THE AMERICAN IRON ORE AND STEEL INDUSTRIES:
TWO ESSAYS

by

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Dear Professor Brown:

In partial fulfillment of the requirements for the degree of Doctor of Philosophy in Economics, I hereby submit the following thesis entitled

The American Iron Ore and Steel Industries: Two Essays.

Richard B. Mancke
ABSTRACT

The American Iron Ore and Steel Industries: Two Essays
Richard B. Mancke

Submitted to the Department of Economics on May 16, 1969, in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Economics.

The two unifying themes of this thesis are that of necessity all industries exist and function in a milieu of different but interdependent markets and that each such market is characterized by a unique vector of structural, spatial, and time dimensions.

Iron ore and steel are one pair of closely related industries. In this thesis we attempt to explain how the economic performances of both have evolved and interacted over time. We do this in two closely related essays.

Essay I, "The American Iron Ore Market," examines how the United States' steel industry has provided itself with its major raw material input -- the mineral iron. This study focuses on the economic structure and performance of the iron ore industry in the post-World War I period; however, given the nature of the subject this division is somewhat arbitrary. Therefore, considerable attention is also devoted to discussing the problem of the provision of iron ore in earlier periods. Throughout this essay the nature of the linkage between events in the iron ore market and events in the steel market is discussed in detail.


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To Professor Morris Adelman I owe an even further expression of thanks. He suggested the original idea of this study and provided continued encouragement until its completion. I suspect that the "knowing" reader will see his influence throughout this work.

I am also grateful to Miss Kathryn LaPerche for typing the final draft.
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The American Iron Ore and Steel Industries:

Two Essays

One feature characterizes the entire history of the American iron ore and steel industries; i.e., they have continuously been the subject of public controversy and criticism. Beginning with the formation of The Bessemer Association in the 1870's and especially since the formation of the United States Steel Corporation in 1901 and Judge Gary's notorious dinners for "rival" steel leaders in 1907 and 1908, most of the criticism has been based on one often implicit premise:

The American iron ore and steel industries have a highly oligopolistic industry structure and the member firms have an exceptionally high appreciation of their interdependence; therefore, both industries behave like a monopoly. Since these industries are not subject to any formal public regulation this must lead to gross economic and social inefficiency.

There is no question that economic theory does imply that monopoly leads to economic inefficiency. Specifically the higher prices which the profit-maximizing monopolist is able to charge result in too little production of the monopolized product. However, serious as it is, recent critics of these industries do not rest content with the above charge. In fact most ignore it or mention it only in passing. Instead they argue that the sanctuary from competition provided by "near" monopoly has permitted and has led to the perpetuation throughout both industries of a grossly inefficient and obtuse management--a management which often fails to even attempt to maximize profits. As proof they cite such items as the alleged slowness of the American steel industry to innovate; e.g.,
the lag in adopting the basic oxygen process for making steel; the great
postwar rise in steel prices and the resultant sharp rise in steel im-
ports, and the "terrible" relations between the steel companies and the
United Steel Workers of America.¹

Such charges if true are serious. Even more serious is the im-
plication, often drawn from them by analogy, that other industries with
similar monopolistic structures will be similarly inefficient.

The "truth" of the above and similar charges have been widely and
too often uncritically accepted by the economics profession. One ques-
tion we should ask is why? A second and more important question is
which of the charges and the facts upon which they are allegedly based
are true? For if the facts are wrong then the implications drawn from
them, no matter how dramatic, are sterile. This thesis will be concerned
with answering the second question. We shall attempt to accomplish this
task in two related essays: The first essay focuses on the behavior of
the American iron ore industry throughout its entire history. The second
essay focuses on the behavior of the American steel industry since the
end of World War II. Both essays will stress the importance of the tech-
nical, financial, and economic interrelations between these two industries.

Of necessity all industries exist and function in a milieu of dif-
f erent markets. Each such market is characterized by a unique vector of
structural, spatial, and time dimensions. In this thesis we propose to
ask:

¹The best example of these alleged "terrible" labor-management
relations was the 1959 steel strike which disrupted steel production for
116 days.
1. What are the economic structures of the major factor and product markets in which the American steel industry is engaged?

2. What has been the American steel industry's performance in these markets?

3. What sort of interaction occurs between these markets; i.e., how does the economic structure and performance in any given market interact with the economic structure and performance in any other market?

4. Judged according to economic criteria has this performance been conducive to the steel industry behaving in a way at least approaching optimality?
Essay I

The American Iron Ore Market
CHAPTER I

Introduction

The United States' Steel Industry
and the Supply of Iron Ore

In the production of pig iron, and therefore steel, there appears
to be one necessary, very specific input—the mineral iron. While other
factors of production are needed to produce either pig iron or steel, the
requirement for none appears to be as specific as the requirement for
iron. For example, the chemical reaction by which iron ore is trans-
formed into the metal pig iron requires for its consumption the application
of energy. But this energy may come from many sources: historically the
first was charcoal, then coal (coke). Now natural gas and oil are gain-
ing increased prominence. Similarly, the production of pig iron requires
labor. But this too is a general classification. The labor may be very
unskilled—witness the labor used to operate the backyard blast furnaces
of Communist China's "Great Leap Forward," or highly skilled as is much
of the labor employed by the American steel industry. Of course many
other combinations of skilled and unskilled labor are possible. Finally,
the production of pig iron also requires capital. Again Communist China
during the years of the "Great Leap" and any of the economically advan-
ced Western countries illustrate two extremes of capital input. Thus
iron appears to be the one necessary and very specific prerequisite for
the existence of a steel industry, because without iron there could be
no steel.²

In this essay we propose to examine how the United States' steel industry has gone about providing itself with its major raw material input—the mineral iron. Our study will focus on the post World War I period; however, given the nature of our subject this division will be seen to be somewhat arbitrary. Therefore, considerable attention will be devoted to discussing the problem of the provision of iron in earlier periods. More specifically, we shall consider the following: First we shall stress that it is in fact a mistake to view the mineral iron as being a unique, very specific input. Instead we shall view the factor iron as being analogous to the factors fuel, labor, or capital; i.e., as a general heading which incorporates a great variety of heterogeneous specific factors. For example, unskilled labor is obviously very different from skilled labor. The only economic similarity is that they are in some often imperfect sense substitutes for one another.³ Similarly steel scrap is obviously very different from all types of iron ores; less obvious, Brazilian iron ore which

²If there were no iron and hence no steel one would guess that some other metal, perhaps aluminum, would have developed to a much more advanced state than it has at present. This metal would share the economic role if not the physical characteristics of steel.

³Any economic taxonomy of the myriad of heterogeneous factors into a few broad classifications (for example, capital and labor) is premised on the assumption that the elasticity of factor substitution between any of the various factors classified as labor is greater than it is with any of the factors classified as capital. In actual practice our classification of factors as being either capital or labor does not always conform to this theoretical ideal. For example, a steam shovel may be a better substitute for unskilled labor than is skilled labor. More realistically both skilled labor and a steam shovel may be needed in order to replace unskilled labor.
is powdered (so-called fines) is economically very different from lump Brazilian iron ore. This explains why, even though they have almost identical iron contents (64 percent versus 68 percent), the lump ore once commanded a price almost twice as high as the fine ore. French iron ore (33 percent iron content) is very different from Venezuelan iron ore (64 percent iron content). Natural iron ore (so-called direct shipping ore) from the Mesabi Range (50 percent iron content) unless it has further processing has little economic similarity with taconite pellets from the same Mesabi Range. In fact much recent investment in the development of taconite ore appears to be primarily a substitute for capital investment in blast furnaces and only secondarily a substitute for competing iron ore bodies. Thus, for example, the National Steel Company upon opening a new taconite processing plant in 1967 announced that merely by substituting processed taconite ore for unprocessed Canadian and Mesabi direct shipping ores it expected to be able to reap an additional pig iron output of 500,000 tons per year from eight existing blast furnaces. 4

Second we shall try both to determine and to explain how the "real" price and the nominal price of American iron ore has evolved over time. To adequately perform this task we shall need to discuss the economic structure of the world iron ore industry.

4In [4, p. 1] it is reported that for $75 million National got a taconite pellet plant with a capacity of two and one-half million tons per year. It is estimated that by switching from natural iron ore to these pellets National will increase its pig iron production from eight existing blast furnaces by 500,000 tons per year.
Third, we shall examine what has been the nature of the interaction between the economic structure of the iron ore industry and the economic structure of the steel industry. More specifically, we shall attempt to answer the question: To what extent has the oligopolistic structure of the American steel industry been built upon the control of iron ore deposits?

Fourth, we shall attempt to integrate into our discussion the key role which changing transport costs have played in determining both the geographic and the economic structure of the iron ore market.

We shall attempt to elaborate on the above points by pursuing two major themes: First, in Chapter II we shall consider from a broad macro point of view how the aggregate economic supply curves of steel's two major raw material inputs—iron ore and fuel—have behaved (evolved) over time. Then in Chapters III through VI we shall consider on a micro level how the structure and performance of the United States' iron ore and steel industries have contributed to the observed historical panorama.
CHAPTER II

The Evolution of the Supply of Iron Ore: A Macro View
or
Scarcity, Innovation, and Natural Resource Development

I

One of the fundamental laws of economics is that any given resource at any given time has value if and only if it is presently scarce or it is anticipated that it will one day be scarce. More formally, a resource is by definition scarce if and only if its present discounted value is greater than zero. Scarcity therefore is seen to be an economic rather than a physical concept. There are three major but interrelated reasons which determine whether and to what extent any given natural resource is scarce:

1. Relative to the foreseen demand physical supplies of the resource are limited—either by nature or by monopoly.

2. Though relative to any foreseen demand the physical supply is very large, the resource is not concentrated in particular deposits and hence at any given location (place in space) it is scarce.

3. The cost of separating the resource from the "ground" is greater than zero.

These reasons clearly show that it is the interaction of demand, supply, and market structure which determines the scarcity (hence value)
of any resource body. Scarcity is a relative not an absolute state of being.\(^5\)

According to the above definition iron ore has been scarce since first used. By examining the historical record we shall try to see just what has been the response of iron ore suppliers and demanders to this scarcity. For the purposes of this discussion we shall take as given the fact that at any given time the aggregate marginal cost curve of iron ore producers rises as output rises. This implies, if the industry is initially in equilibrium, that when demand rises ceteris paribus the industry's profits (quasi-rents) rise. Since investment is a positive function of the expected profit stream, this rise in demand should encourage new investment designed to increase the industry's output. Ceteris paribus this investment would lead over time to an outward shift of the industry's aggregate marginal cost curve. A look at the three determinants of scarcity cited above shows that investment may be focused in any one or all of four major areas:

1. There may be investment in new capital to let firms process an otherwise abundant ("free") resource.

2. There may be investment in efforts to find, to develop, and to process new supplies of the relatively scarce resource.

---

\(^5\) The American Iron and Steel Institute in its publication, The Making of Steel [1, p. 9] correctly defines iron ore as follows: "Iron ore is the term applied to an iron bearing material in which the content of iron is sufficient to be commercially useable." It should be evident that what we (and the American Iron and Steel Institute) call iron ore changes over time.
3. There may be investment in projects designed to make economically attractive once economically unattractive iron ore supplies.

4. There may be investment in projects which permit economizing in the use of existing known iron ore supplies.6

The extent to which investment is directed to each of these areas depends on the investor's evaluation of the profits (where profit is an unspecified subjective function of both rate of return and of risk and uncertainty) he expects to achieve there. More specifically, economic theory tells us that investment will be pursued in each area so that the marginal dollar invested in each is expected to yield the same profit.

Our discussion will focus on the last three possible responses of profit-maximizing investors to increased scarcity; i.e., to increase the iron ore supply by discovering and developing new sources or conversely, to indirectly achieve the same goal by discovering and developing new technologies which permit either the use of previously uneconomical iron ore supplies or the more efficient use of existing iron ore supplies. We shall use the terms Exploration and Innovation as our shorthand symbols for these two responses. It should be stressed that

6New investment, exploration and development, and innovation all, ceteris paribus, cause an outward shift of the iron ore industry's aggregate marginal cost curve. If both demand and market structure stay constant, whether or not the real price of iron ore rises over time depends on whether or not the exploitation of the known iron ore bodies causes the industry's aggregate marginal cost curve to shift in by a greater amount than the four factors just cited cause it to shift out.
Exploration and Innovation are not independent of each other. 7

Exploration and Innovation share a similar goal (to gain additional profits by increasing the economic supply of iron ore). They also, at least for the iron ore industry, appear to share similar risks and uncertainties. First, a characteristic of both is a large stochastic element. The stochastic elements which affect Exploration differ from those affecting Innovation; nevertheless, these two sets of responses are not independent. Examples of some stochastic elements and of their lack of independence will appear shortly. Second, most iron ore deposits were known to exist long before they were economically developed. 8

Similarly the basic science upon which most technological change in the steel industry has been based has typically been known many years before it was applied. 9 Hence, we conclude that uncertainty of both Exploration and Innovation may not be as severe a problem to analysis as is sometimes thought.

Assuming that the basic knowledge of a new iron ore deposit or of a new technology exists, then the eventual development of either depends on either one or both of two things:

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7 In fact the reader may prefer to consider the word "Innovation" to denote a vector of possible responses by a profit-maximizing firm to scarcity. This vector would include what we denote by the word "Exploration" as one of its elements.

8 The iron ore deposits discovered since the end of World War II in Australia and Venezuela are significant exceptions to the observation that most iron ore deposits were known to exist long before being commercially developed.

9 Bessemer's patents which refer to the possible use of pure oxygen to produce steel—a process not used commercially in the United States until 1954—is the best example of a new steel technology being conceived of long before being commercially applied.
1. Increased scarcity of iron ore because of its gradual exhaustion leads to a higher relative price over time and eventually makes investment in developing new deposits or new innovations economically profitable.

2. A fall in the relative price of those factors—especially capital and transportation—which are especially important in determining whether or not a given known iron ore deposit or a given technology can be economically viable.\(^\text{10}\)

If the basic knowledge of either the existence of an iron ore deposit or of a new technology does not exist then investment in either becomes much riskier and it is possible that over long periods—until the basic knowledge is discovered—the marginal cost of the iron ore will continuously rise (shift-up) as the best known sources are exhausted. In fact, scarcity and technology have continuously interacted in order to cause the stock of economic iron ore bodies to be constantly changing over time. Illustrations of this interaction follow.

II.

In producing pig iron and steel, two natural resources are essential: the mineral iron and fuel. The evolution of the iron and steel industries can be viewed as a struggle to avoid or to mitigate the constraints

\(^{10}\) Some examples of the above are the discovery of the helicopter, the device which made it economically feasible to construct a rail link between the iron ore mines of Northern Ontario and the St. Lawrence River port of Sept Iles, and the discovery of a cheaper way to make pure oxygen—thus making the basic oxygen process for producing steel commercially feasible.
imposed at varying times by relative shortages of one or the other (or both) of these resources. Historically, the first to be in short supply was fuel. Initially the fuel had been charcoal; however, to produce enough charcoal to produce 1,000 tons of pig iron required a stand of about 3,000 acres of timber. Moreover, the charcoal was very fragile and would not burn properly if crushed. The result was that it was almost impossible to transport, and therefore pig iron production was necessarily in those areas where wood, water, and iron ore existed in conjunction.

By the reign of Elizabeth I in 1550 the iron industry's growth had so depleted England's timber resources that it was considered to be a serious national problem [7]. As a result of the high prices for charcoal, England became a net importer of pig iron, largely from Sweden. Since it was recognized that profits would rise if costs were lowered, numerous attempts were made to substitute relatively abundant mineral fuel for the scarcer charcoal. None succeeded until 1709 when Abraham Darby proved the technological (but not yet economic) feasibility of using coke. It took 41 years, until 1750, before mineral fuel was to become acceptable for anything but the crudest castings. Timber therefore became scarcer. Finally, between 1750 and 1800 scarcity and

11 This is equivalent to saying that the larger the quasi-rents earned by any existing factors, the more incentive there will be to seek either new sources of or new substitutes for these factors.

12 Professor Peter Temin's work [22] is the source for most of the material and for the general emphasis of the discussion presented on the next few pages.
innovation interacted to such an extent that the English engineered a dramatic switch from charcoal to coke; i.e., for the first time the quality of coke iron was high enough, and the relative price of coke low enough, that it paid to substitute coke for charcoal. Nevertheless the English continued to import Swedish pig iron, and no other country followed England in the switch to coke. In fact, in the Far Northwest of England, where timber was still relatively abundant, charcoal continued to be used. The reason why these other areas did not shift from charcoal to coke should be obvious—taking account of the differences in quality as opposed to the cost of coke versus charcoal iron the firms in these regions deduced that it would not be profitable to make such a shift. In these areas timber was not in such short supply, and therefore its relative price had not risen so high as to make investment in coke iron more profitable than investment in charcoal iron.

In the last quarter of the 18th century the above state of affairs was to be changed by a series of innovations (especially puddling) in England. The net result of these innovations was a dramatic switch in England's position from being an essentially high cost marginal producer of pig iron to being the lowest cost producer. Now England's huge reserves of coking coal gave her a comparative advantage in pig iron

13 Until 1709 it was not even technically possible to use mineral fuel to produce pig iron; i.e., it took 150 years from the time the problem was first observed until the basic knowledge for solving the problem was developed. Once Darby demonstrated the technological possibility of substituting coke for charcoal it took 40 more years before the process was economically viable. Thus the secular shortage of fuel persisted in England for over 200 years. This illustrates that the short-run can indeed sometimes be a very long time.
production because puddling and related innovations permitted the replacement of charcoal with coke as the fuel input used in the production of pig and wrought iron. This breakthrough led to a sharp fall in the relative prices of pig and especially of wrought iron, and hence, since pig iron was used to make wrought iron, to a sharp rise in pig iron output. This rise in output was to lead directly to charcoal becoming a constraint in other geographical areas. We shall specifically consider the American case.

In the United States coal was not used as fuel for producing pig iron until after 1830. At this time anthracite came into use east of the Appalachians while charcoal continued to be used in the West. Peter Temin [22] notes that this set of facts presents two additional questions:

1. Why was anthracite the first mineral fuel used in America while coke (bituminous) was the first mineral fuel used in England?
2. Why did the American West wait another thirty-five years, until after the American Civil War, before adopting the widespread use of mineral fuels (coke) even though bituminous was known to be both abundant and accessible?

The answers to these questions will again indicate the tight interaction between scarcity, innovation, and natural resource development.

Long before 1830 the Eastern iron mills were exhausting their stands of timber. As a result, following England's example, American pig iron manufacturers began exploring the feasibility of using mineral fuels. Attention was focused on anthracite—the only mineral fuel known to be available in the East. Unfortunately anthracite proved to be almost
impossible to light; therefore, the English technology could not simply be copied in the New World. Not until 1839 and the almost simultaneous invention by a Welshman and an American of the hot blast did anthracite become an economical fuel.

Meanwhile in the American West bituminous was readily available, but charcoal continued to be used. Why? Two possible explanations have been offered: Mr. Louis Hunter has suggested that the reason for the West's delay in adopting coke was due to the nature of Western iron demand. Specifically before the American Civil War, rails, a high quality item, were the main component of the region's iron consumption. Hunter argued that this high quality could only be achieved using charcoal. Temin disputes the Hunter thesis. He notes that in 1853 the Pennsylvania Railroad completed its mainline to Pittsburgh. For the first time Eastern pig iron (made with anthracite) was sold in Pittsburgh. The price at Pittsburgh of Eastern pig iron was observed to be equal to the price at Pittsburgh of charcoal pig iron. This was considerably in excess of the price at Pittsburgh of Western coke pig iron. Such a price discrepancy could persist only so long as it was thought that there were quality differences between the two products. The suspected quality differences could have only been caused by differences between the fuels. More specifically the Western coal used before the Civil War contained too much sulphur and therefore the pig iron produced with it was of an inferior brittle quality [22, pp. 74-76]. After the Civil War the premium between anthracite and coke pig iron disappeared. This indicated that the quality differential between anthracite and coke pig iron had also disappeared. Western production of coke pig iron began to soar.

But what had caused the end of the quality differential?
Simply the fact that after the War it was finally realized the bituminous coal from the Connellsville region of Western Pennsylvania--first discovered in 1842 but long ignored--did not contain sulphur. Once again Exploration and Innovation had interacted to produce a new and economical fuel supply.

Having given several illustrations of how innovations and the discovery of coal interacted in order to circumvent the fuel constraint, we shall consider how a similar interaction has helped to circumvent the iron ore constraint. In the 1830's the first of the major iron ore deposits in the Mesabi Range was discovered. Initially there was no economic motivation to exploit this discovery; however, by the 1850's the old Eastern iron ore supplies were running out (the marginal cost of mining them was shifting up) and by 1856 it became profitable to use Mesabi iron ore. Meanwhile two technical changes were about to cause a dramatic rise in world demand for iron ore. The first was the Bessemer process for making wrought iron which was invented in 1856 but which was not economically operational in the United States until 1866. After 1866 the process for converting the now much cheaper wrought iron into steel (merely by throwing a bag of carbon into the molten wrought iron) had the direct result of leading to a dramatic fall in the cost of steel. Indirectly this led to a fall in the relative price of steel and this led in turn to sharply higher sales. The end result was that more iron ore was needed. Unfortunately Bessemer

---

14 This of course also implies that the long-run demand for steel was quite price-elastic.
steel could be made only from iron ore which was relatively free from phosphorus. Most known ores did not have this property. As a result the members of the steel industry faced three possibilities:

1. They could try to remove the phosphorus from the iron ore.
2. They could try to discover new iron ore bodies which did not contain phosphorus.
3. They could try to invent a new process so that iron ore containing phosphorus could be used.

All three approaches were tried; however, the third proved to be most fruitful because of two innovations. First, in 1879 two Englishmen invented the so-called Basic Bessemer Process. Use of this process required that iron ore now contain phosphorus; hence, from being almost worthless iron ore with phosphorus now sold at a premium. An indirect and perverse effect of this invention was that it speeded up the fall of England from her position of dominance in the world iron and steel market because, though all of England's iron ore resources had dwindled, those containing phosphorus were near non-existent. Since the innovating nation was actually harmed by the fruits of its innovation, this certainly provides a prime example of the unpredictable nature of the effects of an innovation in the iron and steel industry.

The second innovation was the open hearth furnace. Initially this too required non-phosphorus iron ore; however, further technological innovation soon abolished this constraint. Also steel scrap could be used in the open hearth furnace whereas it could not be used in the Bessemer furnace. Hence the introduction of the open hearth had an effect similar to the discovery and commercial exploitation of another major source of iron ore supply. These two huge increments to the
United States' economic iron ore supply (Mesabi iron ore and steel scrap) meant that from 1880 to World War II there was little fear that the domestic steel industry of the United States would, as a whole, face a secular rise in iron ore costs. However, as we show in a later chapter when we consider in detail the micro structure and performance of the American iron ore industry, individual steel companies may have still faced this problem.

We conclude our history of the interaction between scarcity, innovation, and natural resource development by considering post-1945 developments. Again the major developments have followed the two interdependent strands: Exploration and Innovation. We consider them in turn.

The post-War period has seen a rapid rise in World raw steel production from 150 million tons in 1947 to 503 million tons in 1965. At the same time it has also seen a dramatic shift in the relative importance of the major world steel producers.\textsuperscript{15} New iron ore sources

\textsuperscript{15} The dramatic shift in the post-World War II years of the relative importance of the major world steel producers can be seen in TABLE A. TABLE A compares the share of total world raw steel ingot output produced by different countries (regions) in both 1947 and 1965.

\begin{table}[h]
\centering
\begin{tabular}{|l|c|c|}
\hline
\textbf{Country} & \textbf{1947} & \textbf{1965} \\
\hline
United States of America & 56.7\% & 26.2\% \\
Soviet Union & 14.7 & 19.9 \\
Western Europe (not England) & 12.8 & 22.4 \\
England & 9.5 & 6.0 \\
Japan & 0.7 & 9.0 \\
Others & 5.6 & 26.5 \\
\hline
\end{tabular}
\caption{The Share of World Raw Steel Output: 1947 and 1965}
\label{table:a}
\end{table}

Source [2].
were necessarily developed in order to meet both the increased world demand for iron ore and the different geographical composition of this demand. More specifically any given profit-maximizing steel producer would seek iron ore from those sources which promised the lowest delivered cost for the desired input. The necessary condition for achieving this optimal state of affairs is that the marginal cost (adjusting for quality differences) of all iron ore received at any given plant be the same regardless of its source. In practice, since the development of any iron ore source requires a large fixed investment, the determination of how much iron ore to demand from each source requires a complex and inprecise calculation involving, among other things: current and expected iron ore costs f.o.b. the mine, current and expected transportation costs, the expectation of the possibility of future discoveries of new and more economical iron ore supplies, and the expectation of the possibility that, because of either technical change or a change in the demand for the steel firm's output, future demand for iron ore will be either less or more. Note that most of the above items depend on expectations concerning future factor prices, final goods prices, innovations, quantities demanded, or mineral discoveries. Since all of these expectations must be held with considerable uncertainty, the firm choosing to develop (make a fixed investment in) any given iron ore source faces considerable risk that its choice will not in fact be

16 It should be noted that the line of causation in fact runs both ways. As new points of iron ore consumption (new steel plants) developed, formerly uneconomic iron ore bodies necessarily gain value and new iron ore bodies are developed. However, one of the causes of the changing locational pattern of iron ore consumers is just this development of new iron ore sources.
optimal. It is in order to get some insurance from this risk and uncertainty, by means of pooling, that the profit-maximizing firm typically desires to receive its iron ore from many more sources than would be optimal if it ignored risks. Specifically the firm will quite rationally receive iron ore from many sources even though this implies that it will incur a higher total money cost than it would if it were to obtain its iron ore from only one or a few sources. Note that any firm will get its iron ore from many sources only if the real economies due to pooling reduce the intangible costs due to risk more than enough to compensate for the rise in nominal iron ore costs due to using ore from sources that would be less economical in the absence of risk for that firm. 17

Since the current iron ore mining technology is such that most of the new iron ore sources can be economically developed only if the development is on a very large scale (much larger than the amount of iron ore consumed by all but the largest steel plants) and since because of the uncertainties and risks listed above most firms find it more costly, in a real as opposed to a nominal sense, to get all of their iron ore from one source, this explains why the new sources have typically been developed by consortia involving many participating firms. 18

17 Given risk the new necessary condition for determining the optimal source for all iron ore is that the real marginal cost, including the firm's subjective risk premium, of all iron ore received at the plant be the same regardless of its source.

18 This statement is premised on the assumption, which is empirically valid, that the American iron ore industry is dominated by the steel producers; i.e., the steel companies have integrated backward into iron ore production. We shall later consider why the steel companies face considerable economic incentive to pursue backward integration. If these incentives did not exist we might instead expect to see any given iron ore body developed by one ore firm which would then sell its output to many different steel companies. While such cases exist, they are uncommon.
In the immediate postwar period only the United States had a viable steel industry of any consequence. However, its economic deposits of domestic iron ore had been greatly depleted during the War—the American iron ore industry's aggregate marginal cost curve had shifted sharply upward and to the left. For the first time since the economic development of the Mesabi Range there was recognition that the country would in the foreseeable future run out of Mesabi iron ore. Given the relative import of Mesabi iron ore it was feared that the growth of the American economy might soon grind to a halt.

Hence, there was promise of high quasi-rents to those firms which succeeded in developing new iron ore sources. The obvious result followed: the American iron ore industry was in the forefront in developing new iron ore sources. Attention was concentrated in two areas: A search, led by American firms, for new sources of iron ore in Canada, South America, and Africa. And a search to develop a new technology

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19 Estimates of how long Mesabi iron ore would last, assuming consumption continued at the Wartime rate, ranged from 12 to 25 years.

20 As an illustration of the presumed vital importance of Mesabi Range iron ore consider the following dramatic statement made in December, 1945, by the editors of Fortune [14, pp. 129-37ff.] in an article titled "Iron Ore Dilemma:"

One diagram of the U.S. economy might show it as an immense inverted pyramid, its needle resting on a single strip of gently rolling land, 110 miles long by one to four miles wide in northern Minnesota. Such a diagram would be oversimplified but far from fantastic. For out of this tiny strip the steel-age economy has sucked, like milk from the earth mother's breast, by far the largest proportion of the primal food out of which its bones and muscles have been built...iron ore. ...This fabulous strip is the Mesabi iron range.
which would permit the economic utilization of the massive Mesabi
taconite deposits—deposits which were first discovered in 1870. The
fruit of these efforts took considerable time and cost considerable sums
of money before reaching maturation. As a result, from 1945 to 1950
both government documents and the informed popular press continued to
reiterate the view that the United States was about to run out of iron
ore. To their credit some leaders of the domestic steel industry strove
mightily to correct this naive view. For example, in testimony before
the Subcommittee on the Study of Monopoly Power of the Committee of the
Judiciary of the House of Representatives [24, p. 5] Mr. Ernest T. Weir,
the iconoclastic chariman of the board of the National Steel Corporation,
stated: 21

...the end of the high grade ore deposits in the Lake Superior
district can be foreseen. The continuing supply of iron ore
is a major problem, but it has always been so.

Mr. Benjamin Fairless, president of the United States Steel Corporation,
concurred with Weir's view. He told the same committee [24, p. 5]:

An adequate supply of iron ore in this country is primarily
a production and cost problem. It is not a question of the
exhaustion of the ore reserves of the United States. 22

21 "One of the principal questions raised in the hearings was whether
there would be sufficient domestic raw materials..." [24, p. 3]. The
government thought that the monopolistic iron ore producers were re-
training the search for new iron ore deposits.

22 In a United States Steel publication [9] printed one year after
Mr. Fairless' testimony it was stated:

In sum, there is no scarcity of iron ore in the United States.
The immediate task ahead is one of adjustment to (continued)
It should be noted that most members of the Committee did not appear to hold with the views expressed by Messrs. Weir and Fairless; nevertheless, by 1950 informed popular opinion was changing. Thus the *Economist* [21, p. 323] would write in an article commenting on the United States government's steel probe:

> The real threat to steel supplies and costs, and thus to (U.S.) economic expansion has been the approaching exhaustion of Mesabi iron-ore deposits. But this has been averted, first by the discovery of a new field in Labrador, and now U.S. Steel's rich find in Eastern Venezuela.

And, in 1952, responding to the general fear that the United States was about to run out of most "vital" natural resources, the President's "blue-ribbon" National Policy Commission in its five volume report *Resources for Freedom* stated, as *Fortune* so ably summarized [17, pp.

> The threat of the materials problem is not that we will suddenly wake up to find the last barrel of oil exhausted or the last ton of lead gone, and that economic activity has collapsed. The real and deeply serious threat is that we shall have to devote constantly increasing efforts to acquiring each pound of materials from natural resources which are dwindling both in quality and quantity. ...In short, the essence of the materials problem is costs.

22 (cont.)

other sources of supply. Utilization of low grade ores is primarily a technological and financial problem. ...In the interest of assuring an adequate iron ore supply for its furnaces ...U.S. Steel has pursued a twofold program for many years. One has been the beneficiation of domestic low grade ores and the other has been a search for large rich deposits elsewhere in North or South America.

Though the author finds the sentiment of the above quotation appealing, it is incumbent upon him to note that, on a formal level it is incorrect. More specifically, since iron ore commands a positive price by definition it must be scarce. If iron ore were not scarce, we would not be devoting our attention to it.
The nation faces a very real and growing conservation problem, but many of our difficulties of agreement arise from a failure to recognize the economic dimensions of the problem and give proper weight to its dynamics. It is a popular fallacy to regard our resource base as a fixed inventory which, when used up, will leave society with no means of survival. A related fallacy is that physical waste equals economic waste; that it is improper to use materials in ways that make them disappear. This attitude can lead to devoting a dollar's worth of work to "saving" a few cents worth of waste paper and old string.

*Resources for Freedom* signified a major rise in the degree of sophistication with which the problem of natural resource supply was treated in public.

By 1959 even such bureaucratic branches of the federal government as the U.S. Tariff Commission were prepared to accept the fact that perhaps iron ore exhaustion was not inevitable. For example, the Tariff Commission cited, with obvious approval, the statement made before it by Mr. William H. Johnstone, a Bethlehem Steel Corporation vice president. Mr. Johnstone said [26, p. 21]:

> There is no scarcity of iron ore in the world. In nearly all the Atlantic areas of the Free World enormous deposits of iron ores are found—in such vast quantities that no calculations of so-called "reserves in the ground" are any longer of primary significance. ...Practically unlimited quantities of iron metallics in lower grade ores exists throughout the world. Technological advances in concentration, treatment, and preparation processes have made possible the use of such lower grade ores that heretofore were considered of no commercial interest. The location of ores some distance inland from ports and great distances by sea from existing consuming furnaces is no longer an unsurmountable obstacle to commercial development because of the advances in ore transportation and handling techniques—particularly the great increase in the size of vessels especially designed for the ore trade.

By 1959 the postwar threat of a great secular iron ore shortage had been officially laid to rest. This short-run shortage had lived
for less than fifteen years. The cause of its death was that in the 1940's the threat of ever greater scarcity had led profit-maximizing firms:

1. To explore for and to develop new foreign sources of iron ore.
2. To invest in the development of cheaper ways to transport iron ore.
3. To develop a new technology which by 1958 made the enormous Mesabi deposits of taconite an economic source of iron ore.
4. To develop a new technology and to invest in new capital assets which made better use of any given amount of iron ore input.  

As more new iron ore sources continued to be developed and as transport costs continued to fall the inevitable happened—competition increased and the relative price of iron ore began to fall. Table I-1, presented on the next page, illustrates the changing sources of supply for the United States iron ore market in the post-World War II years. Column 5 illustrates that from 1947 to 1953 imports of iron ore were

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23 Contra to the English experience of a relative fuel shortage lasting 200 years, from 1550 to 1750, in the post-World War II years the basic technology for overcoming the iron ore constraint already existed. Only the applied (economical at current relative prices) technology awaited development. Also the new discoveries of foreign iron ore took relatively little effort—largely because the airplane made possible the cheap exploration of wide areas. Hence the short-run scarcity persisted for only fifteen as opposed to two hundred years.

24 See the article by Gerald Manners [16] for both a description of the recent fall in the costs of shipping iron ore and also for an analysis of the causes of this fall. Manners stresses scale economies in ocean shipping.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>1 Total Imports of Iron Ore (mil. tons)</th>
<th>2 Total Iron Ore Beneficiated at U.S. Mines (mil. tons)</th>
<th>3 Total Shipments of Taconite Pellets (mil. tons)</th>
<th>4 Total U.S. Shipments of Iron Ore (mil. tons)</th>
<th>5 Imports as a Percent of Shipments</th>
<th>6 Benefice as a Percent of Shipments</th>
<th>7 Pellets as a Percent of Shipments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947</td>
<td>4.90</td>
<td>21.4</td>
<td>93.32</td>
<td>4.01%</td>
<td>22.94%</td>
<td></td>
<td></td>
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<tr>
<td>48</td>
<td>6.11</td>
<td>23.6</td>
<td>100.92</td>
<td>6.03</td>
<td>23.41</td>
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</tr>
<tr>
<td>49</td>
<td>7.40</td>
<td>20.7</td>
<td>84.69</td>
<td>8.73</td>
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<td>8.23</td>
<td>26.7</td>
<td>97.76</td>
<td>8.40</td>
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<td>51</td>
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<td>8.73</td>
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<td>50.73</td>
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<td>1960</td>
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<td>23.2</td>
<td>73.56</td>
<td>45.22</td>
<td>77.72</td>
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<tr>
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<td>64.3</td>
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<td>50.31</td>
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<td>34.28</td>
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<tr>
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<td>45.1</td>
<td>65.1</td>
<td>31.0</td>
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<td>77.03</td>
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<td>94.04</td>
<td>49.23</td>
<td></td>
<td></td>
<td>38.49</td>
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</table>

Note: The import data is from The American Iron Ore Association's publication Iron Ore. The pellets data is from the Skillings Mining Review. The beneficiated ore data is from the Minerals Yearbook. The total U.S. iron ore shipments data is from the American Iron and Steel Institute's Annual Statistical Report.
always less than 10 percent of total domestic shipments of American mined iron ore. Between 1953 and 1954 this percentage displayed a remarkable jump from 9.41 percent to 20.52 percent. The simultaneous occurrence of two events caused this jump:

1. After four years of development and a capital investment of $170 million the giant United States Steel mine at Cerro Bolivar, Venezuela began to ship iron ore. The fact that this deposit was discovered by U.S. Steel geologists in 1947 illustrates that even when iron ore is relatively scarce there can be a relatively long time lag between the discovery of and the initial completion of a new ore project. This in turn implies that existing iron ore sources can earn quasi-rents whenever there is an unanticipated rise in iron ore demand.

2. In 1954 the new iron ore deposits of northern Canada, again largely developed by American steel companies, also began shipments. Since 1954 as the massive Canadian and Venezuelan deposits were developed further and as other new foreign iron ore sources came on stream there has

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25 The Labrador development was initiated by Canada's Hollinger North Shore Exploration Company. Shortly after Hollinger began developing the property it took the American iron ore house of M. A. Hanna in as a joint partner. There were two reasons for Hollinger's seeking Hanna's assistance. First, Hanna could provide new capital essential for the development of the deposit. Second, the main reason was probably because Hanna had the connections with the American steel companies that were needed in order to sell the ore. In September, 1950, Hanna and Hollinger set up a new subsidiary, The Iron Ore Company of Canada, to mine and to sell an estimated annual output of 10 million tons of Labrador iron ore. At the end of 1950 five more American steel companies--Armco, National, Wheeling, Republic, and Youngstown--were each sold partial equity interests in the Iron Ore Company of Canada. More information may be found in [11, 15].
been an almost unbroken upward trend in American imports of iron ore as a percentage of domestic American iron ore shipments.

Column 5 illustrates that an increasing dependence on imports of iron ore was one characteristic of the postwar period. Columns 6 and 7 reveal another characteristic: Since the end of World War II there has been a continual rise in the processing of iron ore at the minesite. This represents the substitution of increased capital and labor expenditures at the minesite for lower capital and labor expenditures for transportation and, since the beneficiated ore may be utilized more efficiently in blast furnaces, for lower capital and labor expenditures at the steel plant. In 1956 this tendency received a further boost as, after more than forty years spent in development and more than $300 million in capital expenditures, the first commercial taconite was produced. The American steel industry had a new, competitive, and domestic source of iron ore. The increased use of either beneficiated ores or of taconite pellets showed that steel makers would no longer accept the raw material as dug out of the ground. They also demanded a particular size and shape. This use of a uniform product was found to greatly improve efficiency.

Taken together the commercial success of both high-grade iron ore concentrates made from low-grade natural iron ores and of high-grade foreign iron ore imports meant that instead of a relative shortage there was now a relative surplus of high-grade iron ores [8].

26 As taconite (a rock with a natural iron content of about 30 percent and containing a large amount of the impurity silica) became a commercial source for iron ore, it led to the abandonment of some iron ore mines yielding a higher natural grade ore. This substitution of ore sources appears to reflect the move from a more labor intensive to a more capital intensive method of production.
this relative surplus was that since 1958 the deflated American price of iron ore has displayed an almost constant downward trend. This is in sharp contrast with the almost constant rise in the deflated American price of iron ore which was experienced from 1945 to 1957.

27 We will discuss the behavior of the deflated American price of iron ore more fully in later chapters.
CHAPTER III

The Lake Erie Price of Iron Ore

From before the turn of the present century and until 1915 the states bordering Lake Superior--Michigan and especially Minnesota--increasingly became the main source of iron ore for the United States' steel industry. From 1915 to 1945 this one region annually supplied roughly 85 percent of all iron ore consumed in the United States; however, since the end of World War II the Lake Superior region's share in providing iron ore for domestic consumption has steadily been eroded until reaching what appears to be a new plateau of supplying about 50 percent of all domestic needs in the mid-1960's. The main cause of this secular displacement of Lake Superior iron ores has been increased iron ore imports from Canada, Venezuela, Brazil, Chile, and Liberia. By the mid-1960's this foreign iron ore was supplying roughly one-third of the total U.S. demand; nevertheless, the Lake Superior region continued to be the largest single source of iron ore supply for the United States.

Because of the relative predominance of iron ore originating from just one geographical region, the spot price of this ore at a lower Lake Erie port (commonly known as the Lake Erie Price) has typically been thought to serve as the basis for setting all iron ore prices in the United States. Thus, for example, for a given grade iron ore the maximum spot price at any given place in the United States would be the Lake
Erie price plus transport costs. With few exceptions this price has been (and continues to be) the price which was (is) in fact charged.

In this chapter (a prelude to our more formal discussion of the Lake Erie Price) we shall attempt to accomplish three simple descriptive tasks: First, we shall indicate how the Lake Erie Price is supposedly determined. Second, we shall present a table which gives both the nominal Lake Erie Price from 1915 to 1966 and two versions of what we label the normalized relative Lake Erie Price. Third, we shall comment on the picture which this price data seems to paint. A more detailed economic explanation of the significance of these observations will be presented in later chapters.

I

Mr. L. Gregory Hines in a 1951 article, "Price Determination in the Lake Erie Iron Ore Market," succinctly described the setting of the Lake Erie Price as follows:

Lake Superior iron ore is priced in five classifications: Old Range Bessemer, Old Range Non-Bessemer, Mesabi Bessemer, Mesabi Non-Bessemer, and High Phosphorus ore. [Since 1961 there has been a new classification in order to take account of the emergence of a new major iron ore type--taconite concentrated pellets. This is designated as Pellets.] The division between Old Range and Mesabi ores is primarily in terms of the structure and density of the ores; whereas, the classification of Bessemer, Non-Bessemer, and High Phosphorus is dependent upon the ore's phosphorus content. Within these five broad divisions prices for the ore are adjusted on the basis of a 51.50% Fe. as the standard.28

28 All ores containing 0.045% phosphorus or less are classified as Bessemer, more than 0.045% but less than 0.180% are Non-Bessemer, and above 0.180% are High Phosphorus. Price premiums are given for low phosphorus content, high manganese content, and for lump structure. Penalties are imposed for high silica content and for fine structure. Premiums and penalties are determined by negotiation. A positive (continued)
The procedure followed in the establishment of the season's price for iron ore has facilitated the practice of price leadership in the industry. Prior to the opening of the shipping season of the Great Lakes, the price of iron ore—including shipping charges to lower Lake ports—is fixed by publication in the Cleveland Plain Dealer of the first market transaction involving a substantial sale of iron ore for delivery during the forthcoming season. This event is not, however, left to the caprice of the market. The crucial sale is invariably made by one of the larger ore companies—even though the parties to the transaction are seldom identified—and is carefully selected so as to embody the most generous valuation which is possible in view of the season's expectations and consistent with the interests of the more powerful parent iron and steel companies. ...the price of iron ore represents a conciliatory point which the majority of ore producers find tolerable if not completely satisfactory. Because of the prevalence of long-term ore contracts and the steel industry's preoccupation with stability, the previous years iron ore price has usually been reinstated during periods of normal business conditions [13, pp. 653-55].

It should be noted that once set the announced spot price has, with only three exceptions, remained unchanged for at least one entire Lake Superior shipping season.

Besides the foregoing, there is one other important fact about the spot market for iron ore. It is very narrow. Less than 10 percent of all iron ore consumed in the United States is traded over it. Instead,

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28 (cont.) price adjustment for iron content higher than 51.50% Fe. is applied at a proportional rate of increase. The negative price adjustment for ore with iron content below standard is applied at a progressive rate of decrease.

29 The last sentence of Hine's statement is not quite in accord with this author's assessment of the facts. As TABLE I-2 will show, until the last 1950's the price of iron ore tended to be stable during periods of depressed business conditions and wars (when there were price controls). In other periods it typically rose.

30 The exceptions were in 1946, 1952, and 1953.
most iron ore is either "captive" or sold under long-term contracts.\textsuperscript{31} Iron ore is classified as captive whenever a major steel company supplies its mills with iron ore either directly, by operating its own mines, or indirectly, by being a partner with other firms in a firm which engages in iron ore production.\textsuperscript{32} Iron ore from these jointly owned companies is then allotted to each partner in proportion to its equity interest.

Given the relative narrowness of the American iron ore spot market one might at least suspect that it is not very competitive. If this is in fact the case, then it is quite possible that there is little or no relation between the real cost to the steel firm of its captive iron ore and the Lake Erie Price. In light of this possibility a question which we shall now pose, but only later consider, is how accurate has the Lake Erie Price been as an indicator of both the level of and the trend in either the marginal cost or the average cost of all iron ore (both traded and captive) delivered to these Lake Erie ports? The answer to this question will indicate whether or not the spot price—the only published price—provides a good indicator of both the level of and of movements in the real cost of captive iron ore over time. For the moment we shall just note that since the price on long-term iron ore contracts is some function of the spot price we must conclude that the latter is of at least some relevance in indicating the cost of at least 20 percent of all iron ore

\textsuperscript{31}It is estimated that captive iron ore accounts for about 75 percent of total iron ore consumption in the United States.

\textsuperscript{32}The firms which are typically partners in joint iron ore mining ventures are either steel companies or one or more of the four major "independent" iron ore merchants.
consumed. Moreover, since most large steel companies though they own captive ore nevertheless also buy spot and long-term ore, we would expect the Lake Erie Price to have some functional relationship to what they feel is the marginal cost of producing their own ore. It should be stressed that this functional relation undoubtedly contains a large stochastic element.

II

TABLE I-2, presented on the next two pages, presents the published Lake Erie Prices for the years 1915 to 1966. It is self-explanatory except for the last entry which is titled: Normalized Relative Price of Mesabi Non-Bessemer Iron Ore. An explanation of both the reason for this entry and of how it was actually calculated follows: Examination of the four nominal Lake Erie Prices reveals that they tended to rise over time. A good part of this rise was no doubt caused by inflation; therefore, in order to see how the relative price of iron ore has moved over time it seemed appropriate to deflate the nominal price of the largest single class of iron ore—Mesabi Non-Bessemer—by dividing it by some index of aggregate price movements. The two measures which we chose were the Bureau of Labor Statistics’ Wholesale Price Index and the Bureau of Labor

33 With the notable exception of United States Steel none of the major American steel companies is fully self-efficient in iron ore.

34 TABLE I-2 begins in 1915 because by this date iron ore from the Mesabi region was providing about 85 percent of American ore needs.
### TABLE I-2
The Lake Erie Price of Iron Ore

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<tr>
<th>YEAR</th>
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Source: Metal Statistics
Statistics’ Wholesale Price Index for Metals and Metal Products.\textsuperscript{35} The latter price index is only available from 1929. The figures obtained by this division were then normalized (i.e., placed on a scale ranging from zero to one hundred) in order to foster comparisons between the relative Lake Erie Price of iron ore for any two years.\textsuperscript{36}

III

Our final and most important task is to point out the main features of the landscape painted by the 1915 to 1966 price data presented in TABLE I-2. We shall proceed by first focusing our attention on the nominal price data and only later examining the normalized relative price data.

First, the absolute price differentials between the different iron ore types have remained, with few exceptions, constant for decades. Since over time the absolute prices have tended to rise, this implies that relative price differentials between different iron ore types have been steadily decreasing.

\textsuperscript{35} For the years 1929–1966 we obtained the wholesale price index data from the Statistical Abstracts 1967. For the earlier years we used the wholesale price index of Potter and Christy. Since these two measures have different bases, we linked the two series by the 1929–1933 overlap.

\textsuperscript{36} The procedure for normalizing was to divide each year’s deflated price by the highest deflated price of the fifty-two year period (1932). This figure was then multiplied by 100. This method of normalizing results in the normalized relative price having a value of 100 in 1932—the year between 1915 and 1966 when, relative to both price indexes, the Lake Erie Price was at its peak. For all other years the value of the normalized relative price shows the percentage which that year’s deflated price of iron ore was relative to the deflated price of iron ore in 1932. To illustrate, the deflated price of iron ore in 1915 was only 58.1 percent of its deflated price in 1932.
This apparent constancy of the absolute price differentials gives empirical support to the thesis that over this period the performance of the American iron ore industry has not been that of either a purely competitive or a perfectly monopolistic industry. Instead the performance of the American iron ore industry has been that of an oligopolistic industry with imperfect collusion. The rationale behind this conclusion follows: We assume that all firms regardless of the economic structure of their industry attempt to maximize profits. Since over the 52 years being considered technological and taste changes have caused relative changes in both the demand for and the supply of different iron ore types, we would expect that at any given moment both the monopolist and the purely competitive firm would charge a price for each ore type which was in at least rough accordance with the current marginal revenue and marginal cost conditions. We shall here demonstrate that only in the most unlikely of cases could this result in either a competitive or a monopolistic firm letting the absolute price differentials between different iron ore types remain unchanged over long stretches of time. To illustrate, suppose that in 1945 ore type X was considered to be the equal of ore type Y; i.e., at the same per unit delivered price a steel firm would be indifferent between them. Further, suppose that between 1946 and 1966 there was exogenous technical change which ceteris paribus made one unit of X twice as productive as one unit of Y. Then if the iron ore industry were perfectly competitive, both X and Y were still produced, and all firms were profit-maximizers, we know that in 1966 the price of X ($P_X$) would necessarily be twice the price of Y ($P_Y$). If all other assumptions remain unchanged but the iron ore industry were a perfect monopoly then the price
of X in 1966 need not be twice the price of Y; nevertheless, in the
typical case one would expect it to be approximately twice the price of
Y. More specifically, if we add the additional assumption that the steel
companies (the ore demanders) are perfectly competitive then in 1966 the
condition for profit-maximizing equilibrium, even assuming the iron ore
industry is monopolistic, remains \( P_X = 2P_Y \). This must be the case, for
if \( P_X > 2P_Y \) none of ore type X would be demanded. Conversely if \( P_X < 
2P_Y \) only X would be demanded. If instead we assume that the steel indus-
try is not perfectly competitive, this need no longer be the case, for
then the monopolistic iron ore seller might be able to practice price
discrimination. He would do this by setting a price for each ore type
which depended on both the intersection of its marginal revenue and mar-
ginal cost schedules and on the level and position of its demand curve. 37
If he discriminates by letting those firms with the most price-inelastic
iron ore demand buy only Y while letting the others buy only X then we
would have in equilibrium \( P_X < 2P_Y \). If instead he let those with the
most price-inelastic demand buy only X, then the reverse situation would
prevail; i.e., \( P_X > 2P_Y \). 38 It should be obvious that only given a
relatively price-inelastic demand for Y would it be conceivable that even

37 We are in fact being somewhat redundant since once the level and
the position of the demand curve is known, marginal revenue may be de-
duced.

38 In this example we are assuming that the iron ore monopolist still
finds it profitable to produce both ores in order to satisfy the total
iron ore demand. This will be the case if over some range of output less
than that which the ore monopolist desires to sell \( MC_X < 2MC_Y \). But at
some point before X output reaches the total amount he desires
to sell, \( MC_X > 2MC_Y \).
if the monopolist were a price discriminator $P_X$ would continue to equal $P_Y$ in 1966. The probability of this occurring is slight. We must conclude that the observed constancy of the absolute price differentials between the different iron ore types over time would not occur if the iron ore industry were either perfectly competitive or a perfect monopoly.

Given our assumptions, the observation that in both 1945 and 1966

$$P_X = P_Y + C$$

where $C$ is a constant, would most likely occur only if the iron ore industry were an oligopoly practicing imperfect collusion. In this case it might indeed be rational for the firms to maintain the same absolute price differentials over time because this might help to prevent the one event all oligopolists seem to fear--price-cutting. An industry that never changes price differentials between competing products so as to better reflect changing demand and supply conditions has publicly demonstrated that effective price competition is at best weak. We would expect that this valuable knowledge about the likely behavior of their competitors would quite naturally serve to reduce any fears that other firms would initiate price cuts during periods of bad business. The observation

39 It is of course conceivable, but extremely unlikely, that in this case $P_X$ would actually be less than $P_Y$ in 1966.

40 At first glance the following argument appears to offer an alternative and perhaps more reasonable explanation for the constancy of the price differentials between the different iron ore grades. The constancy could be caused by a combination of inertia and uncertainty about iron ore demand and supply changes. Together these could cause the ore producers to deem it to be wisest to let the ore price differentials remain unchanged. A closer look reveals that this is not really an alternative explanation because given our assumption of profit-maximization inertia could be a valid explanation for refraining from action only if the changes in the marginal conditions were slight. (continued)
that iron ore prices were stable during recessions is, of course, also consistent with this hypothesis.

A closer look at the nominal price data reveals a second point; i.e., it appears that over the period 1915 to 1966 the movements in the posted Lake Erie Price can be divided into three distinct sub-periods: 41

1. From 1915 to 1925 the Lake Erie Price was responsive in both upward and downward directions to changes in demand. The responsiveness of the posted price to demand changes is illustrated by the following cursory price history: From 1915 to 1918 the Lake Erie Price rose every year. This was primarily due to the great rise in steel production (and therefore in iron ore demand) caused by World War I. Following the Armistice in November 1918, the demand for steel fell sharply. The Lake Erie Price fell sharply in 1919. In 1920 there was a sharp recovery in raw steel output to near its 1918 level. The Lake Erie Price also shot up. In 1921 and 1922 there was a dramatic fall in steel demand and again the Lake Erie Price fell. In 1923 steel demand rose and the Lake Erie Price rose. Finally, in 1924 steel demand once again slumped and once again this was joined by a fall in the Lake Erie Price. Any profit-maximizing industry (competitive, oligopolistic, or monopolistic) might have exhibited the above performance. Given only the information so far

40 (cont.)
We doubt that such has been the case from 1925 to 1966. Also uncertainty about iron ore demand should only be a major problem for oligopolists. It should not be a major problem for either the purely competitive firm or the perfect monopolist.

41 In this discussion we shall ignore the years of World War II price control: 1941–1946.
presented we would be unable to identify which of the three types of industries the iron ore industry was during this period. However, later we shall conclude that the performance was that of an oligopolistic industry too weak to prevent all price cuts.

2. From 1925 to 1940 the Lake Erie Price moved constantly upward but in discrete steps. The only exception to this pattern was 1940 when the Lake Erie Price actually fell. The 1925 to 1939 performance of preventing all price cuts—even during the Depression when almost all other prices fell and when iron ore demand fell dramatically—suggests that during this period the oligopolistic American iron ore industry had stronger "effective collusion" (implicit or explicit) than previously. However, the collusion was still far from perfect; therefore, prices were raised only in those years when it was expected that demand would be relatively very high. Here it should be noted that this author, in seeking to find what could have been the signal for price changes, observed the following phenomena. From 1915 to 1957, ignoring the War years 1941 to 1945, with only two exceptions—1940 and 1954—whenever shipments of Lake Superior iron ore were greater than 60 million tons, the Lake Erie Price rose. Conversely there was only one year, 1946, when the Lake Erie Price rose even though Lake Superior iron ore shipments were less than 60 million tons. 42 This case is, however, trivial since shipments

42 Since the Lake Erie Price is set at the beginning of the year, it must be a function of the expected iron ore demand in the nine month shipping season which follows. Therefore the observed relation of iron ore prices rising only in those years when Lake Superior iron ore shipments exceeded 60 million tons must be premised on the assumption that the firms can accurately predict whether or not Lake Superior iron ore shipments in the coming year will be greater or less than (continued)
were 59.6 million tons. This performance is consistent with the view that at any level of iron ore shipments greater than 60 million tons there was a sudden, sharp rise in marginal cost. If this discontinuity were widely known it could serve as a signal for a price rise. Given the nature of the fixed capital investment in both mining and shipping, the possibility of such a discontinuity appears to be quite likely. 43 It

42 (cont.)

60 million tons. Luckily the expected iron ore demand need not be as accurate a predictor of the actual iron ore demand as the reader might at first expect. The reason for this is that from 1915 to 1957 only in two years (1925 and 1946) were Lake Superior iron ore shipments between 55 and 60 million tons. Thus a sizeable margin of error in predicting actual ore demand is possible and still the criterion yields the results mentioned in the text. We tested the validity of the above "signal" by regressing the posted Lake Erie Price (PLE) as a linear function of a constant, the Lake Erie Price lagged one year (PLE₁) and a dummy variable (GR60) which was 0 in all years from 1915 to 1957 except those years when Lake Superior iron ore shipments exceeded 60 million tons. In these years GR60 was defined to be 1. The estimated regression was (with t-statistics presented below the estimated coefficients)

\[ P_{LE} = -0.129 + 0.9962(P_{LE,1}) + 0.706(GR60) \quad R^2 = 0.98 \]

0.808 50 6.3 Standard Error = $0.36

These results show that in those years between 1915 and 1957 when Lake Superior iron ore shipments were less than 60 million tons the Lake Erie Price was virtually unchanged from the preceding year; whereas, whenever Lake Superior iron ore shipments exceeded 60 million tons the Lake Erie Price rose by about $0.70 over the preceding year's price. These results are of course consistent with the observations made in the text.

43 We shall discuss more fully the nature of the discontinuity of marginal cost when annual Lake Superior iron ore shipments are in the region of 60 million tons both in this footnote and later in the text. During the period 1915 to 1940 the profit-maximizing iron ore firms apparently did not find it profitable to make new investments to overcome the iron ore constraint that occurred whenever Lake Superior iron ore shipments were greater than 60 million tons. The reason was that annual shipments were normally considerably less than 60 million tons. Over the whole period 1915 to 1940 average annual shipments of Lake Superior iron ores were 45.8 million tons. In the sub-period 1915 to 1929 they averaged 53.6 million tons while in the Depression sub-period, 1930 to 1940, they averaged only 34.9 million tons.
receives further support from the fact that the two years when Lake Superior shipments were greater than 60 million tons but prices did not rise appear to be explainable exceptions. In the first, 1940, iron ore prices rather than rising actually fell. The probable cause of this seemingly contradictory behavior was that the Oliver Mining Division of United States Steel, by far the largest single iron ore producer in the Lake Superior region, for the first time sold ore (and large amounts) outside "the Corporation." This "entry" created a sudden shift in the supply curve (and the offer curve) of the American iron ore industry—a shift which was quite likely sufficient to explain the observed price fall. 44 The second time when the price of iron ore did not rise even though shipments were marginally greater than the apparent key number of 60 million tons (they were 60.2 million tons) was 1954. This exception is explainable by the fact that in 1953 Lake Superior iron ore shipments reached their historic high of 96.5 million tons. Thus the fall in demand between 1953 and 1954 was, not to exaggerate, dramatic. Also the massive imports of iron ore from Canada and Venezuela began in 1954. Finally, the one year, 1946, when Lake Superior iron ore shipments were less than 60 million tons (59.6) and yet the price rose may also be readily rationalized for this represented the first rise, and it was very small, in the price of iron ore since its price was fixed at the 1940 level by Wartime price controls. Since other prices had risen between 1940 and 1946, the 1946 iron ore price rise may have been simply a response to

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44 Over the entire period 1915 to 1966 there was never entry by any other new iron ore seller which was on a scale to rival United States Steel's sudden entry in 1940.
inflation—a response so obviously "necessary" to all members of the industry that they did not require a firm signal, usually provided by high expected demand, in order to act in unison. 45

3. Finally we observe that in the postwar period until 1957 the Lake Erie Price tended to move constantly upward. Since then, though it has fallen slightly, its most noticeable characteristic has been a remarkable rigidity. Subsequently we shall suggest that this halt in the rise of the Lake Erie Price was due to greatly increased competition in the industry.

We turn now to our second task and seek to indicate what is implied by the normalized relative price data. First concentrating on the pre-World War II period we note that our measure of iron ore's normalized relative price moved inversely with the business cycle; i.e., when business was bad (e.g., between 1920 and 1921, the Depression) this measure rose; whereas, when business was good (e.g., the rest of the 1920's) it fell. The most reasonable explanation for this performance was suggested to the author by Professor Paul Cootner. It rests on the observation that the cost of leaving iron ore unmined is the opportunity cost of the foregone profits. During recessions these will be small because larger outputs could only be sold at sharply lower prices; hence, the firms quite rationally attempt to restrict production and maintain prices. During booms the cost of foregone profits can be large.

45 These three exceptional years could also be explained by the fact that in none was the absolute deviation of actual Lake Superior iron ore shipments from the key number of 60 million tons greater than 3.6 million tons. Given that price changes are premised on expected demand changes we see that in all three cases the signal must have been ambiguous.
Each firm desires to sell a large amount at the going price. Hence price rises become more difficult. The reader should of course note that if the Cootner mechanism is correct, it is quite possible that even though the iron ore industry were perfectly competitive we would expect to observe that iron ore's normalized relative price rose during recessions and fell during booms. 46

During World War II the price of iron ore was fixed at its 1940 level. Since the coverage of wartime price controls was not quite complete, some other prices were rising; hence, this explains the observed Wartime fall in the normalized relative price.

After the War the normalized relative price rose almost constantly until reaching a postwar peak of 91.6 in 1957. There are two possible explanations for this performance:

1. It is possible that the American iron ore industry's economic structure remained the same as it was from 1925 to 1939 and hence that it was simply re-establishing its monopoly profit-maximizing price. This necessarily would take some time because most of the collusion had to be conducted implicitly.

46 An alternative but less convincing explanation for the inverse relation between the business cycle and iron ore's normalized relative price rests on the observation that the American iron ore industry was an imperfectly collusive oligopoly that was strong enough to prevent the Lake Erie Price from falling as much as other prices when business was bad, but was unable to (or did not want to) raise the price of iron ore as much as other prices when business was good. For this explanation to have content we must offer an explanation as to why the iron ore industry's "effective collusion" should be an inverse function of the business cycle. Except for the 1930's, when government policy often explicitly condoned collusion, no such explanation appears to exist.
2. It is possible that United States Steel's entry into the American iron ore market as a supplier in 1940 marked the start of what has been a continual retrogression in the economic structure of the American iron ore industry from near perfect monopoly to a much more competitive state. Given only this fact we would expect to have observed that the normalized relative price fell in the postwar period. In fact we know that it rose. However, when we also remember that the high Wartime iron ore demand led to the realization that Mesabi direct shipping ore would soon be exhausted and hence that iron ore was becoming scarcer, we would expect to observe, ceteris paribus, a rise in the normalized relative price. In turn this rise would encourage the development of competing sources of iron ore supply.

In the argument presented below and more fully in the econometric analysis presented later we shall indicate why we feel that it was this short-run increased iron ore scarcity and not the re-establishment of the pre-1940 level of monopoly power which led to the relatively rising iron ore prices from 1946 to 1957.

Before World War II no one was worried about the possible exhaustion of the rich Mesabi deposits of direct shipping iron ores. These had supplied the bulk of American iron ore demands for 60 years and most presumed that they would do so for another 60. Then came the War and with it huge demands for Mesabi iron ore. The result, as indicated more fully earlier, was that by 1945 many feared that soon--some said within twelve years--the Mesabi Range would be depleted. This alleged fact that Mesabi iron ore would soon run out meant that until substitutes were found, ceteris paribus, the marginal cost of Mesabi iron ore would shift
upwards each year as the less remaining unmined ore was capitalized at ever higher values. Concurrent with this phenomenon the postwar demand for Lake Superior iron ores continued at an historically high level through 1957. Only in 1946, 1949, and 1954 were shipments less than 70 million tons. This long period of very high iron ore demand occurred because of booming steel production in the United States. Remembering the apparent capacity constraint in shipping more than 60 million tons of Lake Superior iron ore it seems likely that the marginal cost of producing and shipping such high outputs was relatively very high. Normally this would have encouraged new investment in capital goods which would have permitted the more expeditious development of the known Lake Superior deposits and in turn this would have tended to eliminate the constraint. However, in this particular case there were two reasons (either one of which would be sufficient to explain the observed phenomenon) why the high marginal costs did not encourage such new investment. First, since it was thought that the high-grade Mesabi iron ore deposits would soon run out it obviously would not pay any firm, unless the price of iron ore soared to almost unimaginable high levels, to invest in new mining and transportation with expected economic lives of 40 or more years. Second, as the 1950's began it appeared quite likely that either foreign iron ore imports or taconite concentrates would provide economically superior substitutes to the Mesabi's direct shipping ores. This meant that in a few years the demand for direct shipping Lake Superior iron ore would almost certainly fall. For both reasons no firm would find it profitable to increase its investments in its deposits of Lake Superior direct shipping iron ore in order to thereby help to eliminate the
capacity constraint that appeared whenever shipments exceeded 60 million tons. Instead they channelled their new capital investments into developing alternative iron ore supplies—foreign deposits and taconite.

Given both the facts that marginal cost was rising steadily in the output range where iron ore was being demanded and that, at least until 1954 when the foreign sources began shipments, the entire marginal cost schedule was rising (shifting-up), we thus see that from 1946 to 1954 some such rise in the normalized relative price could have occurred and in fact would have occurred even if the American iron ore industry were perfectly competitive.

After 1957 the normalized relative price of iron ore fell constantly, indicating either that supply was rising faster than demand or that the market power of the domestic iron ore industry was being eroded. Since this fall coincided with both increased foreign iron ore imports and with the commercial development of a new technology which made taconite an economic source of iron source, we have empirical evidence which, as we later more fully explore, suggests that both increased competition and a downward shift of the iron ore industry's marginal cost schedule have led to the recent fall in the real price of iron ore.
CHAPTER IV

The Visible Structure of the American Iron Ore Industry

Prior to 1892 numerous independent merchant iron ore houses were the chief suppliers of iron ore to the American steel industry. In other words the American steel industry was not fully integrated backward—it bought its basic raw material in what was essentially a competitive market. In 1892 Andrew Carnegie purchased a half interest in the largest iron ore producer in the Mesabi Range—the Oliver Mining Company. By doing so he quite suddenly initiated two concurrent and very significant trends:

1. The United States Steel Corporation, the successor firm to Carnegie, and the other major American steel companies have continued down to the present to attempt to become self-sufficient in iron ore; i.e., they have tried to become vertically integrated.

2. At the same time the net effect of their efforts to achieve this vertical integration was to lead to the concentration of control of most of the iron ore consumed in the United States into the hands of a few major consumers of that product; i.e., the major steel companies. 47

47 Thus, for example, in 1959 the United States Tariff Commission offered the following succinct description of the highly
In this chapter we seek to determine what these two trends imply about the economic structure and performance of the American iron ore industry. Hopefully our discussion will also enable us to explain the timing of the American steel companies' urge to enter the iron industry. More specifically, we shall also seek to explain why there apparently was no special incentive for the steel companies to become vertically integrated before 1892; whereas, since that time this has been a goal of almost overriding concern!

With respect to the economic performance of the American iron ore industry we have already suggested that the behavior of the Lake Erie Price, at least from 1915 through 1966, appears to be most consistent with the hypothesis that the American iron ore industry had the economic structure of a highly collusive but nevertheless imperfect oligopoly. In this chapter we shall refrain from further consideration or comments about the behavior of the Lake Erie Price; instead, we shall examine three other types of evidence which also appear to support the hypothesis that after 1892 the American iron ore industry was indeed a highly collusive but imperfect oligopoly. First some evidence concerning the high degree of collusion is provided by private correspondence between some of the top executives of the industry. Second the web of interlocking directorships, stockholdings, and joint holdings in iron ore mining subsidiaries between the "independent" iron ore companies and the steel

47 (cont.)
concentrated structure of the United States' iron ore industry [26, p. 25]: "By far the greater part of the U.S. iron ore industry is owned or controlled by the nine largest steel producers. ...The remainder is largely controlled by four iron ore houses which although they produce for sale only, are closely tied to the steel makers."
companies suggests that the members of the American iron ore oligopoly must indeed have been quite cognizant of their interdependence. Third there is the indirect evidence provided by a theoretical argument which will suggest that the sudden trend to backwards integration, which began in 1892, is most consistent with the behavior we would expect to observe if in 1892 it was thought, for the first time, that monopoly power could be obtained in the market for the final product of the steel industry—steel. Since most industry observers suggest that such an event did in fact occur about 1892 this argument will suggest an explanation for the timing of the sudden trend to the American iron ore industry becoming almost completely dominated by the large American steel companies. We shall now consider these three types of evidence in turn.

I

The four major independent iron ore houses (Pickands, Mather and Company, Cleveland-Cliffs Iron Company, M. A. Hanna Company—since 1929 a part of National Steel—and Oglebay, Norton and Company) are all head-quartered in Cleveland. Fortune [12] has indicated that the top executives of the "Four" all belong to the same clubs and live virtually next door to one another in the same exclusive Cleveland suburb. Given both their physical proximity and common business interests one would necessarily be quite impressed if there were little inter-communication. And if there is communication, collusion—while not necessary—is certainly possible.48

48 For example, the great economist Adam Smith contended that the almost inevitable result of communication is collusion. Thus in the Wealth of Nations we find the statement: "People of the (continued)
There is in fact some slight direct evidence, first cited in Part 18 of the Temporary National Economic Committee (TNEC) Hearings, "Iron Ore," supporting this supposition. For example, on September 19, 1934, Mr. E. B. Greene, president of the Cleveland-Cliffs Iron Ore Company wrote Mr. George Humphrey, then president of M. A. Hanna and later chairman of the board of National Steel [27, p. 10,295]:

I am glad that the iron ore business is so largely in the hands of a small group of men who all work on a close and friendly basis.

Even more revealing is the correspondence from Mr. Patrick Butler to Mr. Emmet Butler, both officers of the small Butler Brothers Ore Company. 49 This correspondence, which continued throughout the Depression, concerned the price which Butler Brothers should quote Ford, the largest non-steel, non-integrated, consumer of iron ore. On April 10, 1934, Patrick Butler wrote [27, p. 10,321]:

I saw Hoyt [manager of Pickands, Mather] yesterday at which time he told me the ore magnates had desired to retain last year's market price. This price will be held regardless of what Ford does. We mailed list to Ford yesterday as did the others.

Hoyt says Pickands-Mather hope to take their minimum from us of 200,000 tons plus all the stockpiles which we figure to be 117,000 tons.

Earlier [27, p. 10,342] on March 28, 1929, he had written:

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48 (cont.) same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiring against the public, or in some contrivance to raise prices. It is impossible indeed to prevent such meetings, by any law which either could be executed, or would be consistent with liberty and justice" [20,p.128].

49 Butler Brothers was bought out by the M. A. Hanna Ore Company in 1948.
I had a talk with Elton Hoyt yesterday afternoon and he talked me out of quoting Ford on any of our grades at less than the full market price. ...there would be too much danger of the Corporation learning that we were using any other basis for figuring other than that we submit to them. And I'm afraid that our goose would be cooked if Shiras ever heard of it.\textsuperscript{50}

Two years later, on August 4, 1931, he wrote [27, p. 10,343]:

I believe it would be a dangerous thing to quote below this year's market. ...The Ford business is the only open market business left...if we took away the business from Pickands-Mather on a price concession we would incur the wrath of Jim [MacKilliken] and also give the old line companies an excuse to do likewise.\textsuperscript{51} I appreciate your anxiety to land this business but I believe it would be a dangerous thing to cut this price in any way whatsoever. We will however consult with the Big Four [independent iron ore merchants] beforehand to assure ourselves that they will not try any such tricks.

Similar correspondence reveals that throughout the Depression Butler Brothers resisted considerable economic incentives to cut its posted price. The reason, as alluded to in the above, was a combination of moral suasion (coercion?) and a deal whereby Pickands, Mather agreed to absorb part of Butler Brothers' surplus output.

At this point we should note that the stability of the published Lake Erie Price during the Depression does not necessarily imply that

\textsuperscript{50} The "Corporation" refers to the United States Steel Corporation. Mr. Shiras was at that time the ore agent of the Corporation's main subsidiary—the Carnegie Steel Company.

\textsuperscript{51} Mr. MacKilliken would be "wrathful" if Butler Brothers took business away from Pickands, Mather via a price cut because Pickands, Mather were sales agents for his ore. Since Mr. MacKilliken also represented the fee interest of some ore properties that Butler Brothers leased it would not be very judicious to attack his interests.
during this period there was no price competition in the iron ore industry. For example, Mr. L. Gregory Hines writing in 1951 said [13, p. 659]:

...once the price for the season has been established, price shading through negotiation has little effect upon the ore moved under contract as long as it does not result in widespread price cutting throughout the industry. ...(Therefore) competition (in the spot market) is sometimes approached, if not actually achieved, by ore sales at quotations below the published price and by the somewhat more "gentlemanly" practice of sweetening the quality of the ore shipment.

The only evidence which Hines provides of the existence of some such price-cutting during the Depression is the testimony of Mr. C. M. White, president of Republic Steel, concerning Republic's ore buying policies [13, p. 656]:

At different times and in different business cycles we use different methods. At one time--this was prior to the War--it was the fixed policy of our corporation that we did not want to be committed for more than about one-half of our ore. In other words, there was distress ore coming on the market quite frequently, due to the fixed carrying charges that many companies had--steel companies and ore companies--and we could buy ore on a better basis than we could own it, or make long-term contracts. Then, with the war and the post-war periods coming along, when the tremendous ore reserves had been used up due to the war and the postwar activity, after that situation changed we had gone over to an ownership or longtime contract, because there just was not enough ore, as we saw it, to play the market.

Unfortunately there appear to be no available price data which show the actual extent of the alleged price cuts. Moreover, because of theoretical reasons, which will be cited later, and because of the observed persistent long-term stability of both the Lake Erie Price and the price on long-term contracts, this author doubts, contra to the inference that one might draw from Hines, that the price cuts were ever too extensive. To be more explicit, Hines asserts, in the quotation cited above, that
"competition is sometimes approached" in periods of low demand such as the Depression. If this were true and if, as Hines and White seem to imply, it had the effect of causing most iron ore to be sold at a price much less than the posted price, then if the Depression were expected to persist no sales, either spot or long-term, could be made at the obviously too high Lake Erie Price. Therefore it would not pay any firm such as Pickands, Mather, to support the Lake Erie Price by purchasing the surplus output of a small firm such as Butler Brothers. But Pickands, Mather did in fact support the Lake Erie Price by buying Butler Brothers' surplus output throughout the Depression—not just for one or two years—therefore, we must conclude that unless Pickands, Mather were fools any price-cutting must have been minimal.

II

We now consider very briefly the web of interlocking directorships, stockholdings, and joint equity holdings in iron ore mining subsidiaries which bind the independent iron ore companies to the steel companies and the steel companies to each other. We will suggest that the community of interest which these interconnections imply certainly is not conducive to competition; however, we must also stress that this does not necessarily imply that the iron ore industry behaves in a highly collusive manner.

52 By competition he appears to mean only that there was some price cutting. This does not mean that iron ore prices fell to the level where they would be if the iron ore industry performed as if it were perfectly competitive.
Perhaps the most comprehensive summary of the extent of joint subsidiaries in the iron ore industry is to be found in Professor Daniel Fusfeld's 1958 article, "Joint Subsidiaries in the Iron and Steel Industry" [10] from which we quote rather extensively and to which the interested reader is referred for a more detailed account. This author knows of no reason for suspecting that the general picture painted by Fusfeld in 1958 should differ very sharply from the picture which a similar study would lead us to paint today. Fusfeld shows that as of December 31, 1956, there were at least 43 intra-industry joint subsidiaries in the iron ore industry. These joint subsidiaries may be divided into two major groups:

The first group comprises Bethlehem Steel Corporation, Youngstown Sheet and Tube Company, Interlake Iron Corporation, Steel Company of Canada, and Pickands, Mather and Company. Together and in varying combinations they control twenty-five joint subsidiaries, of which twenty-two are iron ore mining companies....

Most of the iron mining companies in this group are operated and managed by Pickands, Mather and Company, which also manages iron mines owned solely by Youngstown and Bethlehem. In addition, Pickands, Mather controls Interlake Iron Corporation through the ownership of 17.7% of its capital stock and is reputed to hold a small stock interest in Youngstown Sheet and Tube Company.

The second important group of steel companies affiliated through jointly owned subsidiaries centers in Cleveland. It comprises the Cyrus Eaton interests and Cleveland Cliffs Iron Company, the M. A. Hanna Company, National Steel Corporation, Wheeling Steel Corporation, Armco Steel Corporation, Inland Steel Corporation, and Republic Steel Corporation. It also includes two large iron ore producers, Consumers Ore Company and Oglebay, Norton and Company. To a lesser extent Jones and Laughlin Steel Corporation is affiliated with this group, and two Eaton-controlled companies, Detroit Steel Corporation and Steep Rock Iron Mines, Ltd., should also be included. In addition there are important connections between the Cleveland group and the Bethlehem—Youngstown—Pickands, Mather group, especially through joint subsidiaries with Bethlehem Steel and Youngstown Sheet and Tube.
Helping to tie the Cleveland group together are minority stockholding interests of Cleveland Cliffs Iron Company in five of the steel companies in the group. These include a 4.74 percent interest in Inland Steel Corporation, a 3.17 percent interest in Wheeling Steel Corporation, a 5.26 percent in Youngstown Sheet and Tube Company, a 2.52 percent interest in Jones and Laughlin Steel Corporation, and a 3.33 percent interest in Republic Steel Corporation....

There are twenty-four joint subsidiaries in the Cleveland group. The web of ownership is highly complex, and the group is by no means as tightly knit as the Bethlehem-Youngstown-Pickands, Mather group....

The ties between the Cleveland group and the Bethlehem-Youngstown-Pickands, Mather group are important. The Bethlehem Pension Trust Fund owns 6.83 percent of the stock of Cleveland Cliffs Iron Company, which in turn has important interests in five large steel companies. Joint subsidiaries provide other links: Bethlehem Steel has interests in three of the joint subsidiaries of the Cleveland group, Youngstown Sheet and Tube in two, and Interlake Iron Company and Steel Company of Canada in one each. Republic Steel has interests in two of the joint subsidiaries in the Bethlehem-Youngstown-Pickands, Mather group, and Inland Steel has an interest in one....In some respects the companies in both groups are bound together into a single web of ownership interests [10, pp. 582-585].

Given the foregoing observations Fusfeld concludes that it has perhaps been a mistake to visualize the steel and iron ore industries as being composed of some dozen large firms and about ten smaller ones, dominated by the market leadership of the United States Steel Corporation. Instead he suggests that both industries should be viewed as being dominated by a triumverate composed of United States Steel and the two groups of companies tied together through their joint subsidiaries and stockholdings.
III

Now we turn to the most important task of this section and seek to answer the question: Why after 1892 did the American steel companies suddenly engage in their rather passionate quest for an assured iron ore supply? We will give an economic explanation for this observed phenomena.

The basis hypothesis of the static theory of the firm is that every firm attempts to maximize profits. A direct implication given that firm A has a constrained amount to invest is that A will seek to invest in those areas which promise to add the greatest increment to its total profits. Furthermore, if another firm, B, can earn even more than A in those areas, then A would find it most profitable to sell out to B. As should be evident this thesis takes as given the truth of the above hypothesis. In this section we use it to explain both the timing of and the fact that iron ore mining has since 1892 come to be almost completely integrated into the operations of the domestic basic steel industry; i.e., we use it to explain the fact that since 1892 the trend has been for virtually all iron ore consumed by the domestic steel industry to be produced either by subsidiaries of or companies closely associated with (the so-called "independent" iron ore companies) the major steel producers.

There are two possible explanations for the observed almost total backward integration of steel-makers into iron ore mining and the consequent elimination of truly independent iron ore merchants:

1. There are economies of operation that can only be achieved through such integration.
2. There are unique opportunities to exploit a monopolistic position and these are only available to those firms which sell the final product, steel.

We examine these explanations in turn and conclude that only the second has validity.

This author can think of no reason as to why a steel company, qua steel company, should have an inate advantage in the actual operation of either an iron ore mine or the transportation medium between mine and mill; furthermore, he can find no statements by anyone either inside or outside the industry who claims that any such advantage exists. Finally, the fact that many steel companies have closely associated but independent firms conduct the actual operation of many of their iron ore properties implies that the motive for such integration cannot be that the steel companies, qua steel companies, can operate either mine or transport medium more efficiently. Therefore, if there is any real economy due to such backward integration we must conclude that it is due to some type of interaction between mine and mill. Specifically, the interaction suggested by the steel industry has been that it is essential for it to completely control its iron ore supply in order to eliminate the uncertainty of that supply. An indication of this rationale can be found in the February 1912 testimony of the Great Northern Railway's James J. Hill before the Stanley Committee of the United

53 The most notable example of this is the arrangement between Bethlehem Steel and Pickands, Mather. Pickands, Mather manages most of Bethlehem's Mesabi Range iron ore holdings.
States House of Representatives [26, p. 14]. In commenting on the efforts of the United States Steel Corporation to gain control over the Mesabi Range, Hill said:

I think it was a fair and no more than ordinary business prudence on their part to secure the absolute control of all of the ore they could get. ...Why upon that ore depends their existence.54

After 1892 a new concept was to enter the "conventional wisdom"; i.e., each firm's security require it to have under its control an assured supply of iron ore. For example, in a 1941 Fortune article commenting on the adolescent years of Bethlehem Steel it was said [5, p. 144]:

The problem was to get a supply of Lake Superior ores, and since they were all leased out, the solution was to buy a company that had some. Luckily this alternative coincided with the management's yearning to make Bethlehem, whose ingot capacity was only about three million gross tons, dominate the East.

From both standpoints there were two very desirable properties in the East. One was the Lackawanna Steel Company near Buffalo, which not only controlled some ore in Michigan but enjoyed the geographical advantage of being close to eastern markets, economically close to the ore supply, and by lake, close to the rapidly growing Detroit market. Bethlehem paid $57 million for Lackawanna in 1922. The other was the Midvale Steel and Ordnance. In 1923 Bethlehem acquired its Cambria plant at Johnstown and its factory at Coatesville for $127 million. ...What made Cambria emphatically worth coveting was its 50-percent stake in a lease on the Mahoning ore pit in the great Hull-Rust mine near Hibbing. This gave Bethlehem an assured supply of more than 100 million tons of Minnesota iron ore.

Numerous other examples of the alleged desire to eliminate uncertainty

54 This quotation may also be taken as indicating the possibility that U. S. Steel may have wished to control the iron ore supply merely to exploit or to prevent others from exploiting a possible iron ore monopoly. We consider this possibility shortly.
by having an assured iron ore supply could be cited; furthermore, there


can be no question that, ceteris paribus, the elimination of uncertainty

would result in real economies. For example, steel mills would require


smaller inventories of iron ore. Nevertheless we shall now see that

integration did not accomplish this task.

There are both short-run and long-run sources of uncertainty of

iron ore supply. The short-run sources are concerned with sudden dis-

ruptions of the flow of ore from mine to mill. But what are the causes

of these disruptions? Consider the case of a mine in the Mesabi Range

and of a mill in Pittsburgh. Over any relatively short period of time

the mill consumes a roughly constant amount of ore per day; therefore,

the mill's managers, in order to prevent costly interruptions of pro-

duction, try to insure that they will have available enough ore on any

given day to meet that day's required consumption. The way they nor-

mally try to provide this certainty is by maintaining inventories. 55

But inventories cost money. Therefore the rational firm tries to carry

the minimum amount of inventories subject to the constraint that its

expectations of having enough ore to meet any day's requirements will be

quite high. The absolute size of this minimum inventory depends on both

the expected and the unexpected disruptions of iron ore shipments from

mine to mill. These disruptions are of two possible types: either a

breakdown in the production of the ore or a breakdown in the transpor-

tation of the ore. Reasons why ore output might be disrupted include


55The cost of shutting down a steel plant is considerable; hence,
the profit-maximizing firm will typically keep large enough inventories
so that its Bayesian probability of this occurring is very small.
the breakdown of a vital piece of equipment, a mine disaster, bad weather
or climatic conditions, labor unrest, and other similar occurrences. It
should be noted that all of these occurrences appear to be exogenous;
i.e., they would occur regardless of whether or not the steel mill owned
the mine. The only way to avoid any of the uncertainty indicated
above would be by having several secondary sources of supply—preferably
located in different geographical and political regions. Because of the
use of and the need to maintain what are for the steel plant higher cost
ore sources, the removal of uncertainty in this way is not without real
cost.

A similar set of exogenous reasons explains the ways in which the
transport of ore may be disrupted. Thus we may conclude that since in-
tegration per se does not eliminate any of the sources of short-run un-
certainty, it cannot lead to any real economies for this reason.

That the long-run supply of iron ore is uncertain has been in-
dicated previously. Then we noted that the uncertainty essentially in-
volves the question as to whether or not new economic sources of iron
ore will be found to replace the continually depleting existing economic
ore bodies. As we indicated earlier the answer to this question depends
on the answers to three interrelated sub-questions:

1. What will be future relative factor prices?

56 Actually, the example of the oil industry in the Middle East sug-
gests that iron ore supply disruptions because of political events might
be more likely rather than less likely if the steel companies own their
iron ore sources.

57 For example, if the relative prices of certain other factors fell
sufficiently it is possible that, due to substitution, no more iron ore
would be demanded.
2. What will be the fruits from present and future exploration?

3. What will be the progress of technical change?

Rather than to attempt to answer these very difficult questions, we need simply to point out that their answers appear to be completely independent of whether or not the iron ore sources are or are not owned by the steel producers. Hence we must again conclude that integration, since it does not remove any of the sources of uncertainty, cannot have been motivated by the desire to obtain increased real economic efficiency.

We turn now to the only other possible explanation as to why, since 1892, the American steel producers have almost totally taken over domestic iron ore mining; i.e., because there are unique opportunities to exploit a monopolistic position and these are only available to those firms which sell the final product, steel. Until the success of Andrew Carnegie the United States was without a steel company with more than regional pretensions. As Carnegie prospered and expanded, and as

58 Paul Cootner has suggested that if the iron ore suppliers' estimates of the profitability of either short-run or long-run iron ore demand differ from similar estimates by the consumers, then there may be an economic incentive for integration. For example, if the consumers anticipate that their future iron ore demand will be high; whereas, the suppliers expect it to be low, then there will be, from the consumers' point of view, underinvestment in iron ore development. Similarly, since Mesabi iron ore can be shipped (except at sharply higher costs) for only nine months each year, if the suppliers expect a lower winter iron ore demand than do the consumers there might be underinvestment in iron ore inventories. In either case the steel companies might quite rationally decide to pursue backwards integration. While recognizing the theoretical possibility of Cootner's suggestion we shall dismiss it for two reasons. First, there seems to be no reason why the expectations about iron ore demand of the suppliers and the consumers should systematically diverge in the necessary fashion. Second, even if such systematic divergence does exist, we would have to explain why it either suddenly appeared, or at least was only strong enough to prompt action, after 1892.

59 That is, in the national market no firm had significant monopoly power.
transport costs continued to fall, the regionalized structure of the American steel industry was eroded—for the first time the prospect of a nationally concentrated steel industry became a real possibility. But with concentration would come the possibility of exerting monopoly power on a national as opposed to a regional level. What we intend to show is that by having the major steel producers control their own iron ore supplies this prospect would be enhanced. We shall do this by considering several possible cases.

The simplest polar case describes approximately conditions in the United States before 1892. At that time the steel industry, on a national level, approached purely competitive conditions; i.e., relative to the size of the market no one firm played a particularly important role and, except over a relatively small quantity range, any one firm had little price discretion. Given this state of affairs we must seek to answer the question of whether or not there would have been any special, unique to a steel company, motive for the steel companies to pursue backward integration into iron ore mining. We first consider the case where the iron ore industry is also purely competitive. Then our answer to the question is obviously no because since there are no real internal economies of operation possible due to integration and since there is also no opportunity to earn monopoly profits either in selling steel or in selling iron ore; therefore, the steel companies would have no special motive for moving into iron ore production and hence we would not expect to find much backward integration. But, some might argue, what if the structure of the iron ore industry could be concentrated. Then wouldn't it pay for the steel companies to attempt backward integration in order
to appropriate the monopoly profits? The answer to this question is that since the steel market is assumed to be perfectly competitive, the monopoly profits would only be a function of conditions in the iron ore market; hence, there would be no special differential profitability which would make investment in iron ore production more profitable for steel than for non-steel companies. As long as the monopoly profits were possible, any type of profit-maximizing firm would have the same motivation as any steel company in seeking to gain a position in the iron ore industry. Thus once again we would not expect the steel companies to dominate the iron ore industry.

Professor M. A. Adelman has noted to this author that the above explanation unrealistically assumes that steel and non-steel companies have equal information on which to base their expectations about what profits can be earned in iron ore. Specifically Adelman suggests that the steel companies have better information about possible iron ore profits than the non-steel companies. Hence, even if both expect the same profits from a given iron ore operation the steel company would hold its expectations with greater certainty and therefore would make the highest bid for the ore property. Adelman feels that this factor might be the main explanation for the observed backward integration by steel into the American iron ore industry. While recognizing that the assumption of equal knowledge is no doubt unrealistic this author, for three reasons, does not feel that Adelman's hypothesis can adequately explain the observed backward integration: First, there seems to be no reason why the steel companies should have systematically better information about possible iron ore profits than do the independent iron ore companies. Second, the hypothesis fails to explain the timing of the steel industry's efforts to become self-sufficient in iron ore. Why did the better knowledge apparently exist (or at least why was it not acted upon) only after 1892? Third, as we shall indicate more fully at the end of this section, after 1892 the steel companies did not appear to evaluate iron ore investments to be only marginally more profitable than did the non-steel companies. Thus, for example, many of them began to receive iron ore from sources which (on a delivered basis) appeared to be much more costly than the ore formally purchased from other Lake Superior producers.
The other polar case occurs if one steel company monopolizes the national steel market. Many allege that this was the goal of the initiators of United States Steel. If the steel industry were a perfect monopoly it would set that price which maximized the industry's (hence the monopolist's) profits. This would be determined by the intersection of the monopolist's marginal revenue and marginal cost curves. Since the marginal revenue of the steel producer is obviously unaffected by whomever owns the iron ore mines, we may ignore it and concentrate on trying to determine whether or not marginal cost is affected by whomever owns these mines. We first consider the case where the owners of the mines are so numerous that this industry may be said to be purely competitive. In this case the price of iron ore equals its marginal cost of production; i.e., the iron ore industry earns no excess profits. Figures I to III presented below indicate what will be the result:

$MC^S_n$ shows the marginal cost of producing steel ignoring iron ore costs. $MC^S$ incorporates the added cost of iron ore (i.e., $P^{ore} = MC^{ore}$) at any given ore output. The result is that the monopolist sells $Q_m$ units of steel at price $P_m$. Now we change our assumption and assume that the monopolist steel company also owns all of the iron ore mines. In this case it could charge itself for accounting purposes almost any price for the iron ore it used; however, since it wants to maximize profits, it would still determine what price to set for its steel by the intersection of MR and $MC^S$. But neither of these schedules is any different from what it was in the case where iron ore production was purely competitive; therefore, the above figures remain relevant and we see that in this case the monopolist has no special incentive to pursue backward integration. Finally we consider the case where the steel industry is still
IV

Price of Ore vs. Quantity of Ore

$P_{ORE}$, $P_{ORE}$, $MC_{ORE}$, $MR_{ORE}$

O $BQ_1$ $AQ_m$
controlled by a monopoly but the iron ore supply is controlled by a few oligopolistic ore merchants. For ease we shall assume that these ore merchants practice perfect collusion; hence, we are able to conduct our analysis as if the iron ore supply were controlled by a perfect monopoly.\(^{61}\) In this case we replace Figures II and III with Figure IV. We now face a situation of bi-lateral monopoly; i.e., both ore buyer and seller are monopolists. In these circumstances, without making more explicit assumptions, we can do no more than indicate what will be the qualitative nature of the solution to our problem; i.e., in this case we can show that the monopolistic steel producer will have lower profits than in the case where the iron ore industry was competitive.\(^{62}\) However, we cannot, without more information, give any quantitative estimate of the possible profit loss. More specifically, the steel producer will now pay a price for iron ore which is greater than \(MC^\text{ore}\). The reason for this is that the iron ore producers note that they do not face a perfectly price-elastic demand and therefore they try to produce an output, not where \(D^\text{ore} = MC^\text{ore}\) as before, but where \(MR^\text{ore} = MC^\text{ore} < D^\text{ore}\). At this output \(BQ_1\) they desire to set their price at \(P^\text{ore}\) which is both greater than \(MC^\text{ore}\) at output \(BQ_1\) and greater than the old \(P^\text{ore}\). Producing an iron ore output of \(BQ_1\) would result in maximum profits for the iron ore industry. In actual fact since the iron ore producers are

\(^{61}\) Acceptance of this simplifying assumption causes no change in the qualitative nature of our results.

\(^{62}\) The one exception to this is if the steel monopolist is such an outstanding bargainer that it can get the ore monopoly to sell its output at a price which yields no monopoly profits. This, while possible, is most unlikely.
selling to the steel monopolist (i.e., the iron ore buyer is a monopsonist) ore output will be $KQ_2$ which is greater than $BQ_1$ but less than $AQ_m$—the amount the iron ore industry would produce if perfectly competitive. The exact value of $KQ_2$ depends on the solution of a game theoretic problem. The more powerful is the bargaining of the single steel producer relative to the iron ore producer the less will be the monopoly profits obtained by the iron ore industry. The net result of this introduction of an iron ore monopoly is that the monopolistic steel producer now faces a higher marginal cost and hence, ceteris paribus, reduces output and has lower profits. This solution has two sources of lower profits for the steel monopolist:

1. At any given output his $MC^S$ is higher.
2. He now produces at lower output than what was formerly optimal.

The steel producer will desire to eliminate both sources of lower profits. The second source may be partially eliminated simply by colluding with the iron ore sellers. Specifically we have already demonstrated that the maximum aggregate total profits for both steel and ore producers occurs when the steel monopolist produces its profit-maximizing output $Q_m$. Hence if the two firms can agree on a distribution of this total profit, both could benefit if the steel company produced there. Hence the second source of lower profits would be partially eliminated. It should be stressed that the second source of profit diminuation (only from the perspective of the steel company, not society) is not fully eliminated

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63 Such an agreement might of course violate the anti-trust laws. Nevertheless, if it were made the resulting greater steel output and lower steel price would also benefit consumers.
because the iron ore merchants will agree to collude only if they receive greater profits than they would receive if they were producing at their optimal no-collusion output, $KQ_2$. That is, they will appropriate part of the increment to aggregate profits. This also implies (again only from the perspective of the steel company and not society) that the first source of lower profits cannot be removed by collusion for though with perfect collusion aggregate profits of both the iron ore and steel industries are no different from what they were in the case where the iron ore industry was perfectly competitive but steel was monopolized, the distribution of these profits has shifted in favor of the iron ore producers.

We may now ask what does all of the foregoing imply? Simply that the monopolistic steel producer will have a positive incentive to pursue backward integration into iron ore mining whenever there exists a possibility that some other firm or firms may establish any sort of monopoly power in this market. The reason for this incentive is that such a move would prevent the erosion of the steel company's monopoly profits in its final goods market which would occur if the iron ore supply were taken over by other monopolistic firms.

We now turn to the most relevant case for describing the American iron ore market since 1892; i.e., when the steel industry has an oligopolistic market structure. In this case we will demonstrate that there exist much more powerful economic motives than any we have previously considered pushing all members of the steel industry into

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64 In Essay II we offer a more complete discussion about the oligopolistic market structure of the American steel industry.
vigorously pursuing backward integration.

In an oligopolistic market each firm faces an indeterminate demand curve about which the only definite fact it knows is that it is more price-elastic than the industry demand curve. The profit-maximizing oligopolist therefore pursues two related policies:

1. It desires to decrease the range of indeterminateness of the demand curve which it faces.

2. It desires to reduce the extent to which the demand it faces is more price-elastic than the demand facing the industry as a whole.

Both of these policies, if successfully carried out, will lead to higher prices and higher profits. A proposition which we shall here assert and then attempt to demonstrate is that one of the best ways for successfully conducting these policies—especially in light of anti-trust laws which make explicit collusion concerning prices and output difficult—is to try to gain control over the basic factor supplies and hence factor costs. We shall now attempt to demonstrate the truth of this proposition for the American steel industry.

First, consider the case where the structure of the iron ore industry is purely competitive. In this case the same arguments pursued earlier indicate that there would be absolutely no special motive for the steel companies to attempt backward integration since no abnormal (monopoly) profits are possible. But what if it were possible to gain some control over the iron ore market. In fact what if, as it was before World War II in the United States, it is easier to control the supply of
iron ore than it is to control the supply of steel? In this case backward integration will be pursued with vengeance, and there will be great temptation to charge the monopoly profit-maximizing price or even higher for iron ore because this will force competitors to set a higher price for steel than would otherwise be the case.

More explicitly, we have indicated that the maximum aggregate total profits that can be earned by the steel and iron ore companies is equal to the maximum profits the steel monopolist could earn if he bought ore from purely competitive iron ore merchants. In terms of Figure I he should sell $Q_m$ at price $P_m$. In an oligopolistic steel industry, ignoring the polar case of perfect collusion, we know that industry output will always be greater than $Q_m$ and hence price less than $P_m$. Any rational firm would try to encourage the industry as a whole to produce less. Assuming that formal collusion is impossible—so that no firm knows the exact position of its own demand curve, much less the position of any other firm's demand curve—we note that it can still, if it is a significant supplier in the iron ore market, force a lower industry output by raising the marginal cost schedule which each non-iron-ore owning steel company faces. It can do this by charging a price for iron ore that is greater than its marginal cost of production. This will lead to two sources of higher profits:

1. A source available to all iron ore producers, steel and non-

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65 It was easier to control the supply of iron ore than the supply of steel because at any given time the known economical iron ore sources were few in number and the development of new sources took considerable time.
steel companies alike, is the monopoly return achieved by charging \( p^\text{ore} > MC^\text{ore} \).

2. A source available only to iron ore producing steel companies results from the fact that the higher \( MC^S \) faced by non-ore producing steel companies leads to lower output and lower profits for these firms; however, this lower steel industry output must lead to higher steel prices and higher aggregate steel industry profits. Therefore the gain in steel profits received by the iron ore producing steel companies must exceed the loss to the non-ore producers. It would pay the iron ore producing steel companies to continue to raise their prices at least until \( MC^S \) for the non-ore producers had risen to that level where the aggregate industry output had fallen to \( Q_m \). It should be noted that this ideal price of iron ore (from the point of view of the ore producing steel company) is greater than the price a non-steel producing, profit-maximizing, perfect iron ore monopolist would choose to charge.

Given this upward bias in the price which the iron ore producing steel companies wish to charge for their ore and assuming that the independent iron ore companies are indeed independent, we would expect that the actual price of iron ore would be equal to what the few independent iron ore producers thought was their profit-maximizing price. Hence we can now begin to understand why after 1892, when Carnegie first became a significant supplier in the iron ore market, all rational steel producers were inexorably forced to establish their own assured iron ore supplies. Such assured supplies would be established even though they might have a
considerably higher current cost than the ore the non-ore owning steel companies were previously able to purchase because the other steel companies now realized that in the near future they could expect sharply higher iron ore prices—perhaps high enough to force them out of business. More specifically any steel firm would establish its own assured iron ore supply so long as its discounted expected per unit iron ore costs were both less than the discounted expected per unit cost of purchased iron ore and also low enough that the firm could profitably remain in business. Thus, for example, we are now able to understand why the Bethlehem Steel Company, from as early as 1912, when all still thought the Mesabi Range to be overflowing with iron ore, when transport costs on shipping foreign ore were high, and even before it owned its steel plant on the Chesapeake Bay tidewater, Sparrows Point; nevertheless, apparently found it profitable to use iron ore from the Tofo mine in Chile.

Finally, we must also note a second important reason for oligopolistic steel producers that are self-sufficient in iron ore favoring high iron ore prices. Simply knowing that most other steel producers value their iron ore at the high traded price helps to define a high minimum price for steel—a price below which no producer would normally cut. This has the effect of making the demand curve for steel which any given company faces both less uncertain and more price-inelastic. Ceteris paribus this implies that it may safely charge a higher price than would otherwise be the case.
To conclude, we may summarize our explanation as to both the timing of and the extent of the massive backward integration by the American steel companies into iron ore production by noting three facts:

1. It was possible to monopolize the supply of iron ore.

2. Steel producers (both a monopolist or oligopolist) would have more incentive than others to enter such an industry because the iron ore producers' monopoly profits would be taken from their potential profits in selling steel.

3. Only oligopolistic steel producers would have the added incentive to integrate because it would permit higher steel prices and profits due to lower steel output by competing steel firms.

These facts, together with our earlier arguments about the American iron ore industry's economic structure and performance, all suggest that by at least 1915 this industry had the structure of a highly collusive but imperfect oligopoly. In the next chapter one of our tasks will be to provide an econometric description of the economic performance of this oligopoly over time.
CHAPTER V

The Lake Erie Price of Iron Ore: An Econometric Analysis (1915-1966)

Having completed our preliminary discussion of the economic structure and performance of the American iron ore industry, we here attempt to accomplish two additional goals: First, utilizing some key economic time series (presented in Appendix II), we shall attempt to test more rigorously many of the hypotheses about the American iron ore industry's economic structure and performance that were advanced earlier. Second, this examination will hopefully suggest new hypotheses to describe more accurately the observed performance of these time series. Our vehicle for this econometric examination is a three-equation simultaneous model for explaining the observed performance of the Lake Erie Price of the major class of Lake Superior iron ore, Mesabi, Non-Bessemer. The motivation behind this model is the widely known implication of microeconomic theory that at any given time, place, and general price level the actual price of any product is a function of only three things: demand, supply, and market structure. The model is presented on the next two pages. Our attention shall be focused on estimating two of the three endogenous equations (1 and 2); however, before attempting this task we shall discuss the model's rationale.
A Three Equation Simultaneous Model for Explaining the Behavior of the Lake Erie Price of Mesabi, Non-Bessemer Iron Ore: 1915-1966

**Endogenous Variables:**

1. The total demand for Lake Superior Iron Ore measured in millions of tons of iron ore with an iron content of 100% Fe.

   \[ Q_{LE} = Q_{LE}(Q^R_S, P_{LE}/P_S, t, M) \]

2. The Lake Erie Price of Mesabi, Non-Bessemer Iron Ore measured in dollars per ton.

   \[ P_{LE} = P_{LE}(P_{LE,-1}, GR60, X, X'GR60, P_W, \text{market structure}) \]

3. Total U. S. imports of iron ore divided by total Lake Superior shipments of iron ore. (This measure is not adjusted for iron content.)

   \[ M = M(P_{LE}, P_F, \text{transport costs}) \]

**Exogenous Variables:**

4. \( Q^R_S \) is total domestic raw steel output in millions of ingot tons.

5. \( P_S \) is the average annual price of scrap (#1 Heavy Melting) at Pittsburgh.

6. \( t \) is the years from 1915 through 1966.

7. \( P_{LE,-1} \) is the Lake Erie Price \( (P_{LE}) \) lagged one year.
8. CR60 is one (1) in those years from 1915 through 1957 when Lake Superior iron ore shipments exceeded 60 million tons, 0 in all other years.

9. X is one (1) from 1915 through 1925, 0 thereafter.


11. The market structure of the American iron ore industry.

12. $P_F$ is the price of foreign iron ore f.o.b. the mine.

13. The cost of transporting iron ore from mine to mill.

Note: See Appendix II at the end of Essay I for a listing of the data used in estimating this model.
The simplest static theory of production suggests that at any given time any firm's demand for any factor of production is a function of only three things: its average technology-in-use (i.e., the firm's operational production function), its output, and the factor's relative price.\textsuperscript{66} It is these implications of production theory which motivate our choice of the four independent variables presented in equation one (1), the demand equation for Lake Superior iron ore ($Q_{LE}$).\textsuperscript{67}

By far the most important use of iron ore is in the production of pig iron. There are no good substitutes for it in this use; therefore, ceteris paribus, we would expect the demand for iron ore to be a positive function of the demand for pig iron. But we are concerned with the demand for Lake Superior iron ore rather than with the total demand for iron ore. There may be many quite close substitutes for any given type of iron ore.\textsuperscript{68}

\textsuperscript{66}In order to simplify our discussion we assume that the firm's factor inventories are a constant percentage of current output.

\textsuperscript{67}$Q_{LE}$ is the total shipments of Lake Superior iron ore adjusted so that each ton of ore is assumed to have a natural iron content of 100 percent Fe.

\textsuperscript{68}Historical records show that over the entire period 1915 to 1945 the Lake Superior region supplied roughly 85 percent of total American iron ore needs; however, in the post-World War II period, and especially since 1954, the relative importance of iron ore from Lake Superior has been declining. Hence we might expect that since the War the demand for Lake Superior iron ore has increasingly become less tightly tied to American pig iron production.
The main use of pig iron is in the production of raw steel \( Q_s^R \). Either pig iron or steel scrap is a necessary input for this product. Hence, ceteris paribus, a rise in raw steel production leads to a rise in the demand for both pig iron and scrap and therefore to a rise in the demand for iron ore. Using partial derivative notation we expect to observe
\[
\frac{\partial (Q_{LE})}{\partial (Q_s^R)} > 0.
\]

But we are interested in explaining the steel industry's demand for Lake Superior iron ore over a period of 51 years, not just in any one year. It is of course unreasonable to assume that the average quality of the technology-in-use (the production function) has remained unchanged over such a long span of time. 69 Hence, in order to test for such a time-related effect, we include the years from 1915 through 1966 \( (t) \) as an independent variable. 70 Assuming that there has been technical

69 The average technology-in-use would typically become more efficient over time for either or both of two reasons: (i) There was technical progress, or (ii) the more efficient firms would tend to replace the less efficient firms; hence, even if there were no technical change, this change in the composition of the iron ore industry would lead to increased efficiency.

70 When we use this variable we are necessarily assuming that the rate of change in the average quality of the technology-in-use is a negative function of the level of Lake Superior iron ore demand. This is the case because the dependent variable fluctuates over a wide range whereas the coefficient of \( t \) is a constant. For the iron ore industry this is not an unreasonable assumption. Specifically, if a firm is a profit-maximizer it will use its most efficient plant first. Hence, if technical progress is relatively constant over time, the foregoing would suggest that the firm's average technology-in-use would be of a relatively higher quality when business was bad than when it was good. This of course implies that the rate of change in the average quality of the technology-in-use would be a negative function of the level of Lake Superior iron ore demand (i.e., a negative function of the iron ore business cycle). Tending to increase this negative effect would be the fact that in times of bad business the most inefficient steel firms would be most likely to be driven out of business.
progress we expect to observe \( \frac{\partial Q_{LE}}{\partial \epsilon} < 0 \).

Since the demand for steel is often thought to be quite price-inelastic (since steel is an intermediate good) we might expect that the steel industry's demand for pig iron and hence Lake Superior iron ore would necessarily be even more price-inelastic. This expectation ignores two important facts: First, one of the main virtues claimed for the open hearth process for producing raw steel was that pig iron and scrap could be very easily substituted for one another over a wide range of combinations. 71 The choice of which combination to use depending on their relative prices. 72 Given this fact we would expect that, ceteris

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71 Such a claim is not made for either the basic oxygen or the electric furnace processes. The basic oxygen technology is such that, ceteris paribus, the substitution of scrap for pig iron raises costs. Conversely, in the electric furnace process the substitution of pig iron for scrap raises costs.

72 The open hearth process was the main way of producing steel in the United States over the entire period 1915 to 1966. However, since the large-scale commercial introduction of the basic oxygen process in 1958, it has progressively played a less important role. Most authorities suggest that of the total iron charge in the open hearth the percentage which is scrap can range at least from 30 to 70 percent with no apparent diseconomies. For example, in the American Iron and Steel Institute publication, The Making of Steel [1, pp. 36-7], it is stated about the open hearth process that

...the limiting proportions of total scrap and pig iron charge... are governed and restricted by availability and economic considerations.

Here it should be noted that between 1948 and 1965 pig iron always composed at least 53.5 percent of the open hearth iron charge and never more than 59.8 percent of this charge. Since between these same two years the ratio of the price of one ton of iron ore to the price of one ton of scrap ranged between 0.149 and 0.395 (specifically in 1963 the relative price of iron ore was over twice as high as its relative price in 1948), this suggests, assuming that these price figures reflect actual costs, that in fact the potential substitution of scrap for pig iron in the open hearth process may not be so great as the "conventional wisdom" asserts.
paribus, when a measure of the relative price of iron ore to scrap, the
Lake Erie Price divided by the average Pittsburgh price of scrap, rose
it would lead to less Lake Superior iron ore being demanded. In other
words we expect to observe \( \frac{\partial (Q_{LE})}{\partial (P_{LE}) / (P_S)} < 0 \).

The second fact ignored in our assertion that we might expect the
demand for Lake Superior iron ore to be quite price-inelastic was that
besides scrap other types of iron ore are substitutes for this product.
Since over the entire period 1915-1966 non-Lake Superior but domestic
iron ores have tended to always supply a near constant percentage (10-
15 percent) of total American iron ore needs, we may ignore them in our
analysis. However, imports have provided a different percentage of
American iron ore needs. In particular they have been relatively very
high and trending ever higher since 1954. Therefore we introduce the
variable \( M \) (equals total U. S. iron ore imports/total Lake Superior
iron ore shipments) into our demand equation.\(^73\) Whenever \( M \) rises it
indicates more effective competition by foreign ores and hence we would
expect, ceteris paribus, a fall in the absolute demand for Lake Superior
iron ore.\(^74\) We expect to observe \( \frac{\partial (Q_{LE})}{\partial (M)} < 0 \).

\(^73\)Ideally we would prefer to use the delivered cost of foreign iron
ore relative to the delivered cost of Lake Superior iron ore as an inde-
pendent variable. Unfortunately because almost all imported iron ore is
captive the data is not available to construct this figure. Therefore
we use \( M \) as a proxy. Ceteris paribus we would expect that a fall in the
relative cost of iron ore would lead to a rise in \( M \).

\(^74\)Since \( M \) equals total iron ore imports divided by total Lake
Superior iron ore shipments (making no adjustments for iron content) it
is of course possible for both \( M \) and \( Q_{LE} \) to rise. In fact, since \( Q_{LE} \)
(continued)
The other major endogenous equation (2) is the price equation (or offer curve) for Lake Superior iron ore; i.e., the equation which explains the Lake Erie Price. In order to fully exploit the data we shall present two versions of this equation. The first version was suggested in Chapter III. To summarize, there we reached two major conclusions:

1. From 1926 to 1957 the Lake Erie Price typically remained unchanged from the preceding year whenever annual Lake Superior iron ore shipments were less than 60 million tons; however, whenever these shipments exceeded 60 million tons the Lake Erie Price was raised.

2. From 1915 to 1925 the Lake Erie Price was responsive in both upward and downward directions to changes in demand. Since 1925 the Lake Erie Price typically has either remained unchanged between any two successive years or has risen. It fell only in 1940, 1962, and 1964.

To anticipate our results it will be found that the foregoing model gives an excellent explanation of the Lake Erie Price. This is of course

74 (cont.)
is the principal component of the denominator of M, a rise in \( Q_{LE} \) would, ceteris paribus, lead to a fall in M. This of course implies that the coefficient of M is biased to be negative. Because of this bias Paul Cootner has suggested that a better variable than M would be its numerator, total American imports of iron ore, \( Q_F \). Use of this variable would eliminate the negative bias between M and \( Q_{LE} \). However, since the total American demand for iron ore has risen over time, it would not be reasonable to interpret \( Q_F \) as a proxy for the cost of iron ore imports. Hence we prefer to use M. It should be noted that we did estimate the demand equation using both \( Q_F \) and M as independent variables. The regression with M yielded more significant results. Nevertheless, the estimated regression using \( Q_F \) as an independent variable will also be presented.
especially the case during the long stretches of price stability, such as 1929 to 1936, which we often observe in this industry. It is just this excellence of prediction, because of the great power of the lagged price variable, which actually obscures some interesting results. Hence we also estimate an alternative price equation without the lagged price variable. Instead we recognize that the offering price of Lake Superior iron ore (the Lake Erie Price) should be a function of the demand, supply, and market structure conditions in the iron ore industry. We shall elaborate on this model when we present our empirical results.

The third endogenous equation attempts to explain movements in M. At any given time we would expect M to be solely a function of the relative delivered costs (the delivered marginal cost schedules) of Lake Superior iron ore and of foreign iron ore. This depends on both the real cost of producing iron ore at Lake Superior and at the foreign mines and on the real cost of transporting both types of ore from mine to mill. Such cost data is unavailable. Therefore, we shall not attempt to estimate the equation for M in this thesis.

The other variables in this explicitly partial equilibrium model are assumed to be exogenous. This assumption may be open to question as regards variables 4 and 5, and 10 through 12. For example, raw steel output (variable 4) is obviously a function of the price of steel and this is of course related to the marginal cost of iron ore. Therefore, what we are assuming when we say that raw steel output is exogenous is simply that iron ore costs are relatively such a small part of the total marginal cost of steel that they do not significantly affect raw steel output. Given the fact that over the relevant price-quantity range the
short-run demand for steel is thought to be price-inelastic, this assumption appears to be reasonable. Variable 5, the price of scrap, the main substitute for pig iron, is also assumed to be exogenous. Quite obviously the scrap price would be an increasing function of $P_{LE}$; nevertheless, to simplify our model we assume it to be exogenous.

Whether or not we treat variable 10, the wholesale price index, as endogenous depends on whether or not we believe the contention of some economists that steel prices were the main cause of the inflation during the 1950's. Since more recent work has tended to discredit this view (in particular questioning whether there is such a thing as cost-push or profit-push inflation) we also think it reasonable to treat movements in the absolute price index as exogenous. Variable 11, the market structure of the American iron ore industry, may also depend on the long-run interaction of iron ore demand and supply. For example, it appears that the relatively very high iron ore prices during the 1930's, even though the iron ore business was very bad, prompted the sudden entry in 1940 of United States Steel as a seller in the spot market. This led, of course, to increased competition and, ceteris paribus, to lower prices. Nevertheless, because of the immense difficulty and subjectivity which would be involved in constructing any market structure variable we feel quite justified in treating it as exogenous.

Finally, we do grant that variable 12, the price of foreign iron ore,

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is endogenous; however, since this data is not available and since equation 3 is not estimated, it does not affect our analysis to treat it as exogenous.

II

Having offered our model we now consider the interesting task of its estimation. Specifically we shall try to estimate two of the endogenous equations: The demand equation for Lake Superior iron ore and the price equation of Lake Superior iron ore. The results of this estimation will, we hope, both confirm the theory that we have enunciated and also indicate how the performance of the American iron ore industry has evolved both with the business cycle and with the mere passage of time.

When appropriate we present both the ordinary least squares and the instrumental variables estimates of the equations. For the demand

\[76\] We estimate the demand equation over the period 1915 through 1966 but exclude the War years 1941-1945. The price equation is estimated for the years 1916-1966 but excluding 1941-1946. In those demand regressions where the lagged Lake Erie Price is introduced as an instrumental variable the estimated regressions begin in 1916.

\[77\] Since the model is simultaneous we know that the ordinary least squares estimates have simultaneous equation bias. The instrumental variables estimates do not contain this bias; however, their greater inefficiency may nevertheless cause them to yield poorer results than the ordinary least squares estimates. The instruments used in the estimation of the demand equation for Lake Superior iron ore were the following 12 exogenous variables: the constant, \(Q^R\), \(P^W\), \(t\), \(P_S\), \(T\), \(UNP\), \(GR60\), \(P_{LE, -1}\), \(X\), \(X'GR60\), \(MDUM\) (a dummy variable which was zero from 1915-1953 and one from 1954-1966). The discussion of some of these exogenous variables will appear shortly in the text. Here we shall simply note that \(Q_T\) denotes annual taconite production. Since the existing (continued)
equation we obtained: 78

**Ordinary Least Squares** (t-Statistics are given below the coefficients)

\[ Q_{LE} = 534.0 + 0.4273(Q_{S}^R) -0.2694(t) -27.08(P_{LE}/P_{S}) -17.65(M) \]

\[
\begin{array}{cccc}
4.94 & 11.96 & 4.71 & 3.80 & 5.68 \\
\end{array}
\]

\[ R^2 = 0.952 \quad DW = 2.107 \quad SE = 2.37 \text{ million tons} \quad n = 47 \]

**Instrumental Variables:**

\[ Q_{LE} = 569.3 + 0.4439(Q_{S}^R) -0.2887(t) -23.31(P_{LE}/P_{S}) -18.63(M) \]

\[
\begin{array}{cccc}
5.01 & 10.06 & 4.79 & 2.41 & 4.61 \\
\end{array}
\]

\[ R^2 = 0.952 \quad DW = 1.950 \quad SE = 2.40 \text{ million tons} \quad n = 46 \]

The results of both regressions are consistent with the entire theoretical argument advanced earlier. The t-statistics indicate that each variable provides considerable explanatory power and each variable has coefficients with the sign our discussion has led us to expect. Moreover, the values of both Durbin-Watson Statistics, adjusted for one gap, (DW) are consistent with the hypothesis that there is no first order serial correlation. This in turn lends support to the hypothesis that we have not ignored any significant independent variables. Finally, the low values of the standard errors of the regressions (SE) confirm that we

---

77 (cont.)

taconite plants were, after 1957, by far the cheapest source of Lake Superior iron ore, and since total Lake Superior iron ore shipments always greatly exceeded Lake Superior taconite output, it is quite reasonable to assume (and this assumption does appear to be consistent with what we observe) that they always operated at full capacity; hence, it is reasonable to assume that \( Q_T \) is exogenous.

78 The mean value of \( Q_{LE} \) was 29.51 million tons of 100 Fe. iron ore. Its range was 1.85 to 48.6 million tons.
have discovered a significant regression.\footnote{As has already been indicated the coefficient of M is biased to be negative; hence, we also estimated the above equation with Q_P, total American iron ore imports in millions of tons, replacing M as an independent variable. We obtained:

**Ordinary Least Squares:**

\[
Q_{LE} = 644.3 + 0.4926(Q_S^R) - 0.3289(t) - 23.65(P_{LE}/P_S) - 0.3456(Q_P)
\]

\[
5.76 \quad 10.68 \quad 5.54 \quad 2.941 \quad 5.08
\]

\[
R^2 = 0.948 \quad DW = 2.441 \quad SE = 2.48 \text{ million tons} \quad n = 47
\]

**Instrumental Variables:**

\[
Q_{LF} = 683.0 + 0.5318(Q_S^R) - 0.3510(t) - 16.59(P_{LE}/P_S) - 0.4052(Q_P)
\]

\[
5.64 \quad 9.09 \quad 5.43 \quad 1.530 \quad 4.75
\]

\[
R^2 = 0.946 \quad DW = 2.235 \quad SE = 2.54 \text{ million tons} \quad n = 46
\]

Both the demand regressions presented in the text and those presented in this footnote suffer from an additional source of bias not previously mentioned; i.e., the coefficient of P_{LE}/P_S is biased to have a negative sign. The cause of this bias is that, ceteris paribus, since iron ore and scrap are substitutes a rise in Q_{LE} would lead to a rise in P_S. But, ceteris paribus, a rise in P_S would lead to a fall in the value of the ratio of P_{LE} to P_S; hence, even if there were in fact no structural relation between Q_{LE} and P_{LE}/P_S we would expect to observe that P_{LE}/P_S had a negative coefficient. Because we assumed P_S to be an exogenous variable this source of bias is also present in the regressions estimated by the instrumental variables technique. Since even with this bias the negative coefficient of the relative price variable is not extremely significant it is quite possible that there is in fact no structural relation between P_{LE}/P_S and Q_{LE}; i.e., the relation estimated in the regressions may be spurious. As we indicated earlier even though the relative price of scrap and pig iron has changed dramatically the actual extent of substitution of scrap for pig iron, even in the open hearth process, was minimal--much less than the glib pronouncements of industry commentators might have led us to believe. Hence, we do not find it surprising that the negative coefficient of P_{LE}/P_S might in fact be spurious.}
explanation of the posted Lake Erie Price of iron ore ($P_{LE}$). The estimated regressions are presented on the following two pages.

First, remembering our earlier discussion, in regression 1 we regress $P_{LE}$ as a function of five exogenous variables: a constant; $P_{LE,-1}$, the Lake Erie Price of the preceding year; GR60, a dummy variable which was defined to be one from 1915 through 1957 in those years when Lake Superior iron ore shipments exceeded 60 million tons, in all other years between 1915 and 1966 it was defined to be zero; $X$, a dummy variable which was defined to be one from 1915 through 1925 and zero thereafter; and $X \cdot$ GR60 which is simply $X$ multiplied by GR60.

The lagged price variable's very significant positive coefficient of 0.998 confirms that, *ceteris paribus*, the current Lake Erie Price is usually unchanged from the previous year's. Besides the foregoing the results of this estimation also suggest:

1. Between 1916 and 1925 whenever annual Lake Superior iron ore shipments exceeded 60 million tons the expected Lake Erie Price was equal to the previous year's Lake Erie Price plus $0.90$.  

2. Between 1916 and 1925 whenever annual Lake Superior iron ore shipments were less than 60 million tons the expected Lake Erie Price was equal to the previous year's Lake Erie Price minus $0.59$.  

3. Between 1926 and 1957 whenever annual Lake Superior iron ore shipments

---

80This answer was arrived at via the following calculation:  
$0.90 = 0.027 + 0.484 - 0.559 + 1.003$.  

81This answer was arrived at via the following calculation:  
$-0.59 = -0.027 - 0.559$.  


\[
P_{LE} = \text{Constant} + P_{LE,-1} + 0.484 - 0.559 + 1.003
\]

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\[
R^2 = 0.954 \quad DW = 1.356 \quad SE = $0.641
\]

\[
P_{LE} = \text{Constant} + P_{LE,-1} + 0.484 - 0.559 + 1.003
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\[
R^2 = 0.893 \quad DW = 1.986 \quad SE = $0.305
\]

\[
P_{LE} = \text{Constant} + P_{LE,-1} + 0.484 - 0.559 + 1.003
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\[
R^2 = 0.951 \quad DW = 1.378 \quad SE = $0.641
\]

\[
P_{LE} = \text{Constant} + P_{LE,-1} + 0.484 - 0.559 + 1.003
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\[
R^2 = 0.958 \quad DW = 1.625 \quad SE = $0.672
\]
|   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| PE = Constant + PE,−1 + GR60 + X + X·GR60 + PW + M + T + UNP + Z |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 4* | -0.300 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|   | 0.387 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| n = 45 | R² = 0.949 |   | DW = 1.612 | SE = $0.676 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 5 | -0.818 | + 0.818 | + 0.154 | -0.562 | + 0.994 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|   | 2.541 | 15.46 | 1.157 | 3.44 | 4.72 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| n = 45 | R² = 0.994 |   | DW = 2.238 | SE = $0.244 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| 5* | -0.706 | + 0.808 | + 0.176 | -0.537 | + 0.962 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
|   | 2.408 | 12.18 | 1.266 | 2.97 | 4.21 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| n = 45 | R² = 0.994 |   | DW = 2.254 | SE = $0.244 |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |

Notes: 1. The instrumental variables were a constant, $Q^R_S$, $P_W$, $t$, $P_S$, $Q_T$, UNP, GR60, $P_{LE,-1}$, $X$, $X·GR60$, MDUM.
2. Asfrisked items denote equations estimated by the instrumental variables technique. All other regressions were ordinary least squares.
3. t-Statistics are presented under each coefficient.
shipments were greater than 60 million tons the expected Lake Erie Price was equal to the previous year's Lake Erie Price plus $0.46.  

4. Finally, in all other years between 1926 and 1966 the expected Lake Erie Price was equal to the previous year's Lake Erie Price minus $0.027.

In regressions 2 and 2* we present an alternative model for explaining the Lake Erie Price of iron ore. Specifically we assume that the Lake Erie Price in any given year will be a function of four variables (ignoring the constant):

1. $P_W$, the wholesale price index.
2. $M$, the ratio of total American iron ore imports to total Lake Superior iron ore shipments (unadjusted for natural iron content).
3. $T$, the ratio of total U. S. taconite pellet production to total Lake Superior iron ore shipments (unadjusted for natural iron content).
4. $UNP$, the national, U. S., unemployment rate.

In order to avoid simultaneous equation bias, this equation was estimated by the instrumental variables technique. Our rationale for introducing these variables follows:

The independent variable $P_W$ is a good measure of the general price

---

82 This answer was arrived at via the following calculation: $0.46 = 0.027 + 0.484$.

83 We actually present the results of both the ordinary least squares and the instrumental variables estimations. The asterisked equation is the instrumental variables estimation.
level. The theory of the firm implies that, ceteris paribus, when there is a change in the general price level we should expect to observe a sympathetic change in the Lake Erie Price.

The independent variable \( M \) is a measure of the importance of iron ore imports in the United States. Earlier we noted that these imports suddenly became much more important in 1954. Our expectation as to the sign of \( M \)'s coefficient depends on which of two theories we hold: One theory contends that imports are a "passive" element in the American iron ore market; i.e., ceteris paribus, they tend to be high when the Lake Erie Price is high. If we believe this theory then our model \( M \) should have a zero coefficient.\(^{84}\)

The second theory holds that American iron ore imports play an "active" role in determining American iron ore prices. In this case since a rise in \( M \) suggests increased foreign competition we would expect that, ceteris paribus, this would lead to a fall in \( P_{LE} \). Therefore, we would expect the coefficient of \( M \) to be negative.\(^{85}\) Since the major

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\(^{84}\) Peter Temin pointed this out to the author. The reason for this is that the "passive" theory assumes that while \( P_{LE} \) affects \( M \), \( M \) does not affect \( P_{LE} \). If \( M \) does not affect \( P_{LE} \) then obviously its coefficient should be zero.

\(^{85}\) When we proposed the demand equation we suggested that \( M \) was a relevant explanatory variable because it was the best available proxy for imported iron ore's relative real cost (a rise in \( M \) would be associated with a fall in imported iron ore's relative real cost). If we continue to hold this view and continue to assume that imported iron ore is a substitute for Lake Superior iron ore then we would expect that, ceteris paribus, a rise in \( M \) would imply a fall in \( P_{F} \) and hence a fall in \( P_{LE} \); i.e., we would expect to observe \( \frac{\partial P_{LE}}{\partial M} \cdot \frac{\partial P_{F}}{\partial P_{LE}} < 0 \).

Since we do not observe the above (\( M \)'s coefficient is very significantly positive) we must conclude either that \( M \) is not a good proxy for \( P_{F}/P_{LE} \) or that, because of the unique control of the American steel companies over most of the relevant foreign iron ore deposits, there is no price competition between domestic and foreign iron ore. Evidence to be presented shortly in the text will be consistent with this second possibility.
American steel companies control most of the relevant domestic and foreign iron ore deposits, we tend to doubt the relevance of this second theory because it would usually be quite irrational for any oligopolist interested in price stability to in effect compete against himself by encouraging large iron ore imports independent of the state of domestic iron ore demand.\footnote{The very significant but positive coefficient of M in regressions 2 and 2\# are inconsistent with the "active" theory being valid.} The independent variable T measures the relative importance of taconite pellet production as a component of total Lake Superior iron ore production. We include this variable in equations 2 and 2\# in order to test the hypothesis that the commercial introduction, in 1956, of the technology for the production of taconite concentrated iron ore pellets precipitated a change in the economic performance of the American iron ore industry. More specifically, the development of the process for the commercial exploitation of taconite caused at one stroke a huge increase in the economic iron ore resources of the Lake Superior region. Unlike the deposits of Lake Superior direct shipping ores, which had been tightly controlled since the 1880's, the taconite deposits were never consolidated; i.e., they were widely held.\footnote{The reason for the lack of even an attempt to consolidate them was that they had always been thought to be worthless. Hence no firm or individual considered it to be profitable to corner these deposits; therefore, when an economic way to process taconite was finally} 

\footnote{See Appendix I to Essay I for details about the American steel companies' investments in foreign iron ore deposits.}

\footnote{The Lake Superior direct shipping iron ore deposits were first controlled by the Rockefeller interests and later largely by Andrew Carnegie and United States Steel.}
discovered, massive entry of new firms—-in practice consortia of steel companies—into Lake Superior iron ore production became possible. We would expect that the mere existence of such a possibility would make the Lake Superior iron ore market considerably more competitive. Therefore we would expect that a rise in T, assuming that this is indeed a good proxy both for the increased entry by new firms and for the lower costs of taconite ore, would lead, ceteris paribus, to a fall in the Lake Erie Price. Since in regressions 2 and 2* the coefficient of T is indeed significantly negative, this hypothesis receives empirical support.

Finally, we introduced the variable UNP, the national unemployment rate, as an independent variable in order to incorporate the observation discussed in Chapter III that during periods of bad business—the most conspicuous example being the Depression—the price of iron ore did not seem to fall as much as did the price of other commodities. If true, this observation suggests that UNP should have a positive coefficient in our price regression. It does.

Having constructed a reasonable alternative Lake Erie Price equation (one not using the lagged price as an independent variable) we shall now study its residuals (the actual value of \( P_{LE} \) in any given year minus its estimated value) in order to see what they imply about the nature of the evolution of the economic structure and performance of the American iron ore industry from 1916 to 1966. From 1915 through 1940 the residuals

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88 An examination of the residuals of regression 1 will yield no information because whenever the current price was the same as the lagged price the residual was forced to be near zero. Also within any one of the five stretches where the Lake Erie Price was stable for at least 3 years (1925–1927, 1929–1936, 1937–1939, 1957–1961, and 1964–1966) the residuals were necessarily the same for all years but the first. In commenting on this analysis Paul Cootner has agreed with the author that (continued)
of regressions 2 and 2* display no serial correlation. This suggests
that over these years the four independent variables appear to incorpor-
ate all of the systematic effects on the American price of iron ore.
Such is not the case for the postwar period. Then, as the residuals
from 1947 through 1966 (presented in TABLE I-3) indicate, there was
significant serial correlation. More specifically we observe the fol-
lowing: From 1947 through 1953 the general tendency was for the actual
price to rise faster than the predicted price. This is indicated by the
fact that, with the exception of 1951, the algebraic value of the re-
siduals became larger with time. This observation is definitely consis-
tent with the theory that over these seven years the effective implicit
collusion among the members of the iron ore industry—which had been dis-
rupted by the sudden entry of United States Steel as a seller in 1940
and by government price regulation during World War II—was gradually
being reestablished to its pre-1940 level. However, the observation is

88 (cont.)
because of the overriding power of the lagged price variable no infor-
mation can be gained by examining the residuals of regression 1. However,
Cootner suggests that perhaps a better alternative than the model dis-
cussed in the text (i.e., the model presented in regressions 2 and 2*)
would be the model presented in regressions 3 and 3*; i.e., Cootner sug-
gested that our price equation should also include as independent variables
the three demand variables of regression 1: GR60, X, and X·GR60. The
reader will note that this suggestion did not prove fruitful: The three
demand variables all have coefficients insignificantly different from zero.
Moreover, X and X·GR60 have opposite signs from what our earlier dis-
cussion suggested. [This was the case because in the years 1915-1925 even
though \(P_{LE} \) rose in those years when \(X·GR60 \) equalled one, it did not rise
as fast as \(P_{w} \), the wholesale price index.] Finally, comparing regression
2 to regression 3 and regression 2* to regression 3* we observe that in
both cases the standard error of the regression was higher when we added
the three demand variables. These reasons all suggest that the model
presented in regressions 2 and 2* is better than the model presented in
regressions 3 and 3*; hence, we ignore Cootner's suggestion in the text.
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<td>+0.47</td>
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<td>53</td>
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<td>+1.71</td>
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<td>10.55</td>
<td>-0.24</td>
<td>-0.08</td>
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also consistent with the theory that our regression is missing a significant variable—specifically a variable representing the annually rising real cost of Lake Superior iron ore because of its growing scarcity. The following analysis will tend to support the validity of the second theory. 89

In 1954 the sudden sharp reversal of the trend of the actual Lake Erie Price rising faster than our model predicted (the algebraic value fell by $1.22) was undoubtedly caused by the opening of the new iron ore sources in Canada and Venezuela. If one believes the "effective collusion theory," this reversal implies that the new foreign iron ore sources (the development of competing iron ore supplies) led to lower effective collusion among the members of the American iron ore industry. We have already indicated that, since the major American iron ore producers also developed these new foreign sources, we doubt that iron ore imports would be an active element in affecting the Lake Erie Price. 90 Empirical support for this doubt was provided by the fact that in regressions 2 and 2* M has a positive coefficient; thus suggesting that iron ore imports tended to be a "passive" function of conditions in the domestic iron ore market. But, one might ask, perhaps iron ore imports played a more "active" role starting in 1954 when for the first time they became relatively large? We tested for this possibility by introducing into the model presented in regressions 2 and 2* the variable Z. Z was defined

89 For ease of presentation our explanation will refer to the residuals of regression 2 because these are more clear cut than the residuals of regression 2*. However, we feel that the same explanation holds for regression 2*.

90 United States Steel was the sole owner of the new Venezuelan mine while the Canadian mine was owned by the Iron Ore Company of Canada, a firm dominated by American steel companies.
to be equal to zero from 1915 through 1953 and equal to M thereafter. 91 The coefficient of Z in this model (regressions 4 and 4*) was positive but very insignificant. This result supports our contention that the hypothesis that iron ore imports played a more "active" role in affecting the Lake Erie Price after 1953 is false. Indeed the positive coefficient of Z is more consistent with the counterhypothesis that iron ore imports played a less "active" role after 1953. We must conclude that the evidence implies that the dramatic rise in iron ore imports which began in 1954 did not lead to lower "effective collusion" in the American iron ore market.

But, if the rise in imports did not lead to lower "effective collusion" and hence to the dramatic reversal in the upward trend of the actual price relative to the predicted price, what did? This author feels that the answer to this question is that the introduction of the new foreign iron ore sources suddenly eliminated the fear that disaster would strike once the Mesabi iron ore was depleted. Now since there were economic substitutes for Mesabi iron ore, the producers would no longer at the end of each year automatically recapitalize their remaining Mesabi iron ore reserves at ever higher per unit levels. This meant that the yearly upward shift of the American iron ore industry's marginal cost schedule was stopped and in fact possibly reversed. Therefore we would expect to no longer observe the actual Lake Erie Price rising faster than the predicted. This is of course what we do observe since in 1954 the upward trend in the algebraic value of the residuals of our price

91Z is equal to MDUM times M.
regression was suddenly and dramatically reversed. The precise coinciding of this reversal with the sudden emergence of the new ore sources gives considerable empirical support to the validity of this theory.

To summarize our results to this point, the proponents of the "collusion" theory would have to argue that the increased sources of foreign iron ore since 1953 have led to an erosion of "effective collusion" and thus the actual Lake Erie Price could no longer continue to rise relative to the predicted Lake Erie Price. The test for this theory is that the coefficient of Z be negative, larger (in absolute size) than the positive coefficient of M, and significant. In actual fact the coefficient of Z was positive but insignificant. This result is inconsistent with the "collusive" theory being valid.

The sudden trend reversal in the residuals between 1953 and 1954 does, however, support the theory that the Lake Erie Price of iron ore would have risen in the immediate post-World War II era even if the industry were competitive. To repeat, the cause of this rise would have been the annual shifting upwards of marginal cost because of the physical depletion of the Mesabi Range. Moreover, the fact that the residuals of regressions 2 and 2* both show that in 1940--the year when effective competition suddenly became much stronger in the iron ore market because of the entry of United States Steel as a seller--the actual Lake Erie Price was greater than its predicted price; whereas, from 1947 through 1951 the actual Lake Erie Price was always less than its predicted price, suggests that the American iron ore industry was more competitive in the early postwar era than it had been in 1940.  

92 In both regressions the algebraic value of the 1940 residual equalled +80.20.
The residuals of regression 2 also show that from 1954 through 1957 the actual price of Lake Superior iron ore continued to exceed its predicted price but at a much lower level than at its 1953 peak. No longer did this measure display an upward trend. Since 1957 the residuals have been randomly distributed about a mean of zero. More formally, since 1957 our model shows no sign of serial correlation. What could have caused the significant change in iron ore pricing behavior which the sudden improvement in the specification of our model implies?

The answer to this question was indicated earlier when we noted that the first commercial production of taconite iron ore was at the end of 1956. This at one stroke ended the monopoly of a few firms over the supply of Mesabi Range iron ore. The ceteris paribus effect of this, if any, would of course have been to promote greater competition in the American iron ore industry. Hence we would expect $T$ to have a significant negative coefficient in the price regression. It does. Assuming that our model once more encompasses all of those elements which systematically affect $P_{LE}$, we would also expect the residuals to be randomly distributed. They are. Given the negative coefficient of $T$ and the sudden improvement in the behavior of the residuals, we conclude that since 1957 the American iron ore industry has become more competitive. In the concluding Chapter of Essay I we shall examine whether or not competition has increased to such an extent that the American iron ore market of the 1960's can be described as being nearly perfectly competitive. Before turning to this new discussion we shall conclude the current one by noting that in regressions 5 and 5* we used as independent variables all of the explanatory variables used in regressions 1 and 2. All of the coefficients have the signs we would expect.
CHAPTER VI

The Absolute Level of the Lake Erie Price of Iron Ore: Is it Competitive?

The implication of all of the preceding analysis is that since the end of World War II and especially since 1957, the trend of movements in the Lake Erie Price of iron ore has been consistent with what we would expect to observe in an industry becoming increasingly more competitive. Now we shall assert that nevertheless the absolute level of the Lake Erie Price of Mesabi iron ore is still considerably higher than the price which we would expect to observe if the American iron ore industry contained no monopolistic elements. We shall "prove" this assertion by appealing to two types of data:

1. The European Coal and Steel Community's (ECSC) data on the average c.i.f. price of iron ore from various foreign sources to West Germany, Italy, France, Netherlands, and Belgium-Luxembourg.93

2. Maximum estimates of the average cost of shipping iron ore between various ports.

In TABLE I-4 presented on the next two pages we show the ECSC c.i.f.

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93 We chose to include the iron ore sources given in TABLE I-4 because (excluding Sweden) all were also regular sources of supply for the United States' market. We only present the c.i.f. prices when the iron ore trade between any given iron ore source and the ECSC country has been fairly regular.
TABLE I-4

C.i.f. Price Per Gross Ton of Iron Ore Imports (Prices are Adjusted by Natural Iron Content)

I. To West Germany

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<tr>
<td>Sweden</td>
<td>$11.30</td>
<td>11.21</td>
<td>12.13</td>
<td>13.08</td>
<td>12.79</td>
<td>11.45</td>
<td>11.41</td>
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<td>9.41</td>
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<td>(Fe. 58%)</td>
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<td>Brazil</td>
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<td>15.14</td>
<td>17.34</td>
<td>19.56</td>
<td>16.61</td>
<td>12.98</td>
<td>11.89</td>
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<td>10.28</td>
<td>9.67</td>
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<tr>
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### TABLE I-4 (Cont.)

#### II. To France

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#### III. To Italy

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<td>14.19</td>
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<td>11.97</td>
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<td>9.76</td>
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TABLE I-4 (Cont.)

IV. To Netherlands

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<td>12.88</td>
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<td>13.66</td>
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<td>10.83</td>
<td>10.45</td>
<td>9.05</td>
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<td>9.54</td>
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V. To Belgium-Luxembourg

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<td>$9.72</td>
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<td>8.79</td>
<td>8.98</td>
<td>7.70</td>
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<td>7.34</td>
<td>7.58</td>
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<td>Brazil (Fe. 65%)</td>
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Source: European Coal and Steel Community (Not for public attribution until publication about May 1967.)
price data from 1954 to 1965 for all regular transactions between iron ore source and destination; however, in our discussion we shall only focus on the last three years: 1963 to 1965. The observations for these years will be sufficient to prove that there must still have been and, since the basic conditions which held in 1965 also hold today, continue to be considerable barriers to competition in the American iron ore market.

We shall proceed with our proof by showing that at certain key points of American steel production maximum estimates of the cost of imported iron ores are significantly less than the quoted price of even the poorest (cheapest) grade of Mesabi iron ore. Since the quoted price of

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The Lake Erie Price is set for iron ore with an assessed content of 51.5 percent natural iron. Since all of the imported iron ore has an average iron content considerably richer than this, we deflate the average price of iron ore at any given ECSC country from any given source so as to express the price in terms of ore with a standard iron content of Fe. 51.5 percent. Our deflation yields an underestimate for the more recent years because the average iron content of these foreign ores has been rising over time. Specifically we used the following four step procedure:

1. From the average iron content of the foreign iron ore we subtract 51.5 percent.
2. Then we divide the remainder from step one by 51.5 percent to find out the fraction by which the iron content of the foreign ore is richer than the Lake Erie standard of 51.5 percent.
3. We then multiply the delivered price which the ECSC quotes for the foreign ore by the result of step two.
4. Finally the result of step three is subtracted from the ECSC posted price to give the entry presented in TABLE I-4.

To illustrate: In 1965 the price of Liberian iron ore (Fe. 66 percent) in West Germany was $10.58. Hence our adjustment was

1. \( (66.0\% - 51.5\%) = 14.5\% \)
2. \( (14.5\%)/(51.5\%) = 0.282 \)
3. \( ($10.58)\cdot(0.282) = $2.98 \)
Mesabi iron ore is apparently the price which those steel firms not self-sufficient in iron ore are often forced to pay, since there is no tariff on imported iron ore, and since Mesabi iron ore is in fact consumed (almost exclusively) at these locations, this implies that there are some barriers to the entry of foreign iron ore.

I

The main countries which regularly ship large quantities of iron ore to the United States and to at least one of the five member countries of the ECSC are Canada, Brazil, Venezuela, Peru, and Liberia. The distance in nautical miles of these five sources of iron ore from the principle ore ports of the United States, Canada, and of the five ECSC countries are given in TABLE I-5 on the next page. TABLE I-5 shows:

1. Both Baltimore, Maryland (which along with Philadelphia, Pennsylvania, is one of the two principle American iron ore importing ports) and Sept Iles, Canada, are at least one thousand miles closer to the principle ore exporting ports of Canada, Venezuela, and Peru than are any of the ECSC ports.

2. The two North American ports are also marginally closer to Vitoria, Brazil than are any of the ECSC ports.

3. The distance to Baltimore from Monrovia, Liberia, is approximately 1,000 miles longer than the distance from Monrovia to any of the ECSC ports. The distance from Monrovia to Sept Iles is approximately 500 miles longer than the distance to any of the ECSC ports.
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<thead>
<tr>
<th>From:</th>
<th>To:</th>
<th>U.S.A.:</th>
<th>Canada:</th>
<th>France:</th>
<th>W. Germany</th>
<th>Nether.:</th>
<th>Italy:</th>
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<td>Baltimore</td>
<td>1,429</td>
<td>948</td>
<td>1,757</td>
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<td>Cleveland</td>
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<td>4,219</td>
<td>4,777</td>
<td>5,491</td>
<td>3,829</td>
<td>3,208</td>
<td>3,560</td>
</tr>
</tbody>
</table>
Making three assumptions and using only the data already presented we will be able to determine maximum estimates of what should have been the c.i.f. price of iron ore shipped from Canada, Brazil, Peru, or Venezuela to either Baltimore or Sept Iles. Since in fact Mesabi iron ore apparently sells at these locations at a higher price than the maximum price that we will compute for the imported ores, we will be forced to conclude either that the data already presented is faulty or that one or more of the three assumptions is untrue. The three assumptions are

1. Iron ore freight rates are purely competitive; therefore, the price of shipping iron ore equals its marginal cost.
2. All elements of the iron ore industry are purely competitive; hence, iron ore importers, regardless of where they are located, pay the same f.o.b. price at any given ore source for any given quality iron ore.
3. Excluding the different percentage contents of natural iron contained in various ores (we have already taken account of this in computing the prices for TABLE I-4) the steel firms assume that there are no other quality or risk differences between foreign or domestic iron ores.

Since the distance to either Baltimore or Sept Iles from any given one of these four ore sources is always less than the distance to any one of the ECSC ports, then given the above three assumptions there would be only two ways that the c.i.f. price for imported iron ore could be higher at the North American ports than at the ECSC ports:

1. If either Baltimore or Sept Iles were unable to handle ore ships as large as the ECSC ports, then, since ore shipping enjoys
scale economies, the c.i.f. price may be higher at these North American ports than at the ECSC ports. Since in actual fact both Baltimore and Sept Iles can handle ore ships at least as large as those which the ECSC ports are capable of handling, this exception is not empirically relevant.

2. In charging a rate to ship any commodity between two ports, a relevant factor to consider is whether or not the ship will be able to find a cargo at the port where it unloads. If it cannot, it will have to travel in ballast, and hence earn no freight revenue, to a port where it can get a new cargo. Therefore it is obvious that, ceteris paribus, the cost of shipping a given cargo a given distance will be less if the prospects of getting some type of back-haul are good. In the case of ore boats the most likely back-hauls are grain and coal. The ECSC countries export minimal amounts of both commodities. Baltimore exports massive amounts of both commodities---especially coal from Hampton Roads. Sept Iles is a major grain and iron ore exporter.

In light of the foregoing, one conclusion appears to be inevitable—the c.i.f. price for any given grade of iron ore from either Canada, Venezuela, Peru, or Brazil must be less at both Baltimore and Sept Iles than it is at any of the ECSC ports.  

---

95. We cannot (and we do not) make such a strong statement about the maximum cost of Liberian iron ore at both Baltimore and Sept Iles because the distance from Monrovia, Liberia, to either of these ports is somewhat greater than the distance from Monrovia to any of the ECSC ports. However, the reader should note that in TABLE 1-4 it is shown that in most ECSC countries Liberian iron ore is typically at least $1 per ton cheaper than iron ore from the next best (cheapest) alternative. Since Baltimore and Sept Iles are at the maximum only 1,011 miles farther from (continued)
In TABLE I-6, which is presented below, we present overestimates of the maximum c.i.f. price of iron ore, from the four foreign sources, at both Baltimore and Sept Iles. This Table was constructed by observing (for the years 1963 to 1965) which of the four ECSC ports had the lowest c.i.f. price of iron ore imported from a given source and then entering this figure in the appropriate cell. 96

TABLE I-6

Maximum Price at Baltimore and Sept Iles
Per Ton of Iron Ore (with Fe. 51.5%) From:

<table>
<thead>
<tr>
<th>Ore Source</th>
<th>1963</th>
<th>1964</th>
<th>1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puerto Ordaz, Venezuela</td>
<td>$9.10</td>
<td>$8.03</td>
<td>$7.75</td>
</tr>
<tr>
<td>Sept Iles, Canada*</td>
<td>7.52</td>
<td>7.34</td>
<td>7.58</td>
</tr>
<tr>
<td>San Juan, Peru</td>
<td>9.24</td>
<td>9.57</td>
<td>9.74</td>
</tr>
<tr>
<td>Vitoria, Brazil</td>
<td>9.09</td>
<td>8.86</td>
<td>7.60</td>
</tr>
</tbody>
</table>

* The entry for the price of iron ore at Sept Iles, Canada, from Sept Iles, Canada, is necessarily a huge overestimate of what should be its cost there. The reason for the large overestimate is that transport costs (which are included in the above measure for about a 3,000 nautical mile trip) are in fact equal to zero.

95 (cont.)
Liberia than is the closest ECSC port, and since the marginal cost of long haul ore shipments is very low (e.g., the ore ship spends proportionately less time in the port), it is very doubtful that the maximum c.i.f. price of Liberian iron ore at either Baltimore or Sept Iles would be more than $1 per ton greater than the c.i.f. price at the ECSC ports.

96 The overestimate which this measure gives is considerable. Some indication of this was revealed in some private correspondence between the author and an official of a major iron ore importing firm. This official indicated that in 1967 most high quality foreign iron ore was being imported at East Coast ports at a cost of about $6.50 per long ton. With one exception this is at least $1 per ton less than the overestimates presented in TABLE I-6.
Over the same three years the Lake Erie Price of Mesabi, Non-Bessemer iron ore (the cheapest class of Great Lakes iron ore) was 1963--$10.65, 1964--$10.55, and 1965--$10.55. Obviously, since the cost of transporting ore from a lower Lake Erie port to either Baltimore or Sept Iles is positive, we would expect imported iron ore to dominate Mesabi iron ore at both locations. This implication is consistent with the statement made to this author by an official of the Bethlehem Steel Company that Bethlehem's huge tidewater plant at Sparrows Point, Maryland, gets all of its iron ore from four sources: Canada, Venezuela, Liberia, and Chile. No Mesabi iron ore is consumed at Sparrows Point. But, Mesabi iron ore is the main type of ore consumed at Pittsburgh. Is this consistent with both our maximum estimates of the cost of foreign iron ore at Baltimore and at Sept Iles and with the published Lake Erie Price?

II

The American Iron Ore Association [3] publishes statistics showing both how much iron ore is consumed in various broad geographical regions of the United States and whether the ore was domestic or foreign: The data show that for the years 1963 to 1965 approximately 50 percent of all iron ore consumed in the New York, Ohio, Pennsylvania, New Jersey, and Rhode Island area was from the Great Lakes region of the United States; whereas, approximately 40 percent of all iron ore consumed here was foreign.  

97 The remaining 10 percent was from such American mines as Bethlehem Steel's Grace Mine at Morgantown, Pennsylvania. Here it is perhaps relevant to note that in 1962 it was alleged that the very high quality ore from the Grace Mine could be delivered to Bethlehem Steel's Bethlehem Plant at a total cost of less than $10 per ton [6].
Most of the non-Canadian foreign iron ore was consumed at four major East Coast steel plants: The Bethlehem Steel Company plants at Sparrows Point, Maryland, and at Bethlehem and Steelton, Pennsylvania, and the United States Steel Company's Fairless Plant on the Delaware River tidewater at Morrisville, Pennsylvania. Most of the Canadian iron ore shipped to this region and not consumed at either the Sparrows Point or Fairless plants was consumed at Bethlehem's large Lackawanna Plant near Buffalo, New York. In the light of the foregoing, it is obvious that most of the Great Lakes' iron ore consumed in the New York, Ohio, Pennsylvania, New Jersey, and Rhode Island region was consumed in Western Pennsylvania (the so-called Pittsburgh Region) and Ohio.

We shall now show, by two different ways, that if the three assumptions listed on page 113 are correct then the maximum cost of foreign iron ore at Pittsburgh must be less than the quoted price of Mesabi iron ore at Pittsburgh. Moreover, if the ore sellers do not cut the quoted Pittsburgh price of Mesabi iron ore; then, given the truth of the assumptions, we would expect none of this ore to be sold at Pittsburgh. Since Mesabi iron ore is in fact the chief iron ore consumed at Pittsburgh and since it is apparently sold at its quoted price, this suggests either that the purchasers of this ore are stupid or that one or more of the three assumptions is false.

The first method by which we shall demonstrate that the cost of imported iron ore is less at Pittsburgh than the quoted price of Mesabi iron ore is simply by adding the published unloading and freight costs from the port to Pittsburgh to the c.i.f. price (at either Baltimore or the lower Lake Erie port) for both types of iron ore. Over the period
1963 to 1965 the published cost [23] of unloading ore boats and of rail shipment of iron ore from the lower Lake Erie ports to Pittsburgh was $2.95 per ton. Over this same period the cost of unloading the ore boats and of rail shipment from Baltimore to Pittsburgh was $3.31 per ton. TABLE I-7, presented below, summarizes these calculations and shows that the maximum delivered price at Pittsburgh of iron ore from the four foreign sources is in all cases less than the delivered price at Pittsburgh.

<table>
<thead>
<tr>
<th>Ore Origin</th>
<th>1963</th>
<th>1964</th>
<th>1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesabi</td>
<td>$13.60</td>
<td>$13.50</td>
<td>$13.50</td>
</tr>
<tr>
<td>Puerto Ordaz, Venezuela</td>
<td>12.41</td>
<td>11.34</td>
<td>11.06</td>
</tr>
<tr>
<td></td>
<td>(-1.19)</td>
<td>(-2.16)</td>
<td>(-2.44)</td>
</tr>
<tr>
<td>Sept Iles, Canada**</td>
<td>10.83</td>
<td>10.65</td>
<td>10.89</td>
</tr>
<tr>
<td></td>
<td>(-2.77)</td>
<td>(-2.85)</td>
<td>(-2.61)</td>
</tr>
<tr>
<td>San Juan, Peru</td>
<td>12.55</td>
<td>12.88</td>
<td>13.05</td>
</tr>
<tr>
<td></td>
<td>(-1.05)</td>
<td>(-0.62)</td>
<td>(-0.45)</td>
</tr>
<tr>
<td>Vitoria, Brazil</td>
<td>12.40</td>
<td>12.17</td>
<td>10.91</td>
</tr>
<tr>
<td></td>
<td>(-1.20)</td>
<td>(-1.33)</td>
<td>(-2.59)</td>
</tr>
</tbody>
</table>

* The difference in the Pittsburgh price of iron ore from any given foreign source as opposed to the Pittsburgh price of Mesabi iron ore is given in parentheses.

** The Pittsburgh price of Sept Iles iron ore (which we present above) must be an overestimate for in fact this ore would be shipped directly from Sept Iles to Pittsburgh.
of the Mesabi iron ore.\textsuperscript{98} If the Lake Erie Price of Mesabi iron ore is at all indicative of its real cost then continued use of this ore in the Pittsburgh district appears irrational.

The second and more dramatic method by which we shall demonstrate that given all of the foregoing assumptions the cost of foreign iron ore at Pittsburgh must be less than the quoted cost of Lake Erie iron ore at Pittsburgh is by showing that even at the lower Lake Erie ports the three assumptions and our overestimates of the c.i.f. price of imported iron ore at Sept Iles together imply that iron ore from Canada, Venezuela, and Brazil could apparently be bought at a price less than the quoted Lake Erie Price for Mesabi, Non-Bessemer iron ore. Hence ore from these three foreign sources should be cheaper than Mesabi iron ore at any point in the continental United States that currently receives its Mesabi ore only after transhipment through a lower Lake Erie port.

We make the above outlined calculation by adding to the maximum estimates of the c.i.f. price of iron ore from the four foreign sources (given in TABLE I-6, page 115) at Sept Iles, Canada, a maximum estimate of the per ton freight and handling costs involved in shipping this ore the 900 miles from Sept Iles to a lower Lake Erie port. Our maximum estimate of the per ton additional freight and handling cost is $1.50--this estimate includes a $1.00 per ton charge for freight and a $.50 per ton charge for handling. The handling charge is an overestimate because only

\textsuperscript{98} Since the foreign ore contains a higher percentage iron content than the domestic direct shipping ore, the difference in transport costs between Baltimore and Pittsburgh, and the lower Lake Erie ports and Pittsburgh is not as great, per unit of iron content, as the above figures indicate. Hence the estimates of the Pittsburgh price of imported iron ore are an even greater overestimate of the true maximum cost than was the estimated maximum cost of this ore at Baltimore.
the largest ore boats would be forced to transfer their cargoes to smaller lake ore boats at Sept Iles in order to complete the journey; hence, since the smaller boats incur no handling charge the average handling charge would be considerably less than $.50 per ton. The maximum estimates of the price of iron ore at the lower Lake Erie ports are presented below in TABLE I-8.

TABLE I-8

<table>
<thead>
<tr>
<th>Ore Origin</th>
<th>1963</th>
<th>1964</th>
<th>1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesabi</td>
<td>$10.65</td>
<td>$10.55</td>
<td>$10.55</td>
</tr>
<tr>
<td>Puerto Ordaz, Venezuela</td>
<td>10.60</td>
<td>9.53</td>
<td>9.25</td>
</tr>
<tr>
<td></td>
<td>(-0.05)</td>
<td>(-1.02)</td>
<td>(-1.30)</td>
</tr>
<tr>
<td>Sept Iles, Canada**</td>
<td>9.02</td>
<td>8.84</td>
<td>9.08</td>
</tr>
<tr>
<td></td>
<td>(-1.63)</td>
<td>(-1.71)</td>
<td>(-1.47)</td>
</tr>
<tr>
<td>San Juan, Peru</td>
<td>10.74</td>
<td>11.07</td>
<td>11.24</td>
</tr>
<tr>
<td></td>
<td>(+0.09)</td>
<td>(+0.57)</td>
<td>(+0.69)</td>
</tr>
<tr>
<td>Vitoria, Brazil</td>
<td>10.59</td>
<td>10.36</td>
<td>9.10</td>
</tr>
<tr>
<td></td>
<td>(-0.06)</td>
<td>(-0.19)</td>
<td>(-1.45)</td>
</tr>
</tbody>
</table>

* The parentheses enclose the difference between the cost at a Lake Erie port of any given imported iron ore minus the Lake Erie Price of Mesabi, Non-Bessemer iron ore.

** The cost of the Canadian iron ores involves a huge overestimate because it includes the cost of transport from Sept Iles to Belgium. To get the actual f.o.b. Sept Iles cost this transport cost should be deducted. Since the completion of the St. Lawrence Seaway only in the rarest of circumstances could the 900 mile trip from Sept Iles to a lower Lake Erie port cost more than the 3,000 mile trip from Sept Iles to Belgium. Hence the most reasonable maximum estimates of the real cost of Sept Iles iron ore at the lower Lake Erie ports are those given in TABLE I-6, page 115; i.e., 1963--$7.52, 1964--$7.34, and 1965--$7.58.
III

If all of the foregoing assumptions and data are approximately true, we face a major dilemma. Specifically, TABLES I-7 and I-8, which were constructed on the basis of the foregoing data and assumptions, reveal that iron ore from at least four countries: Canada, Brazil, Peru, and Venezuela, could apparently be shipped via Baltimore to Pittsburgh and sold there at a price considerably below the quoted Pittsburgh price of Mesabi, Non-Bessemer iron ore. Moreover, iron ore from at least three countries: Canada, Brazil, and Venezuela, could apparently be shipped via Sept Iles to a lower Lake Erie port and could be profitably sold there at a price which was actually less than that price which our earlier discussion indicated was the key price upon which most iron ore sales in the United States are based—the Lake Erie Price of Mesabi, Non-Bessemer iron ore. This latter fact implies that iron ore from any of these three foreign sources should be cheaper than Mesabi iron ore at any point in the continental United States that currently receives its Mesabi ore only after transhipment through one of the lower Lake Erie ports. Hence, since the quoted Lake Erie Price apparently is not cut, we would expect that no sales of Mesabi iron ore would take place in any of these areas where its quoted price was greater than our overestimates of the price of imported ores. Contra to our expectations we do observe that massive quantities of Mesabi iron ore are in fact sold both at Pittsburgh and at the lower Lake Erie ports. Therefore we must conclude either

1. That the facts (data) upon which our results are based are wrong—in particular that they are underestimates rather than overestimates of the c.i.f. price of foreign iron ore delivered to the
major ports.

2. That the lower Lake Erie Price is not a good measure of the real cost of Mesabi iron ore—that it is a price used only for accounting purposes.

3. That one or more of the three assumptions presented on page 113 are false.

As the footnotes on pages 114, 115, 118, and 120 should indicate, the entries presented in TABLES I-7 and I-8 are almost certainly very large overestimates (probably at least $1 per ton) of what would be the actual c.i.f. cost of imported iron ore at either Pittsburgh or at a lower Lake Erie port. Hence, we may dismiss reason one as a possible explanation as to why Mesabi iron ore is in fact sold at both locations.

For the moment we shall ignore reason two and turn to reason three—the possibility that one or more of the three assumptions presented on page 113 may not be true. If they are not true then we must seek to determine whether their violation is strong enough to explain the observed phenomenon of spot sales of domestic iron ore actually occurring at the apparently very high Lake Erie Price.

Of the three assumptions, assumption one—that freight rates for internationally traded iron ore are purely competitive (and hence price = MC)—is most closely met. The main reason why this assumption is necessarily a fairly accurate depiction of the state of affairs in the international iron ore transport market is due to the fact that any steel company always has the option to directly provide for the ocean transport of the iron ore it desires. Moreover, unlike many industries, the steel industry has not been adverse to actually undertaking such a step. Thus,
for example, we observe that United States Steel owns the largest fleet of Great Lakes ore boats and that Bethlehem Steel has traditionally been a large shipper of iron ore in its own bottoms--both from the Great Lakes and from Chile and Venezuela. Why has the steel industry, unlike for example the automobile industry, so actively engaged in providing its own transportation for its raw materials? The answer to this question is indicated in the following quotation [1, p. 9] which describes one of the basic characteristics of any steel company.

Huge quantities of raw materials are needed. The steel industry handles more materials per ton of finished product and in a greater variety of ways than any other large scale manufacturing industry in the world. A ton of steel may require iron from ore mined in Minnesota, limestone from Michigan, coal from West Virginia, manganese from India, fuel oil from Texas, scrap from Oklahoma, magnesite from Washington, dolomite from Oregon, ferrosilicon from New York, and other raw materials from other states or other continents.

Thus one possible view of a steel company (and analogously of an oil company or any other type of natural-resource-orientated company) is simply as a giant transportation complex which assembles a great variety of raw materials at one location and then, using labor and capital, chemically combines them and mechanically processes them to produce the great variety of products which we call steel. Steel companies (unlike, for example, automobile companies) have historically been vitally concerned with the transportation of their factors. They have considerable expertise in the field. Therefore it is almost impossible for any international iron ore shipper to charge the steel companies a price for transportation that is much in excess of the purely competitive price since
such a high price would induce them to enter the ore shipping industry.\footnote{Another reason why it is relatively easy to enter the ocean ore transport market is, as Professor Zenon Zanetos indicated in *The Theory of Oil Tankship Rates*, that there appear to be almost no scale economies associated with owning many ships; i.e., a one ship operator can operate at the same average costs as a twenty ship operator. Also the cost of one ore ship is not large relative to the asset size of most steel firms; hence, a capital shortage should not be a particularly severe barrier to entry. Note the contrast of the foregoing with ore-hauling railroads. These typically enjoy scale economies and have a cost which is large even relative to the asset size of many steel companies; hence, they have often been able to establish effective monopolies and to charge a monopoly price.}

But, even if the ocean ore transport industry can be monopolized, it is nevertheless still unlikely that the monopolist would either find it profitable to or be able to charge American iron ore importers a price which was higher than that which they would charge any of the ECSC iron ore importers for the same service. Hence even if the freight market were monopolistic—and to again reiterate this is most unlikely—we are safe in concluding that any American steel firm which contracts to import iron ore on a regular basis ought to pay a price for freight which is no higher than the price paid for a similar trip by any of the ECSC iron ore importers.\footnote{We have shown that it is very unlikely that any ore shipper could earn monopoly profits by discriminating and charging the American steel companies monopoly freight prices; however, wouldn't it be possible for the ship builders to indirectly monopolize the entire ocean ore transporting business by selling ships to both freight companies and to steel companies but only at the monopoly price? There are two reasons why this is doubtful: First, the ship-building industry appears to be highly competitive—it is very difficult to get effective collusion between independent ship building yards, in, for example, Japan, West Germany, and England. Second, most steel companies have considerable expertise in metal fabrication. Thus the steel companies are one of the most likely firms to enter the ship-building industry (this is of course illustrated by the very important positions which both Bethlehem Steel and Kaiser Engineering have historically played in ship-building). Even if collusion among the current boat builders were possible, it is unlikely that they would engage in a pricing policy which would encourage a potentially very effective competitor to enter the industry.} Hence we as yet have no reason for doubting the assertion...
that TABLES I-7 and I-8 do indeed provide an overestimate of what should be the maximum cost of imported ore at either Pittsburgh or the lower Lake Erie ports.

For the moment we shall refrain from discussing assumption two—that all elements of the iron ore industry are purely competitive—and consider assumption three—that having taken account of the different percentage contents of iron in ore from different sources, the steel firms assume that there are no other quality or risk differences between domestic or foreign iron ore. Obviously this assumption is not strictly true. First it is often alleged that the typical American steel firm's subjective evaluation of the risk associated with foreign as opposed to domestic iron ore is that the former contains the larger risk. Therefore, the argument goes, they quite rationally require a risk premium (more accurately a risk discount) before purchasing the foreign ore. The reasons for requiring a higher risk premium on foreign iron ore are both real and subjective. For example, the following two facts:

1. The foreign supply lines are longer. Hence it is alleged that they are more likely to be disrupted.

2. Most foreign iron ore sources are in countries which are, rightly or wrongly, considered to be politically less stable than the United States. Hence there is the distinct possibility (a la the repeated Suez crises) that for political reasons they may be shut down.

provide two real reasons for foreign iron ore being considered to be riskier than domestic iron ore. However, the way each importing firm

101 Counter balancing these causes for foreign iron ore being riskier than domestic is the fact that pooling iron ore from many different geographic sources reduces risk.
evaluates such additional risks is of course highly subjective. Those firms which make the most realistic evaluation of the real cost of the risk should in the long-run prove to be most successful. Second there are many other relevant aspects of iron ore quality besides percentage iron content. The three most important are phosphorus content, silica content, and physical structure of the ore—whether it is lumpy or fine. These properties are fully specified in individual iron ore sales; however, this author knows of no specific data on these properties with respect to the average unit of iron ore traded between any two countries. We therefore must appeal to a much weaker type of evidence in order to assess this ore's quality. In particular we appeal to the "conventional wisdom" which asserts that iron ore from the foreign sources which we are considering is generally of at least equal quality and usually of higher quality with respect to the three factors cited above than is the Mesabi direct shipping ore. 102 When we remember that the domestic iron ore, upon whose price we have based all of our calculations, is Mesabi, Non-Bessemer, the poorest quality major class of iron ore shipped from the Great Lakes region, it appears very likely that the conventional wisdom must indeed be correct in its evaluation that the foreign iron ore is of a quality at least equal to the domestic.

But, nevertheless, suppose that judged by both the risk and quality criteria, the imported iron ore is indeed inferior to Mesabi direct

102 Almost invariably all references to the imported iron ore mention its high quality. Unfortunately, often this reference only refers to its percentage iron content. For an example of the conventional wisdom about the quality of foreign iron ores see any of the recent editions of the Minerals Yearbook.
shipping ores. Then the real question becomes whether or not this inferior quality is sufficient to cancel out the demonstrated price advantage which this ore apparently has at both Pittsburgh and at Lake Erie. This author doubts that it is for the following three reasons:

1. We have shown that iron ore from at least four foreign sources (and probably five if we include Liberia) can be delivered to Pittsburgh at a price less than the quoted price of Mesabi direct shipping ore. Similarly there are at least three foreign sources (and again including Liberia probably four) which could supply iron ore to the lower Lake Erie ports at a price less than that currently quoted. Given this multiplicity of sources the possibility of political unrest at any given source should not be particularly bothersome for one could rather quickly (and with little additional cost) turn to ore from other foreign sources. 103

2. The supply lines to the United States from any of the foreign iron ore sources (except in some cases from Sept Iles, Canada) are indeed longer than the supply lines over which the Mesabi ore traverses; however, this does not necessarily imply that they are riskier. In particular, ore shipped over the upper Great Lakes encounters two major types of risk not encountered by most shipments of foreign ore to the United States: Risks associated with crossing the northern Great Lakes during violent

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103 In fact the risk premium associated with foreign iron ores should perhaps be less than that associated with domestic taconite pellets. The reason being that if one foreign ore source is, for any reason, suddenly shut down the others can usually (as World War II demonstrated) rather quickly raise production. In contrast if a capital intensive taconite processing plant shuts down the other taconite processing plants--already being run at full capacity--cannot expand their output.
blizzards, and risks associated with navigating the narrow locks which connect these northern lakes to Lake Erie.  

3. Today even the highest quality iron ore typically receives considerable processing before entering the blast furnace. This has had the result of lessening the economic importance of those differences in the quality of iron ores which are not based on different natural iron contents. In particular this has led to a relative rise in the demand for the cheaper types of ore which are then processed in the importing country. In turn this change in the nature of iron ore demand has caused a lessening of the price gap (in the world iron ore market but apparently not in the American iron ore market) between high quality and low quality ores. Perhaps the best example of this has been the dramatic fall in the price of the very high quality Brazilian lump iron ore which has occurred since 1954.

We therefore conclude that for a given quality iron ore, taking into account all real and subjective differences and adjusting for different iron contents, the imported iron ore would indeed be cheaper than the quoted price of the Mesabi iron ore at both the lower Lake Erie ports and at Pittsburgh. Given this we would expect that no Mesabi iron ore would be consumed at either location. In fact, however, large amounts of Mesabi

104 For an example of the real costs due to this risk the reader is referred to [18, p. 104] where Mr. T. M. Rohan states: "Tragedy struck last week as the Great Lakes iron ore fleet wound up a big season. During a vicious storm on Lake Huron, Bethlehem Steel’s ore boat Daniel J. Morell broke and sank; a German steel-carrying cargo ship, The Normadeer, had the same misfortune."
iron ore are consumed or sold at both locations. There remains only one possible explanation for this phenomena; i.e., that assumption two—that all elements of the iron ore industry are purely competitive—is false.

If assumption two were true then since $p^\text{ore} = MC^\text{ore}$ no steel companies (not even those that are integrated backwards) could rationally use the high priced Mesabi ores at either Lake Erie or Pittsburgh. However, if the iron ore industry does contain some monopoly elements then $p^\text{ore} > MC^\text{ore}$ and those steel companies which are integrated backwards into the production of Mesabi iron ore may quite rationally use their own ores. 105 However, in no circumstance would a non-integrated steel producer find it profitable to pay the quoted price for domestic iron ore since imported iron ore could be obtained at a lower price. If we can find that some non-integrated firms did in fact buy domestic iron ore then we must presume that the monopoly power of the domestic iron ore industry was so strong that they were actually able to prevent the foreign iron ores from being shipped to either Pittsburgh or the lower Lake Erie ports and being sold there at prices as low as those which TABLES I-7 and I-8, respectively, suggested were maximums. But what could be the nature of such barriers? We have already indicated that monopolization of the ocean freight market is very difficult and that even if possible price discrimination against American iron ore importers is most unlikely; therefore, the only possible way that the domestic iron ore producers could maintain the high Lake Erie Price for spot sales

105 This is the same as reason two on page 122—that the Lake Erie Price is not a good measure of the true cost of Mesabi iron ore for the backward integrated steel company. The steel companies would use their captive ores so long as the delivered MC of captive ore was less than or equal to the delivered price of foreign ore.
would be by getting the sources of foreign iron ore to set an f.o.b. price for their iron ore which was higher for the non-integrated American steel firms than it was for the European steel firms. Hence we now face two questions:

1. Is this possible?
2. Is this likely?

The answer to both questions is yes.

First, as long as the different foreign iron ore sources can effectively collude price discrimination is possible. Thus the real question is whether or not effective collusion is possible. History is replete with examples (e.g., shipbuilding and agricultural products) where collusion has been impossible when the independent competing firms (sources of supply) have been located in different countries. Therefore, at first glance, we might expect the same to occur in iron ore. It does not! The reason why inter-country competition for sales to the American iron ore market does not exist is because the relevant foreign iron ore sources are dominated by the major American iron ore and steel companies. In Appendix I we give some indication of the extent to which the major iron ore sources of Canada, Peru, Venezuela, Brazil, and Liberia are controlled by the same companies which control the domestic iron ore industry. As we indicated previously, it is in the interest of these companies to maintain a very high nominal price for iron ore. Hence, we would expect them to attempt to prevent the non-integrated American steel companies from importing foreign iron ores at a c.i.f. price lower, at any given point, than the price of Mesabi iron ore because if they succeeded in doing this it would make the Lake Erie Price meaningless.
The obvious way to prevent the occurrence of the foregoing is by charging the non-integrated American steel firms a non-competitive f.o.b. price for foreign iron ore. The fact that at the time of this writing (1968) the Lake Erie Price still functions is perhaps the best evidence that this has in fact been done. 106

Finally, the fact that some domestic steel companies use both captive foreign and captive domestic iron ore is perhaps the best evidence that the marginal cost of Mesabi iron ore is still much less than what we might infer merely by looking at the Lake Erie Price. Specifically, if the American steel companies which own and consume both domestic and foreign iron ore are profit-maximizers we know that the delivered marginal cost of iron ore from both sources must be equal. Hence, if we refer to TABLE I-7) we observe that the real cost of Mesabi iron ore at Pittsburgh (e.g., in 1965) could not have been greater than $10.89 per ton, and since the cost of shipping iron ore from a lower Lake Erie port

106 In [19, pp. 41-43] it is stated: "New imports are knocking on the door too. There are reports of offerings of Australian pellets at 24c per iron unit delivered in Pittsburgh compared to the U. S. published price of 25.2c delivered in lower Lake Erie ports. These would not be available for about two years (1969), but pose a threat." Unlike the other sources of iron ore which we considered in the text, the Australian deposits are not dominated by the same firms which dominate the American iron ore industry. Therefore, it is quite likely that ore from this source might initiate competition for sales to the American market. Recently (fall, 1968) at least one American steel company has apparently responded to this threat. The Bethlehem Steel Corporation has purchased a 3 percent interest in the Rio Tinto Zinc Company and has also agreed to invest $50 million with Rio Tinto in a joint ore mining subsidiary. Rio Tinto is a major producer of Australian iron ore. Here we should perhaps also reiterate that the above discussion is in no way inconsistent with the sharp rise in iron ore imports beginning in 1954. The iron ore imports were almost entirely from mines owned by the American steel companies. These companies pay the marginal cost of producing this ore plus transport costs. We have demonstrated that the marginal cost may indeed be much less than the Lake Erie Price.
to Pittsburgh was $2.95 per ton, we can compute that the maximum Lake Erie Price in 1965 should have been $7.94.\footnote{107} In fact the quoted Lake Erie Price was $10.55. Therefore we conclude that at a minimum in 1965 the quoted Lake Erie Price was at least $2.61 (i.e., $10.55 - $7.94) greater than our maximum estimate of the marginal cost of Mesabi, Non-Bessemer iron ore.\footnote{108} Thus, even though since the War and especially since 1957 the American iron ore industry has become more competitive we must conclude that its performance is still far from what we would expect to observe if it were a perfectly competitive industry.

\footnote{107} We use as our figure for the maximum real cost of iron ore at Pittsburgh for a steel firm owning its own ore the computed price of Canadian iron ore at Pittsburgh. (See TABLE I-7.) We know that this is a large overestimate of the true real cost of this ore at Pittsburgh. A similar calculation for the years 1963 and 1964 reveals that in 1963 the maximum price at the lower Lake Erie ports for Mesabi iron ore should have been $7.88; whereas, in 1964 it should have been $7.70.

\footnote{108} A similar computation as that done above for the years 1963 and 1964 reveals that in 1963 the Lake Erie Price was at least $2.77 greater than the maximum estimate of its marginal cost; whereas, in 1964 it was at least $2.85 greater than the maximum estimate of its marginal cost. The perceptive reader might note that these figures are the same as those presented in parentheses in TABLE I-7, page 118.
APPENDIX I

The Equity Interests of American Steel and Iron Ore Companies in Foreign Iron Ore Deposits

In this Appendix we hope to give some documentation to support our contention that the major American iron ore and steel companies besides dominating the American iron ore industry also tend to dominate the iron ore industries of Brazil, Canada, Liberia, Peru, and Venezuela.

In Canada the two dominant iron ore producers (together accounting for two-thirds of Canada's 1965 iron ore production) are the Iron Ore Company of Canada and the Quebec Cartier Mining Company. The Iron Ore Company of Canada shipped 14.3 million tons of iron ore in 1965. Its American owners are Armco Steel, Hanna Mining, National Steel, Republic Steel, Bethlehem Steel, Wheeling Steel, and Youngstown Steel. Its Canadian owners are Hollinger Consolidated Gold Mines and the Labrador Mining and Exploration Company. The actual mining is managed by Hollinger-Hanna Ltd.--a firm which is equally owned by Hollinger Consolidated and by M. A. Hanna. In contrast to the joint ownership of the Iron Ore Company of Canada, only one firm owns the Quebec Cartier Mining Company--that firm is the United States Steel Corporation. In 1965 Quebec Cartier shipped 8.3 million tons of high-grade (64.5 percent Fe.) concentrates. Other smaller sources of Canadian iron ore include:

1. The Marmora Mine which is wholly owned by Bethlehem Steel and which shipped about .5 million tons of iron ore to Bethlehem's Lackawanna Plant in 1965.
2. The Wabush Mines which shipped 1.9 million tons of pellets in 1965. Wabush is an internationally owned company which is managed by Pickands, Mather. Jones and Laughlin, Inland Steel, and Pittsburgh Steel are part owners.

3. The Adams Mine which shipped 710,000 tons of pellets in 1965 and which is wholly owned by Jones and Laughlin.

4. The Steep Rock Iron Mines Ltd. which in 1965 was controlled by the Cyrus Eaton iron and steel interests.

There are only two developed sources of iron ore in Venezuela. The Orinoco Mining Company is a wholly owned subsidiary of United States Steel. In 1965 it produced about 14.4 million tons of high-grade iron ore. The Iron Mines Company is a wholly owned subsidiary of Bethlehem Steel. In 1965 it produced almost three million tons of high-grade iron ore.

The Liberian iron ore industry is composed of four firms. By far the largest is the Liberian American-Swedish Minerals Joint Venture Operating Company (LAMCO). In 1965 this firm shipped 8.7 million tons of ore. Bethlehem Steel owns 25 percent of this firm. The remaining 75 percent is owned by the Liberian American-Swedish Minerals Company. This latter company is 50 percent owned by the Liberian government and 50 percent owned by the Liberian Iron Ore Company. Bethlehem Steel takes 25 percent of LAMCO's output. The balance is contracted to West German, Belgium, French, Italian, Swedish, Japanese, and British steel interests. Liberia's second largest iron ore company is the National Iron Ore Company, Ltd. In 1965 this firm shipped 2.9 million tons. The author was unable to ascertain the ownership of this firm. The Liberia Mining Company which in 1965 shipped 2.2 million tons of iron ore, is Liberia's third
largest producer. In 1964 Republic Steel owned 59.18 percent of this firm. The author knows of no change in Republic's position since that time. Finally the smallest Liberian ore producer is the Bong Mining Company. In 1965 it shipped 1.5 million tons of iron ore. Its two owners are the Deutsch-Liberian Mining Company—a consortium of West German, Ruhr steel interests—which has 75 percent ownership and the Societa Finanziania Ria Siderurgica per Azioni which owns the remaining 25 percent.

The Brazilian iron ore industry (especially for exported non-manganese iron ore) is dominated by the government controlled Companhia Vale do Rio Doce. In 1965 it accounted for 10 million tons of Brazil's 12.7 million tons of iron ore exports. Almost none of this ore entered the United States.

The Peruvian iron ore industry is relatively small. It contains only two firms. The Marcona Mining Company and Panamerican Commodities S. A. In 1965 the former produced 6.8 million tons and the latter 800,000 tons. We are unable to ascertain who owns these firms. However, most of their output goes to Japan, and it does appear that Japanese iron and steel interests have a controlling interest in their affairs.
APPENDIX II: Data Used in Estimating the Iron Ore Model

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Percentage Iron Content of Lake Superior Iron Ores

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Sources for APPENDIX II

1. *Metal Statistics 1967* was the source for $P_{LE}$ and $P_S$.

2. *Minerals Yearbook* was the source for the percentage iron content of Lake Superior iron ores.

3. *The Economic Report of the President* was the source for $P_N$ and UNP.

4. *The Annual Statistical Reports of the American Iron and Steel Institute* were the source for $Q_F$, $Q_S$.

5. The American Iron Ore Association's yearbook, *Iron Ore*, was the source for $Q_S$.

6. *The Skillings Mining Review* was the source for $Q_T$. 
References to Essay I


Essay II

The American Market for Steel and Steel Labor:
1947 to 1968
The American Market for Steel and Steel Labor:
1947 to 1968

In Essay I we examined in detail the economic structure and performance of the American iron ore industry. Our major conclusion was that since at least 1915 this industry has been dominated by the major integrated American steel companies and moreover its performance has been most consistent with what we would expect to observe in an industry in which significant monopoly power was being exploited. A subsidiary implication was that the economic structure and performance of the American iron ore industry would have most likely been observed if the American steel industry had a similar economic structure and performance.

In Essay II we explicitly consider the economic structure and performance of the American steel industry in the post-World War II era. Unlike the more pristine iron ore industry, this subject has been oft violated. Indeed it has long been and remains one of the most popular and controversial areas in applied industrial economics.\textsuperscript{109} Hence we shall restrict our attention to an attempt to explain three interdependent phenomena:

1. The absolute level of and changes in steel prices from 1947 through 1968. In particular, why steel prices rose so much faster than most other prices between 1947 and 1958 whereas

\textsuperscript{109}\textsuperscript{See [1], [2], [4], [5], [6], [9], [10], [13], and [36] for examples.}
since then they have actually risen at a slower rate.


3. The fact that from 1947 through 1958 steel blue-collar wages rose roughly one and one half as fast (and started at a much higher absolute level) as most American manufacturing wages; whereas, from 1958 through 1967 these wages have risen at a rate roughly only two-thirds as fast as the rate in other American manufacturing.

We shall contend that the most reasonable explanation of the above phenomena is the following three-pronged hypothesis: 110

110 Besides our hypothesis (which is a variant of one presented by M. A. Adelman in [2]) there are two major alternatives: One, associated with Professors Joel Dirlam and Walter Adams, contends that the American steel industry has significant monopoly power and is run by rather stupid—non-profit-maximizing—and capricious men. The result has been that the price of steel has been set according to a rather arbitrary cost-plus formula. The second hypothesis was first suggested to this author by Professor Paul Cootner. Cootner suggests that perhaps the American steel industry had, at least since 1947, a competitive industry structure. But that until 1958 government pressure was strong enough to keep steel's price below what would be its competitive equilibrium. Thus Cootner would explain the almost continuous rise in the relative price of steel between 1947 and 1958 as being caused by the long-run adjustment of the firms in the industry to the short-run unprofitable (in an economic, not an accounting, sense) prices. Here we shall just note that the following six facts tend to cast some doubt on the validity of the Cootner hypothesis:

1. Until 1958 reported profit rates in the steel industry were roughly the same as in all U. S. manufacturing; moreover, conservative accounting practices tended to understate the true level of steel profits.

2. The existing steel companies engaged in massive investment programs throughout the 1950's.

3. Since the conclusion of World War II there has been entry by four new integrated forms—of which, McLouth, had major financial support from General Motors. (continued)
1. From 1947 through 1957 the American steel industry always had some potential unexploited market (monopoly) power. At any given moment the member firms were constrained in trying to fully exploit this power both by uncertainty about competitors' reactions and by repeated threats of government intervention. Naturally we would expect that the steel companies would attempt to circumvent both constraints. Recognizing that hourly labor costs typically rose at once and by almost the same amount for all steel companies (hence providing a good signal for initiating price hikes) and that the federal government did not look so askance at price hikes that were "cost justified," they began a practice of granting relatively large wage hikes followed by price hikes that were relatively even larger. This process has been labelled by Professor M. A. Adelman as the "Rites of Spring" [2]. The successful consumation of the "Rites" was that from 1947 through 1957 steel wage hikes, though larger than in most other industries, were nevertheless more than 100 percent shifted to steel consumers; i.e., steel price rises were, ceteris paribus, more than large enough to compensate for the higher hourly wage costs. Therefore, until 1958 both steel wages and steel profits rose. The result was comparative bliss for steel labor and capital. Unfortunately this process was not unbounded because as the relative price of steel continued to rise there would

110 (cont.)

4. Between 1947 and 1958 most steel common stocks performed better than the Dow Jones Industrial Average.

5. In the postwar period (until 1968) there is no evidence of any secret price cutting in steel.

6. Throughout the period steel wages have been at a very high absolute level.
continue to be more and more inducement to substitute other products for it; i.e., steel demand would tend to become more price-elastic. This meant that at some point higher labor costs could no longer be more than fully shifted to steel consumers. In the eleven years from 1947 through 1957 this point was not reached.

2. By 1958 the price of steel had been raised to such heights that—assuming no change in the basic demand and supply conditions—further relative price rises would lead to lower aggregate industry profits.

3. Since 1958 there has been a continued erosion of the American steel industry's monopoly power (i.e., at any given relative price the demand for American steel has increasingly become more price-elastic). The major causes of this have been increased competition from steel imports and a large amount of surplus domestic capacity which has hung over the market and made it more difficult for the domestic steel firms to successfully conduct any implicit collusion. Ceteris paribus the inevitable sum of both effects must be a fall in the relative price of steel.

II

Before attempting to document the above hypothesis we shall turn to a brief discussion of the data (presented in TABLE II-1) which it is intended to explain:
TABLE II-1


Entries:

1. \( Q = \) total steel shipments in millions of tons. The sum of total shipments by the American steel industry \( (Q_D) \) and total American steel imports \( (Q_I) \).

2. \( Q_D = \) total shipments by the American steel industry in millions of tons.

3. \( Q_I = \) total American steel imports in millions of tons.

4. \( Q_I/Q = \) total American steel imports divided by total steel shipments.

5. \( Q_X = \) total American exports of steel in millions of tons.

6. \( P_S = \) the Bureau of Labor Statistics' Index of Total Steel Mill Prices \((1957-59 = 100)\).


8. \( P_W = \) the Bureau of Labor Statistics' Wholesale Price Index.

9. \( P_I = \) the author's constructed index of imported steel prices \((1958-59 = 100)\).

10. \( P_F = \) the relative price of imported steel \((i.e., P_I/P_W)\).

11. \( W_B^S = \) the price of American steel blue-collar labor; \(i.e., \) the sum of all expenditures by the American steel industry for wage labor divided by the total hours worked.

12. \( W_B^M = \) average gross hourly earnings in all U.S. manufacturing.

13. \( AVC = \) the average variable cost of producing one ton of raw steel ingot.

14. \( TL = \) total labor costs per ton of raw steel ingot.

15. \( TI = \) total cost of materials, supplies, freight, etc. per ton of raw steel ingot.
Entries (Cont.)

16. \( Q^R_S \) = the American steel industry's total production of raw steel ingot.

17. \( \text{CAP} \) = the American steel industry's total capacity to produce raw steel ingots.

18. \( \text{CU} \) = the American steel industry's annual rate of capacity utilization (i.e., \( \text{CU} = 100(\text{CAP}/Q^R_S) \)).

19. United States Steel's share of total domestic steel shipments.

20. \( \text{TIP} \) = the Federal Reserve Board's Index of Total Industrial Production.

Sources:

1. Entries 1-8 and 11-18 may be found in or computed from data presented in the American Iron and Steel Institute's *Annual Statistical Report*.


3. Entry 19 is constructed from data presented in the annual reports of the United States Steel Corporation.

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1. Total steel shipments (Q) is defined to be the sum of total shipments by the American steel industry (Q_D) and total American steel imports (Q_I). This variable provides the best indicator of the maximum demand, at reigning prices, for American steel. Its value rose from 63.1 million tons in 1947 to a peak of 103.1 million tons in 1965. The rise was not near constant. Specifically, from 1947 through 1957 it tended to rise. In 1958 there was a dramatic fall and from 1959 through 1962 it fluctuated about a low plateau. Since 1962 it has resumed its rise once more.

2. Total shipments by the American steel industry (Q_D) rose from 63.1 million tons in 1947 to a peak of 92.7 million tons in 1965. Since this variable is the principal component of Q it has tended to move in analogous fashion; however, since 1958 the increasing role of steel imports has lessened the closeness of this relation.

3. Total American imports of steel (Q_I) were rather small in absolute terms until 1959. In that year there was a sudden dramatic rise. Since then the upward trend has continued. Perhaps a better measure of the importance of imports in the American steel market is provided by the ratio of Q_I to Q. This measure shows a sharp rise between 1957 and 1958. Since then it has trended ever higher. This suggests that steel imports first played a significant role in the United States in 1958 (not 1959) and that since that time their importance has increased.

4. Total American exports of steel (Q_X) averaged 3.96 million tons from 1947 through 1957. Between 1957 and 1958 they fell by 2.5
million tons and from 1958 through 1967 they averaged a mere 2.31 million tons. Two additional facts—that since 1958 world steel consumption has soared and that most American steel exports have been made only because they have been explicitly tied to American foreign aid—suggest that until 1957 American steel was competitive in the world market; whereas, since 1958 it has no longer been so.

5. Our measure of the American price of steel (P_S) is the Bureau of Labor Statistics' Index of Total Steel Mill Prices (1957-59 = 100). This data is of course beset with the usual index number problems. In addition some problem is caused by the fact that it is constructed from list prices. Between 1947 and 1967 there was no reported secret price-cutting; nevertheless, some implicit deviation from list prices did occur as individual steel companies responded to changing competitive conditions with changes in either freight absorption or service charges. All observers of the industry suggest that such implicit and unreported price-cutting was minimal; hence, the exclusion of its effects in the Bureau of Labor Statistics' data does not appear to be crucial. However, since 1967 the widespread secret price cuts have tended to rob this measure of meaning.

We tested this contention by regressing P_S as a function of a constant and the American steel industry's total revenue divided by its total sales. Examination of the residuals revealed the presence of significant first order serial correlation; however, except between 1957 and 1958 and 1965 and 1966, the examination did not support the hypothesis that there existed widespread secret cutting of list prices between any two years. Note: evidence for secret price-cutting would be provided if between any two years the algebraic value of the residuals (the actual list price minus the predicted list price) fell sharply.
6. The real price of steel \( P_{SR} \) is defined to be the Bureau of Labor Statistics' Index of Steel Mill Prices \( P_S \) divided by the Bureau of Labor Statistics' Wholesale Price Index \( P_W \). This measure rose constantly and dramatically from 1947 through 1958. Since then it has been stable.

7. The measure of the relative price of steel imports \( P_F \) is defined to be an index of imported steel prices \( P_I \) divided by the Bureau of Labor Statistics' Steel Mill Price Index \( P_S \). The author constructed the index of imported steel prices (1958–59 = 100) as the weighted average (weighed by the total value of American imports) of the Brussel's export price of merchant bars, wire rod, and plate. Because of data limitations the index begins in 1955 and ends in 1967. Data problems also prevented basing the index on a broader range of products. Since in recent years imports of steel sheet have soared, its exclusion may lead to some bias. The Brussels export prices are available for January of each year. Hence, to get the value of \( P_I \) presented in TABLE II-1 we simply averaged the two relevant observations; e.g., the 1955 entry for \( P_I \) is simply the average of \( P_I \) as calculated for January 1955 and \( P_I \) as calculated for January 1956. Finally, it should be noted that the relative price of steel imports \( P_F \) was very high from 1955 through 1957. Between 1957 and 1958 it fell dramatically (from 1.30 to 0.99). A fall of such magnitude—which was probably prompted by sudden over-capacity in Western Europe—could explain why in 1958 steel imports became for the first time an important (economic) substitute for American steel.
8. The price of steel's blue-collar labor \( (w^S_B) \) is defined to be the sum of all expenditures by the American steel industry for wage labor divided by the total hours worked. This measure (which includes all payments for pensions, social security, etc.) has risen almost without exception from $1.95 in 1947 to $4.93 in 1967. Part of this rise may have been due to improvement in the quality composition of the work force; however, most was undoubtedly due to wage and benefit rises. Over the same period the average gross hourly wages in all U. S. manufacturing \( (w^M_B) \) rose from $1.22 to $2.83. The fact that throughout this period there was always a queue of workers desiring employment in steel suggests that at least part of the absolute difference between steel and non-steel wages was not because the steel labor was of a higher quality or had to perform more onerous tasks; but rather, was because of the monopoly power of the United Steel Workers of America--the union which by 1947 had effectively eliminated price competition between steel workers. As was indicated earlier the data also reveals that from 1947 through 1958 steel wages rose at a faster rate than non-steel wages; whereas, since that time the converse has occurred. We have already suggested, and shall later attempt to document, that the cause of this sudden change in the relative behavior of steel and non-steel wages was intimately connected with changes in the competitive nature of steel's final goods market.

9. The average variable cost of producing one ton of raw steel ingot (AVC) is defined to be the sum of total labor costs per ton of
raw steel ingot output (TL) and the total cost of materials, supplies, freight, etc., per ton of raw steel ingot output (TI). This measure of average variable cost rose almost continuously from $66.68 in 1947 to a peak of $123.98 in 1959. Since then it has tended to fluctuate slightly about a mean of $111.41. Its labor cost component rose from $29.02 in 1947 to a peak of $56.18 in 1958. Since then this measure has actually fallen. Since total labor costs per ton of raw steel output (TL) are a function of both the average level of steel wages and steel labor's average productivity, and since the average level of steel wages continued to rise between 1958 and 1967, the observation that since 1958 TL has fallen implies that average steel labor productivity has risen by more than enough to counteract the wage rise.112

112 Many observers of the relative stability of TL since 1958 have concluded that it has been caused by a sudden rise in average labor productivity—total raw steel output (QₘR) divided by the total hours of steel labor input (Qₜ)—because of the widespread American introduction of the basic oxygen furnace which began in 1958. The introduction of the basic oxygen furnace may explain why average steel labor productivity has risen since 1958; however, it should be stressed that steel's average labor productivity was rising long before that time. For example, in 1947 it took an average of 13.75 hours of labor to produce one ton of raw steel ingot, in 1957, 10.85 hours, and in 1967, 8.51 hours. [Note: we present 1957 figures rather than 1958 figures because the very depressed state of the steel market in 1958 would undoubtedly lead to an upward bias in that year's estimate of the number of hours needed to produce one ton of steel ingot.] These figures show that the average annual absolute decrease in the hours needed to produce one ton of raw steel ingot was greater (0.26 hours) from 1947 through 1957 than it was from 1957 through 1967 (0.21 hours). Moreover, the percentage decrease in the total labor input needed to produce one ton of steel was 21.2 percent for the 11-year period from 1947 through 1957 and 21.6 percent for the 11-year period from 1957 through 1967. These data suggest that the American steel industry has had considerable innovation and new investment over the entire post-War period—it has not been, as many have suggested, restricted to the post 1958 period.
10. The capacity variable (CAP) is defined to be the American steel industry's total capacity to produce raw steel ingots. More complete comments about this variable (and the capacity utilization variable mentioned below) may be found in Appendix I to an earlier paper by the author [13, pp. 157-59]. This variable has risen over the entire period.

11. The capacity utilization variable (CU) is defined to be total output of raw steel ingot by the American steel industry \( Q_s^R \) as a percent of total American capacity to produce raw steel ingot. From 1947 through 1957 this variable fluctuated about a relatively high mean of 89.4 percent. In 1958 it experienced a dramatic fall to 60.6 percent. Since that time it has fluctuated about a mean of 67.8 percent. We would expect that price cuts might be more likely in this latter period when so much surplus capacity hung over the market.

12. United States Steel's share of total domestic shipments was stable at about 31.4 percent from 1947 through 1954. In 1954 its share began to fall. Since "the Corporation" was publicly committed to maintaining its market share we might expect that as the fall was perceived and as it continued, United States Steel might become the firm most resistant to price hikes and most likely to initiate price cuts. Such behavior would of course be a sharp departure from "the Corporation's" behavior from its birth through the mid-1950's; nevertheless, since 1957 this has indeed been the way it has often acted.
III

Having briefly discussed the data we now present a history of the American steel industry from 1947 through 1968. Like our hypothesis for explaining the steel industry's postwar behavior, this history will be divided into three parts: 1947 through 1957, 1958, and 1959 through 1968. Both for ease of description and dramatic flare we label these The Revival, The Break, and The Regression.

The Revival: 1947-1957

As the data in TABLE II-l show the years 1947 through 1957 were ones of progress and prosperity for steel labor, management, and capital. The American steel companies free from significant competition from either foreign steel or other products had only to avoid federal regulation and to act in unison in order to achieve their goal of maximum industry profits. The following history will attempt to document their successful efforts to achieve this goal.

In 1947 after a brief postwar setback American steel demand soared leading to a fourteen and one half million ton jump in steel shipments over the 1946 level. The existence of a black market (e.g., the New York Times reported that some buyers were paying up to $225 per ton for steel products which the industry listed for $90 per ton) implied that the industry was producing at an annual rate near its maximum sustainable level [15]. In April the United Steel Workers of America and the United States Steel Corporation agreed without a strike to a new wage contract calling
for a rise of 15¢ per hour in the basic wage. Shortly thereafter the other steel companies made similar wage settlements. In July, 1947, Armco Steel (then the American Rolling Mill Corporation) led the industry in a general price rise. The federal government's official reaction to this rise was prompt. Just three weeks later the Federal Trade Commission charged the American Iron and Steel Institute and 25 member companies with illegal price fixing. In the charge explicit reference was made to the recent July price rises [16]. Also, the newly created Council of Economic Advisers in a report to President Harry S. Truman labelled this price rise inflationary and suggested that there be direct public intervention if there were no voluntary cuts [17]. Finally the Federal Trade Commission issued another indictment. This one charged the American Iron and Steel Institute along with 101 companies with conspiring to block an increase in steel output [18].

In 1948 steel continued to be very scarce and the American economy continued to be inflationary. When in February the industry, blaming higher operating costs, raised the price of semi-finished steel $5 per ton, President Truman ordered separate investigations by the Department of Justice, the Department of Commerce, and the Council of Economic Advisers. He also ordered the Federal Bureau of Investigation to question executives of 16 steel companies about their price rise [19]. In April, United States Steel, in the midst of protracted wage negotiations with the United Steel Workers, suddenly cut prices by an amount which it estimated

\[113\] It should be noted that by the end of World War II almost all of the blue-collar labor employed by the American steel industry had been organized by the United Steel Workers of America. The price of this labor was set by bi-lateral negotiations between union and management. The interested reader may find more information on the steel labor market in [2], [6], [10], [33].
would reduce its 1948 total revenues by $25 million. "The Corporation" suggested that it had made this "magnanimous" cut in order to publicly demonstrate its desire to end the postwar inflation. Moreover it suggested that the United Steel Workers should respond to this display of good will by agreeing not to demand a wage rise. Five days later, as United States Steel persisted in selling at the new lower price, the rest of the industry most reluctantly followed.

Unfortunately such dramatic, but on the macro level very insignificant moves, could not halt the postwar American inflation. Hence as other prices rose steelworker's real wages continued to fall. The "Steel Workers," though bound by a pledge of their president, Mr. Phil Murray, not to strike, quite naturally continued to press for a wage hike. Finally on July 16, 1948, the United Steel Workers and United States Steel agreed to an average wage rise of 13c per hour. The rest of the industry again followed.

Nine days prior to the new wage contracts there had been a sudden change in the method of pricing followed by the American steel industry. In response to the Supreme Court's "Cement Case" decision, which outlawed the basing point system, United States Steel announced that it would replace basing point prices with f.o.b. mill prices. Once more the rest of the industry followed. One week later, and just two days before United States Steel agreed to the new labor contract mentioned above, Bethlehem Steel raised some prices. On the day it contracted for higher wage costs "the Corporation" supported Bethlehem by announcing that it had plans for a "cost-compensating" price rise. On July 20, 1948, United States Steel "compensated" by means of a general price rise of 9.6 percent.
The other steel companies followed.

Having had requests for steel price stability and capacity expansion continuously rebuffed, President Truman launched a counter-offensive. In his 1949 State of the Union Message he recommended that if it were necessary in order to alleviate the persistent postwar steel shortage, Congress should authorize government loans for new steel plant construction. Moreover, if private enterprise failed to respond to this incentive then, Truman suggested, the government should itself commence construction [4, p. 16]. Meanwhile Phil Murray's United Steel Workers were once again negotiating a new wage contract. When in July, 1949, Murray suggested a 30¢ per hour wage package, Bethlehem Steel's board chairman, Mr. Eugene G. Grace, replied that that would raise costs an average of $2 per ton [20]. In September a Presidential inquiry board in an unanimous report urged a 10¢ per hour rise in pension and social insurance programs but opposed any rise in take home pay. Four days later United States Steel flatly rejected the board's recommendations, thus causing the union to go on strike. On October 5, 1949, five days after the strike began, Kaiser Steel capitulated by signing a pact embodying the Presidential Board's recommendations. The rest of the industry held firm until the end of the month when Bethlehem Steel signed a nearly identical pact. By November 11 all other industry members had reached similar agreements and the industry was once more able to argue that higher wages necessitated higher prices. In mid-December United States Steel responded to this "cost pressure,"

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114 Contrast this with United States Steel's Chairman Benjamin Fairless' statement in 1951 that a 15¢ hourly wage rise would necessitate a $10 per ton price rise [24].
even though the conjunction of a fall in real GNP and a change in its composition to less steel intensive items had led to a drop of 10.6 million tons in American steel consumption, by raising its prices $4 per ton. Given the 10¢ per hour cost of the wage settlement, Chairman Grace's remark of late July would suggest that less than 20 percent of this $4 per ton price rise could be directly attributable to the need to counteract the higher labor costs. Since demand had also fallen and since the federal government had not relaxed its pressure on the domestic steel industry, we must conclude that this price rise indicates increased exploitation of monopoly power.

1950 was a year of recovery for the national economy and, because of a sharp shift in the composition of aggregate demand to more steel-intensive items, a boom year for steel. Late in the year, because of demand Korean-War-induced speculative inventory buildups, steel soared even farther. Therefore the United Steel Workers had considerable economic power when they again sought higher wages. The result was a 10 percent wage rise (16-18¢ per hour) negotiated in November and, in order to meet the higher wage costs, a five and one half percent rise in steel's price [21].

In 1951, as the American economy boomed and as a major American military force was committed to Korea, steel consumption rose even farther. The American Iron and Steel Institute's measure of steel capacity utilization showed that over the year the industry operated at 101 percent of rated capacity. 115 Government price controls (which were put on in

115 Steel capacity utilization is defined by the AISI to be total American production of raw steel ingots divided by the total (continued)
1951 and taken off in spring 1953) prevented what would have been a sharp demand-induced price rise. But because of the controls and the high demand there was once more need for rationing. Thus, for example, in the second quarter of 1951 the NPA cut by 20 percent the amount of steel which would be available for automobiles and other civilian products [23]. Also once more there was public clamor, again led by President Truman, about the need for new steel capacity. However, by this time the once reluctant industry--by now apparently convinced that the Depression would not soon resume--had judged that perhaps large investment for new capacity would be profitable. Therefore it was no longer fighting President Truman's suggestions in this area. Hence we observe that between 1950 and 1951 steel ingot capacity rose by 4.8 million tons, between 1951 and 1952 it rose by 4.4 million tons, and between 1952 and 1953 it rose by the huge amount of 8.9 million tons.

In late November, 1951, as, largely because of Korea, steel was very scarce, wage talks again re-opened between the United Steel Workers and United States Steel. No noticeable progress was made in the negotiations; hence, in mid-December the United Steel Workers' Wage Policy Committee called for a strike to begin New Year's Eve. On December 28, 1951, because of extreme public (White House) pressure, the strike was postponed. The "Steel Workers" continued to agree to strike postponements

115 (cont.)
American capacity to produce raw steel ingots. For short periods of time it is possible for the steel companies to operate at more than 100 percent of capacity. They may do this by deferring maintenance, etc. Nevertheless, this need not have been the case in 1951 because since steel capacity figures are determined as of January 1 and since during the year there were some additions to capacity, the actual annual rate of capacity utilization during 1951 may have been less than 100 percent.
until April, 1952. Then, after the companies refused to accept the recommendations of the federal government's Wage Stabilization Board for an 18.8¢ per hour wage package—to which the union had agreed—Phil Murray announced a strike. President Truman, offering as his reason the country's dire need for steel, responded by ordering the strike-bound steel companies to be seized by a representative of the United States government and to be operated under his auspices. The steel companies, with small American flags flying "proudly" from the desks of many executives, reopened the mills. They also protested President Truman's action more directly by questioning its constitutionality in the courts. On June 2, 1951, the United States Supreme Court by a 6 to 3 vote voided President Truman's steel industry seizure. The majority decision declared that President Truman had acted in violation of the Constitution of the United States by usurping the Congress' rights. Upon receipt of this decision Phil Murray immediately ordered resumption of the strike. For the next 55 days both the Korean War and the steel strike went on. Since even before the strike, steel had been in very tight supply, a major part of the approximately 12 million tons of strike-caused lost shipments would not be made up until the following year. Finally on July 25, 1951, United States Steel chairman Fairless met United Steel Workers' president Murray at a conference presided over by President Truman. Messrs Fairless and Murray agreed to a settlement which gave the "Steel Workers" a modified union shop, a 16¢ per hour wage rise, and fringe benefits totaling

116 Part of the explanation for the length of the strike was that the union was committed to winning a union shop—a concession which most steel companies were unwilling to make.
5.4¢ per hour. To compensate for their concessions (higher labor costs) the steel companies were permitted to raise their prices by $5.20 per ton. Steel production was quickly restored to full capacity.

In 1953 business remained good and the Republican Dwight D. Eisenhower replaced Harry Truman as President. The main reason for steel's exceptionally strong year appears to be that American industry was trying to rebuild its strike and war depleted inventories. The excellent state of the steel business encouraged the United Steel Workers' Wage Policy Committee—now chaired by the recently deceased Phil Murray's successor, David McDonald—in April to announce that further wage increases would be sought in 1953 and that a guaranteed annual wage would be the union's prime goal in 1954 [25]. On June 11, 1953, the United Steel Workers and United States Steel agreed to a 9¢ hourly wage increase. On June 16, 1953, United States Steel announced a $3.40 per ton across the board price hike. In late 1953, after the War and strike depleted steel inventories had been rebuilt and as the economy began to enter a recession, the demand for steel fell sharply. For the first time since the 1930's a buyer's market began to appear for most steel products. To meet the increased competition United States Steel adopted a flexible pricing formula for some sales. This led to lower consumer costs because "the Corporation" absorbed part of the freight costs [26].

117 Throughout the entire period 1947 through 1967 there is little evidence of the secret cutting of list prices by any of the American steel companies. Nevertheless, some implicit price-cutting did occur for the individual steel companies always maintained some discretion over the pricing of service charges, extras, etc. In 1968, for the first time since before World War II, considerable "secret" cutting of list prices appeared. It seems, in sharp contrast to the situation before the War, that United States Steel was the chief instigator of this policy. We shall consider this phenomena shortly.
In 1954 as the American economy was in recession the demand for steel continued its sharp fall. The rate of capacity utilization, even though no events disrupted production, fell to 71 percent—what was at that time the postwar low. The year began with large layoffs of workers and short work weeks. Hence the steel companies were not very susceptible to the union's strike threat. The result was that the "Steel Workers" conveniently forgot about their 1953 statement that they would seek a guaranteed annual wage in 1954. Instead, on June 30, 1954, they signed a 2-year pact calling for a total one year cost of 9-10¢ per hour. Two days later United States Steel, in the face of slack demand, nevertheless was "compelled" by the higher labor costs to raise steel prices $3 per ton.

In 1955 the American economy entered the Eisenhower boom. Total shipments of domestic steel rose to a level that was not again reached until 1964. The McDonald-led United Steel Workers, with bolstered market power because of the high steel demand, requested that the labor contract be re-opened. On July 1, 1955, dissatisfied with the lack of progress, a strike was called. A few hours later the industry capitulated by agreeing to a 1-year pact with a 15¢ hourly pay rise. That same day United States Steel announced that because of higher labor costs steel prices would be raised $7.50 per ton. The rest of the industry followed.

In 1956 the American economy continued to perform well and steel demand continued strong. This year's labor negotiations had a new twist because for the first time the major steel companies bargained as one with the United Steel Workers. No longer did the settlement determined
by bi-lateral bargaining between the "Steel Workers" and "the Corporation" set a pattern for all of the other steel companies. Nevertheless, the new form of bargaining did not prevent the by now familiar result. On July 1, 1956, the union went out on what was to be a strike costing 34 days of lost production. When settled the labor contract was, however, quite different from those that had preceded it. It offered a 3-year no strike package calling for benefits worth a total of 41-45c per hour over the entire period. A few days later United States Steel, citing higher labor costs made inevitable by the new wage contract, raised steel prices $8.50 per ton. Again the rest of the industry followed.

Approximately one year later, on June 28, 1957, the eve of the date when the second round of wage and benefit rises negotiated the preceding year were to go into effect, "the Corporation" was once again "forced" to raise prices in anticipation of the higher labor costs. This time it raised them $6 per ton. Again the rest of the industry followed.

Having recounted the tale we may summarize the foregoing by making three points:

1. At no time were steel imports mentioned. The explanation for this deliberate omission is that their relatively high prices and low quality prevented them from playing a significant role in the American steel market; i.e., at the reigning price most foreign steels were not an effective substitute for the American product.

2. During this period the market value of steel common stocks soared. The prime causes of this were a sharp rise in profits and a rise in the common stocks' price-earnings ratios. For long-term
investors an equity position in steel had proved to be quite profitable.

3. From 1947 through 1957 steel wages rose faster than non-steel wages even though there was always a queue of workers seeking employment. Simultaneously steel prices were rising so much relative to non-steel prices that, ceteris paribus, steel profits also rose. Regardless of the steel industry's market structure we would expect higher wages to lead to higher prices because, ceteris paribus, they would lead to a higher marginal cost. However, if the industry were perfectly competitive we would not expect to observe that the higher labor costs were more than 100 percent shifted; i.e., ceteris paribus, in the short-run profits would necessarily fall. Similarly if the industry were an unconstrained profit-maximizing monopoly the short-run shifting of the higher labor costs would necessarily be less than 100 percent. Only if the industry were a constrained monopoly could there be greater than 100 percent shifting of labor costs. Such appears to have been the case in the American steel industry where there were two obvious constraints which prevented complete success in its attempts to maximize industry profits from 1947 through 1957. One, associated with all oligopolies, was uncertainty about how others would respond to any price changes. The other, more specific to the American

118 This of course implies that the union had monopoly power in steel's labor market.
steel industry, was the constant threat (and sometimes, a la the 1951 steel seizure, the actual implementation of the threat) of federal intervention. The steel companies reacted to these two constraints by seeking ways to avoid them. They found one such way in their periodic negotiations with the United Steel Workers of America. More specifically, the steel "barons" quickly perceived that higher wages served two purposes besides pleasing the workers: First they provided a convenient signal for the steel companies to raise prices. Second, as was repeatedly revealed in our history, the companies could always tell the federal government that their higher prices were made necessary by higher labor costs. Hence, we observed the chain of events that M. A. Adelman has labelled "The Rites of Spring": Early in the year union leaders would make bellicose threats, steel management would reply with cries about the high costs of granting such threats. After several months—the public finally being properly prepared—the workers would be granted a large wage increase and the steel companies would raise their prices by an amount which more than compensated for the higher labor costs. The inevitable result of this ballet was that both steel labor and management were rewarded and the public was damned.\textsuperscript{119}

\textsuperscript{119} It should be noted that steel wages rose more than competitive wages in other industries because the "Steel Workers" were able to appropriate a large part of steel's higher profits due to any price rise. Steel labor had this power because its price was set by bi-lateral negotiations. The union leaders, recognizing that the steel companies would gain higher profits simply by raising prices, demanded as the price for settlement that the companies share part of any higher profits with their workers. Thus we observe steel wages rose more than comparable non-steel wages. Moreover, since the union leaders also recognized that higher steel prices could only be "justified" to the government if there were higher labor costs, their hand was strengthened in this bargaining.
The Break: 1958

1958 was a year of recession and very low steel demand. It was also the year in which there occurred a major break in the economic performance of the American steel industry. At the end of July, Mr. Roger M. Blough—Ben Fairless' successor to the job of Chairman of the Board of United States Steel—stated that "the Corporation" planned no price rise [28]. This statement was made even though, because of the third round of wage and benefit rises granted in the 1956 wage contract, the oft used rationale of higher labor costs was again applicable. The other steel companies were outraged by what seemed to be "the Corporation's" abdication of its traditional price setting power. Three of them—Republic, Jones and Laughlin, and National—raised most of their prices an average of $4.50 per ton the day following Chairman Blough's announcement. One imagines that they must have awaited Bethlehem's and United States Steel's reactions with bated breaths. The next day a reluctant United States Steel joined in what was to be the last major steel price rise until 1963. 120

Having recounted the tale, what we must here seek to explain is why United States Steel, but not the other steel companies, sought—even though the government was friendly and there existed the ready rationale of higher labor costs—not to raise prices. There are two possible

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120 In contrast to the earlier years all of the 1958 price hikes were not initiated over-night but rather were issued product by product over a four month period.
economic explanations: First, given the weak level of steel demand it is possible that United States Steel (but not the others) thought that a price rise could not be maintained. Acceptance of the hypothesis requires that we demonstrate that for some reason "the Corporation" did not have expectations about its ability to successfully raise prices that were symmetric with those of the other steel firms. In particular we must assume, contra to our intuition, that United States Steel thought the possibility of successfully raising steel prices to be less than did the smaller steel firms. The second possible explanation is that United States Steel, but not the smaller steel companies, thought that even assuming a price rise could be maintained it might not be, from a long-run point of view, profitable. Since the demand for steel has always been thought to be quite price-inelastic this explanation at first also seems to be quite doubtful. Moreover, in order for it to be adequate we must seek to determine why United States Steel but not the others thought that its demand was sufficiently price-elastic so as to make further price rises unwise. We shall return to a discussion as to why the second explanation is in fact correct as soon as we finish demolishing the first.

Given United States Steel's long history of trying to prevent all price cuts and, in the postwar period until 1958 its unblemished success at achieving this goal, there is no obvious reason why it should have suddenly lost confidence in its ability to maintain prices. Moreover, in contrast to "the Corporation", the smaller companies had traditionally been price-followers rather than price-setters. Given the fact that the

121 This would be the case if United States Steel's relevant demand curve had become so price-elastic that any price rise would lead to a fall in discounted total revenue greater than the fall in discounted total cost.
dominant firm in the industry had just announced that it planned no price rise it was obviously very doubtful that these small firms could successfully maintain their price rise. We must conclude that if any firm should have questioned its ability to successfully initiate a price rise it was obviously a National, a Republic, or a Jones and Laughlin; not a United States Steel. Since the needed asymmetry of expectations is in the opposite direction from what all reason suggests, we may safely discard the first explanation.

For the second explanation to be sufficient we must give an adequate answer to the following question: Why did United States Steel but not the smaller steel companies feel that another price rise might lead to lower profits? The obvious answer to this question is that in 1959 at the reigning level and structure of prices "the Corporation" judged the demand it faced to be relatively more price-elastic than the other steel companies judged the price-elasticity of the demand they faced. Unfortunately this answer, though at first blush neat and succinct, is trivial. It has content only if we can answer two additional questions:

1. Was it a fact that United States Steel did face a demand which was more price-elastic than that faced by most other steel companies?

2. Assuming that the answer to the above is yes, what explains this greater elasticity?

Available empirical evidence is consistent with a yes answer to question one. Specifically, the officers of United States Steel could, and did, observe (see TABLE II-1) that from 1947 to 1954 the long-term steady decline in their firm's market share had apparently finally been arrested.
From 1947 to 1954 "the Corporation" always supplied between 31 and 32 percent of all domestic steel shipments. Unfortunately for "the Corporation" the prewar fall in its market share resumed once more in 1955. Since there was no observed evidence of price-shading by any of the other steel firms, and since the officers of "the Corporation" were publicly committed to maintaining its share of the market, the only reasonable explanation for the fall in U. S. Steel's market share was that it tended to produce more of those steels that for some reason were over time increasingly relatively less in demand. But, what steels were these and why? The answer to the first part of this last question is that over time the lowest quality (least expensive) and heaviest types of steel have in fact experienced a relative decline in their share of total steel shipments. These were the steels in which U. S. Steel tended to specialize. Hence, this change in the composition of steel demand would seem to explain the fall in U. S. Steel's market share. But then we must answer the second question by explaining why these steel types experienced a relative decline. The answer to this question has three parts. First, we observe that most of the postwar steel price increases tended to be general rather than selective. Since these general price rises were most often absolute rather than proportional, the prices of lower quality steels relative to the prices of higher

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122 If for both 1947 and 1958 we sum total shipments by the American steel industry of semi-finished steel, shapes and plates, rails and accessories, bars, pipes and tubing, and wire and wire products and divide by total domestic steel shipments, we observe that in 1947 these products accounted for 63.7 percent of total domestic steel shipments whereas in 1958 they accounted for only 52.7 percent of domestic steel shipments. Since these tend to be the lowest quality types of steel, we observe that there was indeed a significant decline in their share of total steel shipments.
quality steels were higher in 1958 than previously. Ceteris paribus this would imply that in 1958 the demand for these lower quality items was relatively more price-elastic than previously. Hence in 1958 a given

123 We present in TABLE II-A some data to document our contention that between 1947 and 1958 the list prices of low quality, "heavy" steels rose by a greater percentage than the list prices of high quality "light" steels. In each cell (except for Cold Rolled Sheet) we present two pieces of data: 1) The Pittsburgh price for one pound of a given steel product in a given year. 2) The price of the given product as a percent of the price of Cold Rolled Sheet. This calculation was premised on the assumption that the price of Cold Rolled Sheet is a good proxy for the general price level of most high quality steels. The fact that between 1947 and 1958 the list prices of all of these low quality steels rose relative to the list price of Cold Rolled Sheet supports the contention in the text. A second fact, that between 1958 and 1967 this relative upward trend in the list prices of "heavy" steels was arrested, suggests that perhaps market conditions (particularly demand) played a more important role in the pricing of the individual steel products after 1958 than it had before.

TABLE II-A: Prices of Some Selected Steel Products

<table>
<thead>
<tr>
<th></th>
<th>1947</th>
<th>1958</th>
<th>1967</th>
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<tbody>
<tr>
<td>Hot Rolled</td>
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<tr>
<td>Carbon Steel</td>
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<tr>
<td>Bars</td>
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<tr>
<td></td>
<td>2.72c</td>
<td>5.53c</td>
<td>5.92c</td>
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<tr>
<td></td>
<td>75.5%</td>
<td>83.8%</td>
<td>83.0%</td>
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<tr>
<td>Carbon Steel</td>
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<tr>
<td>Plate</td>
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<tr>
<td></td>
<td>2.77c</td>
<td>5.18c</td>
<td>5.62c</td>
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<tr>
<td></td>
<td>76.9%</td>
<td>78.5%</td>
<td>78.8%</td>
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<tr>
<td>Rails</td>
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<tr>
<td></td>
<td>2.75c</td>
<td>5.75c</td>
<td>6.00c</td>
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<tr>
<td></td>
<td>76.4%</td>
<td>87.1%</td>
<td>84.1%</td>
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<tr>
<td>Structural Shapes</td>
<td></td>
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<tr>
<td></td>
<td>2.62c</td>
<td>5.40c</td>
<td>5.85c</td>
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<tr>
<td></td>
<td>72.8%</td>
<td>81.8%</td>
<td>82.1%</td>
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<tr>
<td>Cold Rolled Sheet</td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3.60c</td>
<td>6.60c</td>
<td>7.13c</td>
</tr>
</tbody>
</table>

absolute (or even proportionate) rise in all steel prices would lead to a greater change in the composition of the aggregate steel demand—from the low quality to the high quality items—than would have occurred in any of the preceding years. Therefore a producer that tended to produce relatively more of the lower quality steels (United States Steel) may have quite rationally opposed a price rise that the other producers might marginally favor.\textsuperscript{124} Second, when we also note that the share of imports in the American steel market jumped by 70 percent between 1957 and 1958, even though there was an abundance of steel, and moreover, when we note that at this time most of the imported steel tended to be low quality, "heavy" steel, we have an additional explanation for the relatively greater price-elasticity of demand facing United States Steel.\textsuperscript{125} Third, we could explain the observed apparent difference in the price performances of U. S. Steel and the other steel companies simply by noting that, even ignoring changes in relative price, the tastes of the steel consumers (in the aggregate) were changing from "heavy" to "light" steels. This taste change meant that the demand curve faced by U. S. Steel was not simply a scalar multiple of the industry demand curve. Taken together these three reasons appear to offer

\textsuperscript{124} Further evidence supporting the truth of this elasticity argument would be provided if we observe that in the near future no steel companies thought that it would be profitable to raise prices. This would imply, as we would expect if the cross price elasticities between different steel products were high, that United States Steel faced a demand curve which was only slightly more price-elastic than the demand curve faced by the other firms in the industry. This is of course what we do observe since steel prices did not rise again until 1963.

\textsuperscript{125} Until 1958 American steel imports were relatively high only in those years when the domestic steel demand was pressing domestic capacity. After 1958 imports tended to rise independently of pressures on American capacity. This indicates that after 1958 foreign competition became a much more serious problem.
sufficient explanation for the observed events of 1958.

Besides the abrupt change in U. S. Steel's pricing behavior and in the importance of imports, 1958 heralded one other significant change—the export market for American steel nearly disappeared. The sudden sharp drop in our measure of the relative price of foreign steel \( P_F = P_I / P_S \) between 1957 and 1958 (caused by the sudden appearance of excess foreign capacity—for the first time since before the War) and the increasingly higher quality of the imported steels suggest that the observed drop in American steel exports was caused by the fact that they were suddenly no longer competitive. The really interesting question is to determine what led to the sudden sharp fall in the competitiveness of American steel in the world market. The answer to this question appears to be imbedded in the evolution of the European, Japanese, and other steel industries since the end of World War II. More specifically by the end of the War most of the prewar non-American, non-Soviet steel industry had been decimated. The immediate result was great shortages of steel.\textsuperscript{126}

In Europe and Japan the long-run response to this scarcity was a massive attempt to rebuild the war-destroyed steel making capacity and, as demand continued to soar, to add new capacity. Simultaneously many of the newer political states (the former European colonies) deduced that a domestic steel industry was a prerequisite for a modern economy; hence, they set out, almost regardless of cost, to build these industries. The sum of both effects was yearly quantum increases in world steel capacity and

\textsuperscript{126} Because of the shortage of steel in the U. S. the government restricted American steel exports until after the Korean War. The shortage of foreign exchange also severely limited American steel exports.
moreover, in Western Europe and Japan—since major new technical advances were being embodied in the new plant—quantum jumps in the economic efficiency of the world steel industry. Continuation of the two trends, coupled with the fact that after 1954 iron ore delivered to America was in many cases more costly and seldom less costly than iron ore delivered to Western Europe (and by the mid-1960's this was also the case for Japan) implied that unless the American steel industry came up with a major cost-reducing breakthrough, American steel would become increasingly less competitive in the world market. The sudden appearance in 1958 of excess European capacity and the resultant sharp fall in European export prices precipitated this event. The tendency of foreign steel's relative price to continue to fall since 1958 suggests that the declining export position of the American steel industry would not soon be reversed.

127 Most experts agree that by the 1960's the European and Japanese steel industries were technically as advanced as the United States'. Given their lower labor costs this suggests that they had a comparative advantage.
The Regression: 1959-1968

1959 was a year of recovery for both the national economy and steel. It was also the first year in three in which a new labor contract needed to be negotiated. Fearing the worst (mainly because of the very tough bargaining stance which the steel companies appeared to be taking) steel consumers sought to build large inventories. As the quality of foreign steel was continuing to improve and as its prices continued to fall they also turned increasingly to foreign sources of supply. The American steel industry's response to the rising imports was probably best expressed by United States Steel's chief labor negotiator, R. Conrad Cooper. Mr. Cooper warned the United Steel Workers that their excessive wage demands were jeopardizing jobs because the resultant higher labor costs were making it increasingly more difficult for the steel companies to meet foreign competition [29]. Hence, Cooper concluded, the industry, if only for the welfare of its workers, should oppose any wage rise.

Given this adament stand by the industry, agreement between labor and management proved impossible. On July 15, 1959, there began a strike which (though interrupted by a Taft-Hartley injunction) cost 116 days of lost steel production.128 The 1959 steel strike was notable for three major reasons:

128 The terms of the settlement were a 41c per hour, 30-month contract. Vice President Nixon and Secretary of Labor Mitchell actively intervened in order to get this settlement. One steel company, Kaiser Steel, did not take 116 days to reach a settlement. Instead, in October, Kaiser—an industry maverick since its inception during World War II—broke with the major steel companies' united front and signed a contract with the United Steel Workers.
1. It was the longest industry-wide steel strike in history and it was settled only after massive intervention by what was thought to be a pro-business, Republican administration.

2. It was prolonged by the almost complete intransigence of the steel companies to conceding a significant wage rise.

3. Even though in the months following the strike steel demand was very high and the favorite rationale for a price rise—sharply higher hourly labor costs—again existed, no steel company even attempted a price rise.

But how can we explain the above behavior? The explanation we prefer was first put forth by M. A. Adelman. Adelman suggested that by 1959 the remaining firms in the steel industry had joined with United States Steel in realizing that by raising their prices so much during the 1950's they had succeeded in moving to points on their long-run demand curves that were sufficiently price-elastic so that, ceteris paribus, they now expected any price rise would lead to lower profits.\(^{129}\) This means that the other members of the American steel industry now also realized that they could no longer fully shift the burden of higher labor costs simply by raising prices. For the first time since the end of the War higher labor costs necessarily implied lower profits. Hence we can understand both why the industry so militantly opposed almost all wage concessions

\(^{129}\) See Adelman's article [2] for more elaboration of this thesis. The reader should note that the other long postwar steel strike was in 1952. Then the companies refused to settle until the federal government agreed to let them shift the burden of the higher labor costs by raising steel's price.
and why once it was finally forced to make some it nevertheless did not raise prices. 130

The years 1960 and 1961 were ones of bad business but otherwise relative calm for the steel industry. Steel's rate of capacity utilization hovered near 65 percent and imports maintained, but did not increase, their newly acquired significant position in the American steel market. The one major event of these years was that for the first time since before World War II many minor, but very selective, cuts in list prices appeared. The cuts were for those items where demand for the domestic product was noticeably weak. Since from the conclusion of World War II to 1960 almost no analogous cuts were ever observed, this suggests that the pricing for specific steel products may have been more competitive after 1960 than before. If Adelman's argument were true, this is of course a result which we would expect.

In late 1961 the Democrat President, John Kennedy, hoping to end the (cost-push?) inflation of the late 1950's, urged the United Steel Workers to limit their demands when negotiating the 1962 wage contract [30].

130 Further indication of the competitive erosion of steel's monopoly power is provided by its poor profit and stock market performance since 1957. The price-earnings ratios of most steel stocks have plummeted and in those firms where there have not been major changes in the nature of their equity financing, the total value of the common stock has actually fallen. This latter event occurred in the face of massive reinvestment of retained earnings. We contend that the poor stock market performance is in essence the reverse of the "watering" which many allege occurred at United States Steel's incorporation. For some reason investors now expected a lower rate of return on the steel industry's equity capital. Given the persistence of these expectations (they remain in force as of this writing—January, 1969) it appears that the expected lower return on capital was not caused by short-run changes in the demand or cost parameters facing the industry, but was caused by the expectation that the potential exploitable monopoly power in this industry had quite suddenly been reduced. This loss of monopoly power led to the observed recapitalization of steel common stocks at lower prices.
Early in 1962 President Kennedy implicitly repeated this threat when his Economic Report advocated the doctrine of wage-price Guideposts. Events suggest that the United Steel Workers were susceptible to Kennedy's pressure because in late March they signed a 2-year contract calling only for fringe benefits worth 10¢ per hour in the first year and with a clause permitting wage re-opening the second year. There had been no steel strike. President Kennedy was widely hailed for having prevented an inflationary wage settlement and thereby breaking the vicious circle of higher wages leading to higher prices leading to higher wages... Then on April 10, 1962, the Chairman of the Board of United States Steel, Roger Blough, suddenly shattered Washington's and Wall Street's euphoria. Chairman Blough announced that "the Corporation," in order to compensate for the higher production costs incurred since its last price rise in 1958, would initiate a general steel price rise of $6 per ton. There abound many excellent accounts of the confrontation between big business and big government that then ensued. Here we shall refrain from commenting on this incident except for noting that considering the poor state of the domestic steel market and the rising level of imports it was most doubtful that, even if there had been no government pressure, an across-the-board steel price hike could be maintained. The best evidence for this conclusion is that later in the year—after President

131 We would of course also expect that the relatively weak state of both the national labor market and the steel labor market also contributed to the union's acceptance of what was by past standards a very modest economic package.

132 Two books deal exclusively with this incident [9] and [12]. Most of the major biographies of President Kennedy also pay considerable attention to this incident.
Kennedy's successful steel price roll-back--there was a continuance of the selective price cuts that had begin in 1960. Moreover competitive pressures from Japanese imports caused Kaiser Steel to abolish the traditional $12 per ton West Coast price premium. Thus steel prices were actually lower at the close of 1962 than at its beginning.

In 1963, as the American economy entered what would become the longest period of continuous economic expansion in modern history, there was a modest recovery in steel demand. In April, Wheeling Steel, citing higher labor costs, announced a general price rise of $6 per ton. Bethlehem Steel's Board Chairman, Arthur B. Homer, citing the relatively depressed state of demand for American steel, commented that he doubted that competitive pressures would permit the maintenance of an across the board price hike [32]. Events quickly proved Chairman Homer to be right. When no other steel company followed its lead Wheeling was forced to rescind its general price hike; nevertheless, selective price hikes for certain products with either relatively high or price-inelastic demands did prove to be successful. Two months after this rather abortive attempt to raise most steel prices the United Steel Workers and the steel companies agreed to a 2-year contract which had a total two year cost of only 15¢ per hour--a postwar low. The contract called for no wage rise but instead stressed job and income security.

In 1964, as the American economy continued to prosper, steel shipments rose by another 9½ million tons. However, aside from a few selected price changes (both hikes and cuts) and aside from a further rise in the share of the American market supplied by imports, nothing of particular note occurred.
1965 opened with considerable uncertainty in steel's labor market. The cause of the uncertainty was a challenge by Mr. I. W. Abel to replace David McDonald as President of the United Steel Workers. Abel charged the urbane McDonald with being too friendly with the steel "barons." McDonald, fighting for his union life, needed a big wage victory. He refused to step down as the "Steel Workers" chief wage bargainer. Finally, as the ballots were being counted for what appeared to be an Abel victory, McDonald agreed to a 4-month postponement in the strike deadline so that the union's new president would be able to negotiate the new steel labor contract. As the price for this postponement the union was granted an 11.5¢ per hour wage rise which, though effective May 1, 1965, was to be held in escrow until after the new contract was signed. As expected, Abel was elected and four months later—under the gun of massive Presidential pressure—both union and management agreed without a strike to a 35-month, 48¢ per hour contract. The President of the United States, Lyndon B. Johnson, quite obviously pleased by his success in preventing a steel strike, personally announced the agreement. Again no general price hike followed the new wage contract; nevertheless, imports continued to rise—reaching over 10 percent of total (domestic plus foreign) steel shipments. By now even industry spokesmen were publicly confessing that imports were seriously interfering with their ability to raise steel prices.

On New Year's Day, 1966, Bethlehem Steel announced a $5 per ton rise in structural steel prices. For the third time since the War a Democratic President of the United States was to become enraged. When a few days later United States Steel only raised some structural steel prices $2.75
per ton and, moreover, in order to meet Japanese competition, cut the West Coast price of cold rolled sheet by $9 per ton, Bethlehem was of course forced to partially rescind its price rise. Unfortunately, we cannot identify to what extent it was President Johnson's threat—and the government's exertion of its economic power in the markets for some steel products—or other competitive pressures which led to Bethlehem's partial recision of its price rise. Later in the year, as steel demand continued relatively high, there were further selective price changes in both directions.

1967 was to witness a continuation of the selective price changes and more mutterings from the government about the need for steel price stability. The fact that the American economy was in the throes of the Vietnam-War-caused demand-pull inflation tended to remove most moral thrust from any government utterances. Much more significant than the minor price revisions were the industry's attempts to restrict imports. Remembering the "good old days" before 1958—when steel imports were low and steel profits and stock market values were relatively high—the industry actively sought to restrict imports. The most obvious way of stopping imports, competitive price cuts, was deemed to be unfeasible because it would lead to even further erosion of already low profits. Hence, in February the American Iron and Steel Institute began a drive for temporary tariffs on both pig iron and steel. This drive was initiated at an American Iron and Steel Institute breakfast for about 100 members of the United States Congress and received partial backing from one of President Johnson's major labor allies—I. W. Abel, president of the United Steel Workers of America [33]. Nevertheless the drive
failed to make progress in Congress.

Perhaps anticipating such failure the industry also lobbied to get the states to pass laws that would effectively exclude some steel imports. Thus, for example, the industry succeeded in getting the Pennsylvania legislature to pass a bill requiring all state financed projects to use steel manufactured in the United States. Almost immediately this bill was vetoed by that state's governor. Once more the steel industry had been rebuffed. Its response to adversity was to turn to even another approach. In November, 1967, Senator Hartke (Democrat-Indiana) and Senator Dirksen (Republican-Illinois) announced they would co-sponsor a bill calling for "moderate" mandatory quotas on steel imports. The United Steel Workers--realizing that lower imports would permit (by increasing the domestic industry's monopoly power) higher steel prices, profits, and therefore wages--lent its full support to the industry's efforts. Recognition of the harmony of interests of both sides of the steel labor market in steel's successfully achieving increased market power in its final goods market had at last been made explicit by both parties.

In early 1968 because of the conjunction of a high level of aggregate demand and the possibility of another steel strike, American steel demand was relatively high. Even though imports again experienced a sharp rise the demand for domestic steel was also quite high. Nevertheless, for what appears to be the first time since J. P. Morgan's creation in 1901 of the United States Steel Corporation, even though demand was high selected secret price-cutting appeared in steel. Even more surprising
was the source of this price-cutting—United States Steel [35].

Before we try to explain why United States Steel acted as she did a few other facts need be mentioned. In early May published reports that U. S. Steel was shading prices began to receive wide publicity. "The Corporation's" reaction was to stop the practice. One month later formal wage negotiations began between union and management. On July 30, 1968, the steel companies successfully negotiated a 3-year pact with the "Steel Workers" union. Because of the inflationary conditions the settlement was expensive. The whole package was estimated to be worth at least $0.54 per hour. The next day Bethlehem Steel announced a 5 percent "cost-compensating" across-the-board price hike. After a brief confrontation with the government, United States Steel "sued for peace" by posting average price increases of only 2½ percent. Moreover, there were restricted to about 63 percent of the industry's total output. So far the story has the familiar post-1958 ring: a rise in labor costs led to an initial rise in steel prices which, after a short period of government and market pressure was adjusted partially downward; however, this air of familiarity soon ended.

After the strike threat was over the demand for American steel plummeted. Meanwhile imports stayed high. At the same time rumors that U. S. Steel was offering large secret price cuts once more abounded. Official denials were made but the rumors persisted. Suddenly on

133 Between 1901 and 1968 there were many cases of the secret cutting of list prices in steel. However, prior to 1968 all such documented cases had three things in common: they occurred before World War II, they were never initiated by the industry's historic price leader, United States Steel, and they occurred during recessions. Given these past events the spectacle of the industry price leader U. S. Steel initiating secret price cuts even though the steel business was booming was certainly an unusual event.
November 5, 1968, in the midst of a very overheated American economy, Bethlehem Steel made a shocking move. It announced a huge 22 percent price cut ($25 per ton) on the industry's second largest volume product—hot rolled sheet. In its official announcement Bethlehem said that the cut was made to meet import competition; however, most industry observers interpreted the move as being aimed at United States Steel's price-cutting. Specifically it appeared to observers that Bethlehem was attempting to assume a role long played by United States Steel: "policeman" for the industry. Nevertheless, regardless of what motivated Bethlehem's action, the result was that Bethlehem's price for hot rolled sheet was now reported to be $2 to $3 per ton less than the delivered price the foreign steel companies charged for the same product. It was obvious that given the greater delivery reliability and extra services associated with domestic steel, the new price was well below the existing price of imported steel. The response by Bethlehem's competitors and by industry observers to this action was one of near complete disbelief. Such a huge cut in a list price had been unheard of since the early years of United States Steel. Nevertheless, after much grumbling, competition forced the others to follow. A few weeks later United States Steel, in what was interpreted by industry observers to be a peace offering to Bethlehem, attempted to raise the price of hot rolled steel by $25 per ton; i.e., back to its early November level. Wheeling and Republic quickly followed. At this point all eyes turned to Bethlehem because it was realized that no price hike could persist if Bethlehem failed to join. On December 6, 1968, Bethlehem announced that it would indeed raise the price of hot rolled steel; however, its raise would be only $17 per ton.
By this move Bethlehem emphatically stated that the industry's second largest producer would no longer weekly follow the lead of United States Steel. The net result of all of these events was that 1968 closed with steel prices in a most unsettled state.

Having briefly described the events of 1968, what we must now do is explain why they happened. Specifically, what caused U. S. Steel to lead the secret price cutting and hence to lead to the near complete price demoralization which threatened the American steel industry by late 1968? Our answer to this question is that 1968 marked another year of transition in the American steel market. Since 1958 imports had been trending ever higher; however, beginning in 1965 this trend accelerated. Earlier we outlined how the steel companies sought to control this onslaught by political means. All efforts failed and imports kept soaring. The result was that by 1968 total American steel imports were at least as large as total shipments by the American steel industry's second largest firm, Bethlehem Steel. Moreover, the foreign firms behaved as if the American steel industry were purely competitive; i.e., they did not, as did the domestic firms, seem to realize that because of the oligopolistic structure of the industry the shape and position of any one firm's demand curve was very dependent on the actions of the other firms. Hence, they were not members of the "community of interest" which had worked to maintain high steel prices. The result appeared inevitable, unless steel imports were bounded by political means, the American steel industry would at some point be forced to compete on a price basis. We have suggested that such price competition was minimal prior to 1968; i.e., the low price of imported steel tended to restrain the size of domestic steel price
hikes but it did not lead to many competitive price cuts. Instead the industry willingly gave up volume in order to maintain prices. However, by 1968 it was apparent to all that the sharp price differences between imported and domestic steels could not long persist. The price-elasticity of imported steel had become too high. The firm to first realize this was United States Steel because, more than any other steel company, it was hurt by imports. As we mentioned earlier, United States Steel's share of total domestic steel sales had fallen steadily since 1954. This implies that the other steel companies made up for some of the sales lost to imports by taking sales away from U. S. Steel. "The Corporation" repeatedly announced that it would arrest the fall in its market share. All attempts failed. By 1968 there remained only one untried measure—secret price cuts. The ultimate result of "the Corporation's" adoption of this measure was the price uncertainty just described.
IV

We shall now attempt to summarize and extend the foregoing history by means of a simple simultaneous equation econometric model of the postwar (1947-1967) American steel industry. Hopefully this model will provide a good summary of the actual performance in the American steel market; thereby permitting us to test many of the hypotheses advanced earlier. The model will focus on explaining the list price of steel; however, our earlier discussion has clearly shown that this is a function of several endogenous economic variables; hence, the model will attempt to explain the behavior of the following four variables:

1. The price of steel ($P_s$) from 1947 through 1967.
2. Total labor costs per ton of raw steel output (TL) from 1947 through 1967.
4. The share of imports in meeting total steel shipments in the United States (SI58) from 1958 through 1967.

Turning our attention to equation 1, we seek to explain steel list prices in the United States. An overriding theme of our history was that until 1968 the American steel industry had sufficient implicit collusion so that its members sought to maximize industry profits. It

\[134\text{ The framework of the discussion that follows owes much to a previous paper by the author [13].}

\[135\text{ In this way they would maximize the size of the pie from which each would then take his appropriate slice.}\]
The Model

**Endogenous Variables:**

1. The List price of American steel:
   \[ P_S = F_1(TL, CU, Z\cdot58, \overline{P_T}) \]

2. Total labor costs per ton of raw steel output:
   \[ TL = F_2(P^R_S, CU, (CU)^2, \overline{W^M_B}, \overline{t}) \]

3. The American steel industry's rate of capacity utilization:
   \[ CU = F_3(TIP, SI58, P^R_S, \overline{CAP}) \]

4. The share of imports in meeting total steel shipments in the United States:
   \[ SI58 = F_4(P_F) \]

**Definitions:**

5. \[ Z\cdot58 = CU\cdotDU58 \]

6. \[ P^R_S = P_S/P_W \]

7. \[ (CU)^2 = CU\cdotCU \]

8. \[ P_F = P_I/P_S \]

**Exogenous Variables:**

9. \[ DU58 = 0 \text{ from } 1947 \text{ through } 1957, 1 \text{ from } 1958 \text{ through } 1967. \]

10. \[ P_I = \text{ the price of imported steel from } 1958 \text{ through } 1967 (1958-59 = 100). \]

11. \( P_W = \text{ the Bureau of Labor Statistics' Index of Wholesale Prices.} \)

12. \[ W^M_B = \text{ average gross hourly earnings in all U. S. manufacturing.} \]

13. \[ \overline{t} = \text{ the years from } 1947 \text{ through } 1967. \]

14. \[ TIP = \text{ the Federal Reserve Board's Index of Total Industrial Production from } 1947 \text{ through } 1967. \]

15. \[ \overline{CAP} = \text{ total capacity of the American steel industry to produce raw steel.} \]
must be admitted that uncertainty and government pressure at times prevented success in this attempt; nevertheless, it seems reasonable to assume that this was their goal. More generally any industry which corresponded to the foregoing description would attempt to maximize the following expression:

\[ \pi^I = TR^I - TC^I \]  
\[ = P(Q)\cdot Q - w\cdot L^I(Q) - m\cdot M^I(Q) - F \]

where \( \pi^I \) is the total profits of the industry, \( TR^I \) is its total revenue, \( TC^I \) is its total cost, \( P(Q) \) is the price of the product as a function of its sales, \( Q \) is the total sales of the product, \( w \) is the total hourly labor costs paid by the industry, \( L^I(Q) \) is the industry's total labor input as a function of its sales, \( m \) is the industry's total cost per unit of intermediate goods consumed in producing the product, \( M^I(Q) \) is the industry's total consumption of intermediate goods as a function of sales, and \( F \) is the industry's total fixed costs. Setting the first derivative equal to zero and solving for \( P \) yields

\[ P = w\cdot (\partial L / \partial Q) + m\cdot (\partial M / \partial Q) - (\partial P / \partial Q)\cdot Q \]  

If we assume that at any given time \( w \), \( m \), \( \partial L / \partial Q \), and \( \partial M / \partial Q \) are constant regardless of the level of \( Q \) then

\[ P = \frac{w}{\text{APP}_L} + \frac{m}{\text{APP}_M} - (\partial P / \partial Q)\cdot Q \]

where \( \text{APP}_L \) is the average physical product of labor and \( \text{APP}_M \) is the
average physical product of material inputs. Using our earlier notation we may rewrite (D) as

\[ P_S = TL + TI - (\partial P_S/\partial Q) \cdot Q \]  

(E)

or

\[ P_S = AVC - (\partial P_S/\partial Q) \cdot Q \]  

(F)

This simple formulation tells us that the profit-maximizing steel industry would seek to set a price for steel which was some positive (since $\partial P_S/\partial Q$ is negative) markup over its average variable cost. The absolute size of this markup depending on the position (Q) and shape ($\partial P_S/\partial Q$) of the industry demand curve. Assuming that all steel companies face the same costs then obviously for any given feasible output in the price-quantity locus the more price-inelastic is the demand the higher will be prices and profits. Typically the firm's demand will be most price-inelastic if it is a scalar multiple of the industry's demand. Hence we see why in industries such as steel—where entry is difficult, where the product is homogeneous, and where the relatively few major firms have near-identical costs—there is considerable economic incentive to collude in order to maximize industry and hence each firm's profits.

The foregoing analysis has suggested that $P_S$ is a function (positive) of AVC and of the general shape and position of each firm's demand curve. However, the shape and position of any firm's demand curve depends only

\[ \text{136 This is equivalent to assuming that the average variable cost of producing steel is constant regardless of the level of output. In this special case steel's average variable cost coincides with its marginal cost.} \]
on the shape and position of its industry's demand curve and on that industry's economic structure and performance. Recognizing the foregoing we may now explain the variables included in equation 1.

First, we include TL as the best indicator of steel's marginal cost of production. Given our preceding discussion the reader no doubt expects that AVC (= TL + TI) would be a superior explanatory variable. While in theory this expectation would indeed be correct, data problems suggest that in practice it will not be. The reason for this paradox was hinted at in our earlier essay on iron ore. There we demonstrated that the Lake Erie Price of iron ore bears almost no relation to its real marginal cost. Our explanation for this was that the major steel companies, who were also the major iron ore producers, found it both profitable and possible to charge a price higher than marginal cost for their ore. Unfortunately, in their accounting records most own ore consumed by these companies is valued at this artificially high price. Hence, the accounting value which they place on their iron ore yields an overestimate of its real worth. Similar artificial accounting prices are used in valuing most other intermediate inputs (limestone, coal, transportation, etc.) that are produced by the steel companies; hence, the variable TI, which is what we observe, contains much noise. In contrast the variable TL (= total steel labor costs divided by raw steel output) is quite pure. This measure does show what the steel companies actually paid for their labor input. Except for small measurement errors it offers a near perfect measure of steel's total average labor costs. We conclude that since AVC = TL + TI but that the observable measure of TI is most impure; therefore, it is wisest to estimate our model using TL rather than AVC as an
independent variable. We of course expect to observe that

\[ \frac{\partial P_s}{\partial TL} > 0. \]

To briefly anticipate our empirical results, we may note that our suspicion of the noise present in our measure of AVC appears to have been quite well founded. Replacing AVC with TL greatly improved the estimated results of the model.

The second and third independent variables are CU and Z58. CU is the American steel industry's rate of capacity utilization from 1947 through 1967. Z58 was zero from 1947 through 1957 and identical to CU thereafter. We include the variable CU as the best indicator of the relative level of steel demand. _Ceteris paribus_ a rise in CU implies a rise in relative steel demand. Our earlier formulation (equations E and F) suggests that this would lead to a price rise. Hence we expect to observe

\[ \frac{\partial P_s}{\partial CU} > 0. \]

Our earlier history suggested (a la Adelman) that until 1958, because of uncertainty and government constraints) the price of steel tended to be below its profit-maximizing level. If this were indeed true we would expect to observe that steel prices were more responsive to changes in CU after 1958 rather than before. We expect this result because prior to 1958 the steel companies, realizing that their prices were suboptimal, tended to raise them almost regardless of the level of demand.137

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137We would still expect that even from 1947 through 1958 Ps would be a positive function of CU because the higher was CU, _ceteris paribus_, the less uncertainty any steel firm would have about the possible failure of others to follow a given price hike.
(During these years the major constraint limiting price rises was political pressure, not low demand.) Since 1958, if steel prices had by then indeed reached their profit-maximizing level, we would expect to observe that changes in $P_S$ were much more responsive to changes in $CU$. The test of this hypothesis would be to observe that $258$ had a significant positive coefficient; i.e., that

$$\frac{\partial P_S}{\partial 258} > 0.$$ \(138\)

The fourth independent variable is $P_I$, the constructed index of foreign steel prices from 1958 through 1967. We include this variable because we earlier observed that steel imports first became important in 1958 and have become even more important since that time. Since imports are a substitute for domestic steel, we would expect to observe, assuming that the American steel companies are rational pricers, that ceteris paribus they would set high prices when $P_I$ was high and low prices when $P_I$ was low; i.e., we expect to observe

$$\frac{\partial P_S}{\partial P_I} > 0.$$ 

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138 Professor Paul Cootner has noted that we would expect to observe similar relations to those described above between both $CU$ and $P_S$ and $258$ and $P_S$ if the American steel industry were perfectly competitive but that until 1958 outside forces constrained it from charging what would have been the competitive price. Unfortunately examination of the coefficients of $CU$ and $258$ in our estimated model will not offer any evidence for distinguishing whether or not "Adelman's" or "Cootner's" hypothesis for explaining steel's postwar price behavior is superior. Of course, if the coefficients' signs differ from those we have suggested, this would imply that both hypotheses may be wrong. This author feels that the implication of both our earlier discussion and the behavior of some of the subsequent equations in this model permit us to suggest that the "Adelman" explanation is more likely.
To again anticipate a result, what we shall actually observe is that \( \partial P_S / \partial P_I < 0 \). This suggests of course that from 1953 through 1967 the pricing behavior of the American steel companies actually exacerbated their import problems.

In equation two (2) we seek to explain the American steel industry's total labor costs per ton of raw steel output (TL). Since this variable is constructed by multiplying the average price of steel labor by the inverse of its average productivity we expect it to be a function of those variables which explain either the average price of steel labor, its average productivity or both. The first two variables discussed below are included because we feel that they help to explain steel labor's average price.

The most obvious independent variable for explaining steel labor's average price is average gross hourly earnings of all U. S. manufacturing employees (\( W_B^M \)). We expect \( W_B^M \) to have a positive coefficient in this equation because most types of labor are economic substitutes; hence, as the price of one class of labor rises we would expect competition to drive-up the price of competing classes. \textit{Ceteris paribus} this would necessarily lead to a rise in TL. Therefore we expect to observe

\[ \partial TL / \partial W_B^M > 0. \]

The second independent variable for explaining TL is the list price of steel (\( P_S \)). In order to justify our inclusion of this variable we must consider four possible cases:

1. If the American steel industry's labor market and final goods market were both perfectly competitive we would expect to observe
that the price of steel was equal to its marginal cost. Since labor costs account for a large part of steel's marginal cost we would of course expect to observe that ceteris paribus the price of steel was some positive function of our proxy for the marginal cost of steel labor (see our discussion of equation 1) TL. However, we would not expect TL to be a positive function of \( P_S \) since in pure competition steel labor's real wage must necessarily be equal to the real wage of equal quality non-steel labor. Hence if we believe that the American steel industry's labor and final product markets were both perfectly competitive we would not include \( P_S \) as an independent variable for explaining TL.\(^{139}\)

2. The second case assumed that steel's final market is no longer perfectly competitive but that its labor market continues to be so. In this case any steel company hires that quantity of labor indicated by the intersection of two curves: the labor's marginal revenue product (MRP\(_L\)) and the labor's marginal cost (MC\(_L\)). In terms of Figure I, \( L_0 \) units of labor would be employed at price \( W_0 \). Once again we would expect \( P_S \) to be a positive function of TL (equation 1) but we would not expect TL to be a positive function of \( P_S \).\(^{140}\)

\(^{139}\) A test of this hypothesis would be to include \( P_S \) as an independent variable in estimating this equation and to then look at its coefficient. If steel's final market and labor markets were both competitive, we would expect its coefficient to be insignificantly different from zero.

\(^{140}\) If the steel company were a monopsonist in its labor market (i.e., it faced a rising supply curve of labor), then, ceteris paribus, (continued)
FIGURE I

Price of Labor

$S_L = M C_L$

$M R P_L$

Units of Labor
3. The third case assumes that steel's final market is perfectly competitive but the supply of steel labor is completely controlled by a monopolistic union. In this case the union leaders will attempt to maximize something—unfortunately just what this might be we cannot with certainty say. For example, they may try to maximize the total revenue of their members, or the total employment of steel labor subject to some minimum wage. A multitude of other "reasonable" objective functions are possible. However, though we do not know what the union will maximize, we do know that regardless of what this might be it will be constrained at any given time by the shape and position of the total (industry) demand for steel. To the extent that the union can determine just what the shape and position of the aggregate demand curve for American steel is, it will charge that price for steel labor which causes the steel industry's price and output to be, from the union's perspective, optimal. Without knowing the union's objective function we cannot of course state what this optimal price will be; however, we can state that it will be functionally related to the level and position of the aggregate demand curve for steel and hence also to steel's price. Thus in this case we expect to observe both that \( P_S \) is functionally related to \( TL \) and that \( TL \) is functionally related to \( P_S \).

140 (cont.)

A rise in \( P_S \) would lead to a rise in the price of labor and hence to a rise in \( TL \). The cause of this would be that the rise in \( P_S \) led to an upward shift in labor's marginal revenue product; hence, it would intersect \( S_L \) at a higher price. The observation that there have almost always been queues of people desiring employment in steel suggests that the empirical assumption that most steel companies have significant monopsonistic power in their labor markets would not be reasonable.
4. The fourth and most realistic case assumes that steel's final market is imperfectly competitive and its labor market is dominated by a monopoly. Moreover, as our history suggested, government pressure (either potential or actual) often exerted some restraining pressure on steel prices. More specifically, the government tended to frown on all steel price rises which were not "cost justified" and it often appeared that the only permissible type of "cost justification" was higher hourly labor costs. Operating in this type of market and institutional setting and assuming that either because of uncertainty or government pressure the steel industry had potentially exploitable monopoly power, there would be considerable economic incentive for union and industry to cooperate in their activities. In particular we might expect to observe the following sequence of events: Early in the year the union would start demanding higher wages, and the top industry executives would respond with statements that the expected higher labor costs could only be paid with higher prices. Having properly prepared both the government and their competitors as to the extent of the "needed" price rise, the industry wage would be raised and, given this signal, across the board steel price rises would almost immediately follow. If there were unexploited monopoly power (because of prior uncertainty and government pressure) the industry would be

141 The queue of blue-collar labor desiring employment in steel provides evidence that steel's labor market is imperfectly competitive.
able to more than shift the full burden of the higher wages and
both steel capital and steel labor would gain from the higher
wages.

Earlier we noted that M. A. Adelman [2] suggested that such
a pattern of behavior was actually observed in the American steel
industry from 1947 through 1958. Adelman labelled it "The Rites
of Spring." Unfortunately for the direct participants such a
mutually beneficiary pattern could persist only so long as the
industry had some unexploited monopoly power in its final goods
market. As has already been suggested after 1958 this was
probably no longer the case. Hence the steel industry—recog-
nizing that higher wage costs could no longer be more than fully
shifted via higher prices—now proved to be a tougher wage bar-
gainer. One bit of evidence supporting this conclusion was the
bitter 116 day steel strike in 1959. Another was that between
1947 and 1958 average hourly steel wages rose roughly 1.8 times
as fast as average gross hourly earnings in all U. S. manufactur-
ing (131% vs. 73%); whereas, from 1959 through 1967 average gross
hourly earnings in all U. S. manufacturing rose roughly 1.5 times
as fast as steel's average hourly wages (29% vs. 20%). These
figures confirm of course that from 1947 to 1958 steel wages rose
faster than non-steel wages; whereas, from 1959 to 1967 non-steel
wages rose faster than steel wages. Since in the former period
steel prices rose roughly three times as fast as the wholesale
price index (108% vs. 35%); whereas, in the latter period whole-
sale prices rose marginally faster than steel prices (5% vs. 4%).
the hypothesis that the price of steel labor has been a function of steel's price does appear to be consistent with the evidence. Hence, ceteris paribus, we expect to observe that TL is a positive function of $P_S$; i.e., in our model we expect to observe

$$\frac{\partial TL}{\partial P_S} > 0.$$ 

The motivation for including $W_B^M$ and $P_S$ as independent variables for explaining TL was that they represented the key forces explaining steel labor prices. More specifically, $W_B^M$ was a proxy for the supply forces affecting steel labor's price; whereas, assuming both labor and final market imperfections, $P_S$ was a key proxy for the demand forces. Now we include three additional variables which are primarily aimed at explaining the average productivity of steel labor in any given year.

The domestic steel industry's rate of capacity utilization (CU) is included because we recognize that within any one year steel labor almost certainly contains some fixed cost elements. Thus a rise in CU should lead to a rise in steel labor's average productivity and therefore we would expect to observe a negative functional relation between TL and CU; i.e., we expect to observe that

$$\frac{\partial TL}{\partial CU} < 0.142$$

The square of the domestic steel industry's rate of capacity utilization $(CU)^2$ is also included because we would expect that as CU continued to rise the continued rise in steel labor's average productivity would

\[142\text{Remember } TL = P_L^S \cdot \frac{1}{APP_L} \text{.}\]
lessen. There are two reasons why this should be so. First, as output average fixed costs approach zero. Second, bottlenecks tend to appear at very high rates of capacity utilization. For both reasons we would expect to observe (assuming that steel labor's productivity is positively related to CU) that steel labor's productivity will be negatively related to \((CU)^2\); hence, we expect to observe

\[
\frac{\partial TL}{\partial (CU)^2} > 0.
\]

Finally we also include the years from 1947 through 1967 (\(t\)) as an independent variable. Our rationale for including this variable is that many authorities have suggested that perhaps there has been a secular trend towards improved steel labor productivity and that this trend has not been explained by our other independent variables. We would explain the alleged trend as being caused by exogenous, labor-saving technical progress and by the substitution of capital for labor. Evidence of such a trend would be provided if TL and \(t\) are negatively related; i.e., we hope to observe

\[
\frac{\partial TL}{\partial t} < 0.
\]

In equation three we seek to explain the level of capacity utilization in the American steel industry (CU) in any given year. Since CU is defined to be one hundred times the ratio of total American raw steel output \((Q_S^R)\) divided by total American raw steel capacity (CAP) it is obvious that CU should be a function of those variables which affect either \(Q_S^R\) or CAP. Since in this essay we are abstracting from steel's investment decision, CAP will be treated as exogenous. (We shall provide more justification for
this assumption later.) This suggests that, ignoring CAP, the other independent variables in this equation will be concerned with explaining changes in $Q_S^R$.

The most obvious variable for explaining $Q_S^R$ is some measure of the level of output of the steel consuming sectors of the American economy. In this model we chose the Federal Reserve Board's Index of Total Industrial Production (TIP) for this measure. Since most steel is used as an input in the production of TIP we would expect to observe, ceteris paribus, that the relation of TIP to $Q_S^R$ was positive; i.e., we expect to observe that

$$\frac{\partial Q}{\partial \text{TIP}} > 0.$$

A measure of the real price of steel ($P_S^R$) is included because we expect that, ceteris paribus, a rise in the real price of steel would cause less to be demanded. Because the demand for steel is often thought to be price-inelastic the short-run relation between $P_S^R$ and the quantity of steel demanded may be very weak.\(^{143}\) Also we face the problem of determining what is the relevant price by which to deflate the price of steel. The customary answer to this question would be to deflate by the price of its chief substitutes. Unfortunately there are many possible substitutes for steel. Hence, in this model we simply deflate by the Bureau of Labor Statistics' Index of Wholesale Prices ($P_W$). Given the foregoing problems we nevertheless expect a negative, but perhaps weak,

\(^{143}\) Economic analysis suggests that the demand for intermediate goods is typically much more price-inelastic than the demand for the final goods which they help to make.
relation between $Q_S^R$ and $P_S^R$; i.e., we expect to observe

$$\frac{\partial C}{\partial P_S^R} < 0.$$ 

The ratio of total steel imports ($Q_I$) to total steel shipments in the United States ($Q$) from 1958 through 1967 (labeled SI58) is included because since 1958 imports have been the main substitute for American steel. By definition a rise in the market share of imported steel must lead to a fall in the market share of domestic steel. Therefore, except in most unusual circumstances, we would expect to observe that

$$\frac{\partial C}{\partial SI58} < 0.$$ 

Finally the measure of total American raw steel capacity (CAP) is included since this is by definition the exogenous denominator of $C$. Of course this implies that

$$\frac{\partial C}{\partial CAP} < 0.$$ 

The fourth (and final) endogenous equation is the equation which seeks to explain the market share of steel imports from 1958 through 1967 (SI58). We have suggested that the sudden and increasing importance of steel imports since 1958 has been caused by the interaction of two factors: First, the relative price of foreign steel ($P_F$) fell dramatically between 1957 and 1958 and has trended lower ever since. Second, both the relative quality of foreign steel and the reliability of its deliveries have been increasing over time. Moreover, American steel consumers have become increasingly more aware of this fact. Hence any given value of our measure of foreign steel's relative price has (effectively) become cheaper over time. Unfortunately it is nigh impossible to quantify either improved quality or
improved consumer recognition. Therefore, in our model we assume that SI58 has only been a function of the relative price of steel imports. We expect to observe

$$\Delta SI58/\Delta P_F < 0.$$ 

Besides the four endogenous variables our model includes seven exogenous variables and four definitions. Here we shall briefly defend our treating the variables DU58, $P_I$, $P_M$, $W_B^M$, $t$, TIP, and CAP as exogenous.

The variables DU58 (which is zero from 1947 through 1957 and one from 1958 through 1967) and $t$ (the years from 1947 through 1967) are obviously exogenous; i.e., a change in any of the model's endogenous variables can have no effect on either. Therefore, in our discussion we may completely ignore them. We may not be so cavalier in assuming the five remaining variables to be exogenous because in a general equilibrium world such an assumption is patently false. However, since our model is specifically a partial equilibrium one, the assumption that these variables are exogenous will not lead to difficulties provided we can demonstrate that any changes in the model's endogenous variables will have at most only a slight effect on these so-called exogenous variables.

The variable TIP furnishes information about the level of operation of the chief steel consuming sectors of the American economy. Since steel output itself accounts for only a very small percentage of TIP it does not seem unreasonable to assume that it is exogenous.

Whether or not we treat the variables $W_B^M$ and $P_W$ as exogenous depends on whether or not we believe the argument (associated with Otto Eckstein and Gary Fromm [6]) that steel wage and price rises were the most important cause of the 1950's inflation. If we believe, as did Eckstein-Fromm,
that steel wage and price rises were indeed the main cause of this inflation then obviously both $w_B^M$ and $p_w$ must be treated as endogenous. It should be evident that to be valid the Eckstein-Fromm explanation requires that something like cost-push inflation be not only possible but likely. Here we shall refrain from indulging in a diatribes about the unreasonable-ness of any theory of cost-push inflation; instead, we shall simply note that today almost no economist (of either neoclassical or monetary schools) believes cost-push inflation to be a meaningful concept. Rather, they would assert that by themselves steel wage and price hikes would have almost no effect on either $w_B^M$ or $p_w$. Given this predominance of educated sentiment we do not feel it to be unreasonable to assume both $w_B^M$ and $p_w$ exogenous.

$P_I$ is the price index for foreign steel from 1958 through 1967. By assuming it to be exogenous we are really assuming that at least since 1958 changes in the American steel market have had no effect on foreign steel markets. Obviously this extreme assumption is not tenable; however, the European and Japanese price and quantity data does suggest that domestic conditions do play by far the most important role in explaining steel prices in both regions.

Finally, economic theory suggests that the American steel industry's capacity to produce steel (CAP) must be some function of past, present, and expected profits. In turn these profits are some function of past, present, and expected demand, cost, and prices; i.e., they are a function of the endogenous variables of our model. Therefore, for complete rigor we should seek to treat steel's capital stock (as measured by CAP) as endogenous. For ease of presentation we have not done this. Moreover,
since the time lag between the initiation of investment in new basic steel capacity and when it bears fruit ranged from one to four years, we feel quite justified in assuming it to be exogenous.

V

Having described the model, we now estimate it using the method of two stage least squares.\(^{14}\) Regression 1 is the price equation. Besides including the four independent variables specified in the preceding discussion (TL, CU, Z58, and \( P_I \)), we also include a constant, DU58, and KOR as independent variables. The constant (a so-called free constant) is introduced because if it were not the regression line would be arbitrarily forced through the origin. DU58 is introduced in order to test whether or not the increased importance of CU after 1957, when the mean value of CU was relatively low, also modified the constant. More specifically, we may use Figures II and III to illustrate two possible cases. In the first case we assume that \( P_S \) is only a function of a constant and CU; however, CU is assumed to play a stronger role (i.e., has a steeper slope) after 1957 (when CU is observed to have been relatively low) than before. Therefore in this regression we regress \( P_S \) as a function of a constant, CU, and Z58. In this case, where the constant is fixed over the whole time span, we observe a regression such as that presented in Figure II. If Z58 is significantly positive this procedure forces the regression line to have a gap. It also biases the estimates of the coefficients of both CU and Z58. In the second case we also include DU58 as an independent variable. Then, if Z58 has a positive coefficient and

\(^{14}\) In all regressions the instrumental variables were the seven exogenous variables of the model (\( P_U \), \( P_T \), TIP, CAP, DU58, \( W_{BM} \), and \( t \)) plus a constant, the variable KOR (which is introduced in the text), and DCAP which is equal to the exogenous variable CAP times the exogenous variable DU58.
DU58 has a negative coefficient we observe a regression such as that presented in Figure III. This procedure eliminates the arbitrary gap. A gap may of course still exist but it is no longer arbitrary. Also, assuming that the model is accurately specified, the estimates of CU and Z58 are no longer biased. We conclude that just as it is almost always best to estimate a regression with a free constant, when a new variable is introduced sometime after the start of the regression (e.g., both $P_I$ and Z58 start in 1958) the regression should also be estimated with what we might label a free dummy.\footnote{145} Finally, KOR is a dummy variable which is defined to be zero in all years except 1951 through 1953 when it is one. This variable is included because, in order to help to prevent the Korean-War-induced sharp rise in steel demand from leading to a sharp price rise, steel prices were regulated by the federal government from 1951 to early 1953. Naturally if the regulation were successful KOR should have a negative coefficient.

The estimated regression for the 21 years from 1947 through 1967 was

\[
P_S = -62.23 - 41.51(\text{DU58}) - 5.97(\text{KOR}) + 2.635(\text{TL}) + 0.382(\text{CU}) + 1.012(\text{Z58})
\]

\[
3.93 \quad 1.810 \quad 3.04 \quad 16.9 \quad 2.806 \quad 4.29
\]

\[
-0.282(P_I)
\]

\[
2.684
\]

\[
N = 21 \quad \quad \quad \quad R^2 = 0.988 \quad \quad \quad \quad DW = 2.271 \quad \quad \quad SE = 2.551
\]

\[
F\text{-test (6,14) } = 186.2
\]

\footnote{145} The reader may affirm for himself that it is quite possible that in a model similar to the above Z58 would have a negative coefficient if the model were estimated without DU58 and a positive coefficient if it were estimated with it.
These results show:

1. KOR has a significant negative coefficient. This indicates that the Korean War price controls reduced $P_S$ below what it would have otherwise been. Since for the years 1951 through 1953 the mean value of $P_S$ was 70.6, and since the coefficient of KOR (-5.97) is 8.5 percent of 70.6, this suggests that ceteris paribus the Korean War price controls led to the constrained price of steel being about 92 percent of what it would have otherwise been.

2. The very significant positive coefficient of TL supports our contention that the price of steel depends crucially on the level of our measure of its marginal cost. Remembering that $P_S$ is an index number with values ranging between 48.2 and 106.0, $P_S$'s coefficient of 2.67 implies, ceteris paribus, that a $1$ rise in TL would lead to a rise in $P_S$ of 2.635.

3. The coefficient of CU is significantly positive. As predicted the coefficient of 258 is also significantly positive. Ceteris paribus, the results show that from 1947 through 1957 a one point rise in CU led to a 0.382 rise in $P_S$; whereas, from 1958 through 1967 an equal rise in CU would lead to a rise of 1.394 in $P_S$. The increased responsiveness after 1957 of steel's price to its rate of capacity utilization is consistent with our earlier suggestion that beginning in 1958 the American steel industry priced more competitively. Moreover, the fact that TL was near constant from 1958 through 1967, coupled with the suddenly much greater effect of the CU variable suggests that in this period
prices tended to rise when demand was high and to fall when it was low. This contrasts sharply with the near steady rise in steel prices prior to 1958.

4. The coefficient of $P_I$ is significantly negative. This result runs counter to our expectations because it suggests that when the price of imported steel was relatively high, ceteris paribus, the price of American steel was relatively low. Conversely, when the price of imported steel was relatively low the price of American steel was relatively high. Assuming that the American steel companies feared foreign steel imports (and since 1958 this has most certainly increasingly been the case) this would be an irrational pricing policy because it would lead to even higher imports in just those years when imports were especially likely, by virtue of their low price, to be highest.\footnote{An alternative test of the American steel companies' "irrational" pricing was to replace $P_I$ with $S_{I58}$ in the price regression. If $S_{I58}$ had a positive coefficient this would indicate that, ceteris paribus, since 1958 in those years when imports had the highest share of the American steel market, the price of American steel would be highest. The positive coefficient of the variable $S_{I58}$ supported this hypothesis.}

We also estimated the foregoing steel price regression with AVC (= TL + TI) replacing TL as an independent variable. The new estimated regression was

$$P_S = -32.02 - 33.96(DU58) - 8.24(KOR) + 1.170(AVC) + 0.010(CU) + 0.977(Z58)$$

\begin{center}
\begin{tabular}{lcccc}
1.355 & 0.910 & 2.521 & 10.4 & 0.047 & 2.547 \\
\hline
-0.313(P_I) & & & & & \\
1.828 & & & & & \\
\end{tabular}
\end{center}

\begin{center}
$n = 21$
\end{center}

\begin{center}
$R^2 = 0.967$
\end{center}

\begin{center}
$DW = 2.784$
\end{center}

\begin{center}
$SE = 4.147$
\end{center}

\begin{center}
F-test (6,14) = 69.0
\end{center}
Comparing this regression with the preceding one we note that every coefficient has reduced significance, the value of the Durbin-Watson Statistic rose from 2.271 to 2.784, the multiple correlation coefficient fell from 0.988 to 0.967, and the standard error of the regression rose from 2.551 to 4.147. These results clearly demonstrate that the variable TL is superior to the variable AVC. There are at least two possible explanations for this:

1. The TL variable reflects the real cost of steel labor, whereas the TI variable bears little relation to the true cost of these factors. Hence, the "pure" variable, TL, is a better proxy for marginal cost than is AVC.

2. The steel companies, somewhat irrationally, ignore all variable costs except for labor costs when they set prices.

It is the author's feeling that the first explanation is more likely.

Regression two seeks to explain the behavior of TL--total labor costs per ton of raw steel ingot output. The two stage least squares estimated regression was

\[
TL = 5153.6 + 0.466(P_S) - 1.204(CU) + 0.006(CU)^2 + 28.597(W_B^M) - 2.632(t)
\]

\[
\begin{array}{cccccc}
2.491 & 7.81 & 2.415 & 2.010 & 1.986 & 2.456 \\
\end{array}
\]

\[n = 21, \quad R^2 = 0.985, \quad DW = 2.365, \quad SE = 1.256, \quad F-test (5,15) = 197.5\]

All of the coefficients have the signs that our earlier discussion suggested. More specifically the regression results show:
1. A rise in steel prices does indeed lead to a rise in TL. The great power of this variable supports our contention that the steel labor market is very imperfect. Coupled with the results of regression one this result suggests that Adelman was indeed correct in asserting that steel labor and management were coupled in "The Rites of Spring"; i.e., that steel labor both because of its monopolistic power and its knowledge that higher steel prices were difficult to "justify" unless there were higher labor costs, was able to appropriate part of any higher profits obtained because of a price hike. Since 1958 the erosion of steel's monopoly power, as shown by the stability of $P_S$, has removed this source of higher steel wages. Hence we observe that TL has also failed to rise.

2. When the American steel industry's rate of capacity utilization (CU) rises TL falls. The economic reason for this is that the average fixed cost component of total labor costs falls as steel output rises; however, since as output expands average fixed costs asymptotically approach zero, we expect this relation to be non-linear. Also bottlenecks are more likely when CU is high and ceteris paribus these would lead to higher total labor costs. For both reasons we expected that $(CU)^2$ would have a positive coefficient. It does.\footnote{There is one obvious anomaly in our specification of this regression; i.e., even when $CU = 100$ in the TL-CU plane the regression for TL has a negative slope. This indicates the existence of scale economies. Only at the impossibly high rate of $CU = 185$ do these economies cease.}

3. When the average hourly earnings of all American manufacturing labor \(W^M_B\) rise, TL rises. We expected to observe this because we felt that steel and non-steel labor are substitutes. Ceteris paribus this implies that a rise in \(W^M_B\) must lead to a rise in TL.

4. The time variable \((t)\) has a negative coefficient implying that ceteris paribus over time TL has fallen. The most likely economic reason for this is that over time there has been exogenous technical progress and educational improvement which have made any given unit of steel labor more efficient.

Regression three seeks to explain the American steel industry's rate of capacity utilization (CU). The two stage least squares estimate is

\[
CU = 122.7 + 1.425(TIP) - 275.7(SIS58) - 26.46(P^R_S) - 1.158(CAP)
\]

\[14.8 \quad 7.776 \quad 6.639 \quad 2.250 \quad 7.252\]

\[
\begin{align*}
\bar{R}^2 &= 0.934 \\
DW &= 1.962 \\
SE &= 3.7762 \\
F-test (4,15) &= 52.9
\end{align*}
\]

Before expanding on the above, we must here note that (only in estimating this equation) we combined the years 1952 and 1953 by adding the observations for TIP and CAP and by averaging the observations for all other variables. We did this because our earlier discussion stated that

\[148\] The above regression was also estimated with DJ58 as an independent variable. We did this because we thought that the sudden introduction of the imports variable in 1958 may have led to a change in the regression's constant. The coefficient of DJ58 was insignificantly different from zero; hence, we do not present that regression here.
in 1952, because of the Korean War, the desired demand for steel could have been satisfied only if the American steel industry operated for the entire year near full capacity (i.e., CU = 100). Unfortunately steel strikes led to 58 days of lost production and therefore the measured value of CU was only 85.8. Steel inventories were depleted. In light of the foregoing we would expect to observe that in 1952 predicted CU exceeded actual CU. Conversely in 1953 the Korean War was concluded, the United States entered a minor recession, and there was no steel strike. Steel consumers, whose inventories had been depleted in 1952, successfully rebuilt them back to their desired levels. Hence we would expect to observe that in 1953 the actual value of CU exceeded its predicted value. When the regression was estimated without combining the years 1952 and 1953 the residuals did have the expected pattern. In the results presented here we combine these two years since our discussion has suggested that they should be treated as one. The residual for the combined year (1952.5) was almost zero, suggesting that our procedure was quite reasonable.

In looking at the results, the coefficients present only one surprise. All had the expected signs and were significant. The only surprise was the large size of the coefficient of SI58. It implies that each rise of 0.01 in the value of SI58 led to a fall of 2.75 in CU. Such a large fall due to rising imports is unrealistic. This suggests that beginning in 1958 there was perhaps another force, besides imports, leading to a lower demand for domestic steel, but that our imports variable (SI58) was a good proxy for this other force. The most obvious other forces were either exogenous technical change, which made it possible to do the
same job using less steel input, or the substitution of other materials for steel. 149

Finally in regression four we attempt to explain the share of imports in the American steel market from 1958 through 1967 (SI58). We suggested that this should be a function of their relative delivered price, their quality, and the consumers' tastes. Since we were unable to quantifying these last two items we simply regressed SI58 as a function of two variables: a constant and $P_P$, the price of foreign steel divided by the price of American steel. The two stage least squares estimated regression was

$$SI58 = 0.2765 - 0.2155(P_P)$$

$$\begin{array}{cc}
3.474 & 2.608 \\
\end{array}$$

$$n = 10$$

$$R^2 = 0.460$$

$$DW = 1.038$$

$$SE = 0.0234$$

$$F-test(1,8) = 6.824$$

In TABLE II-2 we present the residuals of this regression (the actual value of the dependent variable minus the fitted value). These show that the share of actual steel imports exceeded predicted in 1959 and 1960 and from 1965 through 1967. We suspect that the main cause of the very high share of imports in 1959 and 1960 was the 116 day 1959 steel strike. This strike ended in January 1960; however, it is known that steel consumers, being desperately short of steel in late 1959, agreed to sign contracts for foreign steel which was to be delivered in 1960; hence, even after the conclusion of the strike, imports stayed high. There is no similar obvious explanation for the sharp rise in the share of imported

---

149 Since our price variable ($P_S^R$) was stable from 1958 through 1967, perhaps it failed to provide a good measure of the falling costs of some substitutes for steel. The author's attempts to estimate the total American demand for steel have indeed yielded results which suggest that since 1957, ceteris paribus, the American demand for all steel has decreased for exogenous reasons by almost two million tons per year.
TABLE II-2

Residuals of Regression 4

<table>
<thead>
<tr>
<th>YEAR</th>
<th>RESIDUAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958</td>
<td>-0.347</td>
</tr>
<tr>
<td>1959</td>
<td>+0.0137</td>
</tr>
<tr>
<td>1960</td>
<td>+0.0149</td>
</tr>
<tr>
<td>1961</td>
<td>-0.0129</td>
</tr>
<tr>
<td>1962</td>
<td>-0.0205</td>
</tr>
<tr>
<td>1963</td>
<td>-0.0221</td>
</tr>
<tr>
<td>1964</td>
<td>-0.0071</td>
</tr>
<tr>
<td>1965</td>
<td>+0.0238</td>
</tr>
<tr>
<td>1966</td>
<td>+0.0167</td>
</tr>
<tr>
<td>1967</td>
<td>+0.0282</td>
</tr>
</tbody>
</table>
steel from 1965 through 1967. These results do however confirm what we suggested in our history; i.e., *ceteris paribus* imports have become an even stronger competitor in the American steel market since 1965. We suspect that the main cause of this increased competition is an increased awareness by the American steel consumers that for many purposes foreign steel is not inferior to domestic steel. Moreover, we have one bit of evidence supporting this assertion. Specifically, the reader should note that the value of the constant, 0.2765, implies that even if $P_F = 0$ (i.e., the price of foreign steel is zero; whereas the price of American steel is positive) the value of $S158$ would be only 0.2765. This rather surprising result suggests that over the entire period 1958-1967 imported steel and American steel were not as close substitutes as is commonly thought. It also provides a way to implicitly test whether or not foreign steel and domestic steel have become better substitutes over time. Specifically, if we do the same regression for the periods 1958-1964, 1958-1965, and 1958-1966 we obtain the results presented in TABLE II-3. This TABLE shows that as the period of time lengthens from 1958-1964 to 1958-1967 both the constant and the negative coefficient of $P_F$ continuously increase in absolute size. This is indeed what we would expect if our assertion, that since 1965 imported steel has increasingly become or been recognized to be a good substitute for domestic steel, is true.
TABLE II-3
Import Regression Results

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Constant</th>
<th>P_F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1958-1964</td>
<td>0.1264 (2.041)</td>
<td>-0.074 (1.190)</td>
</tr>
<tr>
<td>1958-1965</td>
<td>0.1745 (2.046)</td>
<td>-0.117 (1.360)</td>
</tr>
<tr>
<td>1958-1966</td>
<td>0.2278 (2.798)</td>
<td>-0.169 (2.017)</td>
</tr>
<tr>
<td>1958-1967</td>
<td>0.2765 (3.474)</td>
<td>-0.2155 (2.608)</td>
</tr>
</tbody>
</table>
References to Essay II


15. ________, July 26, 1947, p. 25.


17. ________, November 2, 1947, p. 55.


22. ________, December 1, 1950, p. 19.


26. ________, October 1, 1953, p. 45.

27. ________, August 28, 1955. Section IV, p. 3.

28. ________, August 30, 1958, p. 25.

29. ________, June 3, 1959, p. 32.


33. ________, February 9, 1968, p. 49.


35. Wall Street Journal, November 6, 1968, p. 3.

BIOGRAPHICAL NOTE

<table>
<thead>
<tr>
<th>Name:</th>
<th>Richard B. Mancke</th>
</tr>
</thead>
<tbody>
<tr>
<td>College Attended:</td>
<td>Colgate University</td>
</tr>
<tr>
<td>Date of Graduation:</td>
<td>June, 1965</td>
</tr>
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<td>Degree Received:</td>
<td>B.A. <em>Magna Cum Laude</em> with High Honors in Mathematical Economics</td>
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<td>Academic Year 1968-1969: Half-time Instructor, Massachusetts Institute of Technology</td>
</tr>
</tbody>
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