees. In 1913 the company merged with Hamilton Malleable Iron Company and became Dominion Steel Foundry Company Limited.

The period after 1900 is when the iron and steel industry realized the power of electrical energy. The technology was still in its infancy at the turn of the century and its full capabilities were still untapped. The production process had become largely mechanized reaching a point where the raw materials never touched human hands. Use of the electric furnace was replaced by the open hearth furnace which could produce more steel and at a higher quality. A problem with this equipment was its expense and large land requirements needed to operate properly.

By 1921 Dofasco had grown in size, steel producing capacity and also in levels of employment. The plant could produce 750 tons (762 tonnes) of steel per day and now possessed eleven open hearth furnaces, a rolling mill, additional forging equipment, a plate mill and a total of approximately 2,300 employees. The company was still lacking a blast furnace, the piece of equipment which would not come for another two decades and subsequently make them a fully integrated steel factory. The quick growth of the company was stunted by the recession in 1921. All the open hearth furnaces were shut down. Reliance was put onto two electric furnaces to produce enough steel to keep the company in business. Competition also had to be contended with from the larger domestic and foreign producers who could produce at a much lower cost.

Dofasco spent $400,000.00 in the three year period between 1928 and 1930. This investment was initiated to upgrade present equipment, purchase new equipment and insure that Dofasco had a technology level that produced top quality steel. The depression was setting in and the market for steel was stagnating rapidly.

New technologies and new steel products were being introduced into the market from established steel producing countries like the United States and the United Kingdom. Canada usually had to wait for these innovations. Dofasco was always trying to compete at the same level as the larger producers. 1935 marked a year that Dofasco pioneered tin plating to the Canadian steel making industry.

Dofasco continued to expand by purchasing new equipment and upgrading existing facilities. Expenditures in the years between 1935 and 1944 included the purchase of soaking pits, a pickle line, upgrade of electric furnaces, expansion of tin plating mill, new railway lines and a $1.2 million cold rolling mill. These additions, other than the electric furnace upgrade, had no affect on the actual production capacity of the company. The range of products that could be sold was increasing.

Demand for flat rolled steel was increasing quickly. Dofasco supplied armour plate and other products to satisfy military needs for World War II. After the War high demand was still present. Production was expanding and investments were being made every year to satisfy the demand. Dofasco had become a steel producer for the global market.

1951 marked the year Dofasco acquired its first blast furnace and became the fourth largest integrated steel producer in Canada, behind Stelco, Algoma, and Scotia Steel. This meant that the entire production process could be satisfied at Dofasco's plant. The raw materials would come in by rail or ship and Dofasco was capable of turning it into steel. Prior to this Dofasco would purchase iron from other producers such as Stelco and U.S. companies.

The future continued to look bright for Dofasco. Within the next eight years expenditure on equipment and new technology cost Dofasco tens of millions of dollars. The company purchased such machinery as two cold rolling mills, a continuous galvanizing line, a second blast furnace, two annealing facilities, a pickling line, and a third battery of coke ovens. The major addition to Dofasco though, was their #1 Basic Oxygen Furnace. Dofasco now had the most efficient steel making furnace North America. The basic oxygen furnace made steel quicker and at lower cost than the open hearth and electric furnaces. This technology could not have come at a better time for Dofasco. Four years later, in 1958, the workers at the neighbouring steel maker Stelco went on shrike. Dofasco was practically supplying all of Canada with flat rolled steel. Two major additions were made in 1960. The first being the #2 Galvanizing Line and the second being the #3 Blast Furnace. Total production capacity was now up to one million tons of steel per year.

The next period from 1964 to 1987 are the years to be analyzed through the production function and will be referred to when explaining the fluctuations in the different ratios. 1966 was the culmination of many expansion projects which included: a temper mill, soaking pits, pickling and annealing lines. Dofasco's history becomes a series of capital expenditures for the purpose of acquiring new equipment. The machinery was becoming more advance and increasingly expensive.

Major occurrences such as the maintenance performed, starting in 1973, on all of the blast furnaces and in 1978 the purchase of #2 Basic Oxygen Furnace had direct impacts on output. The steel output from the basic oxygen furnace was what the earlier accumulation of equipment was awaiting so that it could operate at a higher capacity.

Dofacso came through the 1981 recession with little damage. All but one of the expansion project were halted, most of the equipment was shut down, and 2100 employees were laid-off, but the impact was not very severe. Operations went back to normal in 1983 and the company resumed its massive expenditures on new technologies in equipment.

The next important development was the addition of the Continuous Slab Caster in late 1987. Through the deletion of a stage of production, large amounts of capital could be saved on equipment and labour. The molten steel would skip over the ingot teeming and travel straight to the caster were slabs of steel are made.

4.0 Method of Analysis

4.1 The Production Function

Technology, and how it influences the labour force is the issue which must be addressed. As noted in Section 2, the processes which the raw materials go through to make steel are quite simple. It is the necessary machinery and technology utilized to make the sellable product which complicates the production process. To account for the impact of technology on the way Dofasco has operated, the concept of a production function will be employed. Simply defined, the production function shows how much output can be made from given amounts of labour and capital (Hall and Taylor, 1988). Using symbols, the production function can be written as Q=f(K,L), where the quantity of output (Q) is a function of capital (K) and labour (L). These relationships will be graphically represented and interpreted on this basis. To accommodate such a method data on Dofasco's employment levels, fixed asset depreciation, output and sales are needed. Analyzing the data requires a knowledge of Dofasco's history and how the company has operated and expended capital in the past.

The years of 1964 to 1987 inclusive, will be the confines for analyzing the four variables, labour (Figure 1), capital (Figure 2), output (Figure 3) and sales (Figure 4). The average number of people which Dofasco employs will be representative of labour. Factory workers, office workers, and anyone else employed at Dofasco's Hamilton operations are included into this category. Capital will be represented as a dollar value of the accumulated depreciation of Dofasco's fixed assets. This measure is used so that a constant proportion of the companies capital is obtained and also because it excludes assets like cash, accounts receivable, and land. These are not desired for the simple reason that they have little affect on the technology used by Dofasco to produce steel. The weight, in tons, of ingots and castings produced on a annual basis will represent Dofasco's output. The total value, in dollars, received by Dofasco from its customers for the purchase of outputs in a given year will be noted as sales. These values have been deflated using a Manufacturers Price Index for Output so that they would be consistent with the 1986 value of a Canadian dollar.

For information to be extracted from the raw data it will be utilized in a ratio form. The four ratios which will be considered include the Sales/Labour, Sales/Output, Output/Labour, and Capital/Labour ratios. These ratios will supply an explanation of how technology has influenced Dofasco's productivity, quality of output, capital utilization and labour force. Dofasco's history will be referenced to explain how the ratios within the production function reflect changes in its steel making operations.

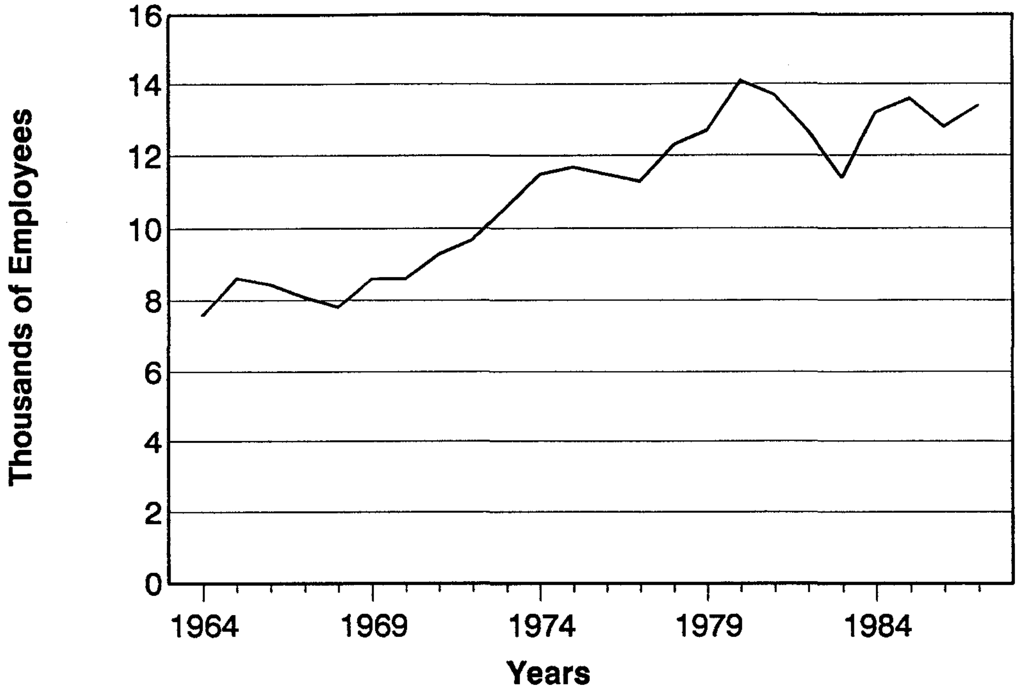


Figure 1: Average Annual Employment at Dofasco(Labour)

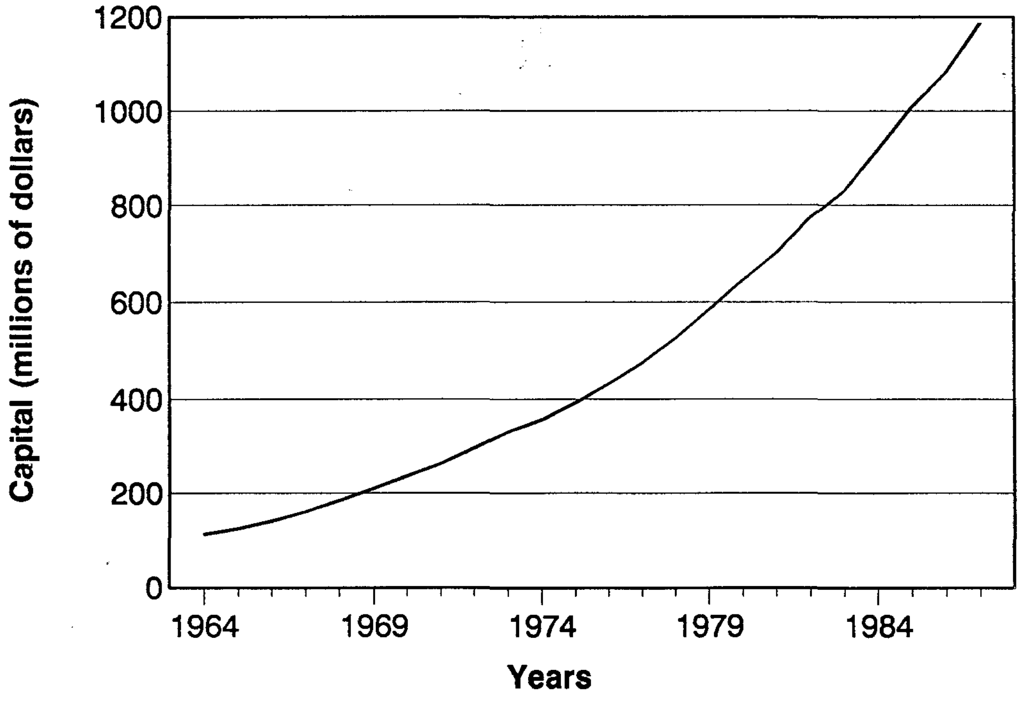


Figure 2: Accumulated Depreciation of Dofasco's Fixed Assets(Capital)

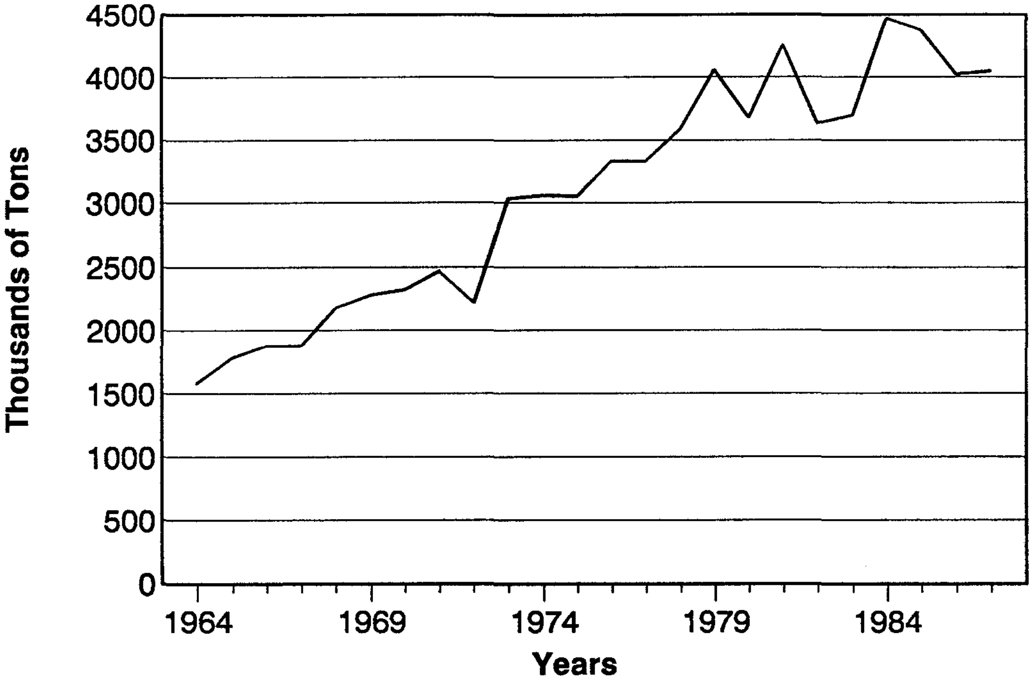


Figure 3: Dofasco's Annual Tonage Production of Ingots and castings (Output)

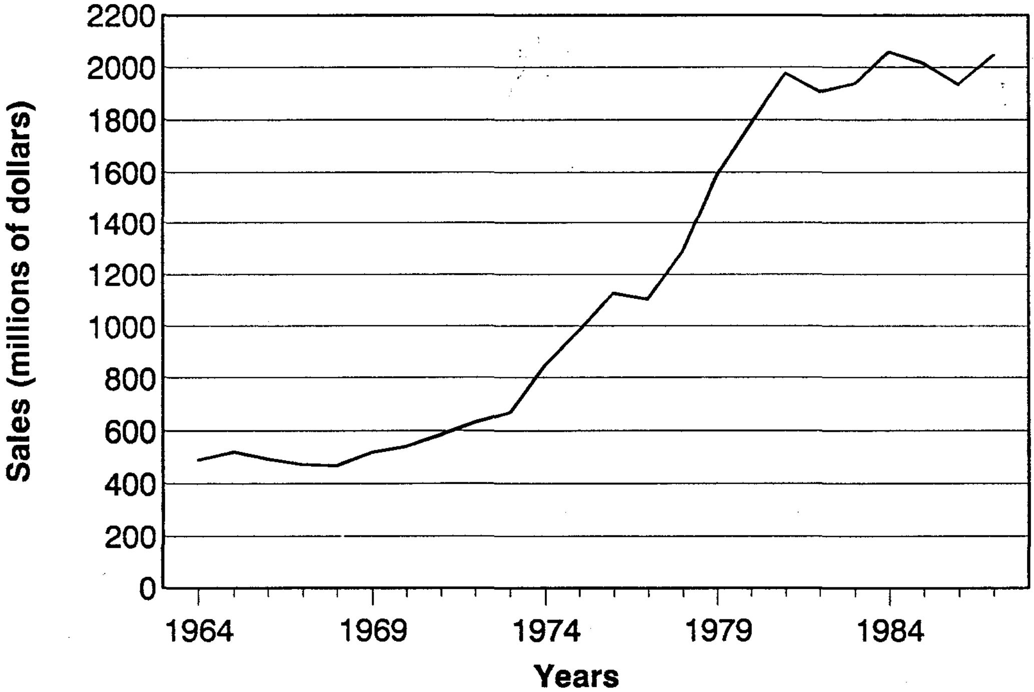


Figure 4: Annual Sales Levels at Dofasco (Sales)

4.2 Analysis of Ratios

4.2.1 Output/Labour Ratio

The output/labour ratio (Figure 5), measured in tons of output per employee, can be used to assess the productivity of Dofasco's operations with respect to changes in the labour force. Technology has a large influence on the productivity of production. At Dofasco, technology affects the efficiency of operations and its output capacity. To acquire the equipment, large capital expenditures are required. The justification, or trade off to this expense is found in the higher output capacity and also in the quality of the product produced.

Oscillations in this ratio can reflect circumstances other than changes in productivity. In very large operations with considerable amounts of equipment and machinery, such as Dofasco, periodic maintenance must be performed. When equipment is shut down for maintenance it will invariably have some effect on output. When major production facilities such as a blast furnace or a basic oxygen furnace have to be shut-down, the impact on output is quite noticeable because of their integral importance to steel making. The lengthy time involved in maintenance of these facilities makes the impacts of their shut-down even more pronounced. In essence, this type of shut-down can be considered a momentary decrease in productivity. Once the repairs are complete, the equipment can usually produce more than before the maintenance, thus increasing productivity.

Given the increasing nature of Dofasco's capital expenditure on new, high technology equipment, the levels of employment and quantity of output would almost definitely fluctuate. The initial trend of the ratio, up to 1968, was a movement upward. Labour was declining while output exhibited a slight increase. Several years earlier, in 1960, the third blast furnace was installed. Coupling this with some of the smaller equipment additions which Dofasco made, the capability for increased output existed. The size of the jump in the ratio was also due to the slight decline in the labour force.

The ratio fell leading up to 1972. Not much equipment was purchased between the years 1968 and 1972 causing little change in the level of output. The magnitude of the drop was amplified because there was a relatively small increase in labour and a decrease in output. An equally large increase in the ratio was observed in 1973. The shut-down of all the blast furnaces was being anticipated and stockpiling of steel had to occur. This explains the jump in output, but at the same time labour levels were also on the rise. The workers productivity had increased greatly and it was due to having the blast furnaces working at full capacity to achieve an unusually high output.

From 1973 to 1978 Dofasco made few changes or additions to its production facilities. Output did continue on its upward journey while the a labour force which declined slightly. The ratio dipped somewhat in 1974 but rebounded back up in 1976. The larger jump took place in 1979 when Dofasco passed the four million ton barrier in its output. Labour totals were also on the rise, but not as quickly as output, thus causing the ratio to climb. A variety of factors can be cited to explain the increase. The main reasons being the blast furnaces producing at full capacity and the addition of the #2 Basic Oxygen Furnace in 1978. The were other projects complete in 1979 such as: #3 Coke Plant; a hot strip mill; a cold mill; normalizing plant, a melt shop, soaking pits, an annealing tunnel and expanded shipping facilities. These smaller expansions allowed Dofasco to produce more steel. Along with the larger acquisitions, the blast furnace and basic oxygen furnace, Dofasco's output per employee, or productivity increased. The capability of each employee to produce a higher level of output had been achieved through Dofasco's use of more equipment which was able to produce large quantities of output with a compliment of workers comparably smaller than in previous periods.

In 1980 the output/labour ratio dropped sharply. Employment continued its rising trend from the previous years. Granted, the machinery which had just come on-line in 1979 operated with high technology and was very efficient, but it still needed workers to operate and maintain it. To do this it was necessary to hire additional labour. The recession though, was starting to set in and demand for steel began to decrease. This decline in demand translated into a one week shut-down of Dofasco's plant. Adding to this the fact that #4 Blast Furnace, the largest of the four, was having maintenance done on it, output dropped significantly. Declining output and rising employment caused the factories productivity to fall which is illustrated in the ratio.

The ratio swung back up in 1981. The recession was upon the country and Dofasco responded with a decrease in its labour force. Even though there were fewer workers, total output did increase causing the upward rebound of the ratio. Lay-offs came in 1982. Twenty-one hundred workers were laid-off due to the economic conditions. The productivity of the workers only decline slightly in 1982. Output also dropped, but not by very much considering it was occurring during a recession.

Employment levels continued to drop into 1983, while output remained consistent with 1982. No changes in the amount of equipment owned by Dofasco occurred leading up to 1983. It would be safe to assume that the less efficient equipment would be shut-down during the recession. The workers were able to be more productive given that they were only using the top machines to produce steel. During the recession Dofasco believed that the #2 Hot Strip Mill project was important enough to continue. These factors caused the ratio to increase. Different reason made the ratio continue on its assent into 1984. Both employment and output increased in this year, output just increased at a faster rate. The laid-off workers had been called back and most of the equipment was back on line. From 1984 to 1987 the ratio declined. Employment was remaining relatively stable while output slowly declined. The output decline in 1986 and 1987 can be attributed to the shutdown of the #4 Blast Furnace and the #2 Basic Oxygen Furnace, two large contributor to total output.

Looking at the ratio for an overall trend, a gradual increase in Dofasco's productivity can be observed. Both labour and output grew, but output grew at a quicker pace. As noted above, the fluctuations in the ratio can be explained through the changes which Dofasco experienced. Some of these movements were self-induced by the company, like the maintenance of equipment, but economic factors such as the 1981 recession can also be credited with causing disturbances in Dofasco's productivity. Dofasco has purchased large quantities of new equipment over the years and it seems evident that they do not need the same amount of human inputs as they used in the past.

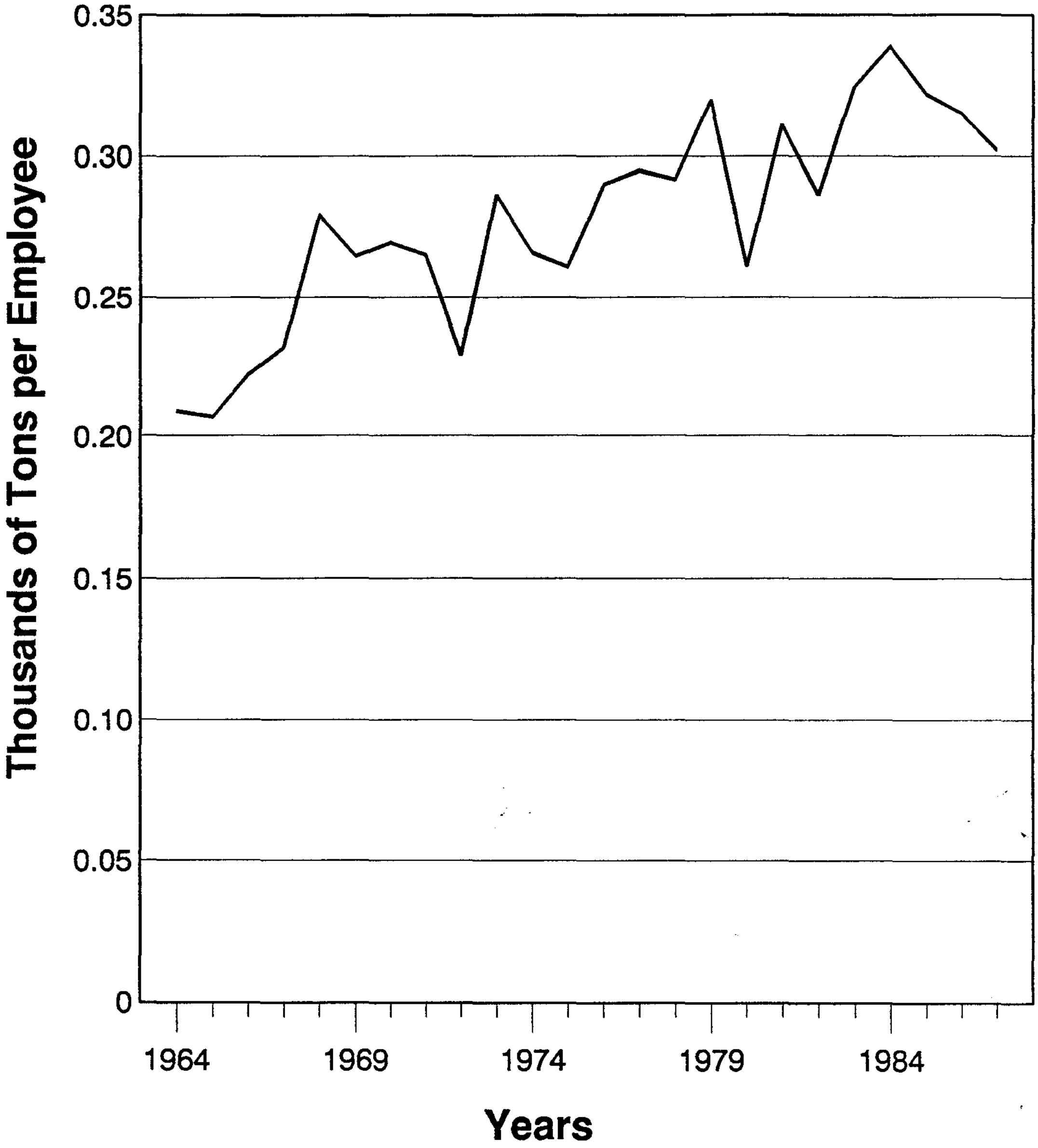


Figure 5: Output/Labour Ratio

4.2.2 Sales/Output Ratio

The sales/output ratio, measured in dollars per ton of output (Figure 6), can be used to assess the value of Dofasco's steel output. Fluctuations in this ratio can represent a variety of circumstances within a steel producing environment. A change in the price of steel would affect this ratio. Higher prices for the same amount of steel could be attributed to an economic factor such as inflation. In difficult economic times the price of steel, along with sales, could decline and the ratio would drop, assuming the level of output was maintained. It could also represent a higher quality in the produced output. Higher quality would be reflected in higher prices and would directly translate into a higher dollar value of sales. The ratio would grow because output would not necessarily increase to accommodate a higher quality product. Technology can often be credited with causing an increase in the quality, and thus the value of the product. Modern technology in steel production facilities can produce large amounts of very high quality output.

As indicated earlier the sales/output ratio will be used to interpret the trend in the value of Dofasco's product and also to the related issue of the company's product quality. This ratio experienced a substantial drop in the years between 1964 to 1968. The output of the company (Figure 3) was increasing at a considerable pace. Smaller components in the production process were being added such as three rolling mills, two galvanizing lines, a tin plating line, an oxygen plant, soaking pits and very importantly a battery of fifty-three coke ovens. These coke ovens provided the capability to increase output by providing prepared raw materials on site. This complimented the earlier purchase of a third blast furnace in 1960. Alone these additions would have little affect on Dofasco's output. This coupled with stable sales (Figure 4), caused the ratio to decline. If they were combined with the addition of a blast furnace of a basic oxygen furnace output could be greatly increase.

During the period after 1968, the new equipment had a stabilizing affect on the ratio. Sales grew gradually while output grew only slightly. The value of the steel may have been increasing. The addition of the tin plating and galvanizing lines, for example, directly influence the value of the steel and may have been the cause for the increase.

At the end of 1973 the #1 Blast Furnace was shut down. As this was the beginning of a major maintenance project, where all four blast furnace were to be shut down at some time over the next six years, the impact of the decreased output of molten iron would be noticeable. To compensate for such a drop in output, stockpiling of steel occurred in the previous year which explains the surge in output in 1972 and the drop in 1973. Ingots were also purchased from Stelco to counteract the decline in output caused by the shutdowns.

The next period of time was very important in

Dofasco's history. Sales started to climb at a much swifter pace while output was remaining level. In the seven year period extending from 1973 to 1980 Dofasco amassed an enormous amount of new equipment. These additions included: fourteen soaking pits; a continuous annealing tunnel; a cold mill; hot strip mill; a normalizing plant; #2 melt shop; #3 coke plant; increased shipping facilities; and most importantly in 1978, the addition of the #2 Basic Oxygen Furnace. This furnace was capable of producing one million tons of steel per year.

Considering all the new technology and equipment collected over the past sixteen years, Dofasco had spent immense amounts of capital on diversifying its product line of flat rolled steel. The machinery would extend the processes which the steel was capable of being exposed to before it became a final product. Before the basic oxygen furnace was installed this machinery could not be used to its full potential. With the new basic oxygen furnace there was potential for increased output and utilization of the acquired facilities.

Output did grow relatively slowly in the period of 1973 to 1979. In 1980 the output of steel decreased. Despite this, sales continued to grow at a very rapid pace. The reason behind this trend was the higher value of the steel produced by Dofasco. The new galvanizing, tin plating, annealing, and other product improving facilities were being realized and this is reflected in the upward movement of the ratio.

1980 reinforced the trend of the previous few years. The Recession of 1981 was starting, Dofasco's output dropped off but sales continued its push upward. Sales continued to increase in 1981 but output also rose, which caused the ratio to drop. Galvanizing capacity had just increased by 35% with the completion of #4 Galvanizing Line.

With the recession upon the country, both output and sales were affected. Surprisingly sales only dropped slightly while output decreased considerably. Both domestic and foreign demand were down significantly. Dofasco cut back by shutting down several lines of production and stopping almost all expansion projects. For the first time in the companies existence, workers had to be laid off. Employee lay-offs totalled 2100 in 1982.

The ratio remained level leading into 1983 due to the stabilized output and sales levels. Dofasco weathered the recession with comparably very little damage. During this year #2 Hot Strip Mill was started up, #4 Pickle Line was completed, there was an expansion of annealing capacity and the laid-off employees were all being called back.

The years covering 1973 to 1981 were characterized by very fast growth in sales and cautious growth in output. Even though output was declining or remaining level, sales continued to grow at unprecedented rates. It can be inferred from this, that the price of the steel must have invariably got higher due to the higher quality output. The higher quality was achieve in part by exposing the steel to the new production technologies extended the processing procedure and thus directly increasing the price.

The ratio fell in 1984. All the laid-off employees were now back on the job and the factory was producing at normal, or at least expected levels considering the trend established prior to the recession. Leading up to 1987 the ratio began another upswing. Output was declining while sales were remaining relatively constant.

The main characteristics which the sales/output ratio shows that the quality and the value of Dofasco's products were growing during the past fourteen years, starting in 1973. The data is marked by a sales growth rate greater than the rate of growth in output. The use of modern equipment directly added value to the raw steel. If Dofasco had chosen another growth avenue and focused on just producing ingots and castings, the present trends observed may not have occurred. Blast furnaces and oxygen furnaces could not have added a value to the steel comparable to that of galvanizing, or tin plating. The further lines of productions are what caused the ratio to attain its height.

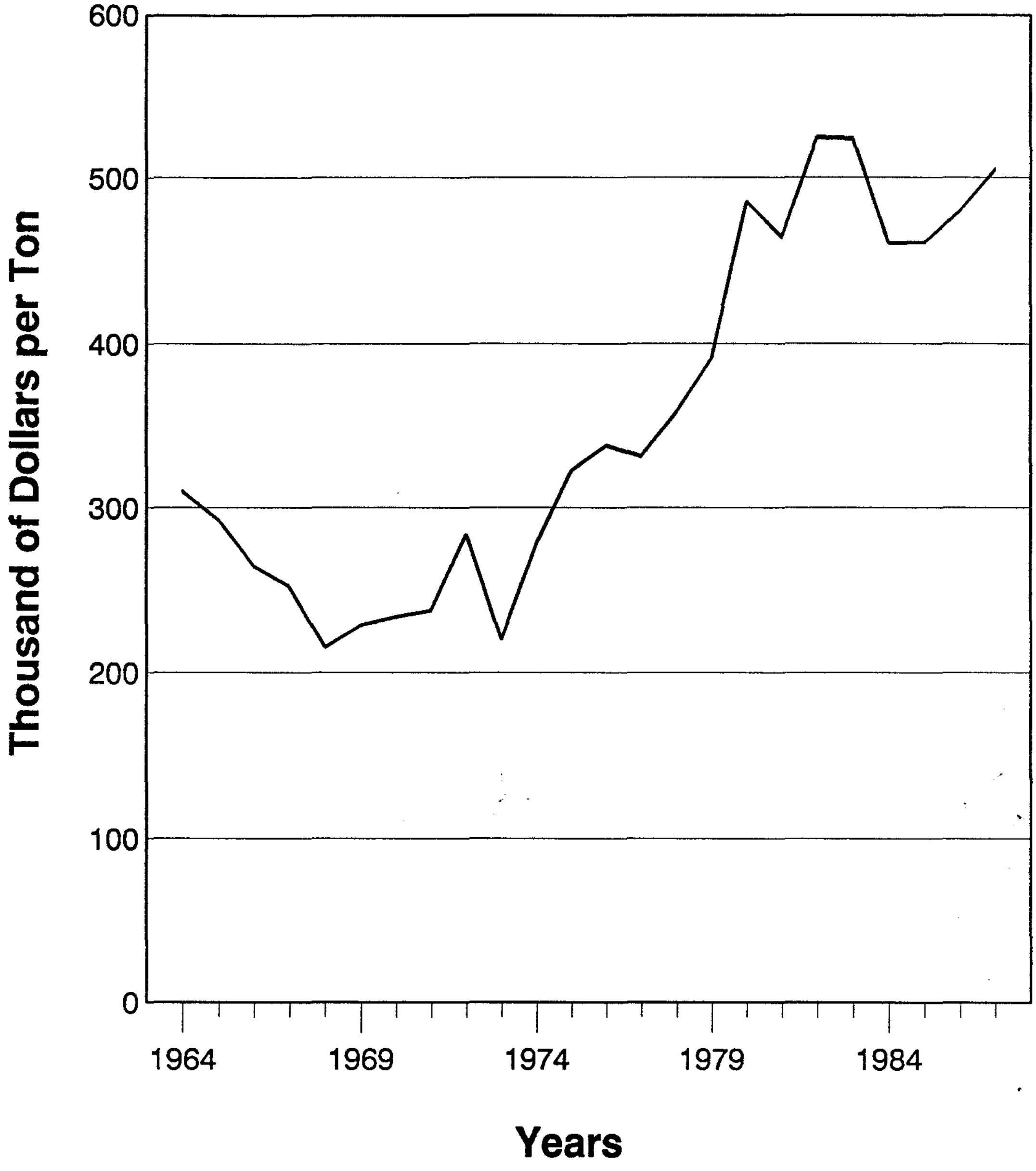


Figure 6: Sales/Output Ratio

4.2.3 Sales/Labour Ratio

The sales/labour ratio (Figure 7), represents the dollar value of the steel products sold with respect to the number employees at Dofasco. This can also be looked at as a measure of what each employee, on average, generates in way of sales dollars. As mentioned in the sales/output ratio, the economic conditions can have a pronounced effect on the sales of a steel producer. Increasing demand creates a situation where the sale of steel would grow rapidly and the equipment would be working at capacity so as to fulfill orders. Even though the facilities may be at full capacity, the man-power needed to operate the equipment would not have to change drastically because the technology used in steel production does not require more workers to produce more steel. It is when new equipment is purchased, and production capabilities are increased, that more workers would be needed to operate the machines. The replacement of old equipment would not have as pronounced effect on the labour requirements. Labour needs would probably decrease when equipment is upgraded. Conversely in slow economic times both sales and labour could be affected. Demand may be low, thus, directly affecting sales. The labour force can be affected because less equipment may be needed to satisfy customers need thus less workers are needed. The company may also find it necessary to cut payroll in declining economic periods to save money.

A very similar trend is observed in the sales/labour ratio as in the sales/output ratio. The ratio remains level until 1973 and then it shoots upward only to level off again in 1984. This can be explained using much of the same arguments used in supporting the sales/output ratio.

As mentioned for the sales/output ratio, 1973 was the start of new operating environment for Dofasco. Large quantities of new equipment had been accumulated over the past decade. The technology utilized in the production was creating a increasing range of products with a higher value and quality, translating into much higher sales levels. This is a relatively continuous trend for Dofasco's sales after 1973 and up to 1983.

The influence of labour now becomes the important variable to be considered. The amount of labour Dofasco has utilized through the time period being considered does not fluctuate to a great extent, except during the recession of 1981. The changes in the sales/labour ratio were driven more by the forces of sales than the forces of change found in the labour data from year to year. Labour totals were growing prior to 1973. This increase was gradual and had little effect on the ratio. The sales attributable to each employee was remaining constant. After 1973 labour continued to raise but the sales growth drowned any effects it may have had on the ratio. The value of what each worker was producing climbed very quickly after 1973.

The ratio experienced two short periods of little movement. The first being in 1976 when labour declined slightly and the second was in 1979 when the growth in employment experienced a small surge causing the ratio to stall momentarily. These two occurrences were minor observations considering the obvious pattern exhibited by the ratio.

When the recession hit, employment levels started to drop immediately. The decline began in 1980 can continued until 1984. This decline can be attributed to the recession. Machinery was being shut down and expansion projects were stopped. As mentioned earlier this was the first time that Dofasco had to lay-off workers.

It would naturally be expected that the sales of a company would decline during a recession. This did occur for Dofasco but as mentioned with the sales/output ratio, sales did not decline very much considering they were in the middle of a world wide recession. Dofasco was producing products which were high in value and did not need a large input of labour. The equipment was doing all the work. The most efficient equipment would have been kept on line, while the older facilities were shut down to save on expenses.

The ratio dropped in 1984 from its momentary peek achieved in 1983. The employees which were laid-off in 1982 were now being called back to work. This was a large one year increase. Sales did increase but could not keep pace, thus causing the ratio to decline. From 1984 to 1987 neither sales

Figure 7: Sales/Labour Ratio

or labour fluctuated a large amount. The ratio remained relatively stable. Both labour and sales experienced little activity, thus leaving the ratio at a stable level from 1984 to 1987.

It is important to emphasise the change which occurred in the dollar value of the sales which each employee could account for over different times in Dofasco's history. Employment levels grew from 7529 in 1964 to 13400 in 1987, while sales increased from $491.3 million to $20.5 billion respectfully. Labour, in 1987, was able to generate a more valuable product using a larger stock of machinery which was accumulated starting in the 1960's and 70's.

4.2.4 Capital/Labour Ratio

This ratio reflects a comparative utilization of two of the key factors of production, these being capital and labour. The capital/labour ratio represent the dollar value of capital per employee at Dofasco (Figure 8). As mentioned earlier, capital is being depicted by the accumulation of Dofasco's depreciable fixed assets (Figure 2), and labour as the average annual employment (Figure 1).

Changes in the level of capital used by a firm would reflect changes in the way the firm purchases things such a equipment, buildings and other assets. Assets which, in general, have an influence in some way how steel is produced. Increases in the amount of capital being utilized would hopefully be followed by a positive change in output or the type of output produced. It stands to reason that when a firm uses capital for the benefit of its production then these added assets should create benefits, possibly in the form of higher levels of output, productivity or maybe product quality.

Changes in the quantities of labour on the other hand would also be expected to have an effect on output. There are a variety of possible reasons why a firm would need to employ more labour, but at some point this increase in personnel would hopefully work for the betterment of the company, possibly in the form of higher output or revenue. A firm may choose to hire more labour and not to purchase additional equipment. This could create increases in the firms output depending on whether the production process is either labour or capital intensive.

Dofasco's relationship between capital and labour shows a general upward trend in the ratio. Labour experiences minor fluctuations except during the recession of 1981 where the movement was relatively dramatic. Data on Dofasco's capital reveals a steady growth, moving at an increasing rate. Due to the consistent nature of the value of Dofasco's capital, the fluctuations in the labour levels become the influencing factors when considering the movements in the capital/labour ratio.

In recent years, Dofasco experienced one relatively large surge and two subsequent small increases in its employment levels with one major decline during the recession of 1981. The first increase was the large one and was form 1961 to 1965. Employment nearly doubled, growing from approximately 4500 to 8500 workers. The second surge come in 1968 and ended in 1973, and the third from 1977 to 1980, which signified the highest level of employment in Dofasco's history. These increases in labour have a dampening effect on the capital/labour ratio. During the periods between the jumps in employment, the ratio increases because of the continual growth of Dofasco's capital stock.

The beginning of a small surge in labour occurred in 1970 and ended in 1974. This had a reducing effect on the capital/labour ratio. Capital was continuously pushing the ratio upward, until periods of high labour additions arose. Another calm period started in 1977 and continued into 1980. Again the reason was a growth in Dofasco's employment level.

The most significant increase in the capital/labour ratio occurred during the recession of 1981. Labour dropped off dramatically but capital continued to grow. It was in 1982 when Dofasco discontinued most of its expansion projects and laid-off twenty-one hundred of its workers. Lines of productions were still running but at reduced capacity. Output was maintained to a certain extent and the productivity of the plant had initially declined but actually increased toward the end of the recession. The capital/labour ratio did decline in 1983 because of the call-back of the laid-off workers but shot upward subsequently with a stabilization of the labour force.

It becomes difficult to explain the occupance of a recession using the capital/labour ratio within the production function. It is true that the level of capital increased during the recession and labour decreased. Dofasco had control over its labour force and showed this through the lay-offs in 1982. Capital on the other hand cannot be manipulated as easily. The equipment has direct influence on the level of capital. Dofasco can shut the equipment off, which it did during the recession, but stopping short of selling the equipment, the company still has to count it as capital. With this in mind the fluctuation in the capital/labour ratio during the recession can be slightly misleading.

In general, the utilization of capital with respect to employment greatly increased over the period of analysis. Both capital and labour had an increasing trend. Only labour had fluctuations in its data. Dofasco hired its employees in surges. A certain amount of new equipment would be bought, and in effect increase the ratio. In the ensuing years Dofasco would acquire the labour to properly operate the machinery.

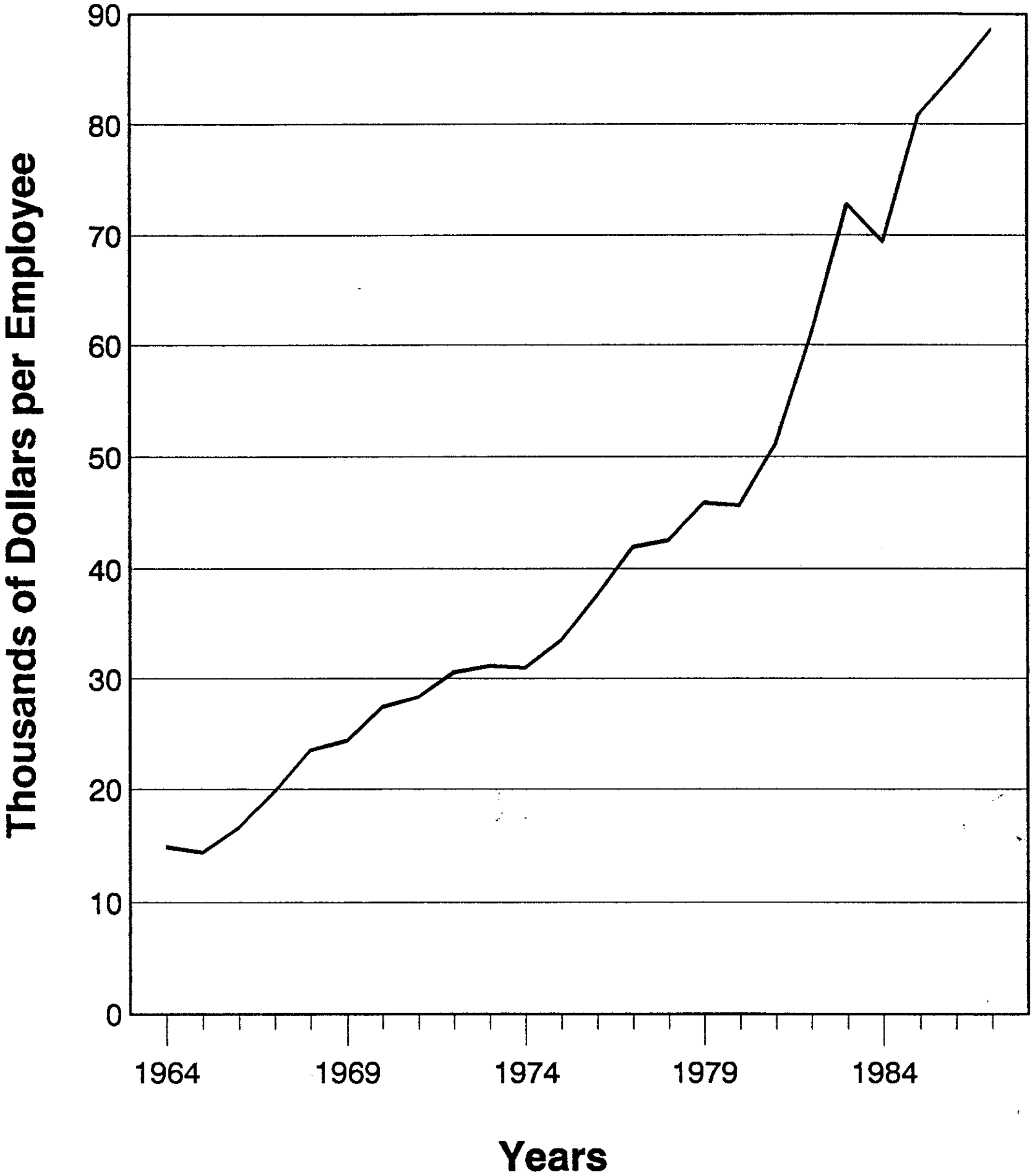


Figure 8: Capital/Labour Ratio

4.3 Summary

The performance of the four ratio give a strong indication of how Dofasco has changed over the past decades. Similar trends characterise the sales/output and sales/labour ratios, and for comparable reasons. A significant increase in the value of Dofasco's steel was revealed in the sales/output ratio. Sales levels grew rapidly compared to the increases in output. Minor fluctuations could be attributed to occurrences connected with equipment repair and temporary shutdowns. The larger jumps include the 1973 assent which was caused by the culmination of many expansion project and also the recession in 1981, even though Dofasco did not suffer much during this period. The growth of this ratio reflects an increase in the quality of output and thus creates a higher value. The sales/labour ratio experiences the same rapid grow in the sales and relatively slow growing labour. Again the surge in 1973 was cause by the rapid growth in sales, but during the recession it was the lay-offs which caused the ratio to stall.

The capital/labour and output/labour ratios can be linked. The swift growth of the capital utilization per employee is reflected in a growth of Dofasco's output per employee. Dofasco was spending considerable amounts of money on equipment and it translated into a rise in the company's labour productivity.

5.0 Conclusion

Dofasco as a company had undergone significant changes since its beginning in 1912 as a foundry and today as Cananda's largest fully integrated producer of flat rolled steel. Competition from the established producers in Canada, the United States and the United Kingdom made growth slow in the company's early years. But as Hamilton's site advantages and government promotion emerged in the early twentieth century, Dofasco's growth became more pronounced.

Equipment acquisitions became common and progressively larger in quantity and cost. The heightening expense of expansion and the increasing complexity of the steel making process made it more difficult to increase total output in a short time period. Dofasco adopted a incremental growth fashion, purchasing equipment such as galvanizing, tin plating, annealing and pickling line which influenced the value of their steel. Included in these additions would also be rolling mills, soaking pits, coke ovens and storage facilities, all of which pave the way for the addition of the major production equipment. Once these preliminary expansions were made, Dofasco would purchase a blast furnace or a basic oxygen furnace and immediately have the facilities and capacity to process the primary outputs of either of them.

The information obtained from the ratios explains the observations just stated. A major accumulation of high technologically advanced equipment occurred leading up to

1973. While the total output of Dofasco did not make any dramatic leaps at any time in their recent history, it was the change in the value of the steel which is most noticeable. 1973 mark the time when the value related equipment was beginning to be utilized. With the anticipation of the #2 Basic Oxygen Furnace in 1976, Dofasco was successfully able to increase the quality and value of its steel.

To attain this outcome, significant amounts of capital had to be utilized. This was done at the expense of a stagnating labour force. When Dofasco purchased equipment it would be on the most modern equipment available. As the technology level grew so did the technology in Dofasco's factory. The art of steel making has been removed from the hands of man, as it was in the eighteenth and nineteenth centuries and into the control of computers. Many workers are still needed to execute to steel making process but their productivity level has shown an increasing trend.

Through a commitment to innovation, Dofasco has emerged as a world wide force in the steel making industry. By utilizing the best equipment available and taking advantage of the site advantage in Hamilton, it has achieved a position where fewer workers are needed to produce a larger quantity of steel which can be sold at much higher prices compared to twenty years ago. This is a trend which does not appear to have the potential to change. Dofasco though, remains an integral part of Hamilton, but will not contribute directly, any substantial increases to local employment. Dofasco has reached a point where its labour requirement may actually decrease because of the technology existing in the industry.

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APPENDIX A

Glossary of Terms

Glossary of Terms

Annealing: is a process which steel is put through to make it less brittle after being cold rolled.

Basic Oxygen Furnace (BOF): is a furnace which uses supersonic blasts of ultra pure oxygen as a source of fuel to produce steel.

Billet: is a long narrow rectangular piece of steel with a square cross-section. These are used to make bars, rods, and tubes.

Blast Furnace: is were the iron ore, coke, and lime and mixed together and heated until they form molten iron.

Bloom: in a large rectangular piece of steel with a square cross-section. These are used to make rails and structural shapes.

Coke Oven Battery: is where coal is taken and exposed to very high temperatures to drive off impurities and convert it into coke.

Cold Rolled Steel: is manufactured hot rolled steel by pickling and cold reduced to a desired thickness.

Cold Strip Mill: manufactures cold rolled steel.

Electric Furnace: is a type of furnace used to produce steel. The only inputs needed are scrap metal, limestone, and sufficient electrical power to melt the scrap.

Foundry: is a metal works where steel is made out of purchased pig iron.

Galvelume: is a protective coating for steel developed by Dofasco which is composed of zinc and aluminum.

Galvanizing: is a process of applying a protective coating made of zinc to steel.

H.H.C.: Hamilton Harbour Commission. (from Map 2)

Hot Rolled Steel: is manufactured by rolling ingots or slabs to a required thickness.

Hot Strip Mill: is where hot rolled steel is made.

Ingot teeming: is when molten steel is poured into ingot moulds so that it can cool and solidify.

Melt Shop: is where scrap metal can be melted before being put into the basic oxygen furnace.

Open Hearth Furnace: is a large saucer furnace which produces steel, by combining coke, iron ore, limestone and very high temperatures and air.

Oxygen Plant: is where high purity oxygen is made to be used in a Basic Oxygen Furnace.

Pickling: removes sulphur dioxide from the surface of hot rolled steel.

Pig Iron: is the iron which comes out of the blast furnace. The name was derived from the configuration the iron moulds were in around the blast furnace.

Sintering: is the process where iron ore is put into pellet form to be used in the blast furnace.

Skelp: is steel plates which are bent and welded into pipes and tubes.

Slab: is a flat steel shape which is rolled to varying thicknesses.

Slag: is the waste material which forms on the surface of the molten iron and steel when the lime flux reacts with their impurities.

Soaking Pits: are were steel ingots are taken to be heated to an even temperature so they can be shaped in the rolling mill.

Wrought Iron: is a very low quality iron produced using charcoal in the late nineteenth century to make things like bars, nails, and ploughs.

APPENDIX B

Explanation of Data

Explanation of Data

The information utilized by this paper was obtained from a variety of sources. The major source was Dofasco Inc. A large quantities of valuable information was obtained from an interview with Dofasco's Media and Public Relations Manager, Mr. W. Gair and numerous brochures on the companies history and steel making operations in Hamilton. The interview provided a general insight into the reasoning behind Dofasco's expansion policies. The brochure were used to explain specific characteristics about Dofasco's production process, range of products, and historical facts.

Dofasco's Annual Report's proved to be a valuable sources of data and historical information. The raw data on labour, capital, output and sales (see Appendix A) were all obtained from these reports. The historical information acquired took the form of dates which Dofasco purchased and started utilizing new equipment. Much of the historical information on the iron and steel industry in general was obtained from a variety of literary sources.

Table 1: Data Obtained from Dofasco's Annual Reports

YEAR	NUMBER OF EMPLOYEES	INGOT AND CASTING PRODUCTION (tons)	SALES (dollars)	CAPITAL (Accumulated Depreciation Dollars)
1964	7,579	1,584,000	491,318,172	113,000,000
1965	8,625	1,785,000	522,226,597	125,000,000
1966	8,445	1,877,000	495,662,147	141,000,000
1967	8,100	1,879,000	473,846,449	161,000,000
1968	7,800	2,180,000	469,959,868	184,000,000
1969	8,600	2,279,000	521,275,336	210,000,000
1970	8,600	2,322,000	542,580,851	236,000,000
1971	9,300	2,468,000	586,009,680	264,000,000
1972	9,700	2,223,000	631,786,546	297,000,000
1973	10,600	3,036,000	667,491,851	331,000,000
1974	11,500	3,060,000	850,335,211	357,000,000
1975	11,700	3,053,000	986,756,125	392,000,000
1976	11,500	3,335,000	1,127,670,381	432,000,000
1977	11,300	3,333,000	1,104,620,069	475,000,000
1978	12,300	3,588,000	1,288,498,024	524,000,000
1979	12,700	4,060,000	1,589,930,596	584,000,000
1980	14,100	3,681,000	1,787,981,105	645,000,000
1981	13,700	4,258,000	1,977,842,571	701,000,000
1982	12,700	3,636,000	1,908,539,935	774,000,000
1983	11,400	3,700,000	1,938,267,340	830,000,000
1984	13,200	4,468,000	2,058,630,819	917,000,000
1985	13,600	4,373,000	2,017,016,723	1,007,000,000
1986	12,800	4,026,000	1,934,571,000	1,083,000,000
1987	13,400	4,048,000	2,046,049,407	1,187,000,000