ONE of the more widely discussed aspects of the geography of the United States has been the shift of manufacturing from the traditional Manufacturing Belt, within the Northeast and East North Central census divisions, to the South and West. Political leaders have sought remedies to staunch the flow or to ameliorate the resulting problems; academics have attempted to understand the causes of this trend from the perspectives of theories about the locational patterns of industries and the causes of uneven development.

In this paper, the relative decline of the Manufacturing Belt is seen as the most recent episode in the sporadic process by which the Manufacturing Belt attained its current areal extent. Consider the time and place of the innovation of each of these four crucial "propulsive industries": factory system textile production in Lowell, Massachusetts in the 1820s; hot blast smelting and puddling furnace refining of iron in Catasaqua, Pennsylvania in the 1840s; Bessemer steel refining in Pittsburgh, Pennsylvania in the 1870s; and the mass production of automobiles in Detroit, Michigan in the early 1900s. It is obvious that the time series from youngest to oldest industry is also the geographical sequence from east to west. The purpose of this paper is to demonstrate that this correspondence of historical series and geographical sequence cannot be explained by existing theory without the addition of a new element, the Industrial Frontier hypothesis. Before this hypothesis is presented, the deficiencies of existing theory will be described.

EXISTING THEORY

Existing theory may be conveniently discussed under two headings: Weberian, or least-cost, manufacturing location theory, and Growth Pole theory.
Weberian Location Theory  Weberian theory is based upon the common sense notion that factories located where the sum of production and shipping costs are minimal will eventually eliminate those in higher cost locations. To simplify analysis, manufacturing industries are often assumed to be oriented to one most crucial cost factor; one which constitutes a large proportion of total costs, in addition to being significantly variable locationally. Each industry is then expected to have a locational pattern that approximates one that would minimize the most crucial cost.

In this context, the United States textile industry is labor oriented because of its high labor intensity, as indicated by its low value added per man hour of production labor. The relocation of the textile industry from its New England birthplace to the Piedmont South, where labor was cheaper, is consistent with Weberian theory. But why did the industry originate in southern New England? It would be difficult to demonstrate that, in the early 1800s, New England had a significant advantage over the South in any of the usual Weberian cost factors other than the cost of distributing the product to the northeastern market. But there is no reason to suppose that the early textile industry was market oriented, and if it were, the South surely had a sufficient demand for factory-made fabric to support its own textile industry.

The automobile assembly industry, because of its capital intensive nature, and resulting high value added per man hour of production worker labor, was relatively insensitive to spatial variations of labor costs within the United States. Indeed, the automobile firms in Detroit and other northern centers were raising wages to attract southern labor at the same time that the textile industry was relocating to gain access to less costly southern labor. Because the more fragile and bulkier finished product costs more to ship than the material from which the automobile is produced, assembly plants should be market oriented. In fact, the locational pattern of the United States plants, with some in nearly every one of our largest metropolitan areas, does resemble that of a market oriented industry. But the concentration in southern Michigan is too large to be accounted for by market orientation. Like the textile industry of New England, the automobile assembly industry of Michigan is an inertial remnant of an initial concentration that cannot be explained by Weberian theory.

Beginning in the nineteenth century, the iron smelting and refining industries shifted from material to market orientation as innovations gradually reduced the ratio of coal and ore required per ton of product. However, the high degree of locational inertia in the industry permitted
obsolete, material oriented locations to persist as production centers for prolonged periods. Thus, anyone inferring the orientation of this industry from its locational pattern could be misled by the prevalence of inertial remnants of the days when the least cost locations for iron and steel production were at coal fields. Two of the most important of these inertial remnants are the eastern and western Pennsylvania locations of the innovations of hot blast, puddled iron and Bessemer steel. Unlike the innovative centers that remain as inertial remnants in the textile and automobile industries, those in the steel industry are consistent with Weberian theory.

The apparent deficiency of the least cost approach, then, is in its inability to explain why the textile and automobile industries experienced their initial growth in order than least cost locations. Growth Pole theory provides a rationale for industries initially concentrating in non-optimal locations.

**Growth Pole Theory** This treatment of Growth Pole theory is limited to those elements that pertain to the question of why some industries initially concentrate in other than Weberian least cost locations: the industrial cycle concept, cumulative causation, and core-periphery relationships. According to the industrial cycle concept, industries are born with the innovation of a new product or process; they experience rapid growth and technological change during their youth; they reach maturity when the product and process become standardized; and they eventually decline unless they are revitalized by new innovations. Before the industry attains maturity, firms will succeed only if they are located near that industry’s innovators, even though it is very unlikely that such locations will prove to be least cost ones. At this time, access to information about rapidly changing technology and the ability to lure skilled workers from the innovating firms and obtain backing from willing financiers are more crucial to success than are the Weberian considerations of access to markets, materials, or cheap labor. W.P. Strassman provides persuasive evidence that the ideas of Samuel Slater and his associates were more important than cheap labor in the early phases of the United States textile industry. Likewise, the initial concentrations of the Bessemer steel and automobile assembly industries could be explained by the need to have immediate access to the ideas of people such as Andrew Carnegie and David Thomas, in Pittsburgh, and Ransom Olds and Henry Ford in Detroit.

If one accepts the idea that non-optimal initial locations result from the need for firms in young industries to locate near clusters of innovators, then the next step is to explain the locational pattern of
industrial innovation. According to the cumulative causation component of Growth Pole theory, industrial innovations occur most frequently, if not exclusively, in places that are already intensively industrialized. It is only in such places that Growth Pole theorists expect to find the required concentrations of technological expertise, financial resources, demand for new products, and "... the social structure and psychological attitudes ... favorable to the adoption of ... innovations." The idea of cumulative causation is useful for explaining the persistence and growth of manufacturing regions but, as Simmons points out, it "... provides no mechanism for altering the location of growth." In Growth Pole theory, the mechanism for altering the location of growth is called spread effects, one aspect of core-periphery relationships.

In Growth Pole theory, the spatial components of economic systems are a densely populated, highly urbanized and industrialized core which dominates a periphery of lesser population density, urbanization, and industrialization. In the early phases of core development, core-periphery relationships are mostly backwash effects which drain skilled labor, capital, and raw materials from the periphery to support the industrialization of the core. Spread effects, by which industries diffuse from the core to the periphery, begin as core industries reach the mature stage of the industrial cycle. Firms in these industries, which typically originated in the largest and oldest core city, open branch plants to tap new markets, material sources and labor pools. Proceeding down the urban hierarchy and outward from the center of the core, this process leads to the areal growth of the core. But the initial nucleus of the core retains the headquarters of the firms and persists as the site of subsequent industrial innovation.

One does not have to agree with Gauthier that "... the concept of growth poles in geographical space does not give any new insight into the location process beyond those already provided by classical [i.e., Weberian] location theory..." to be convinced that Growth Pole theory cannot account for the events that are the major concern of this paper. The American Manufacturing Belt, or core region, did not expand by branch plants of mature industries diffusing from core to periphery while new industries were being periodically innovated in the nucleus of the core. Rather, it expanded by each later propulsive industry being innovated on the western edge of the area previously incorporated into the core. In 1840, anthracite iron processing was innovated just west of the cluster of major textile producing counties, as indicated on Figure 1. By 1860, the value of iron production ($94 million) exceeded that of woolen goods ($61 million) and nearly
equalled that of cotton goods ($107 million). The major iron producing counties in 1860 were clustered in eastern Pennsylvania (Figure 2), which had been on the western edge of the Manufacturing Belt in 1840. Pittsburgh, located near the western edge of the cluster of major iron processing counties in 1860, was the center of innovation of the Bessemer steel industry in the 1870s. The concentration of major steel producing counties along the Ohio-Pennsylvania boundary in 1900 (Figure 3) reflects the focus of growth that existed there as the Manufacturing Belt again expanded westward between 1860 and 1900. Thus, in 1900 when the modern automobile industry was emerging there, Detroit was on the western edge of the steel era Manufacturing Belt. The idea, suggested by these facts, that conditions are more conducive to innovation on the edges than in the centers of industrialized cores has been implied by other observers. The Industrial Frontier hypothesis is an explicit statement of that idea.

**THE INDUSTRIAL FRONTIER HYPOTHESIS**

The Industrial Frontier hypothesis, like Growth Pole theory, postulates that demand for raw materials by industries in the core stimulates the growth of primary industries in the adjacent periphery. But, contrary to Growth Pole theory, not all of the investment capital
Figure 2
PITTSBURGH, WHERE THE BESSEMER STEEL INDUSTRY ORIGINATED, AND COUNTIES IN WHICH IRON MANUFACTURES WERE VALUED AT OVER $1,000,000 IN 1860.

Figure 3
DETROIT, WHERE THE AUTOMOBILE ASSEMBLY INDUSTRY ORIGINATED, AND COUNTIES IN WHICH OVER 300,000 TONS OF STEEL WERE MANUFACTURED IN 1900. (NOT SHOWN: JEFFERSON COUNTY, ALABAMA).
SOURCE: U.S. CENSUS, 1900 (FOOTNOTE 17).
generated by peripheral primary industries is assumed to be attracted to the core. One assumption of the Industrial Frontier hypothesis is that some capital will be retained to finance the innovation of manufacturing industries along the frontier between the industrialized core and periphery.

According to the Industrial Frontier hypothesis, as the forest and mineral resources in the industrial frontier are depleted, entrepreneurs who have recently made modest fortunes in risky lumbering and mining ventures, forced to find new sources of income, are willing to invest in untried manufacturing enterprises. Some of the technical and managerial talent for the new firms is obtained by attracting experienced employees away from branch plants of core-based, mature industries. New, independent firms provide greater opportunities for ambitious men, eager to have their ideas accepted and their talents rewarded. Furthermore, recent immigrants and sons of established farm families provide a pool of willing unskilled and semi-skilled production workers. Thus, risk capital, technical and managerial talent, and production labor are all readily available to support the innovation of industries on the Industrial Frontier.

In the industrialized core, however, there is no apparent need to invest money in risky new manufacturing ventures. Instead, capital is reinvested in existing mature industries, often in the form of branch plants, many of them in the periphery. For example, in the 1900s, New England capital was available for building textile plants in the South, but not, evidently, for automobile factories in New England. Ironically, Detroit entrepreneurs provided a similar example when they had the chance to take the lead in the post World War II aircraft industry. Instead, according to Wilbur Thompson:

... impatience to get back to the more lucrative automobile business was so great that airplane production was not even accorded a secondary place on Detroit's industrial agenda. Conversely, Los Angeles, with nothing as profitably as making automobiles to reconvert to, fought for and won the postwar airplane business.\(^{19}\)

Another disadvantage of the core, \textit{vis a vis} the Industrial Frontier, is that the rigid structure of successful industries frustrates innovative technicians and managers, and production labor tends to resist cost-reducing innovations.\(^{20}\)

These hypothesized advantages of Industrial Frontiers for the innovation of propulsive industries cannot be verified without examining
particular cases. The following brief accounts of the automobile and the iron and steel industries, though far from conclusive are offered as evidence that additional research on the Industrial Frontier would be worthwhile.

THE AUTOMOBILE INDUSTRY

Detroit emerged as the leading center of the automobile industry in the years between 1900 and 1910. In 1900, the United States Census first provided data for the automobile industry. At that time, Detroit was not recognized as a major center and the automobile industry data were included in the census monographs describing the bicycle, the wagon and carriage, and the locomotive industries. Gasoline powered cars, listed in one census table under the quaint heading of "hydrocarbon," accounted for only 936 of the 4,192 automobiles produced in 1900. In this table, Massachusetts, Connecticut, and New York were credited with the production of 2,733 of the 4,192. Since it was not one of the thirteen states listed separately, evidently Michigan was included in the "all other states" category which only produced 27 cars in 1900. From these data it is evident that, in 1900, New England contained the major concentration of automobile production, and that most of the cars produced there were powered by steam or electricity. Yet, "... between 1900 and 1912 ... the geographic center of automobile manufacturing shifted from New England to Detroit" and gasoline engines became the dominant source of power. These changes in geographic focus and mode of power accompanied the change of the industry from the handicraft stage to that of mass production. The question at issue here is why this transformation took place in Detroit rather than in the Northeast, i.e., on the fringe of the Manufacturing Belt rather than in its core.

Fortunately, the primary sources relating to the rise of the automobile industry have been extensively analyzed so that the facts of the case are fairly well known. But little, if any, attention has been paid to the discrepancies between these facts and the relevant theory. According to Weberian theory, the market oriented automobile assembly industry should have been attracted to the populous Northeast, in 1900. Even as late as 1910, car registrations per capita were greater in both Massachusetts and Connecticut than in either Michigan or Ohio. Surely, the market in the Northeast was more than adequate to support a plant that would have been large enough to compete with the emerging Detroit
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operations of Ford and General Motors. According to Growth Pole theory, the requisite technological innovators and financial capital should have been more concentrated in the Northeast than in the Midwest. Perhaps they were more abundant, but the Northeastern capitalists were reluctant to risk money on untried ventures; and some important innovators moved from the northeastern core to the midwestern periphery, in direct contrast to the backwash, or brain drain, proposed by Growth Pole theory.

Henry M. Leland, the father of interchangeable parts in the automobile industry and a founder of Cadillac, was trained at Crompton and Knowles, Brown and Sharpe, and Colt—the very creches of New England machine tool technology. But, in 1890, he decided to move to Detroit "... because in that city he found the financial backing he needed. ..." After building the first successful American gasoline powered car, in Massachusetts, the Duryea brothers moved back to Illinois to found the Duryea Motor Company. Several machine tool firms were in the Midwest at the time of the founding of the automobile industry as the result of the migration of indispensable individuals or entire firms from the Northeast. The list includes: Christian Sharps, who invented the Sharps rifle in Cincinnati; Lodge, Davis and Company, of Cincinnati, "... the pioneer in the quantity production of standardized machine tools in the interchangeable parts system..."; Warner and Swasey, who apprenticed together in Exeter, New Hampshire, and worked together at Pratt and Whitney in Hartford before founding the well known Cleveland firm that bears their name; and the National Acme Company, which was founded in Hartford by Edwin Henny, one of the two inventors of the multiple-spindle automatic screw machine, who moved the firm to Cleveland in 1901 to obtain capital that was not available in Connecticut.

A striking feature of the list of early financial backers of the Detroit automobile industry is the frequent occurrence of men whose fortunes were made in local primary industries. William H. Murphy, who financed the early Ford factory which later became, with additional backing from Murphy, the first Cadillac factory, was the scion of a Michigan family that had made a fortune in the lumber industry. Alexander Malcomson, the principal backer of Ford's first successful venture in making inexpensive cars, was a Detroit coal dealer who "... owned a thousand acres of coal land in West Virginia." A Detroit copper tycoon, named S.L. Smith, provided the money to convince R.E. Olds to build his 1897 plant in Detroit. Other crucial figures involved in
the rise of General Motors were financed by Michigan lumber fortunes, including: W.C. Durant, who built Buick Motors into the nation's largest producer of cars in 1908; James Dempsey, who was a major backer of the Oakland Motor Company which later became Pontiac; and the Falkner of the Leland-Falkner-Norton firm which eventually became Cadillac Motors.39

It is evident that Michigan was well provided with entrepreneurs who had recently made fortunes in primary industries, and that these entrepreneurs were willing to invest in risky, local business ventures. In the Northeast, on the other hand, bankers were directing investment capital into what they considered to be risk free ventures and away from the daring game of financing the production of gasoline powered automobiles. Unfortunately, the authors who have commented on the reluctance of eastern bankers to finance automobile producers have said little about the reasons for their reluctance.30 However, reasons may be inferred from the writings of Benjamin Chinitz, Lance Davis, and Glenn McGlaughlin. In comparing the behavior of big and little investors, Chinitz said, "If you have U.S. Steel and Westinghouse on your rolls, you do not have to learn to make money by the insurance principle."31 That is to say, unlike small investors, established financiers will invest in a few sure things rather than invest in many small long-shots in the hope that one of them will pay off. Chinitz also contends that compared to large firms, small firms: 1) generate more entrepreneurs per capita, 2) are much more dependent upon local capital, and 3) are much more likely to reinvest earnings in the local area, even if it means investing in an industry other than that of the reinvesting firm. Large firms, on the other hand, tend to reinvest in the same industry, even if it means exploring capital to another region.32 To the extent that, in 1900, the Northeast was, compared to the Midwest, a region of larger firms and financiers, Chinitz's generalizations provide reasons for significant differences between these regions in their willingness to support the modernization of the automobile industry. Lance Davis33 found that in the United States financial capital was generally immobile between regions and industries until at least 1900, and that early western industries were financed almost entirely by reinvestment of earnings and other local sources of capital. In a similar vein, Glenn McGlaughlin found that

Capitalists in newly developed regions . . . often looked favorably on the possibilities of speculative profits in new industries, whereas investors in older areas . . . may prefer a fixed regular return.
Usually, a new industry is not initially financed by the central money markets.\textsuperscript{34}

It may be that innovative individuals and firms were attracted to the venturesome entrepreneurs who were more prevalent in and around Detroit than in New England for the reasons implied by the ideas of Chinitz, Davis and McGlaughlin. But some authorities cite other advantages as being responsible for the emergence of Detroit as the dominant center of automobile production. These include a better trained and more docile labor supply, plentiful stands of hardwood timber supporting the requisite carriage and wagon industries, the Great Lakes small boat industry leading to the prerequisite gasoline motor industry, an early preference for gasoline powered cars that depended upon poor roads restricting the use of electric cars, and the historical accident that so many industry leaders were born in and around Michigan.\textsuperscript{35} Disregarding historical accident, each of these supposed advantages was examined. Some were found to support the Industrial Frontier hypothesis as they were conditions more likely to be found on peripheries than in cores. Others were found to be factors in which the Midwest had no real advantage over the Northeast in 1900.

According to some writers, the more docile and better trained labor supply in the Midwest was provided by farmers’ sons who, presumably, were more docile because they hadn’t been exposed to the radical ideas prevalent in eastern cities and were mechanically inclined because they had grown up working on farm machinery.\textsuperscript{36} If true, this idea would support the Industrial Frontier hypothesis, since farmers would be more plentiful in peripheries than in cores. However, others have attributed the superior labor force to the existence of antecedent carriage and bicycle industries. With regard to the carriage and wagon industry, the 1890 rank order of value production was Ohio, New York, Illinois, Indiana, Pennsylvania, Massachusetts and Michigan. The combined value of production of the three leading midwestern states was \$33,900,000, while that of the three leading northeastern states totalled \$28,700,000. Michigan produced \$6,300,000 in carriages and wagons in 1890.\textsuperscript{37} Clearly, the Midwest had only a minimal advantage over the Northeast, and Michigan was not a leader in this industry. A better case might be made for the bicycle industry, as the four leading states in order of their 1890 value of production were Illinois, Ohio, New York and Connecticut. Production in the two midwestern leaders was worth \$13,000,000 and the two northeastern leaders produced bicycles worth \$7,500,000.\textsuperscript{38} But even in this industry, there was considerable produc-
tion in the Northeast, including that of the progressive Pope Company, an early entrant into automobile production. At any rate, if the carriage and bicycle industries of the Midwest provided a sufficient pool of mechanically proficient workers to support the development of a modern automobile industry in Detroit, it would seem evident that the Northeast was also adequately supplied with such workers.

Examination of data pertaining to internal combustion engine production leads to similar conclusions. In 1900, according to Victor Clark, Pennsylvania and Wisconsin were the leading states in this industry—Pennsylvania led in value of production and Wisconsin led in the number of engines produced. In the same year, these two states ranked eighth and ninth in the value of production of automobiles powered by internal combustion engines. By value of production, the leading states in the production of gasoline powered cars in 1900 were New York (21% of the national total), Ohio (18%), Connecticut (18%), New Jersey (14%), and Massachusetts (6 1/2%). Four northeastern states accounted for just about one-half of the total value of internal combustion cars produced in the U.S. in 1900. These data are not consistent with the idea that the Midwest had a significant lead over the Northeast in experience with gasoline engines.

In summary, the only really significant contrast between Detroit and New England in 1900 may have been the contrast between complacent entrepreneurs who failed to recognize the potential of the automobile industry and desperate entrepreneurs eagerly seeking new ventures.

**ANTHRACITE IRON AND BESSEMER STEEL**

From the Weberian viewpoint, the anthracite iron and Bessemer steel industries were innovated at Catsauqua and Pittsburgh because of their proximity to the necessary fuel resources. Changes in technology brought about changes in fuel requirements which dictated a change in location; and it was only coincidence that the required fuel, in each case, was located on the edge of the manufacturing belt at the time of innovation. But according to the Industrial Frontier hypothesis, these innovations occurred on the edge of the Manufacturing Belt because that is where entrepreneurs were willing to risk money on new ventures, and they adapted the new technology to fit the requirements of nearby coal resources.

Consider the following: (1) the first successful coke-fueled blast furnace was fired in 1709, and by 1810 over ninety percent of English blast furnaces were using coke; (2) Connellsville coke was offered for
sale to Pittsburgh blast furnace operators as early as 1813;\textsuperscript{42} (3) the open hearth and Bessemer processes for making steel were both put into operation in the United States before 1870;\textsuperscript{43} and (4) the open hearth process, which eventually replaced the Bessemer process as the preferred way for making steel, did not have to be located near Connellsville to be successful. Given these facts, it is difficult to understand why coke-fueled open hearth steel did not dominate in the United States until about 1910. During the anthracite era (1840 to 1870) resources and technology were already available to support coke-fueled blast and puddling furnaces; and the resources and technology to produce open hearth steel were available during the Bessemer era (1870 to 1910).

The Anthracite Iron Era Two opposing theories have been proposed to explain the long delay in the general use of coke for smelting and refining iron in the United States. First, Hunter maintained that the reason was that the pre-Civil War market for iron was dominated by the demand of rural blacksmiths and other small scale producers of agricultural and domestic implements, who preferred charcoal iron for its greater adaptability to many varied uses.\textsuperscript{44} This theory was rejected by Peter Temin, who pointed out that it was a preference for anthracite iron, rather than for charcoal iron, that delayed the adoption of coke. Temin argued that iron made from coke, in the early days, was inferior to iron made from anthracite because the coke was made from sulphurous coal. In order to explain why they did not use coke made from sulphur-free Connellsville coal, Temin supposed that the iron masters of the 1840s and early 1850s did not realize that sulphur was responsible for the poor quality of iron made with coke. But Temin conceded that "The process by which Connellsville coke was brought into use, therefore, retains some of its mystery even now."\textsuperscript{45} But the intervention of an eastern Pennsylvania anthracite iron era before a western Pennsylvania Connellsville coke-fueled era is not a mystery if these events are interpreted in the context of the Industrial Frontier hypothesis.

The entrepreneurs who introduced hot-blast smelting and puddling furnace refining into the United States very probably knew about Connellsville coal, and they certainly knew about the coke-fueled iron industry in England. But they were more interested in England's successful anthracite furnaces, because these entrepreneurs, who lived in eastern Pennsylvania on the edge of the existing Manufacturing Belt, needed a market for their anthracite coal holdings. Having failed in an early attempt to build and operate an anthracite furnace, and given the lack of claimants to a prize they offered for a practical method to smelt iron ore with anthracite, the Lehigh Coal and Navigation Company
acquired the services of David Thomas, who was ironmaster at George Crane's original anthracite furnace in Wales.

Several of the Lehigh managers formed a new company named the Lehigh Crane Iron Company in honor of George Crane, to finance Thomas' efforts. Thomas put the first furnace into production in the summer of 1840 along the Lehigh Canal at Catasauqua, Pennsylvania. With Thomas as manager, the Lehigh Crane Iron Company built four more successful furnaces in the next decade, and remained a center of innovation in anthracite iron technology. Catasauqua became the principle model which other ironmasters sought to copy and improve on.

Indeed, Catasauqua became the center of an eastern Pennsylvania region in which anthracite iron processing was so widespread and efficient that coke-fueled production did not predominate in the United States until sixty years after such technology dominated British industry. But there is no need to presume that, during this time, entrepreneurs in the United States were ignorant of either the existence or the advantages of Connellsville coke. It is just as reasonable to attribute the delay to the time required for the Industrial Frontier to reach western Pennsylvania. Then, in the 1870s, the entrepreneurs of western Pennsylvania would become innovators of the Bessemer process to utilize nearby Connellsville coal deposits, just as the entrepreneurs in eastern Pennsylvania had innovated anthracite furnaces to utilize their local resources in the 1840s.

The Bessemer Steel Era

Although most authorities use Weberian concepts to explain the innovation of Bessemer steel in Pittsburgh, some of their findings may be used to support the Industrial Frontier concept. After analyzing the cost of producing pig iron and transporting it to eastern markets in the 1880s, Peter Temin concluded that:

...the costs of transporting the iron to market from a furnace in the anthracite region were sufficiently lower than the costs from a furnace near Pittsburgh to balance the extra cost of coke at the eastern furnace. The anthracite areas cannot be said to be under a locational disadvantage with respect to the Eastern market relative to the other pig iron producers of the time.

Since Pennsylvania pig iron producers had no cost advantage over eastern Pennsylvania producers in eastern markets in the 1880s, and since Pittsburgh's Bessemer steel would have no cost advantage in
western markets once open hearth mills were established in Chicago and other western centers, the geographical and historical span of Pittsburgh's least cost status may have been quite limited and dependent more upon the delay in the adoption of open hearth technology in other places than upon any advantage inherent in Pittsburgh's location near Connellsville coal.

Although he stressed the importance of Connellsville coke in explaining the shift of iron refining from eastern to western Pennsylvania, Kenneth Warren also recognized the importance of the "... rapid economic growth..." in western Pennsylvania and that "... older plant and, equally important, less expensive habits of thought also penalized the eastern works." In comparing labor conditions, Warren noted that:

Labour ... cost more in the west and was less tractable there, but the loyal Pennsylvania Dutch furnace labour [in eastern Pennsylvania] ... may have been a disadvantage in the long run by delaying mechanization.

With regard to entrepreneurship and innovativeness, Warren had this to say:

Eastern entrepreneurs generally seem to have been less enterprising, less ready to innovate. ... Aided by superior fuel, ironmasters west of the Alleghenies soon became pioneers of new technology.

Warren's comments on the advent of open hearth steel and the eclipse of Pittsburgh by Chicago are also pertinent.

Pittsburgh's leadership, which had owed so much to technical excellence and commercial drive, now passed back to the area which had from long before the most advantageous location and Chicago re-established its ascendancy in rails.

Warren even maintained that the shift to open hearth technology gave the producers in the old eastern centers, as well as those in Chicago, an advantage over Pittsburgh producers.

... its great wealth of scrap ... and large centers of population made it [the eastern region] more favorable for the open hearth ... but the big firms struggled on in the old trades [Bessemer furnaces and rail mills] until the change was literally forced on them by competition from the west.

When structural steel replaced rails as the major market for the
industry, the eastern centers were better located than either Pittsburgh or Chicago.

[But] Bethlehem steel, as John Fritz exposed . . . frittered away the advantages of location by wrong choices or [indecision]. . . . In the early nineties the directors refused . . . Fritz's suggestion that the firm should go into structural steel . . . and so it lost to Pittsburgh the opportunities which proximity . . . gave it. 54

Paul Strassman indicates that one of the reasons that the owners of Bethlehem Steel resisted the introduction of labor saving technology was that "They owned all the houses in South Bethlehem and the company stores . . ."55 Later in the same work, Strassman states that Andrew Carnegie's propensity to invest in new technology " . . . may have been first inspired by the contrast between torpid Dunfermline, Scotland, [Carnegie's birthplace] and booming Pittsburgh around 1850. . . ."56

The point of including all these direct quotations is to show that even analysts who explicitly use Weberian reasoning to explain why Pittsburgh dominated the Bessemer steel era, nevertheless recognize that the issue has not been fully explained and that conditions in western Pennsylvania were more favorable to innovation, then, than were conditions in eastern Pennsylvania. These favorable conditions attracted machinists and innovators, who had learned their trade from the iron masters of eastern Pennsylvania, to migrate west in much the same way that Henry Leland and others would be induced to migrate to Detroit from southern New England in the 1900s. The legendary Captain Bill Jones came from David Thomas's Catasauqua iron works to play an indispensable part in establishing the Bessemer steel industry in western Pennsylvania.57 Likewise, Alexander Holley, who learned steel making from Henry Bessemer and who helped build most of the early eastern Pennsylvania Bessemer convertors, was hired by Carnegie in 1872 to supervise the erection of Carnegie's first steel mill.58 Consistent with Growth Pole theory, the established industrial region provided the technical experts required to spawn a new industry. However, they had to migrate to the Industrial Frontier to find entrepreneurs willing to finance risky new ventures.

Another pertinent similarity between the steel and automobile industries is the importance of local fortunes, made in primary industries, as sources of initial risk capital. In 1872, when Andrew Carnegie abandoned his other enterprises to concentrate on steel production, he organized the Carnegie-McCandless Company to finance the operation. One half of the $700,000 initial investment in Carnegie-McCandless
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came from Carnegie ($250,000) and William Coleman ($100,000). The other $350,000 came from seven local investors who each supplied $50,000: David Stewart, president of Columbia Oil Company; David McCandless, a local businessman; two local railroad executives; and three former partners in Carnegie's Union Iron Company.59 In 1861, Coleman persuaded Carnegie to help organize and finance the Columbia Oil Company to exploit the fields around Titusville, Pennsylvania. Carnegie, then in his twenties, made over one million dollars on this venture, one of his earliest ones. But, convinced that "... oil had seen its best days ..." Carnegie sold his interest in Columbia Oil in 1865.60 Thus, Carnegie epitomized the entrepreneur on the Industrial Frontier. Having made a modest fortune in an extractive industry located on the edge of the Manufacturing Belt, he was looking for a new investment just when a new industry needed a willing investor.

The innovation of the Bessemer steel industry in Pittsburgh—like that of the anthracite iron industry in Catasauqua and the automobile assembly industry in Detroit—illustrates three components of the Industrial Frontier hypothesis: (1) industrial innovations occur on the edges of manufacturing belts; (2) they are financed by local investors who made money in primary industries; and (3) technological expertise is provided by migrants to peripheries from cores.

CONCLUDING REMARKS

After demonstrating that Weberian and Growth Pole theory are insufficient to explain the time and place of innovation of three industries that were instrumental in shaping the geography of the United States manufacturing belt, a supplement to those theories has been proposed, the Industrial Frontier hypothesis. The basic premise of this hypothesis, that conditions are more conducive to industrial innovation on the edges of industrial cores than in their centers, has been supported by evidence from secondary sources. The verification, or possible rejection, of this hypothesis awaits more intensive analysis of the industries and places discussed in this paper, as well as some others. For example, Johnstown, Pennsylvania, intervened geographically and historically between Bethlehem and Pittsburgh in the development of iron processing technology in the United States. The role of the innovative Cambria Iron Company, of Johnstown, in attracting crucial technicians to western Pennsylvania needs to be examined from the point of view of the Industrial Frontier hypothesis. The Industrial Frontier hypothesis also appears to be relevant to the machine tool
industry, which experienced a technological revolution in the 1890s, the
decade in which Ohio, on the Industrial Frontier, replaced Connecticut
as the leading state in the industry. Analysis need not be limited to
regions and industries of the past. Witness California’s Silicon Valley,
which has been described as an “amazing” concentration of innovative
industries supported by “... an intellectual and business atmosphere
that venturesome entrepreneurs need in order to succeed.” The idea of
an Industrial Frontier may even have some value in anticipating the
future. That is not to say that the United States, or any region within the
United States, is predestined to lose its industrial vitality. But policy
makers should recognize that, contrary to Growth Pole theory, innova-
tive industrial enterprise has been resisted by strong forces in industrial
cores. Perhaps concern should be less about policies to protect existing
regions and industries and more with policies to permit, if not to
promote, growth on the Industrial Frontiers.

NOTES

1. Some recent examples are: Thomas A. Clark, “Regional and Structural Shifts in the
American Economy Since 1960,” in Stanley Brunn and James O. Wheeler (Eds.), The
American Metropolitan System: Present and Future (New York, 1980); William Keinath,
Economic Geography 58 (1982), 343-357; and George Sternlieb and James Hughes
(Eds.), Revitalizing the Northeast: Prelude to an Agenda (New Brunswick, New Jersey,
1978).

2. Briefly stated, propulsive industries are ones that grow rapidly and induce growth in
other industries. J. R. Boudeville, Problems of Regional Economic Planning (Edinburgh,
1966) 112; David M. Smith, Industrial Location: An Economic Geographical Analysis

3. This sequence of industries combines those specified in W. W. Rostow, “A National
Policy Towards Regional Change,” in Sternlieb and Hughes, Revitalizing the Northeast,
129; and Harold G. Vatter, The Drive to Industrial Maturity: The U.S. Economy

4. For a concise summary of Weberian theory see F. E. I. Hamilton, “Models of
Industrial Location,” in Richard Chorley and Peter Haggett, Models in Geography
(London, 1967); or Smith, Industrial Location, 68-75.

5. Walter Isard, “Some Locational Factors in the Iron and Steel Industry since the Early

6. These aspects of Growth Pole theory are explained in Niles Hansen (Ed.), Growth
Centers in Regional Economic Development (New York, 1972); John Parr, “Growth
Poles, Regional Development and Central Place Theory,” Papers of the Regional Science
Association, 31 (1973), 173-212; Morgan Sant, Applied Geography: Practice, Problems,
and Prospects (New York, 1982); and Morgan D. Thomas, “Growth Pole Theory,
Technological Change and Regional Economic Growth,” Papers of the Regional Science

7. This sequence has been called the “Law of Industrial Growth” that every industry
obeys in E. B. Alderfer and H. E. Michl, Economics of American Industry (New York,
INNOVATION ON THE FRONTIER


23. Ibid., 78.

24. Mrs. Wilfred C. Leland, with Dubbs Millbrook, Master of Precision: Henry Leland (Detroit, 1966), 52.


27. Flink, *America Adopts the Automobile*, 298–300.


35. Flink, *America Adopts the Automobile*, 311.


