The Iron Industry in the United States

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Source: *The Quarterly Journal of Economics*, Feb., 1900, Vol. 14, No. 2 (Feb., 1900), pp. 143-170

Published by: Oxford University Press

Stable URL: https://www.jstor.org/stable/1883767

THE

QUARTERLY JOURNAL

OF

ECONOMICS

FEBRUARY, 1900

THE IRON INDUSTRY IN THE UNITED STATES.

I.

A Survey of Growth.

In the following pages I propose to consider the growth of the iron industry in the United States during the last thirty years, and the effect on it of the protective duties which have been maintained throughout this period. The rate of growth has been so extraordinary, and has been attended by changes so striking, as to make the mere chronicle an instructive chapter in economic history. We see here at work on a huge scale the forces which have transformed modern industry, and get vistas of new social problems, as well as more light on the questions which chiefly engaged the attention of economists a generation ago. Both for the interest of the subject itself, and by way of clearing the ground for the discussion of the protective duties, I shall first describe the revolution which has taken place in the American iron and steel industry, proceeding thereafter to those aspects of the industry which are especially connected with the tariff controversy.

Thirty years ago Great Britain was still the world's commanding producer of iron and steel. Notwithstanding half a century or more of almost continuous protection, the United States held but a distant second place. The output of pig iron in the old country in 1870 was very nearly six millions of tons: that in the new country was but little over a million and a half. But between 1860 and 1870 the product in the United States had doubled,—a geometrical progression, which, if maintained, must soon cause all rivals to be distanced. It is much easier, however, to double a small number or a small output than a large one: the rate of growth in the beginnings of a movement is rarely maintained for long during its later course. Yet in this case the unexpected happened: for three decades the geometrical progression was maintained in the output of pig iron in the United States. The product of 1870 had been double that of 1860, 1880 doubled 1870, and 1890 again doubled 1880. The iron industry of Great Britain held its own, and, indeed, between 1870 and 1880 made a notable advance; but it could not match the astounding pace of its young rival. In 1890 the United States turned out more than nine million tons of pig iron, for the first time passing Great Britain, and displacing that country suddenly as the leading producer. The depression which followed the crisis of 1893 caused a sharp decline in the American product, the lowest point being reached in 1894. But with the revival of activity after 1896 the figures again mounted, reaching near twelve millions in 1898, and fourteen millions in 1899. The year 1900 will hardly show a repetition of the feats of the previous decades. The pace of the geometrical progression is too killing to be maintained; yet all present indications are that the close of the decades will show an output beyond the dreams even of five years ago,*

*The figures as to the production of iron in the two countries are easily found in the excellent statistical reports prepared for the trade in the two countries,—the *Statistical Reports of the British Iron Trade Association*, of

This enormous increase, however, has been by no means evenly distributed over the United States. Within the country a revolution has taken place, which is part and parcel of the changed relation to other countries, and which must be followed before the latter can be understood.

The first great impulse to the production of crude iron on a large scale came in the United States with the successful use of anthracite coal as fuel. During the twenty years preceding the Civil War (1840–60) the site of the industry and its growth were governed by this fuel.* Hence eastern Pennsylvania was the main producing district. The supplies of ore near this region were smelted with its anthracite coal, and Philadelphia was the central market. Proximity to the seaboard made foreign competition easy, except so far as it was hampered by the tariff duties; and the very existence of the iron industry was felt to depend on the maintenance of protection. For some time after the close of the Civil War this dominant position of anthracite iron was maintained. In 1872, when the systematic collection of detailed statistics began,

which Mr. J. S. Jeans has long been secretary, and the *Statistical Reports of the Iron and Steel Association*, of which Mr. J. M. Swank has been the equally efficient secretary. For quinquennial periods the output of pig iron in Great Britain and the United States has been as given below. The figures for Germany (including Luxemburg) are given also: the growth there, too, has been extraordinarily rapid: —

	Great Britain.	*United States.*	*Germany.*
1870	5,963	1,665	1,391
1875	6,365	2,024	2,029
1880	7,749	3,835	2,729
1885	7,415	4,044	3,687
1890	7,904	9,203	4,658
1895	7,703	9,446	5,464
1896	8,563	8,623	6,375
1897	8,817	9,653	6,864
1898	8,681	11,774	7,216
1899	—	14,000 (est.)	—

For the United States and Great Britain the figures denote thousands of gross tons of 2,240 pounds; for Germany, metric tons of 2,204 pounds.

* For an account of the industry during this period I refer to my *Tariff History of the United States*, pp. 123–135.

out of a total production of 2,500,000 tons, one-half was smelted with anthracite coal, a third with bituminous coal or coke, the remainder with wood (charcoal). The use of soft coal, which had begun before 1860, became rapidly greater. Already in 1872 it was important; and from year to year it grew. In the periodic oscillations between activity and depression, which mark the iron trade more distinctively than any other industry, anthracite iron shrank sensitively in the slack periods, and barely regained its own in the succeeding periods of expansion. Bituminous or coke iron, on the other hand, held its own during the hard times, and advanced by leaps and bounds with each revival of activity. In 1875 for the first time its output exceeded that of the rival eastern fuel, and since that date the huge advance in the iron product of the United States has been dependent on the use of coke. Indeed, the use of anthracite alone began to shrink at a comparatively early date. It soon ceased to be used on any large scale as the sole fuel, coke being mixed with it for use in the blast-furnace. The production of iron with anthracite coal only has shrunk to insignificant dimensions. What is classed as "anthracite iron" is smelted with a mixture of coke and hard coal; and, even with the aid of the coke, this means of reducing the ore has come to be of less and less importance. Virtually, anthracite coal has been displaced as an iron-making fuel.*

This change is easy of explanation. It is the inevitable result of the greater plenty and effectiveness of coke; and it has been powerfully promoted by the rapid development of the United States west of the Appalachian chain, and the nearness of the coke region to this growing market. Anthracite, at best, is an obdurate fuel. At the same time its strictly limited supply, and the cleanliness and freedom from smoke which make it an ideal domestic

*The production of pig iron by fuel at quinquennial intervals is given below. By way of illustrating the trend over a long period, the year 1855 has

fuel, have maintained its price at a comparatively even level. On the other hand, the almost unlimited supplies of bituminous coal and the feverish competition in opening coal lands and marketing their product have caused an almost uninterrupted fall in its price. Coke has proved, ton for ton, a better fuel than anthracite: the supplies of bituminous coal available for coking are virtually limitless; and the processes of coking have been applied on a huge scale and with tireless energy.

Pittsburg, long ago seen to be destined to become a great iron centre, is situated in the heart of the region where coking coal is plentiful. To this point the iron industry has converged, attracted first by cheap fuel, and soon by other geographical advantages of the region,— its easy access to the growing western country, and the added opportunities of securing super-abundant quantities of the best ore. Pennsylvania has remained the greatest iron-producing State in the Union; but since 1880 it has been western Pennsylvania, and no longer eastern, which has secured to the State its leading position. Since 1890 this district alone has yielded steadily forty per cent. of the enormous iron product in the country; and it is here, and in the other western districts in

been taken as the starting-point. The figures, as in the previous table, indicate thousands of gross tons: —

	Pig Iron smelted with			
	Anthracite.		*Bituminous.*	*Charcoal.*
1855	341		56	303
1860	464		109	248
1865	428		169	234
1870	830		508	326
1875	811		846	367
1880	1,614		1,741	480
	Anthracite alone.	*Anthracite and Coke.*		
1885	250	1,059	2,389	357
1890	249	1,937	6,388	628
1895	56	1,214	7,950	225
1896	111	1,034	7,166	310
1897	21	912	8,465	255
1898	22	1,181	10,274	297

which the same industrial forces have been at work, that we have to study the conditions on which the growth of the iron industry has depended.

The westward movement has been spoken of in the preceding paragraph as affected by the geographical distribution of the fuel. But it has been no less affected by the distribution of the ore supply; and the effect of this in turn has rested on the revolution wrought in the iron trade by the Bessemer process.

The first inventions which made plentiful the iron indispensable for all our material civilization were Cort's processes for puddling and rolling. Through the first three-quarters of the century this was the mode in which the world got its supply of the metal in tough form, usable where heavy strain must come on it. The processes involved at once a considerable plant, complex machinery, and strenuous exertion by skilled and powerful laborers,— conditions which during this period promoted the supremacy of the British iron trade. In the decade 1860–70 the process devised by Sir Henry Bessemer, to which his name attaches, began a second revolution in the iron trade. That process involves a still larger plant and still more elaborate machinery; and it applies machinery more fully to the elimination and subsequent replacing of the carbon on which the toughness of the iron depends. By the new methods the production of mild steel— that is, tough iron — became possible on a vastly greater scale. Bessemer steel has displaced puddled iron in most of its uses. Not only this: the cheap and abundant supply, besides filling needs previously existing, has opened vistas for new plant, machinery, durable instruments of production of all sorts. The first great application of the method was to rails, where the elastic and impact-sustaining steel enabled railway engines and cars to be doubled and quadrupled in size, and to become more efficient in even greater ratio.

Gradually and steadily, new and wider uses were found for the cheap steel. From great ships down to every-day nails, almost every iron instrument became cheaper and better. Wood was supplanted by steel for a variety of uses, and the slow-growing and easily exhausted stores of timber were re-enforced by the well-nigh limitless deposits of ore in the earth's crust. A new domain in nature's forces was opened to man.

But the Bessemer process depends for its availability on special kinds of ore and pig iron,—such as are well-nigh free from sulphur and especially from phosphorus. Variants of the process, free from this limitation, have indeed been applied on a great scale, especially in Germany, where supplies of non-phosphoric ore are not readily available. But the original Bessemer process remains the most effective and the most economical. Ores adapted to it have hence become doubly valuable, and the accessible parts of the earth have been scoured to find them. The deposits of Great Britain in Cumberland and Lancashire contained important supplies, yet not in quantity adequate to the new demand; and the Spanish fields of Bilboa, on the Bay of Biscay, have become an indispensable supplement for the British iron-masters. In the United States, also, some of the sources previously used in the region east of the Appalachian chain proved to be available,—such as the famed deposits, once unique in their ease of working, in the Cornwall hills of eastern Pennsylvania. But the greater part of the eastern ores were too highly charged with phosphorus, or for other reasons unavailable. Here, as in Great Britain, a distant source of supply was turned to. The Lake Superior iron region, long known to explorers and geologists, suddenly sprang into commanding place. Here were abundant and super-abundant supplies of rich and properly constituted ore. These and the equally abundant coal of Pennsylvania were brought together, the iron made from them was converted into steel

by the Bessemer process; and thus only became possible the astounding growth in the production of iron and steel in the United States.

The iron mines of the Lake Superior region stretch in widely separated fields along the lake, from the middle of its southern shore to its extreme north-western end. Intercalated between them is the great copper-bearing peninsula, whose rich yield of that metal has affected the copper trade in the same manner and almost in the same degree as the iron mines have the iron trade. At the extreme eastern end is the Menominee iron field, usually described in connection with the other Lake Superior fields, yet differing from them in important respects. The ore of the Menominee district is easily mined; and it is easily shipped, finding an outlet by the port of Escanaba on Lake Michigan, and thus traversing a much shorter journey to its Eastern markets than that from the Lake Superior mines proper. But it is usually of non-Bessemer quality, and hence can play no considerable part in the most characteristic effects of the new developments. The great Bessemer ore fields of Lake Superior are four in number: in geographical order from east to west, the Marquette, the Gogebic, and the neighboring Vermilion and Mesabi. As it happens, the geographical order has been also, in the main, the order of exploitation. The easternmost, the Marquette, finding its outlet by the port of that name, was the first to be worked on a great scale. Even before the Civil War, mining and smelting had begun; and, as the Bessemer process was more and more largely used, especially after 1873, it was exploited on a larger and larger scale. Here began the digging on a great scale, and the transportation to great distance, of Bessemer ore. After a considerable interval the second field, the Gogebic, began to be worked, in 1884. Lying some two hundred miles further west, along the boundary line between Wisconsin and Michigan, and finding its

outlet by Ashland, on the southern shore of Lake Superior, here was found perhaps the richest and purest Bessemer ore. At about the same time, in 1884, began the development of the most distant of the fields, the Vermilion, lying to the north of the extreme end of Lake Superior, in the State of Minnesota, close to the Canada frontier. Here, too, were great stores of rich Bessemer ore, shipped by the port of Two Harbors, on the northern shore of the lake.

In all these fields the ore has been secured by what we commonly think of as "mining,"—by digging into the bowels of the earth, and bringing the material up from a greater or less depth. But in very recent years the latest and now the most important of the fields has given opportunity for the simplest and cheapest form of mining: great bodies of ore are lying close under the ground, and, when once the surface glacial drift has been removed, obtainable by simple digging and shovelling, as from a clay pit.* Along the Mesabi † range of hills, lying about one hundred miles north-west of the end of Lake Superior, distant not many miles from the Vermilion range, vast tracts of rich iron ore, finely comminuted and easily worked, lie close to the surface. Here a new source of supply was added, offering unique opportunities for exploitation on a great scale. These opportunities were availed of with astounding quickness. The Mesabi field at once sprang into the front rank among the Lake Superior fields, and, indeed, among all the iron-ore fields of the world. Ten years ago the region was a trackless waste. In 1892 it was opened by railway. Towns sprang up, huge steam-shovels attacked the precious ore, and long trains carried it to the newly constructed docks at the port of Duluth. Even during the depression that followed the crisis of

* It should be noted that in the Marquette region, also, the iron ore was secured at the first working and for many years thereafter by open cuts. But the extraction of ore on a great scale has proceeded by underground operations.

† Variously spelled: Mesabi, Mesaba, Messabi, Messaba.

1893 the output from this field mounted year by year. In 1893, virtually the first year of operation, 600,000 tons were shipped from it; in 1894, thrice that amount; and in 1895 it became, what it has since remained, the most productive of the iron-mining districts. A little less than half of the ore is of Bessemer grade. Its physical constitution, moreover, is such that, for advantageous use in the furnace, other ore needs to be mixed with it. Were it all of the prized Bessemer quality, and in the best form, the other fields might be entirely displaced. With the limitations in the quality of the new ore, the other fields still find themselves able to hold their own in the market, though their supremacy is ended by the favored rival.

For many years the Lake Superior mines have been the main sources of supply for the iron ore of the American iron industry. More than half of the total supply had here been secured; and the Bessemer supply, which has been by far the most effective and significant part of the total, has come mainly from this region.*

* The United States Geological Survey, in its successive admirable *Reports on the Mineral Resources of the United States*, has followed the history of the iron fields of Lake Superior, as, indeed, of all the mineral resources of the country. In the issue for 1895-96 (forming vol. iii. of the *Seventeenth Annual Report* of the Survey) a summary description is given, with convenient sketch maps showing the location of the several fields. In *Cassier's Magazine* for October, 1899, Messrs. J. and A. P. Head, two English engineers, published an excellent brief account of the Lake Superior mines, and of the modes of working them.

The relative importance of the fields, the order in which they have been developed, and their relation to the iron ore production of the whole country, are shown by the following figures: —

Iron Ore Production (in Thousands of Gross Tons).

	1880.	1885.	1890.	1895.	1898.
Menominee	592	690	2,282	1,924	2,527
Marquette	1,384	1,430	2,993	2,098	3,125
Gogebic		119	2,847	2,548	2,498
Vermilion		225	880	1,079	1,265
Mesabi				2,781	4,614
Total Lake Superior	1,987	2,466	7,071	10,429	14,030
Total United States	7,120	7,600	16,036	15,957	19,434

For 1899 the Lake Superior product was about 18,500,000 tons.

In this brief description of the Lake Superior iron region, reference has been made to the ports by which the ore is shipped,— Escanaba, Marquette, Ashland, Duluth, Two Harbors. To each of these the ore must be carried by rail from the mines,— sometimes a few miles, sometimes, as with a large part of the Minnesota supplies, a hundred and more. And, with this first movement, only the beginning is made in its long journey. From the shipping port it is carried eastward by water to meet the coal,— the coal being coked at the mines, and in that form made best available for smelting purposes. Some of the ore goes down Lake Michigan to Chicago, where it meets the coal from Pennsylvania about half-way. Some of it goes farther, through Lakes Huron and Erie, and meets the coal at Toledo, Ashtabula, Cleveland, and other ports on Lake Erie. The largest part is unloaded from the vessels at lake ports, and carried by rail to the heart of the Pittsburg coal district, there to be smelted by the coal on its own ground. No small amount goes even beyond,— to the eastward in Pennsylvania, beyond the Pittsburg district, even into New Jersey and New York, almost to the seaboard itself. Hence the cities of Erie and Buffalo have become important ore-receiving ports on Lake Erie, the ore, if not smelted there, going thence by rail on its journey to the smelter. This last and farthest invasion of distant regions by the Lake Superior ore has been promoted by the import duty on the competing foreign ore which seeks to find an entrance by the Atlantic seaboard,— an aspect of the iron trade of which more will be said in the second part of this paper.

The iron-producing region which depends on the Lake Superior ores thus stretches over a wide district, the extreme ends being separated more than a thousand miles. Close by the iron mines are a number of charcoal-using furnaces in Wisconsin and Michigan. The still unexhausted forests of these States supply this fuel in abun-

dance; and charcoal iron, though long supplanted for most uses by the coke-smelted rival, has qualities which enable a limited supply to find a market, even at a relatively high price. Next in order come Chicago (South Chicago) and some neighboring cities, among which Milwaukee in Wisconsin and Joliet in Illinois are the most notable. It is one of the surprises of American industry that iron manufacturing on a huge scale should be undertaken at such points, distant alike from ore and from coal, and having no natural advantages whatever. The coke is moved hundreds of miles by rail from Pennsylvania, and meets the ore which has travelled no less a distance from Lake Superior. Ease of access to the western market gives these sites an advantage, or at least goes to offset the disadvantage of the longer railway haul of the fuel. Other iron-producing points of the same sort are scattered along Lake Erie. At each of the ports of Toledo, Lorain, Ashtabula, Erie, Buffalo, especially Cleveland, ore is smelted, and iron and steel making is carried on. But the coal region itself — western Pennsylvania and the adjacent parts of Ohio — remain the heart and centre of the iron industry. Hither most of the ore is carried; and here the operations of smelting, converting into steel, fashioning the steel into rails, bridges, plates, wire, nails, structural forms for building, are performed on the greatest scale. For some years the natural gas of this region added to its advantages and aided in its exceptionally rapid growth. But each supply of gas exhausted itself before long, and new discoveries did not maintain the inflowing volume at its first level. It was the abundant and excellent coal which formed the sure basis of the manufacturing industries, and the permanent foundation more especially of iron and steel making.

Whether the ore goes to the coal or the coal meets the ore half-way, one or both must travel a long journey, by land as well as by water. One or both must be laden

and unladen several times. A carriage of 800, 900, over 1,000 miles must be achieved, with two separate hauls by rail. Fifty years ago, even twenty years ago, it would have seemed well-nigh impossible to accomplish this on a great scale and with great cheapness. The geographical conditions on which a large iron industry must rest were supposed by Jevons in 1866 to be the contiguity of iron and coal.* But here are supplies of the two minerals separated by a thousand miles of land and water, and combined for iron-making on the largest scale known in the world's history. One of the most sagacious of American students of economics, Albert Gallatin, early predicted that the coal area of western Pennsylvania would become the foundation of a great iron industry, and that only with its development would the American iron manufacture attain a large independent growth.† But he could not dream that his prophecy would be fulfilled by the utilization of ores distant fifteen hundred miles from the seaboard, transported from a region which was in his day, and remained for half a century after his day, an unexplored wilderness.

*Jevons, *The Coal Question*, second edition, chap. xv. Jevons in that chapter looked for important changes in the United States, chiefly from the wider use of anthracite in iron-making. The fact that "the Americans are, of all people in the world, the most forward in driving canals, river navigations, and railways," was noted by him as sure to affect the American iron trade; but even his keen imagination and wide knowledge could not foresee how much and in what directions this "driving" would operate.

† "A happy application of anthracite coal to the manufacture of iron, the discovery of new beds of bituminous coal, the erection of iron-works in the vicinity of the most easterly beds now existing, and the improved means of transportation which may bring this at a reasonable rate to the sea-border, may hereafter enable the American iron-master to compete in cheapness with the foreign rolled iron in the Atlantic district. . . . The ultimate reduction of the price of American to that of British rolled iron can only, and ultimately will, be accomplished in that western region which abounds with ore, and in which is found the most extensive formation of bituminous coal that has yet been discovered in any part of the globe, and this also lying so near the surface of the earth as to render the extraction of the mineral less expensive than anywhere else." Albert Gallatin, *Memorial to the Free Trade Convention* (1832), as reprinted in *State Papers and Speeches on the Tariff*, pp. 179, 180.

The history of the American iron trade in the last thirty years is thus in no small part a history of transportation. The cheap carriage of the ore and coal has been the indispensable condition of the smelting of the one by the other.* And, clearly, this factor has not been peculiar to the iron industry. The perfecting of transportation has been almost the most remarkable of the mechanical triumphs of the United States. Great as have been the evils of our railway methods, disheartening as have been some of the results of unfettered competition, the efficiency of the railways has been brought to a point not approached elsewhere, largely in consequence of that very competition whose ill effects have been so often and so justly dwelt on. The good has come with the evil; and here, as in the whole domain of private property and competitive industry, the crucial problem is how to eradicate the ill and yet maintain the good. In the carriage of iron ore and of coal the methods of railway transportation developed under the stress of eager competition have been utilized to the utmost; and the same is true of the transfer from rail to ship and from ship to rail again, of the carriage in the ship itself, and of the handling of accumulated piles of the two materials. The ore is loaded to cars at the mines by mechanical appliances. At the Mesabi mines the very steam-shovel that digs the ore from the ground deposits it in the adjacent car. At the lake, high

* "Few people who have not actually run a blast-furnace realize what it means to fill the capacious maw of one of these monsters with raw material. A stack of 200 tons' daily capacity, running on 50 per cent. ore, must have delivered to it each day something more than 400 tons of ore, 250 to 300 tons of coke, according to the character of the metal required, and over 100 tons of limestone,—say 900 tons of raw materials. Add the 200 tons of pig iron shipped out, and we have a daily freight movement of 1,100 tons, taking no note of the disposition of the slag. This is 55 carloads of 20 tons each [a modern ore car will carry 30 tons.—F. W. T.]. . . . Starting up a furnace of ordinary capacity calls immediately for the labor, from first to last, of nearly a thousand men; for the use of at least a thousand railway cars, and many locomotives; for perhaps several steamers and vessels on the lakes." A. Brown, *The Outlook in the American Iron Industry*, in the *Engineering Magazine*, October, 1899, p. 88.

ore-docks protrude hundreds of yards into the water. On top of them run the trains, the ore dropping by gravity from openings in the car-bottoms into the pockets of the docks. Thence it drops again through long ducts into the waiting vessels, ranged below alongside the dock. At every step direct manual labor is avoided, and machines and machine-like devices enable huge quantities of ore to be moved at a cost astonishingly low.* The vessels themselves, constructed for the service, carry the maximum of cargo for the minimum of expense; while the machinery for rapid loading and unloading reduces to the shortest the non-earning time of lying at the docks. At the other end of the water carriage, especially on Lake Erie, similar highly developed mechanical appliances transfer from boat to railway car again, or, at will, to the piles where stocks are accumulated for the winter months of closed navigation. At either end the railway has been raised to the maximum of efficiency for the rapid and economical carriage of bulky freight. What has been done for grain, for cotton, for coal, for all the great staples, has been done here also, and here perhaps more effectively than anywhere else: the plant has been made larger and stronger, the paying weight increased in proportion to the dead weight, the ton-mile expense lessened by heavier rails, larger engines, longer trains, and easier grades, the mechanism for loading, unloading, transshipping perfected to the last degree, or to what seems the last degree until yet another stage towards perfection is invented. And evidently here, as elsewhere, the process has been powerfully pro-

* "Every extra handling means more cost. . . . Formerly it was necessary to trim the cargoes; and this had to be done by hand, and gave employment to a great many men at exceedingly high wages. The work, however, was killing while it lasted. Now trimming is in most cases done away with, because the immense size of the freighters renders them stable in any weather; and, if there is any great inequality in the trim of the boat, it is rectified by shifting the water ballast from one compartment to another." Peter White, *The Mining Industry of Northern Michigan*, in *Public. Mich. Pol. Sci. Assoc.*, iii. p. 153.

moted by unhampered trade over a vast territory, and the consequent certainty that costly apparatus for lengthened transportation will never be shorn of its effectiveness by a restriction in the distant market.

Still another factor has been at work in the iron trade, as it has in other great industries,— the march of production to a greater and greater scale, and the combination of connected industries into great single-managed systems. Nothing is more wonderful in the industrial history of the past generation than the new vista opened as to the possibilities of organization. The splitting up among different individuals and separate establishments of the successive steps in a complicated industry — those of the mining, carrying, smelting, rolling, fashioning of iron — was supposed to be due to the limitations of human brain and energy: the management of them all was beyond the physical and nervous capacity of any one man or of any small group of associates. But the range of single management, the size of the unit, have enlarged prodigiously. The increasing application of machinery has made it possible to reduce operations more and more to routine and system, and to lessen the need of independent judgment for every step. Technological education has supplied an array of trained, intelligent, and trustworthy assistants,— engineers, chemists, mineralogists, electricians,— to whom can be delegated a multitude of steps and processes that formerly needed the watchful eye of the master himself. That master must possess new powers and new resources; and the freedom of the modern industrial community, and especially the free atmosphere of our restless and reckless democracy, have stimulated and drawn forth the masterful minds from every social stratum. Hence in all directions we see combinations which unite in one whole a number of associated industries, and, at their best, secure the highest industrial efficiency. At their best; for only

then are the gains permanently secured. The retribution for error in management is as great as are the rewards of success; and judgment has become the most highly prized and highly paid human talent.

The iron trade has shown as markedly as any of the great industries the signs and effects of these new conditions. Not only has the size of individual establishments grown,— this is a phenomenon of long standing, — but the number of industries united in one organization has rapidly enlarged. Iron mines, coal mines, coke ovens, railways, steamers, docks, smelting works, converting works, rolling-mills, steel-works, machine-shops,— these have been combined into one imposing complex. The great iron and steel companies operate iron mines on Lake Superior, coal mines and coke establishments in Pennsylvania, docks and railways, as well as iron and steel works proper. The largest of them, the Carnegie Company, has built a railway of its own, specially equipped for the massive and cheap carriage of ore and fuel, from the shore of Lake Erie to the Pittsburg coal district. At its terminus on Lake Erie (Conneaut) a new harbor and a new city have been created. The economy in production from such widely ramifying organizations is not merely or chiefly in dispensing with the services and saving the gains of so many independent middlemen: it arises mainly from consistent planning of every stage, the nice intercalation of operations, the sweeping introduction from end to end of expensive and rapid-working machinery, continuously supplied under homogeneous administration with the huge quantities of material which alone make possible effective and economical utilization of the great plant.*

* Among the great iron and steel enterprises may be noted the following: — The Carnegie Company, in form an unincorporated partnership, having no shares listed on exchanges or publicly dealt in, has grown from comparatively small beginnings to huge dimensions, its capitalization being supposed to be $200,000,000. It owns or controls the most productive mines of

It is not within the scope of the present paper to weigh the advantages or disadvantages of this mode of organizing industry. It may bring the community face to face with the conditions of established monopoly, or, more probably, in this industry at least, may mean sim-

the Gogebic and Mesabi regions, part of the mines in the Vermilion range, and mines also in the Marquette range. Railways, docks, and a fleet of steamers on the lakes are under its control. Its railway from Lake Erie at Conneaut to Pittsburg, equipped in the most solid manner for transporting ore, fuel, and iron, carries freight at rates which are in the lowest range of rates per ton-mile among American railways. Its iron and steel works are at various points centering about Pittsburg. It owns the greater part of the coal lands and coke plants in the Connellsville district.

The Federal Steel Company, a New Jersey corporation, with a capital of $200,000,000, half preferred, half common, is the greatest rival of the Carnegie Company on Lake Superior. It owns mines in the Mesabi range and in the Vermilion range, with a railway of its own leading to both. It has also a fleet of steamers on the lakes, the great works of the Illinois Steel Company (of which mainly it is the successor) at Chicago, Milwaukee, and Joliet, a considerable railway of its own about Chicago, works at Lorain, Ohio (on Lake Erie), and at Johnstown, Pa.

The American Steel and Wire Company, also a New Jersey corporation, with a capital of $90,000,000, owns mines in the Marquette and Mesabi regions, coal lands and coke ovens, iron and steel works at Cleveland and Pittsburg, and a large number of rod and wire mills scattered over the country from Massachusetts to Missouri.

Other very large enterprises are the Republic Iron and Steel Company (capital, $55,000,000) and the National Steel Company (capital about $60,000,000), both with widely ramifying operations. More concentrated in their operations, but still on a great scale, are the Bethlehem Steel, the Cambria Steel, the Pennsylvania Steel, and the Lackawanna Iron and Steel Companies.

Of a different type are certain corporations to which the term "trust" more specially applies, attempting as they do to control the entire production of certain articles. Among these are the American Tin Plate, the American Steel Hoop, the National Tube Companies.

Even for charcoal iron, where the fuel of ancient times is used, the organization of production has developed on the modern plan. "The only way in which charcoal-iron making appears to be profitable in competition with coke iron is by combining a number of industries which are closely related. For instance, the Cleveland Cliffs Iron Company owns its own mines, cars, is a chief stockholder in a railroad and docks, owns, directly or indirectly, its own line of boats, gets its coal from its own stockholders, owns its own forests, kilns, limestone measures, furnace, and chemical works, where wood alcohol and acetate of lime are made. . . . The wood alcohol is made out of the smoke of the charcoal furnaces led through water. The acetate of lime is also from the smoke." White, *The Mining Industry of Northern Michigan*, p. 13.

ply a farther stage in the development of great-scale production. It may prove, in the combinations of the last year or two, to have been carried so far as to transcend the bounds of human capacity, and may therefore portend a series of break-downs, and the subsequent subdivision and reseparation of the component industries. Whether in its social aspects or in its prospects of permanent productive efficiency, we must await further experience before knowing what gains and losses will accrue, what problems must be faced. But it is clear that great organizations of the productive forces — even though perhaps not so huge as some of those launched of late years — are to be permanent factors in the conduct of many industries, and of the iron industry among them. And it is clear, also, that the movement is not peculiar to the iron trade, and points to no forces specially aroused in the protected industries. Whether in the cheapening of transportation, in the advance of the technical arts, in the organization and management of great consolidations, the forces have been such as directed American manufacturing and mechanical industry at large, and indeed have been at work in greater or less degree in all the countries of advanced civilization.

While the Lake Superior ores, utilized under the conditions just described, have been by far the most important source of supply for the iron industry, a large contribution has come from another source, also,— from the Southern States.

In the region where the States of Tennessee, Alabama, and Georgia adjoin, the conditions once thought indispensable for a flourishing iron industry exist in perfection. Here are great deposits of ore, easy of working; and close by them great deposits of coking coal, no less easily worked. Before the Civil War, these natural advantages were not utilized: the régime of slavery and the lack of

means of transportation prevented any resort to them. But with the quickening of the industrial life of the South, when once the Civil War and the trying days of reconstruction were passed, the mineral resources of this region were developed on a rapidly enlarging scale. Alabama, where the best deposits of coal occur, became a great iron-producing State: here again, though for a less distance and on a smaller scale, the ore made its journey to the coal. The rate of growth was most rapid between 1880 and 1890: the pig-iron output of Alabama rose from 69,000 tons in 1880 to 915,000 in 1890. The large supply of labor at low wages has contributed to the easy and profitable utilization of this source of supply. The free negro has turned miner, and has proved not only a docile laborer, but also,— paid, as miners are, according to the tonnage brought to the pit's mouth,— on the whole, an efficient one. It may be a question how far the low-money wages paid to him are low simply in proportion to his still moderate efficiency, and how far they constitute a factor of real importance in enabling the product to be put on the market at a low price. The favorable natural conditions, when once unlocked by the régime of freedom and the means of transportation that came with it, doubtless constitute the main basis for the growth of the Alabama iron industry. There are other aspects of it which deserve the attentive consideration of the student of social questions,— the conduct and the prospects of the negroes suddenly herded together in the mining regions, and the relations of the two races under the new conditions. But these are matters that lie apart from the present inquiry. For good or ill — doubtless, mainly for good — the Southern iron has taken its place as an important part of the iron supply, with the same rapidity, though with no such dramatic features, as that smelted in Pennsylvania from the Lake Superior ores.

The Southern ore contains phosphorus in too large

amounts to make it available for the Bessemer process; and this has given it a place somewhat apart in the iron industry of the country. The iron made from it has not competed with that from the Lake Superior ore, and has been used chiefly for general foundry purposes. Marketed at a very low price, the increasing supplies have made their way to places further and further removed. Pittsburg itself soon used Alabama iron for foundry purposes; the Western States and the Eastern alike were supplied; in New England it displaced Scotch pig, previously imported in considerable quantity; and, finally, it began to be exported to England itself. These exports are probably not of importance in the permanent current of trade: the iron has gone out chiefly in a period of unusually depressed prices, and even at this time only as ballast for cotton ships. Beyond this strictly limited movement we shall probably see the export of iron from the United States, not in its crude form, but in much more advanced stages. But this is a subject for later consideration. It suffices to note here that the possibility of export, even at nominal rates of freight and in times of exceptionally low prices, shows how vastly changed are the conditions from those of thirty years ago.

The outcome of the great changes in the geographical distribution of the iron industry is shown in the tabular statement on the next page.

In the Eastern District the output, notwithstanding a great increase in the period for which the year 1890 stands, has barely held its own. The total production in 1895–98 was not sensibly greater than in 1872. On the other hand, the Central District has increased its production steadily and enormously, whether in western Pennsylvania itself or in the neighboring States of Ohio, Indiana, Illinois. This is the region where Lake Superior ore is smelted with Pittsburg coal: in and about Pittsburg itself, in the immediately adjacent parts of Ohio,

PRODUCTION OF PIG IRON IN THE UNITED STATES.*

(In thousands of gross tons.)

	1872.	1880.	1885.	1890.	1895.	1898.
Eastern District (eastern Pennsylvania, New York, New Jersey)	1,217	1,610	1,312	2,342	1,390	1,431
Western Pennsylvania alone .	387	772	1,081	2,561	3,549	4,435
Central District (western Pennsylvania and also Ohio, Indiana, Illinois) . .	849	1,502	1,874	4,517	6,019	7,787
Southern District (Alabama, Georgia, Tennessee, Virginia, Maryland)	127	238	539	1,554	1,491	1,785
Other States	356	485	319	790	546	770
Total for the United States .	2,549	3,855	4,044	9,203	9,446	11,773

and at the various lake cities where the ore meets the coal,— Cleveland, Toledo, Chicago, and the rest. Not less striking is the rate of growth in the Southern District, of which Alabama is the most important State.

* In this table the figure for eastern Pennsylvania is for the iron smelted in the State with anthracite, or anthracite and coke mixed, while that for western Pennsylvania is for the bituminous (coke) iron. The separation by fuels, it is true, does not indicate with complete accuracy the geographical distribution. But the iron smelted in Pennsylvania east of the Appalachian chain was formerly smelted almost entirely with anthracite, and is still smelted mainly with a mixture of anthracite and coke; and, at all events, this was the only mode in which the statistics at hand made it possible to separate the eastern and western parts of Pennsylvania.

In the Southern District, Virginia and Maryland are near the seaboard, and might be constituted a group apart from the other States there included. But the iron industry in them, as in the others, is of recent growth, and depends both for ore and fuel on different sources of supply from those of the Northern seaboard region. By far the most important iron-producing State in the Southern district of the table is Alabama.

In the preparation of this table and of other statistical matter, I am much indebted for aid to Mr. D. S. Bobb, of the Graduate School of Harvard University.

While the total production here is far outweighed by that in the Central District, it now exceeds that in the East, and bids fair to continue to do so.

Before we close this review of the forces which have been at work in the iron industry, some other aspects of the subject deserve brief attention. Here, as elsewhere, the labor situation and the trade-union movement have had their influence. But the power of the labor unions among the iron workers has been less in the United States than in Great Britain; and this fact has been of no small consequence. It is true that the Amalgamated Association of Iron and Steel Workers has long been a firm and powerful organization, modelled on the British unions and strong in its bargaining with the employers.* But some of the large iron and steel establishments have been non-union; and their competition, as well as the example they set of a possible cutting-loose from the organized laborers, imposed a strong check on the union's control of the conditions of employment. The largest of the American establishments, the Carnegie Company, thus cut loose from the union, as a consequence of the great strike — fairly a pitched battle — at the Homestead works in 1892. The consequence has been that the American iron and steel master has felt more free than his British rival to push on with new processes, to remodel his organization, to readjust his labor force.

No doubt, in the talk of the average business man, there is much exaggeration of the dictates of labor unions, and many an impossible claim to attend to his own affairs in his own way. But, on the other hand, whatever may be one's sympathy with labor organizations, it is not to be denied that a firmly organized trade-union tends to present a stolid opposition to change and to improvements. This is but human nature. The first effect of a new ma-

* See the account of the organization, by Carroll D. Wright, in this Journal, vol. vii. p. 460 (July, 1893).

chine or a better rearrangement is to displace or discommode some laborers; while the disposition to "make work," however disavowed overtly, is too deep-rooted to permit labor-saving changes to be made without strong though silent opposition. Even where no open resistance is offered, the mere existence of a strong and all-inclusive union, not to be fought without heavy loss, has often a benumbing influence, preventing the very consideration of radical changes, and keeping industry in its established grooves. Such has been one of the effects of the strong organization of English iron workmen (the engineers); and the great strike between them and their employers in 1898 was at bottom due to this consequence of their strength. For good or ill the American iron industry has been comparatively free from this benumbing influence. For good, in that the advance of the art of production has been unrestrained; for ill, in that the workman, as is inevitable when standing alone, has bargained on unequal terms with a powerful employer, and has been compelled often to accede to long hours and harsh conditions.

One other of the social aspects in the growth of the iron industry deserves attention: its connection with the coal trade, and with some of the labor problems that have arisen in that allied industry. The dominant position of the Pittsburg coal district has been repeatedly referred to in the preceding pages. For the iron trade the most important section of that district is the famed Connellsville coke region, lying some fifty miles south of Pittsburg, along the banks of the Youghiogheny River. Here is a level and uniform outcrop of the best coking coal; and from this has come most of the coke used in smelting Lake Superior ores, and, indeed, the greater part of that used in the United States. Important supplies have come also from other near-by regions in Pennsylvania and West Virginia; and Alabama has made from her own coal the coke for smelting her iron. But the Connellsville coke is by

far the most important contributor, and alone supplies more than half of the total used in the country.*

The price of coke has gone down markedly in the last twenty years, in sympathy with the price of bituminous coal generally. Thirty years ago coke at the ovens was sold for $3 a ton. In recent years the price has been on the average not far from $1.50 a ton, and in times of depression less than $1 a ton. Fuel has been turned out for the American iron-master at prices lower than those paid by his rivals in any part of the world; while low rates of transportation have enabled the cheap fuel to be carried to furnaces near and distant, without the loss of this cardinal advantage.

Here, as in the mining and transporting of the ore, and in the practice at the furnace and the mill, cheapness has been secured, but by methods that are, in part at least, vitally different. There has been, indeed, the same bold adventure in opening new sources of supply, the same conduct of industry on a great scale, the same firm organization in direct connection with the iron and steel industries. But the nature of the operations caused cheapness to be attained at the coal mines and coke ovens, not only by machinery and organization, but also, to no small extent, by cheap labor. The mining of coal is mainly pick-and-shovel work, requiring little handicraft skill or trained

* The output of coke in the United States in 1897 — a year in which Connellsville turned out less than its usual share — was as follows (in thousands of net tons of 2,000 lbs.): —

Connellsville proper	6,861
Other Pennsylvania	2,106
West Virginia	1,473
Alabama	1,443
Tennessee	369
Virginia	354
Colorado	342
Elsewhere	
Total United States	13,289

The figures are derived from the chapter on Coke in *The Mineral Resources of the United States*, 1897, forming Part VI. of the Nineteenth Report of the Geological Survey.

intelligence; and this is still more true of the work at the coke ovens. The coal mines of the United States have drawn to themselves the lowest and poorest kinds of manual labor; except, indeed, where machines for cutting the coal have proved applicable, and skilled and intelligent mechanics have consequently been called on to work them. The miners in England seem to have maintained a better relative position. Their trade organization has been strong, the standard of living and of efficiency comparatively high. In the United States multitudes of newly arrived immigrants have been drawn to the mines, partly through deliberate arrangement by the employers, partly through the silent adjustment of supply to demand. There they have huddled, inert, stolid, half-enslaved. The nationalities that have contributed of late years so heavily to our immigration — the Italians, Bohemians, Hungarians, Poles, and what not — have here found employment such as they could at once turn to. In times of activity their condition is passable, and doubtless better than it had been in their homes beyond the sea. In times of depression and low prices the barest living is all they can secure, and sometimes not that. The American or Americanized laborers of higher standards have met a disheartening competition, and have vainly tried to stem the tide of falling wages and half-employment, with the attendant misery, strikes, riots, bloodshed.*

Here once more we touch phenomena that lie mainly outside the scope of the present inquiry. The growth of the coal industry is a subject by itself, presenting peculiarities of its own. "Overproduction" has been its constant cry; and undeniably there has been a pressure on the market of a large and constantly enlarging supply of

*See, among others, the article by J. E. George, in this Journal, vol. xiii. pp. 186, 447 (January and July, 1898). Compare with the same writer's more recent articles in the *Jahrbücher für Nationaloekonomie*, vol. xviii. Nos. 4, 5. The similar conditions in the anthracite region are described by G. O. Virtue in the *Bulletin of the Department of Labor* for November, 1897.

coal. The continued opening of new mines, with all the chances of reaping a fortune from the combination of mining and railway ventures, has proceeded with feverish and excessive activity; and, certainly, it is this gilded opportunity which has caused the systematic agglomeration of cheap labor in the bituminous coal districts the country over. It may be, also, that, even under conditions of comparative stability (as in the anthracite regions, where no new fields are available), the nature of the industry, the extreme difficulty of stopping a mine when once in operation, the strong inducement to work it continuously at its maximum capacity,—such causes as these may lead inevitably and recurrently to mounting output and cut-throat competition. Both sets of causes probably have been at work in bringing about the special severity of periods of depression in the coal and coke districts.

At all events, a bitter competition has intensified the evil social conditions which must emerge where great masses of ignorant laborers are congested in out-of-the-way places. Truck-shops, low wages, semi-feudal conditions, cheap coal, have meant a cheap man. At the iron mines the conditions seem to have favored the better mode of securing cheapness,—vigorous and intelligent labor, using highly elaborated machinery. Such, too, has been, in greater degree at least than at the coal mines, the direction in which improvement has marched in the railways, on the vessels, at the docks, in the iron and steel works. But at the very foundation of the industry, at the coal mine and the coke oven, we have a social sore. Perhaps it is but temporary: this great and vigorous organism of ours may absorb the foul matter, even though it be steadily fed from without by new accretions. But foul it is, and remains. When Jevons, a generation ago, surveyed, doubtless with some excess of pessimism, the coal trade of Great Britain, he warned his countrymen that their great structure of material wealth rested on a foundation

of brutishness and pauperism.* We have been wont to thank God that we are not as other peoples. But the plague is on us also; and we, too, must face the social responsibilities it involves.

Thus the growth of the iron industry illustrates all the extremes of the industrial revolution which has taken place in the United States since the Civil War. Unfettered enterprise, unrestrained competition, have worked their utmost. The eager search for new resources in the earth's crust has gone on with feverish haste. The march of the arts has led to unceasingly wider utilization of the forces of nature. Production on the great scale has advanced, until the huge enterprises seem almost ready to crush the foundations on which they rest or topple over of their own weight. Fabulous riches, and misery and squalor most abject, alike have come with this marvellous transformation; and the twentieth century dawns with new conditions, new problems, new duties.

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* *The Coal Question* (1866), Preface, p. xxiii.