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Development of the Major Metal Mining Industries in the United States from 1839 to 1909

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The United States' rich endowment of mineral deposits made possible an enormous expansion in the output of metallic minerals from 1839 to 1909. The expansion of output was far from uniform in time or space, however. This paper develops the industry's statistical record of output and employment, by region and by mineral product. Some of the factors that produced the expansion are also briefly discussed.

Since this group of industries showed substantial changes in rate of output growth and large regional shifts, both among already producing regions and from them to new regions, the effects of some of the causal factors are shown more clearly here than in an already settled country with long-established mineral industries. In many cases, the record of output and employment gives some indication of the influence of the location of existing markets and economic activity, of changes in the cost of transportation, of technological change within the mining industries and, above all, of the quality of natural endowment and changes in it resulting from mining activity. A few comments are possible also on the bearing of the record of the mineral industries on some general issues of economic development.

The major metallic mining industries, which are the subject of this paper, constitute almost all of the industry—98 per cent or more if measured by value of output. This group is defined to include iron ore, copper, lead, zinc, gold, and silver. But major metal mining has been only a minor part of all the mineral industries, which include coal,

NOTE: I wish to acknowledge the valuable work of Selma Rein in investigating and evaluating a very extensive body of source material for output estimates and other data on the development of the mineral industries.

Jerome Milliman and Sam Schurr have given me the benefit of their helpful comments on an earlier draft of this paper.

petroleum, sand and gravel, and clay products, among others. And even this minor share was declining throughout much of the period under study—from one-third in 1870 to one-fifth in 1910, if measured by employment.

All mineral industries have been quantitatively unimportant for the United States as a whole—probably accounting for less than 3 per cent of total employment during the period under study. But in certain regions the mineral industries, and metal mining in particular, have been of far greater importance, and an examination of the record reveals their influence on the timing and pace of regional economic development and especially on the location of certain types of economic activity.

Until the beginning of metallic mining in the West, U.S. production of nonferrous ores was only a small part of the world total, except for lead. In the years that followed, however, the United States came to produce the sizable fractions of world output shown in Table 1.

The U.S. mine output of copper was sufficient to provide a sizable surplus over consumption of primary copper from about the 1860's on. Mine production of lead, however, was closer to apparent consumption over most of the period under study. Zinc mine output was roughly equal to consumption after 1879; in the 1850's none at all was produced.

In this study, the base year data are derived mainly from the various Censuses, supplemented in earlier years by Whitney's comprehensive

TABLE 1

U.S. MINE OUTPUT AS PERCENTAGE OF WORLD MINE OUTPUT: COPPER, LEAD, ZINC, GOLD, AND SILVER,[a] 1849, 1879, AND 1909

	1849[b]	1879[c]	1909[c]
Copper	1	15[d]	60
Lead	16	22	30
Zinc	0	12	35
Gold	24	30	17
Silver	0.3	44	27

[a]Metal content.

[b]World output is from J.D. Whitney, *The Metallic Wealth of the United States, Described and Compared with that of Other Countries*, Philadelphia, 1854. U.S. output is as estimated in the present paper.

[c]World output is from the various *Economic Papers* of the U.S. Bureau of Mines, except for copper in 1879. U.S. output is as estimated in the present paper.

[d]World output is Henry R. Merton's estimate in *Mines and Quarries, 1902*, Census Bureau, Washington, 1905, p. 491.

account of the mineral industries[1] and in later years by the data collected by the U.S. Geological Survey. It is perhaps not surprising that the Census data are defective in important ways. The 1870 Census was the first to make much effort to collect data for the mineral industries. The 1840 and 1850 Censuses are very doubtful, so much so that they seem unusable for our purposes. We have found it better to ignore them and to extrapolate employment back from 1860, by our estimate of output. Throughout the Censuses, the data on number of mines are particularly poor.[2]

The statistical record is not useless, however. It reveals faithfully the general movements of output, by commodity, and the fortunes of the different regions in the production of the various commodities. Less reliance can be placed on its employment data—though even here the general outlines of what happened are evident—and some reliance can be placed on even the more detailed quantitative aspects of the general picture.

Output Behavior, 1839-1909[3]

Within only seventy years, the mine output of the major metals grew to 117 times its 1839 level, a rate of growth averaging about 7 per cent per

[1] J. D. Whitney, *The Metallic Wealth of the United States, Described and Compared with That of Other Countries*, Philadelphia, 1854.

[2] It was difficult to get data and even to find mines in the areas of the Rocky Mountains, the Southwest, and the Pacific Coast. For example, the Census of 1880 explains that the collection of statistics was hampered by, among other things, "the assassination of Colonel Charles Potter, the expert in charge of this territory" (*Census of 1880, Precious Metals*, p. 100).

[3] In this section and in the rest of the paper it is necessary to speak of changes in the output of a "commodity" that in fact is made up of several commodities—iron in ore, copper in ore, etc. These must be combined by some weighting scheme. Since our interest is in mine output, it would be preferable to use as a weight the price of a "real" unit of value added, but this has not been feasible. Instead, 1879 market prices have been used as weights throughout.

However, the market prices used were the prices of metal for copper, lead, zinc, gold, and silver ores, but the price of ore for iron ore. While any weighting scheme other than the value-added one is arbitrary, it is true that the weight for one commodity, iron ore, is taken at the mine level but at the metal level for the others. The problem here is that the ratio of the price of metal to the price of the "ore" of that metal ("ore," because of the joint product problem at the ore level) was considerably higher in 1879 for iron than for copper, gold, silver, zinc, and probably lead.

If the price of iron—about 3.7 times the price of the same quantity of iron in ore in 1879—had been used to weight iron ore output in our tables, a number of statements in the paper would need extensive alteration. For example, all statements about the relative importance of iron ore compared with the other mine products would be liable to change. So also would all statements about movements of a composite that contained iron ore, provided the movement of iron ore differed substantially from the movements of the other members of the composite.

The weighting scheme that uses the price of pig iron instead of the price of ore as a weight will be called the "alternative weighting scheme." As we go along, some effort will be made to indicate the effect of using this scheme.

annum.[4] That growth, while exhibiting considerable steadiness in the aggregate, was punctuated by a number of large and sudden changes, both in the geographical location of production and also in the commodities produced. The two types of rapid change, clearly evident in Tables 2 and 3, are related, of course. We shall see that there have been two major initiators of change: (1) discovery of large mineralized areas with deposits far richer than those previously exploited; and (2) development of cheaper transportation which permitted the exploitation of extensive deposits where in many cases the grade of ore was only reasonably good.

The most obvious change in the location of mineral output over the period was the shift, just before the Civil War, from complete dominance by the East to a marked dominance by the West (including the Southwest, the Rocky Mountains, and the Pacific Coast), and to the West's continued but less imposing dominance at the end of the period (Table 3). In 1839 the share of the East in the total was 100 per cent, but by 1859 the precious metal discoveries in the West had reduced this share to 20 per cent. Thereafter, the share of the East increased to a level of 43 per cent by the end of our period in spite of the great development of mining in the West. Within the eastern region, the major shift was a steady increase in the share of the north central area (which in our classification includes, among other states, Michigan, Minnesota, and Missouri) from a share of one-third in 1839 to 84 per cent in 1909.

In 1839 iron ore and lead dominated major metal mining and continued to do so until the great precious metal discoveries gave gold and silver mining the leading position from 1849 to 1869. Since that time, the relative importance of the other four metals—especially of copper and iron ore—has increased considerably.

Changes in the fortunes of the different regions and the different commodities are so closely intertwined that they must be examined together in order to be understood. Table 3 indicates that the northeast region was of minor importance in 1839 and thereafter dwindled to practically nothing as far as major metal minerals were concerned. The middle Atlantic region was the dominant iron ore producer in 1839 and accounted for a little over one-third of the total major metal mineral output. The output of iron ore in this region increased steadily until 1879, after which it fell. After 1879, the region's output of zinc increased substantially, but neither these changes nor those in the output of iron ore were sufficient to prevent the region's decline to a comparatively low level until by the end of the

[4] All relative rates of growth in this paper are continuously compounded.

TABLE 2

INDEXES OF VALUE OF MINE OUTPUT OF MAJOR METALS, BY REGION AND COMMODITY, 1839-1909
(in 1879 prices, 1909=100)

Region[a] and Commodity	1839	1849	1859	1869	1879	1889	1902	1909	Relative Percentage Share, 1909
Region									
New England	--	--	--	--	--	--	--	--	
Middle Atlantic	12	20	35	54	80	76	67	100	3
South Atlantic	21	34	28	43	61	81	132	100	1
North central	0.8	1.3	2.2	4.6	11	25	69	100	36
South central	2.5	2.6	3.9	2.3	6	35	80	100	4
East	2.0	3.1	4.8	8.0	16	30	71	100	44
Southwest	--	--	0.6	13.0	20	20	35	100	19
Rocky Mountain	--	--	1.0	5.9	18	47	92	100	32
Pacific	--	29.0	130.0	56.0	57	43	71	100	6
West	--	2.9	15.0	14.0	23	38	71	100	57
United States	0.9	3.2	11.0	11.0	20	34	71	100	101
Commodity									
Iron ore	1.9	3.2	4.7	7.4	14	28	69	100	26
Copper	--	0.1	1.4	2.6	4.7	20	58	100	37
Lead	4.5	6.1	4.3	4.5	24	40	71	100	6
Zinc	--	--	1.7	4.1	9.4	24	71	100	5
Gold	0.6	14.0	60.0	43.0	43	41	85	100	14
Silver	b	0.2	0.7	16.0	61	90	98	100	11
									99

Note: All tables with no source given are derived from one of the basic tables in the appendix.

If the alternative weighting scheme had been used (see text footnote 3), the following indexes would have resulted:

	1839	1879	1909
United States	1.3	16	100
Middle Atlantic	20.0	128	100
North central	0.3	8	100

[a]The following states (or predecessor territory) are included in the regions. New England: Me., N.H., Vt., R.I., Mass., Conn.; Middle Atlantic: N.Y., N.J., Pa.; South Atlantic: Del., Md., Va., W. Va., N.C., S.C., Ga., Fla.; West north central: Minn., Iowa, Mo., N.D., S.D., Neb., Kan.; East north central: Ohio, Ind., Ill., Mich., Wis.; South central: Ky., Tenn., Ala., Miss., La., Ark., Okla., Tex.; Southwest: Ariz., N.M., Nev.; Rocky Mountain: Mont., Idaho, Wyo., Colo., Utah; Pacific: Calif., Ore., Wash.; West: Rocky Mountain, Southwest, Pacific; East: all regions not in the West.

[b]Less than 0.5 per cent.

TABLE 3

PERCENTAGE VALUE OF MINE OUTPUT OF MAJOR METALS, BY REGION AND COMMODITY, 1839-1909
(in 1879 prices)

Region and Commodity	1839	1849	1859	1869	1879	1889	1902	1909
Region								
New England	4	1	a	a	1	a	--	--
Middle Atlantic	36	17	9	13	10	6	2	3
South Atlantic	15	6	2	2	2	1	1	1
North central	34	15	8	15	20	26	35	36
South central	10	3	1	1	1	4	4	4
East	100	42	20	31	34	37	43	43
Southwest		a	1	22	19	11	9	20
Rocky Mountain			3	17	29	44	41	32
Pacific		57	76	30	18	8	6	6
West	0	58	80	69	66	63	57	57
United States	100	100	100	100	100	100	100	100
Commodity								
Iron ore	60	27	12	17	18	22	26	26
Copper		2	5	8	9	22	30	37
Lead	30	11	2	2	7	7	6	6
Zinc	0	0	1	2	3	4	5	5
Gold	9	60	79	53	30	17	17	14
Silver	a	1	1	16	34	30	16	11
Total	100	100	100	100	100	100	100	100
Iron ore, copper lead, zinc	90	39	20	30	36	54	68	75
Gold and silver	10	61	80	70	64	46	32	25
Total	100	100	100	100	100	100	100	100

Note: If the alternative weighting had been used, the following percentage distributions would have resulted.

	1839	1879	1909
New England	6	1	0
Middle Atlantic	53	24	3
South Atlantic	12	3	1
North central	15	25	55
South central	14	2	6
Southwest	0	13	11
Rocky Mountain	0	19	19
Pacific	0	12	4
Total, U.S.	100	99	99
Iron ore	85	45	57
Copper	--	6	22
Lead	12	4	3
Zinc	--	2	3
Gold	4	20	8
Silver	--	23	7
Total	101	101	100

[a]Less than 0.5 per cent.

whole period it was decidedly a region of little importance for the major metallic minerals.

The south Atlantic region, which started off in 1839 with 15 per cent of the total metal ore output—a total made up of iron ore and gold in roughly equal parts—enjoyed a small spurt in iron ore output after 1869, but in every decade after 1839 it must be reckoned a region of practically no importance for major metallic mineral production.

TABLE 4

GROWTH OF VALUE OF MINE OUTPUT OF MAJOR METALS, BY REGION AND COMMODITY, 1839-1909
(per cent per year in 1879 prices)

Region and Commodity	1839-49	1849-59	1859-69	1869-79	1879-89	1889-1902	1902-09
Region							
New England	1.3	0	-7.2*	19.0*	-11.0*		
Middle Atlantic	5.5	5.5	4.3	3.8	-0.5	-1.0	5.8
South Atlantic	4.6	-2.1	4.3	3.7	2.8	3.8	-4.0
North central	5.0	4.9	7.5*	8.8*	8.0*	7.9*	5.2
South central	0.4	4.4	-5.6	9.5*	18.0*	6.4*	3.2
East	4.6	4.2	5.2	6.8*	6.3*	6.7*	4.9
Southwest	--	--	31.0*	4.4	-0.4	4.1	15.0
Rocky Mountain	--	--	17.0*	11.0*	9.5*	5.2	1.2
Pacific	--	15.0*	-8.5*	0.3	-2.8	3.9	4.8
West		15.0*	-0.8	5.3	4.8	4.9	5.0
United States	13.0*	12.0*	0.7	5.8	5.3	5.6	4.9
Commodity							
Iron ore	5.1	3.7	4.7	6.2*	7.1*	6.9*	5.3
Copper	--	--	6.3*	6.0*	15.0*	8.2*	7.7*
Lead	3.0	-3.6	0.6	16.0*	5.2	4.5	4.9
Zinc	--	--	8.8*	8.4*	9.3*	8.4*	5.0
Gold	--	15.0*	-3.3	0	-0.6	5.7	2.3
Silver	--	15.0*	32.0*	13.0*	4.0	0.6	0.4
Gold and silver		15.0*	-0.7	4.9	2.1	2.8	1.5

*Indicates rate of growth over 6 per cent per year.

The south central region, whose output of iron ore gave it about 10 per cent of the total in 1839, also enjoyed a rather greater increase in this output after 1869 but, sizable as it was, it was far from sufficient to give the region any more than minor importance in the total.

The remaining regions—east north central, west north central, and the West (the Southwest, Rocky Mountains, and Pacific Coast)—are ones in which spectacular development in metal ore output took place. This can be seen in the top panel of Table 4 since most of the asterisks, indicating an annual rate of growth over 6 per cent per year, are found in these regions. The rates of growth for New England are of no significance since they are based on very small outputs. The north central area enjoyed an early specialization in lead. Although its initial share of output declined because of the tremendous growth of output in the West, output in the north central area increased steadily and sizably after Michigan began to produce copper. Iron ore also enjoyed a steady and an even larger growth, first in Michigan and later in Minnesota. Added to these were the smaller but still significant increases in the outputs of lead and zinc after 1869 and of gold in South Dakota. The result of the growth in output over the whole range of ores was to make the north central region the leading metal ore producer by 1909.

The discovery of gold in California in 1849 opened the great metal mining era of the West. The gold deposits of California were so rich that in 1859 the Pacific region was producing three-quarters of the country's total metal ore output. After the peak Census year of 1859, however,

TABLE 5

VALUE OF GOLD AND SILVER AS PERCENTAGE OF TOTAL METAL ORE OUTPUT OF THE WESTERN REGIONS, 1869-1909

	Rocky Mountain		Southwest		Pacific	
	Gold	Silver	Gold	Silver	Gold	Silver
1869	90	10	36	64	98	2
1879	19	70	24	65	93	6
1889	11	55	24	41	91	8
1902	22	32	13	18	72	7
1909	17	25	19	15	61	7

the region declined in relative importance (6 per cent of the U.S. total in 1909), although its 1909 output was only 23 per cent below that of 1859. After 1890, copper increased to account for about one-third of that share, the remainder being made up of gold and a small quantity of silver.

Metal mining in the other two regions of the West—the Rocky Mountains and the Southwest—began on a significant scale a decade later than it did in California with the 1859 discovery of gold and silver in Nevada and Colorado. Initially, the output was made up almost entirely of gold and silver, since only their values could support the very high cost of moving concentrate or metal out of the producing areas. As time went on, transportation improved with the steady spread of railroads, and it became profitable to mine for products associated with the gold and silver, that is, copper and lead and, to a lesser extent, zinc. This is reflected in a steady decline in the importance of gold and silver in the outputs of those regions, as shown by Table 5.

The bulk of the absolute growth of metal mine output is shown by Table 2 to have taken place in the last two or three decades of the period under review. Although the annual rates of growth were very high for the country as a whole from 1839 to 1859—mainly because of gold—the absolute quantities involved were quite small. After a pause during the Civil War decade, metal mine output grew steadily for the country as a whole but with considerable variability among commodities and regions. For example, total metal mine output in 1889 was only one-third of the 1909 level. Southwest output was only one-fifth of the 1909 level. So also was copper output. Even gold in 1889 was only 41 per cent of the 1909 level, although it had been 60 per cent some twenty years earlier.

In summary, the period 1839–1909 began with all ore produced in the East—iron ore and a little gold on the eastern seaboard and lead in the upper Mississippi valley. In the East, iron ore output increased in the middle Atlantic region until the north central area (Michigan) began to displace it. The spectacular bursts of precious metal output in the West began in 1849, first in California and a decade later in Nevada and Colorado. As transportation improved in the West, the relative importance there of gold and silver declined and that of lead, zinc, and particularly copper increased. The north central region, an important early producer of lead, became the country's leading mineral producing region with the tremendous development of copper in Michigan after 1850 and of iron ore in the Great Lakes states after 1875. The period began with the middle Atlantic and north central regions as the main mineral producers and ended in 1909 with the north central, the Rocky Mountain, and the southwestern regions as the main producers. In 1839, iron ore and lead accounted for most of mineral output (60 and 30 per cent, respectively). In 1859, four-fifths of the country's metal ore output was in the form of gold and silver, practically all of which was gold. By 1909, copper was the leading mineral, accounting for a little over one-third; iron ore accounted for one-quarter and gold and silver together for one-quarter of the major metal ore output.

Employment

Our estimates of employment are based mainly on Census data. There have been special mineral censuses of widely varying worth beginning with the year 1879. In 1869, minerals were given a separate section in the *Census of Industry and Wealth*, but before that time minerals received no special attention. The treatment of minerals in the 1840 and 1850 Censuses is so poor that no useful estimates of employment—or output, for that matter—can be made from them.

Census employment data are for establishments, that is, for industries. While mining industries are identified by the names of commodities, a commodity with a particular name is not necessarily produced entirely within the industry of the same name, nor is an industry with a particular name restricted to production of the commodity of that name. For this reason, it was necessary to consolidate lead and zinc into a single industry and to do the same for gold and silver. In the latter part of the nineteenth century the discrepancy between commodity and industry became wider. In the Rocky Mountain and southwestern regions copper, lead, and zinc began to appear in considerable quantities although employment in these industries was often recorded by the Census in the gold and silver mining industry.

One of the major Census mysteries, especially in 1839, 1849, and 1859, is the definition of mining. A number of nonmining activities closely associated with mining appear to be included in Census tabulations for mining. The iron mining figures seem to be fairly comparable after the 1860 Census in which iron mines were classified with blast furnaces when owned by the same firm, and the noncaptive mines were tabulated separately. For gold and silver, the Census employment estimates definitely contain more than mining operations, but the nonmining operations included have always been closely associated with mining itself. The data for Michigan copper almost certainly include a considerable amount of smelting. This may also be true for some parts of the West in the later decades of the century, although the Census employment data probably exclude smelting more thoroughly in the West than in Michigan. Employment data for lead and zinc are obscure; a substantial number of smelter workers is probably included in the nominal mining employment.

With time, a somewhat clearer line has developed between mining and smelting operations, both in actuality and in the successive Censuses. This has caused "mining employment" to be lower in the later years than it would have been otherwise. Hence an observed decline in the ratio of employment to output is probably somewhat larger than it ought to be.

DISTRIBUTION OF EMPLOYMENT BY REGION AND INDUSTRY

There is naturally a rough correspondence between the distribution of employment among regions and among products and the distribution of output, but a comparison of Tables 6 and 3 reveals numerous departures from this conformity. The differences are all reflected in the ratio of employment to output, examined in detail later.

Because of the similarity between the distribution of employment and output, the general movements over time are much the same. Major metal employment was entirely in the East at the beginning of the period, with the middle Atlantic region dominating. During the next few decades, the initial distribution was radically changed because of the influx of workers into gold and silver mining, first in the Pacific Coast area and

TABLE 6

PERCENTAGE DISTRIBUTION OF EMPLOYMENT IN MAJOR METAL MINING, BY REGION AND COMMODITY, 1839-1909

Region and Commodity	1839	1849	1859	1869	1879	1889	1902	1909
Region								
New England	3.6	1.3	0.5	1.0	1.3	0.4	--	--
Middle Atlantic	43.0	22.0	11.0	23.0	19.0	9.0	4.1	3.0
South Atlantic	24.0	12.0	3.1	3.4	4.3	5.3	5.2	2.7
East north central					13.0	20.0	24.0	21.0
West north central					9.6	7.9	16.0	21.0
North central	19.0	11.0	8.8	17.0	23.0	28.0	40.0	43.0
South central	10.0	4.2	1.9	1.7	1.8	5.1	7.0	5.2
East	100	50	25	46	50	48	55	54
Southwest	0	0.2	1.4	7.3	12.0	8.6	6.3	11.0
Rocky Mountain	0	0.0	1.6	15.0	15.0	28.0	26.0	23.0
Pacific	0	50.0	72.0	32.0	23.0	16.0	13.0	13.0
West	0	50	75	54	50	52	45	46
United States	100	100	100	100	100	100	100	100
Commodity								
Iron ore	59.0	31.0	14.0	32.0	33.0	35.0	35.0	32.0
Copper	0	3.3	8.5	9.2	6.4	5.8	19.0	28.0
Lead and zinc	25.0	8.9	2.1	2.9	7.8	5.8	7.0	11.0
Gold and silver	16.0	57.0	75.0	56.0	53.0	53.0	38.0	29.0
Total	100	100	100	100	100	100	100	100

then around the beginning of the Civil War into the Rocky Mountain and southwestern regions. By 1902 Michigan copper and Lake Superior iron ore had brought the north central region to a leading position. In the West, development of the base metals limited the decline in the region's relative employment position.

MAJOR METAL MINING EMPLOYMENT COMPARED WITH ALL MINERAL EMPLOYMENT

The major metal mining industries do not, of course, constitute the whole mineral industry for, as Table 7 shows, they have accounted for less than one-third of all U.S. mineral employment since 1870. In addition to the major metals, the mineral industries include the comparatively unimportant minor metals, the so-called nonmetallics (e.g., sand and gravel, clay), and the very important category of mineral fuels, coal and petroleum.

While the regional percentages differ considerably even in the earlier years, there clearly has been an increasing regional specialization on major metallics since 1870. In 1870 major metal employment accounted

TABLE 7

COMPARISONS OF EMPLOYMENT IN MAJOR METAL MINING, ALL MINERAL INDUSTRIES, AND TOTAL EMPLOYMENT, BY REGION, 1870-1910

Region	1870	1880	1890	1900	1910
MAJOR METAL MINING AS PERCENTAGE OF ALL MINERAL INDUSTRIES					
New England	11.0	17.0	4.5	0	0
Middle Atlantic	23.0	19.0	6.3	2.2	1.7
South Atlantic	27.0	32.0	21.0	16.0	5.5
East north central	28.0	33.0	26.0	26.0	22.0
West north central	20.0	48.0	22.0	37.0	51.0
South central	28.0	27.0	22.0	15.0	11.0
Southwest	42.0	125.0[a]	71.0	52.0	68.0
Rocky Mountain	48.0	29.0	59.0	48.0	62.0
Pacific	41.0	45.0	54.0	36.0	54.0
United States	32.0	32.0	24.0	21.0	20.0
MAJOR METAL MINING AS PERCENTAGE OF TOTAL EMPLOYMENT[b]					
New England	0.04	0.07	0.02	0	0
Middle Atlantic	0.48	0.49	0.19	0.08	0.07
South Atlantic	0.10	0.15	0.18	0.19	0.10
East north central	0.31	0.35	0.53	0.60	0.58
West north central	0.09	0.46	0.28	0.64	0.93
South central	0.04	0.05	0.15	0.17	0.14
Southwest	6.9	20.0	9.0	6.5	8.4
Rocky Mountain	12.0	7.6	7.5	7.1	5.2
Pacific	6.7	4.8	2.1	1.8	1.3
United States	0.47	0.56	0.47	0.50	0.51
ALL MINERAL INDUSTRIES AS PERCENTAGE OF TOTAL EMPLOYMENT					
New England	0.40	0.46	0.46	0.34	0.31
Middle Atlantic	2.1	2.6	3.1	3.8	4.2
South Atlantic	0.37	0.48	0.86	1.2	1.8
East north central	1.1	1.1	2.0	2.3	2.6
West north central	0.49	0.95	1.3	1.7	1.8
South central	0.17	0.21	0.69	1.1	1.3
Southwest	17.0	16.0	13.0	13.0	12.0
Rocky Mountain	26.0	26.0	13.0	15.0	8.5
Pacific	16.0	11.0	3.9	5.1	2.4
United States	1.5	1.7	2.0	2.4	2.5

Source: Major metal employment is our estimate. 1870-90 are from Table A-4, and 1900 and 1910 (1902 and 1909) are from Table A-5. All mineral industries and total employment are from H.S. Perloff, *et al.*, *Regions, Resources and Economic Growth*, Baltimore, 1960.

[a]Obviously incorrect. The estimate for employment in all mineral industries is probably too low.

[b]Employment data from Table A-4 are used below to calculate major metal mining employment as a percentage of total employment, with the latter assumed equal to all males (including slaves) 15-60 years of age as recorded in the population Censuses.

NOTES TO TABLE 7 (concluded)

	1840	1850	1860	1870
New England	.04	.03	.03	.06
Middle Atlantic	.22	.25	.31	.56
South Atlantic	.15	.19	.13	.14
East and west north central	.14	.15	.20	.28
South central	.08	.07	.07	.06
Southwest	--	.26	2.9	7.2
Rocky Mountain	--	--	2.4	13.0
Pacific	--	11.00	18.00	6.6
United States	.14	.30	.67	.57

for no more than 48 per cent of all mineral employment in any region, but in 1910 four regions had over half of their mineral employment in the major metal mining industries. In 1870 no region had less than 11 per cent of its mineral employment in the metal mining industries, but in 1910 four regions were below that level. In the western regions major metal employment is a more important part of all mineral employment than it is in the East. Indeed, in one year a ratio of major metal employment to all mineral employment of 1.25 was obtained for the Southwest. No attempt has been made to correct this, since the more defective estimate is probably the estimate for all mineral employment, a series which is not the main concern of this paper. Still, taking the whole group of percentages for the western region, there can be little doubt of the dominant position held by major metals in the whole field of mineral employment.

MINERAL EMPLOYMENT COMPARED WITH ALL EMPLOYMENT

Mineral employment has always been a small part of total employment in the United States, although there has been a substantial increase from the 1.5 per cent level of 1870, shown in Table 7.[5] Regional differences are very great, reflecting the rich deposits of minerals in some regions and the other opportunities for economic activity in each of the regions. The regions best endowed with metallic minerals are perhaps less well endowed in other respects. The theory of ore genesis indicates that this is not entirely a matter of chance. The consequence is that in the southwestern and Rocky Mountain areas metallic mineral employment was 5 per cent or more of total employment in each of the five Census years

[5] It should be borne in mind that our estimates of employment are based upon the mineral Census and refer, in most cases, to average employment during the year of operations covered by the mineral Census. I believe the year of operations actually covered by most reports to the Census was the year preceding the nominal year of the Census. Thus the 1870 mineral Census, for example, very likely collected reports on calendar year 1869 from most of the reporting units. The occupational data on which the total mining employment estimates and the total employment estimates are based refer in all cases to the spring of the Census year.

from 1870 to 1910, and even in the Pacific Coast region was 5 per cent or more in two of the five years. In the other regions, major metal employment is a much smaller part of total employment, being under 1 per cent in all cases, even in the west north central region, whose major metal components are lead and zinc, Minnesota iron ore, Michigan copper and iron ore, and South Dakota gold.

The middle Atlantic region emerges as the third most specialized mineral region when all mineral employment is compared with total employment. In 1910 the middle Atlantic region had over 4 per cent of its employment in mineral industries compared with about 2 per cent for the north central region, which is specialized in metallic minerals rather than the nonmetallic minerals that are important in the middle Atlantic area.

In the Rocky Mountain and southwestern regions, mineral employment as compared with all employment was still very high in 1910, 12 and 8 per cent, respectively. In the earlier years, as many as one out of every four employed persons was working directly in a mining industry in the Rocky Mountain area.

These percentages are high for a developed region. Nevertheless, the picture of the West as completely dominated by metallic mineral mining is so strong that many may be surprised that they were not higher there. The circumstances under which major metallic employment could be close to 100 per cent would be most unusual. If a wholly empty region is entered for the first time by prospectors, all of whose activities—including shooting, preparation, and cooking of game—are regarded as part of mining, then employment in the major metallic industries in that area would equal total employment. (The probability would be, of course, that the Census taker would not be able to find the prospector.) But as soon as the region under scrutiny is enlarged, there are necessarily many kinds of activity other than metal mining, even though the mining industries may be the main or even the sole reason for them. Mining must be supported by industries that supply materials and equipment. Equipment, mineral products, food, and other consumer commodities must be transported. Men and their families must be fed, housed, and clothed. And in many mineralized areas there are other bases for economic activity, some of which would be carried on even in the absence of any mineral industries. The consequence is that throughout the whole of the period measured here metallic mineral employment and all mineral employment have been greatly outweighed by employment classified in other industries. Nevertheless, the existence of ghost towns and ghost areas proves that in many smaller areas almost all employment was derived from the major metallic industries. With the development of activity around other economic opportunities, later data show that mineral employment has declined relative to total employment. In 1950, for example, all mineral employment was 3.4 and 3.5 per cent of total employment in the Rocky Mountain and southwestern regions, respectively, compared with 26 and 17 per cent in 1870.

Ratio of Employment to Output

The behavior of employment in relation to output is summarized in Table 8. The ratio of employment to output *E/O* "eliminates" the size of the industry and can thereby show clearly one important aspect of the production structure. The ratio *E/O* for minerals is likely to vary more among industries, among regions, and over time than might be expected in the nonmineral industries. The factors that tend to produce this result are discussed below. Their effects are obscured by the fact that our data are sometimes grossly inadequate measures of the quantities we would like to measure. The reasons for this are explained below before we turn to the "real" factors making for variability in *E/O*. It should be borne in mind that *E/O* is not the inverse of total factor productivity in any meaningful sense but is simply the ratio of employment to output. In particular, it would be quite possible, though perhaps not likely, for *E/O* to increase from one period to the next even though a proper measure of the total productivity of an industry would show an increase. It would be desirable to discuss productivity, its variation among industries and regions, and its variation over time, but estimates of inputs other than labor have not been possible for these industries.[6]

We should like also to measure long-term changes, but our data refer to particular years and sometimes to particular dates. The level of output or of employment may be distorted in any one year by forces that are temporary and will therefore prevent the data from revealing in full clarity the long-run changes that are taking place.

In the mineral industries, the measurement of output is complicated by the fact that the labor force is engaged in producing two types of goods—a "current" good, which comes out in the form of concentrate or ore, and a capital good, which is visible as a developed mineral deposit. It would be desirable in the study of *E/O* to separate the two types of product and to separate the amount of labor used to produce each or—this not being very feasible even in principle—to make certain that the

[6] For comments on the problem of extracting measures of capital used in mineral industries from the censuses, see my review (*Journal of the American Statistical Association*, March 1957, p. 119) of Israel Borenstein's *Capital and Output Trends in Mining Industries, 1870–1948*, Occasional Paper 45, New York, NBER, 1954.

TABLE 8

INDEXES OF EMPLOYMENT DIVIDED BY OUTPUT, BY REGION AND COMMODITY, 1859-1909
(1889 = 100)

Region and Commodity	1859	1869	1879	1889	1902[a]	1909[a]
New England	--	--	--	--	--	--
Middle Atlantic	144	193	182	100	60	46
Iron ore	133	173	164	100	94	88
Lead and zinc	275	618	411	100	20	17
South Atlantic	95	66	95	100	81	74
Iron ore	99	169	105	100	91	102
North central	181	159	148	100	63	63
Iron ore	57	178	155	100	48	40
Copper	484	205	151	100	104	108
Lead and zinc	112	112	234	100	63	93
Gold and silver			55	100	70	86
South central	174	278	186	100	69	64
Iron ore	183	402	202	100	80	75
Southwest	314	69	121	100	58	46
Copper			112	100	112	117
Gold and silver		51	100	100	68	38
Rocky Mountain	147	241	123	100	63	70
Copper				100	131	213
Gold and silver	107	175	99	100	64	65
Pacific	81	83	98	100	65	61
Gold and silver	82	84	99	100	80	81
United States	175	161	148	100	64	60
Iron ore	131	189	168	100	55	46
Copper	752	427	267	100	96	111
Lead and zinc[b]	212	202	228	100	73	106
Gold and silver	149	116	111	100	67	64

Note: The employment estimates do not attempt to take into account changes in hours worked per year. If it had been possible to take account of the decline in the number of hours, the measures of *E/O* would have declined considerably more than they actually did.

1839 and 1849 are not included in the table, since employment in those years was estimated by extrapolating the 1859 quantity by output. Nor does Table 8 include all the possible *E/O* ratios that could be computed. It includes the regional *E/O* ratio (equivalent to a weighted average of the industry ratios within a region weighted by output in the given year divided by the same weighted average for the base year) for all regions having production in 1909, all, that is, except New England. The U.S. values of *E/O* are included, as are the U.S. industry averages, which may be viewed as equivalent to a weighted average of the regional industry ratios weighted by output in the given year divided by the same weighted average for the base year. Estimates have been included for individual industries within regions where these industries were of substantial size. Where outputs are very small, estimates of *E/O* are not to be relied upon, for the estimates of both output and employment for those states of minor importance in the industry are subject to sizable error, both because of undercount of employment and the independence of the regional distributions of output and employment. For example, *E/O* for Middle Atlantic lead and zinc in

NOTES TO TABLE 8 (continued)

the table exhibits a most unusual behavior. Another case of a very sharp change is that of the Southwest from 1859 to 1869 to 1879.

Each industry except iron ore is afflicted by a lack of correspondence between the definitions of output, which is measured on a commodity basis, and of employment, which is measured on an establishment basis. This lack of correspondence affects the estimates of *E/O* in various ways. The most important case is that of lead and zinc. The lead output of the West (produced from silver and lead ores) is included in the lead and zinc industry's output, but the number of mines classified in the lead and zinc industry in the West is very small throughout the whole period. Zinc adds to the problem to a lesser extent since the West's zinc output was a smaller part of the U.S. total. On the other hand, the distortion introduced into the gold and silver series is much less, for the lead omitted from the output of this industry was only a small part of the total output of the industry. Lead and zinc outputs of the West as a percentage of the U.S. total were as follows:

	Lead	*Zinc*
1859	0	0
1869	1	0
1879	70	0
1889	81	0
1902	72	11
1909	57	15

The change in the percentage of lead coming from the West caused *E/O* for the United States to fall more (or rise less) from 1859 to 1889 and to rise more (or fall less) from 1889 to 1909.

A less important problem is caused by the transfer of establishments from the gold and silver industry to the lead and zinc or copper industries. As copper, lead, and zinc became the major parts of the output of a number of mines in these regions, the Census Bureau began to recognize the mines as something other than gold and silver mines, even though gold and silver were contained in the ores. Hence the employment formerly attributed to the gold and silver industry was shifted, in part, to the other major metal industries.

In a number of cases, Census output of a commodity is greatly below our estimates of output based on other and presumably better information, and the Census ratio of employment to output has been applied to our estimate of output. There has been no attempt, however, to correct and make sense of every case of odd behavior in the employment-output ratio. Hence there are many anomalies in the behavior of employment in relation to output, especially where the quantities involved are small. These arise in part because the regional estimates of output are based in some cases on sources that may differ substantially from the regional distribution of output contained in the Census.

[a]1902 and 1909 Census employment data (see Table A-5) have been adjusted in an attempt to make them comparable with 1889 data. 1909 was first put on a 1902 basis by calculating average monthly employment (which was 11 per cent below the Dec. 15 figure used in the 1909 Census for major metallic minerals). 1902 and 1909 state figures were then multiplied by the following factor derived from 1889 data, to get to the 1889 basis:

$$\frac{\Sigma\ (\text{employment})_i}{\Sigma\ (\text{employment})_i \times \dfrac{(\text{days worked})_i}{300}}$$

TABLE 8 (concluded)

where i is the skill level or occupational group. This method of adjustment is suggested in *Mines and Quarries, 1902*, p. 90. 1902 employment in all major metallic minerals for the United States on the 1889 basis is 22 per cent above 1902 employment reported in the Census.

I am indebted to Neal Potter for reminding me of this problem of consistency.

[b]See the second paragraph of the Note above.

output measured includes the capital good part of the output as well as the current product. We have not been able to do this but wish to call the difficulty to the reader's attention. In some years the capital good part of output can be very important. Some mines in any year are nonproducing, for instance, although not necessarily dead or even poor mines, for they may have a substantial labor force at work with little evidence of product visible above the ground. Hence, the labor force is engaged in developing the mine, that is, in producing a capital good. In the nonmining industries, on the other hand, there is usually a rather clear separation between operations on "current account" and operations on "capital account," although in agriculture and some industries the labor force does indeed engage in the production of capital goods to be used by the industry itself.

THE BEHAVIOR OF E/O

The interpretation of Table 8 presents great difficulty both because of the large number of factors affecting the behavior of the ratios and because of the largely unknown errors reflected in the estimates of output and employment. There are many puzzling features of the table that raise the possibility of systematic error in the estimates of employment or output, and also the possibility of fundamental changes in the conditions of production. Unfortunately, possible explanations abound.

1859–69

One of the puzzles is that E/O rose from 1859 to 1869 in two of the four eastern regions and in two of the three western regions. In the two eastern regions, a factor in this behavior is probably the estimate of employment in iron ore. Since the Census data on iron ore employment cover only a small portion of all the iron ore mined, we have been unable to find a satisfactory basis on which to construct an estimate. There are real factors that conceivably could explain the behavior of the ratio, such as that during the Civil War resort to lower grades of ore could have produced an increase in the ratio.

Rate of Change of E/O

The data for the United States as a whole show that *E/O* declined more rapidly from 1879 to 1902 than in the periods before or after (Table 9).

TABLE 9

ANNUAL RATE OF CHANGE IN EMPLOYMENT DIVIDED BY OUTPUT IN MAJOR METAL MINING, BY REGION AND COMMODITY, 1859-1909
(per cent per year)

Region and Commodity	1859 to 1869	1869 to 1879	1879 to 1889	1889 to 1902	1902 to 1909
Middle Atlantic	+2.9	-0.6	-6.0	-3.9	-3.8
Iron ore	+2.7	-0.5	-4.9	-0.5	-1.0
South Atlantic	-3.6	+3.5	+0.6	-2.1	-1.2
Iron ore	+5.4	-4.8	-0.5	-0.8	+1.7
North central	-1.3	-0.7	-4.0	-3.6	0
Iron ore	+11.5	-1.3	-4.4	-5.7	-2.4
Copper	-8.6	-3.1	-4.1	+0.3	+0.6
Lead and zinc	0	+7.3	-8.5	-3.5	+5.5
South central	+4.6	-4.0	-6.2	-2.9	-1.0
Iron ore	+7.9	-6.9	-7.1	-1.8	-0.8
Southwest	-15.2	+5.9	-1.9	-4.2	-3.2
Copper	--	--	-1.1	+0.9	+0.7
Gold and silver	--	+6.8	0	-2.9	-8.5
Rocky Mountain	+4.9	-6.8	-2.0	-3.6	+1.5
Copper	--	--	--	+2.1	+6.9
Gold and silver	+5.0	-5.7	0	-3.4	+0.3
Pacific	+0.2	+1.6	+0.2	-3.3	-0.8
Gold and silver	+0.2	+1.7	+0.1	-1.8	+0.2
United States (total)	-0.8	-0.9	-3.9	-3.5	-0.8
Iron ore	+3.7	-1.2	-5.2	-4.6	-2.5
Copper	-5.7	-4.7	-9.8	-0.3	+2.1
Lead and zinc	-0.5	+1.2	-8.3	-2.4	+5.3
Gold and silver	-2.5	-0.5	-1.1	-3.1	-0.7

Note: See note to Table 8.

This pattern is much less clear for industries within regions, however; in part, the movements of the weighted averages for the United States reflect shifts among regions and among industries. But the maximum annual rate of decline in *E/O* occurs in one or the other of the two "decades" from 1879 to 1902 in five of the seven regions shown in Table 9.

The annual rate of decline for the United States is less rapid from 1902 to 1909 than from 1889 to 1902. This is also true of each of the seven regions although for only eight out of the eleven industries within regions included in Table 9. Although the leveling off of the rate of decline in *E/O* may reflect in part the adjustment to the employment data for 1902 and 1909, these two years should be reasonably comparable if the Census adjustment for 1902 resulted in annual data equal to the average of monthly data. The adjustment of 1889 and 1902 to a common basis offers greater possibility for error.[7]

FACTORS AFFECTING *E/O*

In view of the uncertainties in the data, especially the levels and allocation of the employment data and the lack of correspondence between product and industry, any discussion of the factors affecting *E/O* must be tentative. However, some of the factors involved have left their traces even in our rough data.

Quality of Deposits

The decline in *E/O* for the period from 1879 to 1902 for the United States as a whole is explained in part by a shift of output to regions with lower ratios of *E/O*. For example, middle Atlantic *E/O*'s for iron ore were considerably higher than those for the north central region, as can be seen below:

	1869	*1889*	*1909*
Middle Atlantic	1.76	1.02	0.89
North central	1.46	0.82	0.33

Similarly, the *E/O* ratio for copper in the West was considerably below that for copper produced in the north central region, as seen in the following figures:

	1869	*1889*	*1909*
North central	0.85	0.42	0.45
Rocky Mountain	—	0.10	0.22
Southwest	—	0.17	0.20

And the *E/O* ratio for gold and silver for the Rocky Mountain region was well below that for the Pacific Coast region. The main shift in output from 1879 to 1902 was between these two regions:

	1869	*1889*	*1909*
North central	—	0.60	0.52
Rocky Mountain	0.85	0.48	0.32
Southwest	0.30	0.59	0.22
Pacific Coast	0.97	1.16	0.94

Not all of the observed differences among the regional ratios are attributable to differences in the metal content of deposits, however, for

[7] See note b to Table 8.

the richness of the deposit is only one facet of quality. Perhaps even more important are size of the deposit and ease of working it.

Transportation and Exhaustion

For gold and silver it seems possible to see the effects on *E/O* of the discovery-exhaustion sequence and associated changes in transportation. When a new mining region is opened up, the heavy load of development work as new mines are brought to the point of production would tend to raise *E/O*. Independently of this factor, if the richest mines are discovered first we should expect a later rise in *E/O*. On the other hand, if the richer discoveries came later, *E/O* would decline, to rise at a still later point in time. What happened in the West was that both rich and poor deposits were discovered in these great mining regions. The factor that exerted the dominant influence on *E/O* probably was transportation. As transportation improved, it became profitable to work leaner and poorer deposits, and we should expect an increase in *E/O*, especially with improvements of the magnitude represented by the change from pack train and wagon to rail transport.

Something of this effect may be visible in Table 8. We do observe an increase in *E/O* in the gold and silver industry of the Southwest from 1869 to 1879. The change from 1859 to 1869 is unreliable because 1859 was the first big year for mining in the Southwest. Similarly, in the Rocky Mountain area, which opened up in 1859, we observe an increase in *E/O* for gold and silver. The Pacific Coast region had been producing since 1849, but here also an increase in *E/O* is shown from 1859 to 1869 and from 1869 to 1879.

The effects of improved transportation on the composition and level of output in the West are much clearer than the effect on *E/O*. When transportation is costly—as it was in the West until the development of the rail network—mining is restricted to ores that have a high value per unit weight of the material to be transported any distance. The products that met this requirement best were gold and silver, while the other metal products with lower value per unit weight were of no importance until 1879 and even then only small.[8] Ten years later, the "cheaper" commodities were considerably more important, and by 1902 they were more more important than gold and silver in the Southwest and nearly so in the Rocky Mountain region. The close association between the development of the rail network and the growth of the base metal commodities

[8] But gold and silver were not the only commodities to get over the transportation barrier. Furs succeeded in an earlier period as did cattle and sheep during the time when mining was spreading throughout the Rocky Mountain and southwestern regions.

is suggested very clearly by Table 10 which shows rail mileage by states at decadal points.[9] The association is much poorer for the Pacific Coast region than for the other two. Placer deposits (gold only) were far more important in California than in the states of the other two regions.

According to the 1880 Census, wagon haulage rates were seldom as low as 1 cent a pound for the trip from the mine and were as high as 6 to 8 cents a pound for the more distant mining camps.[10] In the same Census

TABLE 10

UNITED STATES RAILROAD MILEAGE IN THE WESTERN STATES, 1870-1910
(thousand miles)

	1870	1880	1890	1900	1910
Southwest	0.6	1.8	3.3	4.2	7.4
New Mexico	--	0.8	1.3	1.8	3.0
Arizona	--	0.3	1.1	1.5	2.1
Nevada	0.6	0.7	0.9	0.9	2.3
Rocky Mountain	0.9	3.2	9.3	11.6	15.5
Idaho	--	0.2	0.9	1.3	2.2
Wyoming	0.5	0.5	0.9	1.2	1.6
Utah	0.3	0.8	1.1	1.5	2.0
Montana	--	0.1	2.2	3.0	4.2
Colorado	0.2	1.6	4.2	4.6	5.5
Pacific region	1.1	3.0	7.6	10.4	14.9
Washington	--	0.3	1.8	2.9	4.9
Oregon	0.2	0.5	1.4	1.7	2.3
California	0.9	2.2	4.4	5.8	7.8

Source: *Statistical Abstract of the United States, 1920*, Census Bureau, Washington, 1921, Table 226, p. 333.

Note: Table 5 shows the decline of gold and silver relative to the total output of these regions.

it is observed that Arizona produces chiefly gold and silver, "though lead and copper, particularly the former, are rather abundant, and will, no doubt, be exploited on a large scale when the railroad system is further developed."[11] When mining first began in Arizona, some of the mines were as much as 300 miles from the nearest railroad. The only way to transport concentrate was by wagon or pack train. Even in 1880, no mine could be worked in Arizona unless its ore contained products worth at least $150 a ton. As late as 1885, some ores in Colorado bore freight charges ranging from $50 to $100 a ton before reaching a railroad

[9] See note to Table 10.
[10] *Census of Minerals, 1880,* p. ix.
[11] *Census of Precious Metals, Statistics and Technology, 1880,* 1885, p. 44.

but, by the turn of the century, all important mining camps were connected by rail with the main railroad lines.[12] Indeed, the Census report observed in 1880, ". . . now not only are there practically four great railway systems crossing the mountains from east to west, but a great number of short lines, generally narrow gauge, penetrate them in every direction, reaching mining towns which not many years since were only accessible by pack trains or saddle animals."[13]

Technological Change

To link major changes in technology with changes that have taken place in our data from 1859 to 1909 appears to be impossible, except, of course, for the persistent and very sizable decline in *E/O* for the United States as a whole and for each industry taken separately. It has not been possible, for example, to link definitely any particular change or set of changes with the accelerated declines in *E/O* in the two decades from 1879 to 1902, although some suggestions can be made. Fortunately, there are available two helpful examinations of technology in metal mining. One, by Lucien Eaton, is a straightforward account of changes in mining technology from 1871 to 1946.[14] The other is a survey of the long sweep of changes in technology in mining by C. E. Julihn.[15] It is on these two expert accounts of changes in mining technology that the following remarks are based.

Julihn's view is that over most of the period there were many small advances with significant cumulative effect but nothing that could be characterized as a major improvement. Toward the end of the century, however, a major change was in the making—abandonment of the selective, small-scale methods of mining where the miner had to make sure the ore he mined was not diluted or lost on the way to the smelter and development of nonselective, large-scale, mass production methods of mining. This shift in attitude and in method developed almost automatically as it became necessary to go to lower- and lower-grade ores during the latter part of the century. By using cheaper methods for breaking and handling large volumes of material, it was profitable to mine ores in which the desired mineral was diluted by large quantities of

[12] *Census of Mines and Quarries, 1902*, 1905, p. 577.

[13] *Census of Precious Metals, 1880*, p. xii.

[14] See his "75 Years of Progress in Metal Mining," in *75 Years of Progress in the Mineral Industry*, A. B. Parsons, ed., American Institute of Mining and Metallurgical Engineers, 1947, p. 40.

[15] See his "Copper: An Example of Advancing Technology and the Utilization of Low-Grade Ores" in *Mineral Economics*, F. G. Tryon and E. C. Eckle, eds., New York, 1932, p. 111.

waste material, which could by then be cheaply separated from the desired mineral.

There were, of course, many developments in technology during the last half of the nineteenth century, but not all constituted improvements. Many of the changes were associated with development of new regions which contained new types of deposits or deposits of sizes different from those in the older producing regions. Other changes represented not innovations but rather adaptations to improved transportation. All that can be done here is to enumerate some of the more significant changes and recall that no single one or set of them was powerful enough to leave traces in the data at our disposal.

One of the more significant changes was the introduction of dynamite around 1870. Drilling, formerly done by hand, gradually came to be carried on by compressed air. Steam power gradually became generally used for lifting—electric power not becoming a significant factor in metal mining until after the turn of the century. There were constant advances in the arts of breaking and grinding ore, one of the most important being improvements in the processes available for separating minerals from each other but, of course, the array of sink and float methods now in the mining engineer's repertoire came into use only after the turn of the century. Surveying and mapping became more accurate and helped to cut costs in developing and in working mines. The steam shovel came into general use in the last quarter of the century in open-pit mining. Loading became mechanized. And even in so simple a thing as the design of the hand shovel, abandonment of the old long-handled shovel was a significant improvement. Along with these narrower aspects of changing technology came a series of gradual advances in mining methods, such as the sequence of operations, the spacing of shafts and drifts, and so on. There were two innovations that had their origin in the United States: the square-set system developed on the Comstock lode and hydraulic mining.[16]

If this study had been carried beyond 1909, the major innovation involved in shifting to nonselective mass methods of mining would have been evident in copper.[17] In iron ore, methods of mass mining were applied in Michigan and Minnesota long before their use in the rather different problems of copper and other nonferrous ores. In mining districts in which lead and zinc deposits were sizable the impact of the change in method should also be apparent.

[16] *Census of Precious Metals, 1880,* p. vii.

[17] My study of the copper industry led to the conclusion that this development was clearly evident in the behavior of the price of copper (*Copper Costs and Prices: 1870–1957,* Baltimore, 1959).

NUMBER OF MINES AND OUTPUT PER MINE

The factors influencing *E/O* discussed above have had substantial effects on the number of producing mines and on the average product per mine. These effects have been concentrated on iron ore and copper and, to a smaller extent, on lead and zinc. While the number of gold and silver mines was quite different in 1909 from the number in 1869, the change in output per mine was much smaller than in the other three consolidated industries.[18]

TABLE 11

NUMBER OF IRON ORE MINES AND OUTPUT PER MINE, BY REGION, 1869 AND 1909

Region	Number of Mines		Annual Output Per Mine (thousand short tons)	
	1869	1909	1869	1909
Middle Atlantic	265	48	8	53
South Atlantic	51	89	2	24
East north central	89	88	12	164
West north central	3	144	60	221
South central	8	98	7	58
United States	420	483	8	76

Table 11 shows that the number of iron ore mines was about the same in 1909 as in 1869 for the country as a whole, although there were very large changes within regions. In the middle Atlantic region the number declined to less than one-fifth of its 1869 level, while in the west north central (Minnesota) and south central regions the numbers increased from a few in 1869 to over a hundred in 1909. Accompanying these shifts in the number of iron ore mines within regions were marked changes in output per mine. In the country as a whole, output increased about tenfold. Within each of the regions the increase was sizable, somewhat more than tenfold in the east north central region but decidedly less than tenfold in the west north central region. From the start iron ore mining was on a rather large scale in the west north central region.

In the lead and zinc industry, unlike the iron ore industry, there was a large increase in the number of mines from 1869 to 1909—from 127 to 1,213. As in the iron ore and copper industries, there appears also to

[18] All data on number of mines and output per mine are from the various Censuses. The data in Tables 11 and 12 are not consistent with the output data in Table A-2 but suffice to give a rough indication of change.

have been a substantial increase in the value of output per mine. In the west north central region (Missouri) the increase was of the order of sevenfold; in the east north central region (Wisconsin and Illinois) the increase was of the order of fourfold.

Gold and silver mines present a considerably more complex picture, partly because they consist of two different groups of mines, deep mines and a combination of placer and hydraulic operations. Between 1869 and 1909 the number of deep mines in operation increased very substantially, an increase which in absolute numbers took place mainly in the

TABLE 12

NUMBER OF COPPER MINES AND OUTPUT PER MINE, BY REGION, 1869 AND 1909

Region	Number of Mines		Annual Output Per Mine (thousand dollars)	
	1869	1909	1869[a]	1909
Northeast	2	--	97	--
Middle Atlantic	2	--	2	--
South Atlantic	4	--	24	--
East north central	27	21	86	1,430
South central	2	--	84	--
Southwest	3	120	6	308
Rocky Mountain	--	137	--	400
Pacific	--	23	--	232
United States	40	301	70	438

[a]Value of output per mine in 1869 was multiplied by the ratio of the price of copper in 1909 to the price of copper in 1869.

Rocky Mountain area, with the southwestern and the Pacific Coast regions also involved. The number of placer and hydraulic operations, on the other hand, declined to less than half its 1869 level, the decline taking place in absolute terms about equally in the Rocky Mountain and the Pacific Coast areas. Placer operations in the Southwest were never of any importance. Output per deep mine declined in every region which was in operation in both periods. With the placer and hydraulic operations, on the other hand, output per mine—which was only $5,000 in 1869—slightly more than doubled over the forty-year period, with almost all of this increase taking place in the Pacific Coast region.

Copper production in 1869 was an unimportant industry in every region with the exception of east north central (Michigan). As shown in Table 12, in this region, which had almost as many producing mines in 1909 as in 1870, output per mine in the later year was almost seventeen times that of the earlier year. In 1909, output per mine in the western areas was considerably lower than in the east north central region. Note, however, that we are dealing here with averages and with highly skewed distributions. An examination of the frequency distribution of mining enterprises in the copper industry by number of employees for Michigan, Arizona, and Utah in 1909 reveals that the largest mines were comparable in size to those in Michigan, but that in the western states there was a much larger number of very small mines than in Michigan.

Minerals and Regional Economic Development

The metallic mining industries played a major role in the westward spread of organized economic activity over the period of this study. Most important of all, they provided an export base for regional development and in some cases the only one. An export base is an essential part of the explanation of regional development where expansion of output and geographical expansion are associated, for, without it, there would be no reason to incur the locational disadvantage involved in moving away from established centers of activity. This economic opportunity often takes the form of an abundance of appropriable natural capital—forests, mineral deposits, or agricultural land. The richness of these pieces of natural capital permits higher costs for transportation to be incurred and thereby ensures the geographical expansion of production. The pace of this expansion then depends on the quality of the natural capital, the periods of gestation of man-made capital, the arrangements for spreading information about new economic opportunities, and the complicated mechanism governing the response to such opportunities.

The mere fact that minerals were produced, however, does not entail the conclusion that those deposits constituted valuable natural capital. The question is whether the amount of money spent in finding, developing, and producing the minerals was less than the cost of acquiring the products from the available alternative sources. The iron ore and copper deposits of the Lake Superior area and the coal deposits in all the areas where they were found were, in fact, valuable natural property, for the cost of finding and developing them was extremely low. As for gold and silver and the other metallic mineral deposits of the West, the size of the social surplus is more uncertain. If foresight were perfect, there would be no doubt about the answer, but the fact that the outcome of a mineral enterprise is uncertain opens the possibility that, from the point of view of society, the net rent earned was not large. This is quite different from saying that nobody made enormous profits on these deposits.

There is little possibility of estimating the net rent earned on the western deposits during the nineteenth century. The problem is very complicated from a conceptual point of view and involves expenditures not recorded in mining censuses. The impression, however, is almost universal that a substantial net rent was earned from the point of view of society as a whole. But even if net rents were negative, the fact that the activity was undertaken obviously exerted a profound influence on regional development. During the heyday of gold mining in California, gold was an important part of total economic activity, although there were other locational bases present before 1849. In parts of the Southwest, minerals furnished absolutely the only reason for settling there. In time, locational bases other than mining—agriculture, forestry, and lately "amenities"—developed, and mining diminished in relative importance both over the period under consideration and on down to the present.

Minerals were an export base with a peculiarity which aided regional development in another way. Since they had to be found, prospecting was an important means of accumulating knowledge of the different parts of the West. Assessment of the economic possibilities of a region—a necessity for all types of investment decisions—requires that a large stock of information of many kinds be at the command of many people, not just a few. The West was not unknown to a few white men who, before the Civil War, had roamed over most of the land as trappers. But the knowledge they had amassed was not comprehensive or systematic, and it provided only the bare essentials for the treks to Oregon and California. The extent of the ignorance of the West and the unreliability of what knowledge there was can be seen from the fact that even as late as 1867–79 the national government was induced to spend its money on four surveys of the West (King, Wheeler, Hayden, and Powell). Bartlett, in his account of those four surveys, sums up the situation as follows: "In 1867 men had asked, 'What lies out there?' By 1879, thanks to the work of the Great Surveys, their question had been answered. Now a new question was on men's lips: 'When shall we go there?' " [19]

IS THE PROCESS OF MINERAL DEVELOPMENT SYSTEMATIC?

A fundamental problem in the organization of the mineral industries is whether the finding and development of mineral deposits exhibits a systematic response to economic incentive. Our survey of the spread of metal mining across the continent is relevant to this important question, and I believe the evidence supports the conclusion that for fairly large

[19] Richard A. Bartlett, *Great Surveys of the American West*, Norman, Oklahoma, 1962, p. 376.

areas the search and development do respond in a systematic fashion to economic incentive, once it is widely understood that mineral deposits are probably present in the region. The actual pace of search and development and the actual growth of output do require other preconditions, the main one being transportation. For example, it was impossible for low-value ores of copper, lead, and zinc to be developed in the West until a rail network provided a cheap means of getting these mine products to market. It is true that, if we look at small areas or at the efforts of the lone prospector or even a single corporation, chance—from their point of view—plays an important part in success or failure. But if we step back and look at a larger area and a larger number of prospectors or corporations, the chance element begins to recede and a pattern of relentless expansion in response to economic incentive emerges in region after region.

The presence of copper in Michigan was known from very early times. The Smithsonian Institution has exhibited a large mass of native copper called the Ontonagon Boulder which had rested on the bank of the Ontonagon River in Michigan from prehistoric times until it was moved to Washington, D.C., in 1843. With knowledge of the presence of copper generally available, modern copper mining began in Michigan quite early, in about 1845. It expanded rapidly, and the search for additional deposits was conducted in an intensive manner. A similarly systematic and intense expansion of iron ore mining is observable in the Lake Superior deposits in Michigan and later in Wisconsin and Minnesota.

The presence of silver in what later was to be the southwestern United States was known for a long time. Indeed, the hope of finding large deposits of gold and silver had stimulated some of the earliest explorations in the Southwest—if they can be so dignified—but for a long time the presence of really rich deposits of gold or silver was hoped for rather than suspected. The well-known discovery which opened up the West for mineral exploitation was of California gold, a fortuitous discovery not to be ascribed to any economic activity in search of gold. But once the news of gold in large quantities in California was definite, the search was extended, covering more and more ground as time went on and alerting people to the possible presence of gold in areas far removed from California. The discovery of the Comstock lode in 1859 was an outgrowth of the California activity, and so probably, at a much greater distance, was the discovery of gold in Colorado the same year. After that, the process of combing the West for mineral deposits began. What prospectors and others were looking for depended naturally enough on what they could do with the mineral if they found it. This meant that in areas very far from the more settled ones attention was limited for a long time to ores containing large amounts of gold and silver. But with the development of the rail network, which was significant by 1880 but far more extensive by 1890, mining ores containing much smaller amounts of the precious metals began to pay.

Appendix

TABLE A-1

U.S. ANNUAL MINE PRODUCTION OF MAJOR METALLIC ORES, 1839-1909
(recoverable metallic content)

Year	Iron Ore (million long tons)	Copper (thousand short tons)	Lead	Zinc	Gold (million fine troy ounces)	Silver
1839	0.99		18		0.022	0.011[a]
1840			17		0.023	
1841			20		0.029	
1842			24		0.041	
1843			25		0.056	
1844			26		0.052	0.018
1845		0.112	30		0.054	
1846		0.168	28		0.060	
1847		0.336	28		0.047	
1848		0.560	25		0.145	
1849	1.67	0.784	24		0.517	0.088
1850	1.48	0.728	22		2.09	0.305
1851	1.43	1.01	18		3.84	0.544
1852	1.38	1.23	16	0.95	4.10	0.578
1853	1.63	2.24	17	1.6	3.40	0.490
1854	1.89	2.62	16	3.2	3.49	0.508
1855	2.06	5.09	16		2.79	0.419
1856	2.37	4.71	16		2.88	0.438
1857	2.19	6.39	16		2.18	0.349
1858	1.97	7.08	15		2.33	0.375
1859	2.40	7.72	16	5.1[a]	2.28	0.375
1860	2.55	8.66	16		2.09	0.761
1861	1.96	9.36	14		1.95	1.55
1862	2.05	11.3	14		1.76	3.48
1863	2.38	10.2	15		1.81	6.57
1864	2.76	11.1	15		2.07	8.51
1865	2.18	12.8	15		2.20	8.70
1866	3.05	12.9	16		1.79	7.73
1867	3.17	13.5	15		1.88	10.4
1868	3.34	14.7	16	12	1.69	9.28
1869	3.83	14.5	18	12	1.64	9.28
1870	3.66	14.5	18	13	1.64	11.1
1871	3.68	15.2	20	14	1.57	14.0
1872	5.38	15.0	26	14	1.70	15.5
1873	5.30	17.9	42	15	1.74	19.5
1874	4.87	19.8	51	18	1.71	19.7
1875	4.02	20.4	59	21	1.48	23.4
1876	4.00	24.0	63	22	1.94	29.6
1877	4.74	24.7	80	20	2.05	31.5
1878	5.62	24.6	89	24	1.74	37.2
1879	7.12	26.4	91	29	1.64	34.6
1880	9.13	30.5	96	33	1.51	33.0
1881	8.97	36.6	114	38	1.42	36.0
1882	9.00	45.9	130	42	1.34	39.0
1883	8.40	63.3	140	46	1.29	38.2
1884	8.20	84.8	136	49	1.14	40.1
1885	7.6	85.0	126	53	1.20	42.1
1886	10.0	78.9	128	57	1.38	41.4
1887	11.3	90.7	142	65	1.53	43.0
1888	12.1	113	148	72	1.39	47.4
1889	14.5	113	153	72	1.55	51.3

(continued)

TABLE A-1 (concluded)

Year	Iron Ore (million long tons)	Copper (thousand	Lead short	Zinc tons)	Gold (million fine	Silver troy ounces)
1890	16.0	130	141	80	1.42	51.6
1891	14.6	142	176	100	1.52	53.4
1892	16.3	172	170	111	1.51	53.6
1893	11.6	165	161	98	1.62	49.2
1894	11.9	177	156	91	1.91	47.6
1895	16.0	190	162	106	2.26	53.6
1896	16.0	230	183	98	2.45	50.9
1897	17.5	247	202	122	2.60	53.0
1898	19.4	263	206	145	2.84	52.6
1899	24.7	284	207	169	3.00	54.0
1900	27.6	303	267	176	3.21	57.6
1901	28.9	301	265	189	3.25	55.7
1902	35.6	328	274	216	3.24	55.8
1903	35.0	348	289	218	3.05	55.6
1904	27.6	405	307	248	3.34	56.4
1905	42.5	442	317	266	3.51	56.1
1906	47.8	456	347	266	3.64	57.2
1907	51.8	420	365	260	3.29	52.4
1908	36.0	476	330	234	3.50	50.7
1909	51.4	561	385	305	3.81	57.2

Note: These estimates were prepared by O.C. Herfindahl and Selma Rein. In Table A-2, the columns headed H.R. (Herfindahl-Rein) contain these estimates.

[a]Very rough estimate, see source.

NOTES TO TABLE A-1

Iron Ore

1839: Iron ore consumed in production of pig and wrought iron. Estimated by applying 1849 state ratios of iron ore consumed per ton of metal output (pig and wrought [bar] iron) to 1839 pig and wrought iron production. These were totaled for the national figure. The 1839 data are from *Compendium of the Sixth Census, 1840*, Washington, 1841, p. 358. The 1849 data are from *Compendium of the Seventh Census, 1850*, Washington, 1854, p. 181, and *Report of the Superintendent of the Census*, 32d Cong., 1st Sess., Serial 636, pp. 236–241.

1849: Iron ore consumed in production of pig and wrought iron. See above for sources of data.

1859: Iron ore consumed in production of pig and other iron. The Census figure of 2,310,000 long tons used in the manufacture of pig iron has been increased to 2,400,000 long tons to allow for ore consumed in other iron manufacturing (*Eighth Census, 1860, Manufactures*, Washington, 1865, p. clxxx).

Confusion exists about the unit of weight used for measuring iron ore production in this Census. The Census of 1902 states that the unit was the short ton. *Report on the Mineral Industries, 1892* (Vol. I, p. 271) considers it the long ton, as do James W. Swank (*Iron in All Ages*, Philadelphia, 1884, p. 380) and J. W. Foster (*The Geology and Metallurgy of the Iron Ores of Lake Superior*, New York, 1865, p. 70).

The *Preliminary Report on the Eighth Census* (Washington, 1862, p. 170) presents a figure of 2,514,000 tons for iron ore output, but the state data on which this figure is based are nowhere presented in the final report. See *Eighth Census, 1860, Manufactures*, 1865, pp. clxxiv ff. The iron ore output figure for 1860 generally carried in official U.S. statistics is 2,832,000 long tons or 3,210,000 short tons, obtained from the *Ninth Census, 1870* (pp. clxvii and clxxx) as follows: 2,310,000 tons consumed by furnaces and produced by captive mines, plus 900,000 tons produced by "regular mining" establishments.

An inspection of the Ninth Census for 1870 schedule (Carroll D. Wright and William C. Hunt, *History and Growth of the United States Census, 1790–1890*, Washington, 1900, p. 314) submitted to blast furnaces leads us to conclude that they would have entered all the pig iron they produced and not just pig iron from their own ores, and that they would have put down all the ore consumed and not just ore from their own mines. Hence, total ore consumed already includes that part of the 900,000 tons from noncaptive mines used in making pig iron.

The writer in *Mineral Industries, 1892* also held this view since he took the Census input figure of 2,310,000 and increased it by 100,000 tons for Michigan.

We believe Isaac Hourwich (writing in *Mines and Quarries, 1902*, 1905) and others accepted uncritically the figure of 3,218,000 tons. Since it appeared so high in relation to the input and preliminary mining figures, they assumed it must be in short tons and converted it to long tons to achieve some reduction.

1850–58: Estimated by interpolating by pig iron production series in Sam H. Schurr and Elizabeth K. Vogely, *Historical Statistics of Minerals in the United States*, Resources for the Future, 1960, series M 207.

1869: Iron ore mined (*Ninth Census, 1870*, Vol. III, *The Statistics of the Wealth and Industry of the United States*, 1872, pp. 749 and 768). Census data are in short tons.

1860–68: Estimated by interpolating by pig iron production series; see 1850–58.

1875: Schurr and Vogely, *Historical Statistics of Minerals*, series M 195.

1879: Iron ore mined (*Tenth Census, 1880*, Vol. XV, 1886, p. 19).

1870–74, 1876–78: Estimated by interpolating by pig iron production series; see 1850–58.

1882–1905: Iron ore mined except for 1885–88 which are consumption estimates (*Mineral Resources, 1913*, Pt. 1, p. 300).

1879–81: Estimated by interpolating by pig iron production series; see 1850–58.

1906–09: U.S. Geological Survey figures revised to include manganiferous iron ores (with manganese content higher than 5 per cent) to assure comparability. Before 1906, including 1902, Geological Survey estimates included these ores (see *Mineral Resources, 1913*, Pt. 1, p. 65, for data on production of manganiferous iron ores).

Copper

1845–53: Mine production from J. D. Whitney, *The Metallic Wealth of the United States*, p. 332 (some data used by *Mineral Resources* and Bureau of Mines, *Economic Paper 1*).

1854–1905: Smelter production from domestic ores plus copper content of U.S. ores imported into the United Kingdom.

Smelter production from *Mineral Resources, 1915*, Pt. 1, pp. 662–665 (excluding Alaska). *Mineral Resources* included in the year 1861 a total of 500 short tons produced in New Mexico during 1858–61; this amount has been equally distributed over this four-year period.

Copper ores imported into the United Kingdom in 1854–85 are from Great Britain Board of Trade Statistical Department, *Annual Statement of the Trade and Navigation of the United Kingdom*. Ore exports during 1854–85 went almost entirely to British smelters. After 1885, U.S. ore exports were negligible. British data are used, since U.S. exports do not distinguish between ore and regulus or matte (smelter products) Moreover, U.S. export data during that period are considered extremely unreliable (see F. E. Richter, *Quarterly Journal of Economics*, Vol. 41, pp. 260–262). Copper contents of the ore have been set at 30 per cent (see R. B. Pettengill, "The United States Foreign Trade in Copper by Classes and Countries, 1790–1932," unpublished Ph.D. dissertation, Stanford University, 1934, pp. 325–326). For 1883–85, actual copper contents are presented in *Mineral Resources* (*1884*, p. 360; *1887*, pp. 90–92). For those years, copper content of British ore imports from the United States was 46, 35, and 31 per cent, respectively. These were rich Montana ores, exports of which dropped off when the Anaconda Company started smelting operations (see Richter, *Quarterly Journal of Economics*, Vol. 41).

1906–09: Mine production from *Mineral Resources, 1913*, Pt. 1, p. 532 (excluding Alaska, *ibid.*, p. 215).

Lead

1839–85: Bureau of Mines, *Economic Paper 5*, Table 9, p. 13, "Annual smelter production of lead in the United States." Imports of lead ore did not become significant until 1886 (see W. R. Ingalls, *Lead and Zinc in the United States*, New York, 1908, p. 217). Hence smelter production represents domestic mine output.

1886–1906: U.S. Geological Survey, Bureau of Mines, series on refined pig lead from domestic ores and base bullion is apparently too low. Interpolated between 1885 and *Materials Survey* figure for 1907 by series on refined lead from domestic ores and base bullion (*Economic Paper 5*, p. 14).

1907–09: Bureau of Mines, *Materials Survey: Lead*, May 1951, Table IV-2.

Zinc

1852–1906: Smelter production from domestic ores, plus zinc content of zinc oxide from domestic ores, plus zinc content of ores exported (sources given below).

1907–09: Mine production as reported to the U.S. Geological Survey. Zinc oxide output dates from 1852 (Whitney, *Metallic Wealth*, p. 350, and Ingalls, *Lead and Zinc*, p. 281), while zinc metal was first produced commercially in 1858 (*Economic Paper 2*, p. 17). Zinc smelter product did not surpass zinc content of oxide until the early 1870's.

1. *Smelter production from domestic ores:* 1858–72, *Economic Paper 2*, p. 19; 1873–1909, *Mineral Resources, 1910*, Pt. 1, p. 263; data for 1904-05 include some zinc from foreign ores. Data for 1901-05 adjusted to exclude dross spelter (*Mineral Resources, 1913*, Pt. 1, p. 624).
2. *Zinc oxide production* (zinc content computed at 80 per cent, see Whitney, *Metallic Wealth*, p. 350; Ingalls, *Lead and Zinc*, p. 358; *Mines and Quarries, 1902*, p. 456): 1852–54, Whitney, *Metallic Wealth*, pp. 350–351; 1859, obtained by straight-line interpolation between 1854 and 1868 (smelter output was only 50 tons in 1859); 1868, 1871, 1873, 1874, 1878, Geological Survey of New Jersey, *Annual Report of the State Geologist for 1904*, Trenton, 1905, pp. 303–305; 1879, *Tenth Census, 1880*, Vol. XV, p. 822; 1880–1909, *Mineral Resources, 1890*; Ingalls, *Lead and Zinc*, p. 338; 1907–09, zinc contents of all zinc pigments from domestic ores, *Mineral Resources, 1909*, Pt. 2, p. 705.

In 1879, zinc oxide made in eastern works (*Tenth Census, 1880*, Vol. XV, p. 822) totaled about 10,107 short tons. From this we deducted an estimated 1,000 tons from Middle West ores smelted in the East (*Mineral Resources, 1882*, p. 367). The factor of 80 per cent was applied to the remaining zinc oxide production to yield approximate zinc content of eastern ores.

In the early period of zinc production, zinc oxide was produced largely from New Jersey ores, but between 1861 and 1876 (Ingalls, *Lead and Zinc*, p. 285) an unknown amount came from Pennsylvania. Since data are available only for New Jersey ores, the factor of 30 per cent (obtained by dividing 1879 zinc contents of eastern ores by New Jersey ore output) was applied to New Jersey ore production for 1868, 1871, 1873, 1874, and 1878 (New Jersey Geological Survey) to approximate zinc product of all eastern ores. The intervening years are straight-line interpolations.

3. *Zinc content of ores exported: Mineral Resources.* Zinc ore exports began in 1896, except for a single recorded shipment of Joplin ores in 1892. *Mineral Resources* records data for ore shipments without indicating metallic content. We have assumed that all ores shipped from New York City and Philadelphia were New Jersey ores, at a calculated 25 per cent zinc content (see *Mines and Quarries, 1902*, p. 454). Exports through all other ports were largely Colorado ores, with an estimated zinc content of 42 per cent (Ingalls, *Lead and Zinc*, pp. 264, 340). Actually some Virginia ores were shipped through East Coast ports; since these were richer than New Jersey ores, the estimates tend to minimize metallic content. Similarly, some ores coming from Western states were included in the Colorado totals since they were so small in relation to Colorado; these were also richer than Colorado ores.

Note on Accuracy of Method of Estimating Zinc Production for 1852–1906

The same method was applied to the years 1907–09 and the resulting estimates were checked with the mine production figures of the U.S. Geological Survey. Although there were significant differences between the two figures year by year, the totals for the three-year period were less than 3.5 per cent apart.

The present method, however, gives results very close to the U.S. Geological Survey smelter series for 1907–09, which includes zinc content of pigments, the yearly difference being the estimated zinc content of New Jersey ores exported.

In general, the major differences between a mine and smelter figure for any given year (excluding exports) are due to the various inventory changes and errors in calculating zinc content from assay and in estimating recovery.

Actually there are greater discrepancies between the U.S. Geological Survey smelter and mine figures than are indicated in *Mineral Resources, 1909* (Pt. 1, pp. 208–209) because no effort was made to add estimated zinc content of exported ores to the U.S. smelter data. In these years, New Jersey was shipping abroad a high-grade Willemite ore which assayed 48 per cent less 15 per cent loss for smelter recovery (Ingalls, *Lead and Zinc*, p. 270). For the three-year period, ore exports totaled 60,000 tons, with an estimated metal content of 24,000 tons, or 3 per cent of total mine output for the period.

Gold

Note: All values were converted to ounces at the coining rate of $20.67 which was constant throughout the series.

1839: The only official data of the period are gold deposits at the U.S. Mint, which are too low, since they do not take into account gold going directly to industry and exported.

Whitney increased these figures by 10 per cent to get his final U.S. figure (*Metallic Wealth*, p. 148), while the Bureau of Mines increased them by 15 per cent (*Economic Paper 6*, p. 14). We are taking Whitney's estimates because of the care with which he developed his data, and because he was alive at the time. Whitney says his figures are gold "of domestic origin." Gold deposits of domestic origin at U.S. Mint equal $404,200 times 1.10, i.e., $444,620.

1840: Whitney, *Metallic Wealth*, p. 148.

1841–44: Estimated as for 1839, from table of U.S. Mint deposits (*ibid.*, p. 146).

1845–47: Ibid., p. 148.

1848: Set at 28 per cent of $10,694,000 (1849 revised Census figure) and converted into ounces. Ratio of 28 per cent obtained from *ibid*, p. 148, 1848/1849.

1849: California, U.S. Bureau of Mines, *Economic Paper 3*, estimate of C. G. Yale,

p. 20, Table 10 (value of gold in terms of recovered metal). Other states, value of product of gold mining (*Seventh Census, 1850*).

1859: Gold mining, annual value of product, *Eighth Census, 1860, Manufactures* p. 736. The 1870 Census disputes this figure (see pp. 751–753, *Ninth Census, 1870*, Vol. III), but Yale's figure for California, $45,846,000, is very close to the Census figure of $44,717,000.

1850–58: Interpolated by California production of gold, annual value of product (*Economic Paper 3*, Table 10, p. 20).

1869: Estimate of value of production based on data from *Ninth Census, 1870*, and other sources. See regional table for notes on sources and methods.

1860–68: Interpolated by Alexander Del Mar (*A History of the Precious Metals*, New York, 1902, p. 400). Del Mar was former Director of the U.S. Bureau of Statistics and Mining Commissioner to the U.S. Monetary Commission of 1876.

1870–78: Interpolated by Del Mar (*ibid.*, p. 400).

1879: Estimated from *Tenth Census, 1880*, Vol. XIII, pp. 354–357. State data built up to U.S. total as follows: deep mines, ore raised during Census year times average yield per ton of ore raised and treated, by state; placer gold, mint value of crude placer gold (see regional table).

1889: *Eleventh Census, 1890*, Vol. VII, p. 53, excluding Alaska. Census officials adjusted the U.S. figure to approximate U.S. Mint estimate (see *ibid.*, p. 51).

1880–88: Interpolated by Del Mar (see above).

1902: *Mines and Quarries, 1902*, p. 534, excluding Alaska.

1890–1901: Interpolated by mine production as gathered by Director of the Mint from reports of U.S. Mint operators and mine agents. (*Mines and Quarries, 1902*, p. 553; these data reduced by exclusion of Alaska, *Mineral Resources, 1913*, Pt. 1, p. 215.)

1905: Mine production of gold as reported to U.S. Geological Survey, excluding Alaska (*Mineral Resources*).

1903–04: Interpolated by mine production as reported by U.S. Mint operators and mine agents. Data for 1903 and 1904 from *Mineral Resources*.

1904–05: Interpolated by refinery production as reported by Director of the Mint, excluding Alaska. Indexes of refinery production linked to 1904 mine production to obtain 1902–05 mine series.

1905–09: Mine production as reported to U.S. Geological Survey, excluding Alaska, the Philippines, and Puerto Rico (*Mineral Resources*).

Silver

Note: All values were converted to ounces at the coining rate of $1.29 which was constant throughout this series.

1839: The only mine producing sizable amounts of silver was the Washington Mine, Davidson County, North Carolina. According to Whitney (*Metallic Wealth*, p. 399) this was a silver-lead mine discovered in 1836 and worked until 1852. In 1844, it produced 18,500 ounces and in 1851, 8,000 ounces of silver. We assume that 1837 was the first full year of production and that output in that year equaled output in the final full year of operation—8,000 ounces. If production rose linearly, output was 11,000 ounces in 1839 (*ibid.*, pp. 399–400).

Silver was also found in association with gold in the southern Appalachian Region, and with lead in the New England and middle Atlantic regions (see *ibid.*; Bureau of Mines, *Economic Paper 8*; Walter R. Crane, *Gold and Silver*, New York, 1908; Wm. P. Blake, *Report Upon the Precious Metals*, Washington, 1869; and Ingalls, *Lead and Zinc*).

1844: Whitney, *Metallic Wealth*.

1849: Silver was being mined at the Washington Mine, North Carolina, in New Mexico, associated with gold in California and the South, with copper in Michigan, with copper and lead in New England, and with lead in the middle Atlantic region.

	Ounces	
North Carolina (Washington Mine)	11,000	Output assumed to have declined linearly in 1844–51.
California	69,000	*Economic Paper 3.* Ratio of silver production (oz.) to value of gold production for 1848–59 (.0068) times 1849 value of gold production.
Lake Superior	300	Annual output of Cliff Mine for 1949 (Whitney, *Metallic Wealth*, p. 279). A number of authors state the major part of silver was stolen by the miners: Whitney; Blake, *Precious Metals*, p. 154; W. Gates, *Michigan Copper and Boston Dollars*, Cambridge, 1951, p. 13; A. P. Swineford, *Swineford's History of the Lake Superior Iron District*, Marquette, 1871, pp. 64–65. Silver was found at mines other than Cliff, e.g., Minnesota, Phoenix, Adventure Mines.
New Mexico	8,000	Whitney, Blake, and Ingalls (see above) refer to New Mexico silver output. See 1859 discussion for method of obtaining 1849 figure.
Total	88,300	

1859: Silver produced from California gold ores and silver quartz, Lake Superior copper ores, southern Appalachian gold and lead, New England and middle Atlantic argentiferous lead ores.

	Ounces	
California	312,000	.0068 times dollar value of gold production (*Economic Paper 3*); see also 1849 note.
Lake Superior	23,000	Blake, *Precious Metals*, p. 154.
New Mexico	40,000	1849 output calculated as follows: [40,000 (N.M. 1859) ÷ 312,000 (Cal. 1859)] × 69,000 (Cal. 1849) = 8,000 ounces.
Total	375,000	

1850–58: California plus New Mexico plus Lake Superior plus North Carolina equals United States. Straight-line interpolations for New Mexico, Lake Superior, and North Carolina (1849–51). Estimated annual silver production for California from *Economic Paper 3*, p. 20, using ratio of .0068 applied to annual value of gold.

1860: Growth assumed to be at constant rate of increase, i.e., 103.1 per cent per annum. The U.S. Mint series before 1861 are obviously highly arbitrary and appear less reasonable than the constant rate used here.

1861–68: U.S. Mint Series (*Economic Paper 8*, p. 18).

1869: Estimated from Census and other sources. See regional table for methodology and data. Estimated production came to $12 million, which was the U.S. Mint figure for 1869. Del Mar has a figure of $13 million for 1869 silver output.

1871–76: Del Mar, *Precious Metals*, p. 400. Del Mar made a study of silver production in Nevada for 1871–76 for the U.S. Monetary Commission of 1876 on the basis of returns from mining companies, and estimated the rest of U.S. production from current sources. See *Report of the Monetary Commission* (S. Rept. 703, 44th Cong. 2d Sess., 1877, Ser. 1738), for full discussion of precious metals data available during this period and for detailed data on Nevada production. Del Mar's data are in silver dollars at the coining rate ($1.29) and have been converted to ounces here. He appears to have revised his estimate for 1872 from $18,500,000 (*Report of the Monetary Commission*) to $20,000,000, the figure in his book. Except for 1872, data from the *Report*, which are millions and tenths, were used here instead of data from the book, which are in millions of dollars, for converting value to weight.

1870: Interpolated between 1869 and 1871 by U.S. Mint series.

1879: Tenth Census, 1880, Vol. XIII, pp. 354–357. State data built up to U.S. total as follows: deep mines, ore raised during Census year times average yield per ton of ore raised and treated; plus placer, mint value of silver in crude placer gold.

1876–78: Interpolated by U.S. Mint series.

1889: Eleventh Census, 1890, Vol. VII, pp. 52–53, excluding Alaska.

1880–88: Interpolated by U.S. Mint series.

1902: Mines and Quarries, 1902, p. 534, excluding Alaska.

1889–1901: Interpolated by mine production as gathered by Director of Mint from reports of U.S. Mint operators and mine agents (*Mines and Quarries, 1902,* p. 553). These data exclude Alaska (*Mineral Resources, 1913,* Pt. 1, p. 215).

1905–09: Mine production of silver as reported to the U.S. Geological Survey, excluding Alaska (*Mineral Resources*).

1903–04: Interpolated by mine production as reported to Director of Mint, excluding Alaska (see 1889–1902 above). Data for 1903–04 from *Mineral Resources.*

1904–05: Interpolated by refinery production as reported by Director of Mint, excluding Alaska. Indexes of refinery output linked to 1904 U.S. Mint mine production to obtain 1902–05 mine series.

Note: The mine agent series has been used for interpolating because it appears to represent better the movement of mine production. There is danger, however, that the early years especially are deficient.

TABLE A-2

U.S. MINE PRODUCTION OF MAJOR METALS, AS ESTIMATED BY VARIOUS SOURCES, 1839-1909

	Iron Ore (mill. long tons)[a]			Copper (thous. short tons)[b]					Lead (thous. short tons)[c]			
Year	H-R[d]	H.S.[e]	P-C[f]	H-R[d]	H.S.[e]	E.P.[g]	P-C[f]	Census Per P-C	H-R[d]	H.S.[e]	E.P.[h]	P-C[f]
1839	0.99								18	17.5	17.5	
1849	1.67			0.784	0.784	0.784			24	23.5	23.5	
1850	1.48											
1859	2.40			7.72	7.06	7.06			16	16.4	16.4	
1860	2.55	2.87										
1869	3.83			14.5	14.0	14.0			18	17.5	17.5	
1870	3.66	3.83	3.83									
1879	7.12			26.4	25.8	25.8	25.8	28.1	91	90.8	90.8	91
1880	9.13	7.12	7.12									
1889	14.5	14.5	14.5	113.0	113.0	113.0	113.0	110.0	153	178.0	178.0	152
1890	16.0	16.0	16.0									
1899	24.7	24.6	24.7									
1900	27.6	27.3	27.6									
1902	35.6	35.3	35.6	328.0	330.0	330.0	330.0	313.0	274	368.0	282.0	269
1903	35.0	34.8	35.0									
1909	51.4	51.3	51.3	561.0	563.0	546.0	546.0		385	{447.0 / 385.0}[i]	375.0	353

Note: The estimates of mine production in Table A-1 differ from previous series in a number of respects. It should be borne in mind that our goal is to estimate recoverable content of mine output (except for iron ore, for which the data refer to gross output), whereas the other sources may be estimating smelter output or, in some cases, a highly ambiguous quantity called U.S. "production." Needless to say, it has often been necessary to use smelter or refinery output as the basis for estimated mine output.

[a]The iron ore output figures in the sources cited in Table 1 appear to have been placed in the wrong year in 1859, 1869, and 1879. Hence the present 1859 estimate is comparable with the 1860 Census figure reproduced in *Historical Statistics*, 1960. We believe two errors have been made in the past in interpreting the 1860 Census: (1) Long tons have been called short tons, and (2) 900,000 tons have been double counted. The present 1869 and 1879 estimates agree with *Historical Statistics*, 1960, except for the displacement of one year.

[b]The present estimates for 1859 and 1869, e.g., differ from *Historical Statistics*, 1960, and the *Economic Paper* of the Bureau of Mines, because we have tried to include ore exports.

TABLE A-2 (concluded)

Year	Zinc (thous. short tons)[j]				Gold (mill. fine troy ounces)[k]				Silver (mill. fine troy ounces)[l]			
	H-R[d]	H.S.[e]	E.P.[h]	P-C[f]	H-R[d]	H.S.[e]	E.P.[h]	P-C[f]	H-R[d]	H.S.[e]	E.P.[h]	P-C[f]
1839					0.022	0.023	0.023		(0.011)	0.019	0.019	
1849					0.517	1.94	1.94		0.088	0.039	0.039	
1859	(5.15)	0.05	0.05		2.28	2.42	2.42		0.375	0.077	0.077	
1869	12.0	4.30	4.30		1.64	2.40	2.39		9.28	9.28	9.28	
1879	29.0	21.3	21.3	28.1	1.64	1.88	1.88	1.88	34.6	31.6	31.6	31.6
1889	72.0	58.9	58.9	75.8	1.55	1.60	1.59	1.60	51.3	50.1	50.0	50.1
1902	216.0	157.0	157.0	208.0	3.24	3.87	3.87	3.87	55.8	55.5	55.5	55.5
1909	305.0	256.0 / 302.0[i]	256.0	302.0	3.81	4.80	4.81	4.80	57.2	57.3	54.7	57.3

[c]The difference between the present and the other lead series reflects lead smelted or refined from foreign ores. The present series covers only domestic mine output.

[d]Herfindahl-Rein, see note to Table A-1.

[e]*Historical Statistics*, 1960.

[f]Neal Potter and Francis T. Christy, Jr., *Trends in Natural Resource Commodities*, Baltimore, 1962.

[g]Bureau of Mines, various years.

[h]Smelter production.

[i]Production, mine (recoverable content).

[j]Inclusion of zinc oxide in the present series is the main reason for difference from the other series.

[k]The other series reproduced here all have their origin in what has come to be accepted as the "official" series, the series appearing in the reports of the Director of the Mint. Del Mar's devastating critique of this series (*Precious Metals*) and its deviation from other sources such as the *Economic Paper* on California (U.S. Bureau of Mines, *Historical Summary of Gold, Silver, Copper, Lead, and Zinc Produced in California, 1848 to 1926*, Washington, 1929) and the Censuses indicate that it should not be used to set levels of output. Levels in the present series are based on Censuses and the *Economic Paper* on California, the output of which was especially important in most of the nineteenth century. Note that the present series excludes Alaska and the Philippines, which accounts for the difference between the 1909 figures.

[l]The "official" series on silver appear to be very wide of the mark in some of the early ears. The present estimate for 1839 rests mainly on Whitney (*The Metallic Wealth*). For 1849, a difficult year to estimate since California's output was increasing rapidly, the present estimate makes use of the *Economic Paper* on California (*ibid.*) and Whitney. The 1859 estimate reflects mainly the *Economic Paper* on California. 1871-76 are directly from Del Mar who made a careful study of Nevada output in those years.

TABLE A-3

OUTPUT OF MAJOR METAL ORES IN QUANTITY AND VALUE, BY REGION AND COMMODITY, 1839-1909[a]

Region and Commodity	1839		1849		1859		1869	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
New England		203		232		232		113
Iron ore	0.070	203	0.08	232	0.070	203	0.03	87
Copper[b]	—	—	—	—	0.077	29	0.07	26
Lead[c]	—	—	—	—	—	—	—	—
Zinc	—	—	—	—	—	—	—	—
Gold	—	—	—	—	—	—	—	—
Silver	—	—	—	—	—	—	—	—
Middle Atlantic		1,743		3,007		5,202		7,993
Iron ore	0.591	1,714	1.03	2,987	1.61	4,669	2.57	7,453
Copper[b]	—	—	—	—	—	—	—	—
Lead[c]	0.35	29	0.24	20	0.164	14	0.18	15
Zinc	—	—	—	—	5.15	519	5.21	525
Gold	—	—	—	—	—	—	—	—
Silver	—	—	—	—	—	—	—	—
South Atlantic		703		1,110		903		1,393
Iron ore	0.088	255	0.18	522	0.11	319	0.11	319
Copper[b]	—	—	—	—	0.386	144	—	—
Lead[c]	0.52	43	0.47	39	0.328	27	0.52	43
Zinc	—	—	—	—	—	—	6.94	700
Gold	0.019	393	0.026	537	0.02	413	.016	331
Silver	0.011	12	0.011	12	—	—	—	—
North central		1,652		2,723		4,446		9,431
Iron ore	0.096	278	0.200	580	0.45	1,305	1.08	3,132
Copper[b]	—	—	0.753	280	4.864	1,811	13.2	4,916
Lead[c]	16.6	1,374	22.5	1,863	15.744	1,304	16.4	1,358
Zinc	—	—	—	—	—	—	0.25	25
Gold	—	—	—	—	—	—	—	—
Silver	—	—	—	—	0.023	26	—	—
South central		491		513		794		455
Iron ore	0.148	429	0.17	493	0.16	464	0.04	116
Copper[b]	—	—	—	—	0.849	316	0.87	324
Lead[c]	—	—	0.24	20	0.164	14	0.18	15
Zinc	—	—	—	—	—	—	—	—
Gold	0.003	62	—	—	—	—	—	—
Silver	—	—	—	—	—	—	—	—
Southwest				9		620		14,138
Iron ore	—	—	—	—	—	—	—	—
Copper[b]	—	—	—	—	1.544	575	—	—
Lead[c]	—	—	—	—	—	—	0.18	15
Zinc	—	—	—	—	—	—	—	—
Gold	—	—	—	—	—	—	0.246	5,085
Silver	—	—	0.008	9	0.040	45	8.07	9,038
Rocky Mountains						1,860		10,556
Iron ore	—	—	—	—	—	—	—	—
Copper[b]	—	—	—	—	—	—	0.07	26
Lead[c]	—	—	—	—	—	—	—	—
Zinc	—	—	—	—	—	—	—	—
Gold	—	—	—	—	0.09	1,860	0.459	9,488
Silver	—	—	—	—	—	—	0.93	1,042
Pacific				10,226		45,203		19,397
Iron ore	—	—	—	—	—	—	—	—
Copper[b]	—	—	—	—	—	—	0.29	108
Lead[c]	—	—	—	—	—	—	—	—
Zinc	—	—	—	—	—	—	—	—
Gold	—	—	0.491	10,149	2.17	44,854	0.918	18,975
Silver	—	—	0.069	77	0.312	349	0.28	314
United States		4,796		17,836		59,260		63,499
Iron ore	0.993	2,880	1.66	4,814	2.40	6,960	3.83	11,107
Copper[b]	—	—	0.784	292	7.72	2,875	14.5	5,400
Lead[c]	17.5	1,449	23.5	1,946	16.4	1,359	17.5	1,449
Zinc	—	—	—	—	5.15	519	12.4	1,250
Gold	0.022	455	0.517	10,686	2.28	47,128	1.64	33,879
Silver	0.011	12	0.088	98	0.375	420	9.28	10,394

(continued)

TABLE A-3 (concluded)

Region and Commodity	1879		1889		1902		1909	
	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
New England		753		261				
Iron ore	0.09	261	0.09	261	--	--	--	--
Copper[b]	1.32	492	--	--	--	--	--	--
Lead[c]	--	--	--	--	--	--	--	--
Zinc	--	--	--	--	--	--	--	--
Gold	--	--	--	--	--	--	--	--
Silver	--	--	--	--	--	--	--	--
Middle Atlantic		11,704		11,112		9,814		14,675
Iron ore	3.76	10,904	3.22	9,338	1.82	5,278	2.21	6,409
Copper[b]	0.13	48	--	--	--	--	--	--
Lead[c]	--	--	--	--	--	--	--	--
Zinc	7.46	752	17.6	1,774	0.45[d]	4,536	82.0	8,266
Gold	--	--	--	--	--	--	--	--
Silver	--	--	--	--	--	--	--	--
South Atlantic		2,011		2,651		4,333		3,277
Iron ore	0.43	1,247	0.80	2,320	1.38	4,002	1.13	3,277
Copper[b]	0.79	294	--	--	--	--	--	--
Lead[c]	--	--	--	--	--	--	--	--
Zinc	0.57	57	e	--	f	--	--	--
Gold	0.02	413	0.016	331	0.016	331	--	--
Silver	--	--	--	--	--	--	--	--
North central		22,791		50,544		141,181		203,063
Iron ore	2.51	7,279	8.07	23,403	27.2	78,880	42.2	122,380
Copper[b]	21.6	8,044	43.73	16,285	89.0	33,144	117.0	43,571
Lead[c]	27.2	2,252	28	2,318	77.0	6,376	162.0	13,414
Zinc	18.94	1,909	51.6	5,201	147.0	14,818	167.0	16,834
Gold	0.16	3,307	0.155	3,204	0.356	7,358	0.305	6,304
Silver	--	--	0.119	133	0.54	605	0.50	560
South central		1,178		6,861		15,824		19,750
Iron ore	0.33	957	2.13	6,177	4.52	13,108	5.09	14,761
Copper[b]	0.13	48	--	--	6.0	2,234	9.0	3,352
Lead[c]	--	--	--	--	--	--	3.0	248
Zinc	1.72	173	3.2[g]	322	--	--	9.0	907
Gold	--	--	--	--	--	--	--	--
Silver	--	--	0.323	362	0.43	482	0.43	482
Southwest		21,972		21,136		35,924		105,712
Iron ore	--	--	--	--	h	--	i	--
Copper[b]	1.58	588	17.65	6,573	66.0	24,578	184.0	68,522
Lead[c]	22.7	1,880	9.0	745	3.0	248	9.0	745
Zinc	--	--	--	--	--	--	11.0	1,109
Gold	0.25	5,168	0.248	5,126	0.227	4,692	0.952	19,678
Silver	12.80	14,336	7.761	8,692	5.72	6,406	13.98	15,658
Rocky Mountain		33,093		85,234		167,302		181,979
Iron ore	--	--	0.14	406	.67[j]	1,943	0.77[i]	2,233
Copper[b]	0.53	197	50.0	18,620	154.0	57,350	221.0	82,300
Lead[c]	39.1	3,237	115.0	9,522	192.0	15,898	211.0	17,471
Zinc	--	--	--	--	24.0	2,419	36.0	3,629
Gold	0.31	6,408	0.465	9,612	1.766	36,503	1.524	31,501
Silver	20.76	23,251	42.030	47,074	47.49	53,189	40.04	44,845
Pacific		20,016		15,123		24,967		34,905
Iron ore	--	--	0.03	87	--	--	k	--
Copper[b]	0.26	97	0.076	28	13.0	4,841	30.0	11,172
Lead[c]	1.82	151	--	--	3.0	248	--	--
Zinc	--	--	--	--	--	--	--	--
Gold	0.90	18,603	0.666	13,766	0.875	18,086	1.029	21,269
Silver	1.04	1,165	1.109	1,242	1.60	1,792	2.20	2,464
United States		113,541		193,577		399,285		563,415
Iron ore	7.12	20,648	14.5	41,992	35.6	103,211	51.4	149,060
Copper[b]	26.4	9,831	113.0	42,081	328.0	122,147	561.0	208,916
Lead[c]	90.8	7,518	153.0	12,668	274.0	22,687	385.0	31,878
Zinc	28.7	2,893	72.4	7,298	216.0	21,773	305.0	30,744
Gold	1.64	33,899	1.55	32,038	3.24	66,971	3.81	78,753
Silver	34.6	38,752	51.34	57,500	55.8	62,496	57.2	64,064

NOTES TO TABLE A-3

Source: Regional production tables unless otherwise specified. Where available, physical quantities from original sources have been used. Otherwise percentages have been applied to U.S. total from annual production series to estimate output. 1879 prices, as follows, have been used to measure value: iron ore, $2.90 a long ton; copper, 18.62 cents a pound ($372.40/S.T.); lead, 4.14 cents a pound ($82.80/S.T.); zinc, 5.04 cents a pound ($100.80/S.T.); gold, $20.67 a fine troy ounce; silver, $1.12 a fine troy ounce. All prices except following from *Historical Statistics*, 1960; iron ore, *1880 Census*, Vol. 15, p. 68 (value + output); gold, coining rate.

[a]Quantities are in the following units: iron ore--million long tons; copper, lead, and zinc--thousand short tons; gold and silver--million fine troy ounces. Values are in thousand dollars in 1879 prices.

[b]Copper includes production undistributed to regions: 4 per cent in 1849 and 1.5 per cent in 1889. In 1889, this copper product was worth over $600,000 in 1879 prices. For 1859, undistributed copper totaled 34 per cent of smelter output. Although the geographical distribution of value of copper ore obtained from the 1860 Census is admittedly unsatisfactory, we have used this as a basis to estimate value of output. We have assumed north central and other eastern product to be distributed among regions according to relative census copper product of the regions. The remainder, 20 per cent, is allocated to the southwest region. *Mineral Resources*, 1915, Pt. 1, p. 662, gives north central as 63 per cent. The above procedure results in New England, 1 per cent; South Atlantic, 5 per cent; north central, 63 per cent; south central, 11 per cent; and Southwest, 20 per cent.

[c]Since no data are available for 1859 regional output of lead, the relative regional distribution was arbitrarily held at 1849 for the purpose of computing value of output.

[d]Includes South Atlantic.

[e]See south central.

[f]See Middle Atlantic.

[g]Includes Virginia.

[h]Includes Rocky Mountains.

[i]All West.

[j]Southwest and Rocky Mountains.

[k]See Southwest.

TABLE A-3a

YIELD OF IRON ORE MINED, BY REGION, 1849-1909
(per cent)

Region	1849	1859	1869	1879	1889	1902	1909
New England	41			45	44		
Middle Atlantic	34			49	49		
South Atlantic	39	39		46	41		
North central	40	43		55	58		
South central	34			49	43		
United States	36	43	48	51	53		

TABLE A-3b

YIELD OF LAKE SUPERIOR AND SOUTHERN IRON ORES, 1879-1909
(per cent)

	1879	1889	1904	1909
Furnaces using:				
Lake Superior ores exclusively (Michigan, Minnesota, Wisconsin)	58.2	63.3	53.4	52.3
Southern ores exclusively (Alabama, Georgia, Tennessee)	43.6	44.1	41.4	40.6

NOTES TO REGIONAL DISTRIBUTION OF OUTPUT IN TABLE A-3 AND TO YIELD DATA IN TABLES A-3a AND A-3b

Iron ore

Table A-3

1839: Regional distribution is based on iron ore consumed in manufacture of pig and wrought iron. See notes to annual iron ore series for derivation.

1849, 1859: Regional distribution is based on iron ore used in manufacture of pig iron. See note to annual iron ore series for derivation.

1869–1909: Regional distribution is directly from data for iron ore mined. See notes to annual series. Totals for 1909 differ because of exclusion of high-grade manganiferous ores.

Tables A-3a and A-3b

1849: State and regional yield has been estimated by using pig iron production as though it were metallic yield of ores mined and consumed in the state in that year. This procedure is valid since there was little transportation of iron ores before 1850. "... Up to 1850 little iron ore was transported except for such distances as could be conveniently covered by wagons. The blast furnaces and forges, depending chiefly on charcoal for fuel, were located close to their supplies of raw materials" (*Eleventh Census, 1890*, Vol. VII, p. 13). See notes to annual series.

1859: Because of long-distance transportation of ores, state consumption figures, for the most part, no longer represent ores mined in the state. In the north central and south Atlantic regions, however, pig iron was made almost entirely from local ores. Consequently, these regional yield estimates have been derived as in 1849. It should be noted that regional data conceal the richness of Michigan ores. They were in great demand by the iron works of Buffalo and Pittsburgh, as well as the iron centers of Ohio. In 1864, for example, only 12 per cent of Michigan ores were consumed in Michigan, 31 per cent going to Ohio and 57 per cent to New York and Pennsylvania (J. W. Foster, *The Geology and Metallurgy of the Iron Ores of Lake Superior*, New York, 1865, pp. 62–63). Michigan ores had yields as high as 65 per cent (*ibid.*, p. 51). The same source gives the following yield data for other ores: Lake Champlain, New York, 65 per cent; Clinton, New York, 45 per cent; and Tuscarawas, Ohio, 45 per cent. The national yield is a weighted average based on total U.S. ore consumption and pig metal output.

1869: Ratio of pig metal to iron ore consumed in manufacturing pig iron from *Compendium of the Ninth Census, 1870*, 1872, p. 909. Iron ore imports did not begin until the 1870's and were relatively unimportant until 1879.

1879: See notes to annual series.

1889: *Eleventh Census, 1890, Report on Mineral Industries in the United States*, 1895. Yield data on pp. 10–12 applied to state iron ore output. The resulting U.S. yield of 53.0 per cent is not significantly different from that calculated by the Census, 51.3 per cent.

1902: No yield data computed by Census.

Note to Table A-3b: Metallic yield for furnaces using exclusively southern or Lake Superior ores (*Thirteenth Census, 1910*, Vol. X, *Manufactures 1909*, 1913, p. 216). These yields would be generally higher than those in Table A-3a because of inclusion of states with lean ores in regional groupings, e.g., Ohio in north central, Kentucky in south central. Moreover, Georgia which produced relatively rich ores is part of the south Atlantic region.

Copper

Note: Although no official data on production of copper exist before 1845, copper was being mined in 1839 in the New England states (Maine, New Hampshire, Vermont, Massachusetts, and Connecticut), in the middle Atlantic region (New Jersey and Pennsylvania), in the South (Maryland and North Carolina), and in the north central region (Missouri). Copper ore was still being produced in these general regions in 1849, and in the south central (Tennessee) and Southwest (New Mexico) as well. All the above regions were still producing in 1859, but only one new state—Arizona—reported copper mine output. (It should be understood that the above states were not all producing in 1839, 1849, and 1859.) This information has been collected from Whitney, *Metallic Wealth*, and other sources.

1839: Whitney, *Metallic Wealth.*

1849: *Mineral Resources, 1913*, Pt. 1, pp. 662–665; also Whitney, *Metallic Wealth.*

1859: *Mineral Resources*, as above. For Vermont, see Edward Hitchcock *et al.*, *Report on the Geology of Vermont* (Claremont, N. H., 1861, Vol. II, pp. 850–859); for New Mexico, see note to copper annual series.

1869: *Mineral Resources*, as above. For New Mexico, Ross J. Browne, *Statistics of Mines and Mining West of the Rocky Mountains*, Vol. 2, *1869*, Washington, 1870, p. 403; for Vermont, estimated (see *Report of the State Geologist on the Mineral Resources of Vermont, 1899–1900*, Burlington, 1900); for Tennessee, J. B. Killebrew, *Introduction to the Resources of Tennessee*, Nashville, 1874, p. 249; *Ninth Census, 1870, Industry and Wealth*, p. 767.

1879: *Tenth Census, 1880*, Vol. XV, pp. 798–800.

1889: *Eleventh Census, 1890*, Vol. VII, *Report on Mineral Industries*, 1892, p. 155.

1902: *Mines and Quarries, 1902*, 1905, p. 486. For Tennessee, *Fourteenth Annual Report of the Mining Department*, Nashville, 1904, p. 184.

1909: *Mineral Resources, 1909*, Pt. 1, p. 159.

Lead

1839: Smelter production, *Compendium of the Sixth Census, 1840*, Washington, 1841, p. 358.

1849: Smelter production, annual value of product, *Message of the President of the United States Communicating a Digest of the Statistics of Manufactures according to the Returns of the Seventh Census*, 35th Cong., 2d Sess., S. Ex. Doc. 39, ser. 984, p. 42.

1859: Ingalls, *Lead and Zinc*. This was also the major source used to locate areas of production in 1849 and 1869.

1869: Mine output, annual value of product, *Ninth Census, 1870, Industry and Wealth*, p. 768.

1879: Refined lead from domestic ores, Bureau of Mines, *Economic Paper 5*, Table 11, p. 17.

1889: Production of lead as reported by mines. Except for Mississippi Valley output (29,258 short tons), these data do not take into account smelter losses. *Eleventh Census, 1890*, "Mineral Industries," pp. 163 and 168–169. See also *Mineral Resources, 1889.*

1902: Lead content of ores as reported by smelters. *Economic Paper 5*, Table 11, p. 17.

1909: Mine production of recoverable lead, *Materials Survey: Lead*, Table IV-2, p. IV-73.

Zinc

1859: See notes to annual series.

1869: Zinc mining, annual value of product, *Ninth Census, 1870*, "Industry and Wealth," p. 769. The extremely high figure for the south Atlantic states is misleading without explanation. Apparently, the mines of Davidson County, North Carolina, were worked for lead in a "desultory way" about this time and up to the early 1890's. According to Ingalls (*Lead and Zinc*, p. 89), those ores proved to be zinc rather than lead. A local smelter erected in 1887 was unable to smelt them, however, because of their complex character. There is no indication whether the zinc ores mined in 1869 or thereafter were ever smelted successfully.

1879: Mine production, *Tenth Census, 1880*, Vol. XV, *Directory of Lead and Zinc Mines*, pp. 978–981.

1889: Smelter output plus zinc contents of oxide, *Eleventh Census, 1890, Mineral Industries*, p. 174. Since these data do not trace ore back to state of origin, they tend to distort regional relationships. The Census states that only the New Jersey and Pennsylvania smelters used distant ores, but does not present data on the origin or proportion of such ores (see *ibid.*, p. 748). Other sources indicate that they were imported from Virginia and the Middle West.

1902: Zinc contents of ores mined (by assay), *Twelfth Census, 1902, Mines and Quarries, 1905*, pp. 454 and 456.

1909: Recoverable zinc contents of ores mined, *Mineral Resources, 1909*, Pt. 1, p. 208.

Gold

Note: All values were converted into ounces at the coining rate of $20.67 which was constant throughout these series.

1839: Value of gold produced by smelting houses, *Compendium of the Sixth Census, 1840*, p. 358.

1849: California, value of gold production; other states, value of product, gold mining. For California data, Bureau of Mines, *Economic Paper 3*, p. 20, Washington, 1929; for other states, *Message of the President, Seventh Census, 1850.*

1859: Value of product, gold mining. Although considerable doubt is cast on the California data by the next Census (1870), the 1859 Census figure for California is very close to that given in *Economic Paper 3*. See *Eighth Census, 1860*, state tables, and U.S. total, p. 736.

1869: Value of gold product as follows: for California, *Economic Paper 3*, Table 10; for Colorado, C. W. Henderson, *Mining in Colorado*, Professional Paper 138, 1926, p. 69; for Utah, *Mineral Resources, 1913*, Pt. 1, p. 366; for Washington, *ibid.*, p. 790; for Wyoming, *ibid.*, p. 50; for other states, *Ninth Census, 1870, Industry and Wealth*, Table XIII, pp. 760–766, value of product at mine level. Gold quartz value figure inflated by 45 per cent to allow for value added by milling (see *ibid.*, p. 751); placer mined gold as given. This method appears to yield fairly good results. For example, New Mexico gold mining product was valued at $245,750 for quartz and $97,000 for placer gold. Inflating the quartz figure by 45 per cent, and totaling, gives a value of product of $454,000, very close to an independent estimate of $477,000 presented in Waldemar Lindgren *et al.*, *The Ore Deposits of New Mexico*, Professional Paper 68, 1910, pp. 20–21. Adjustments were required in the case of Idaho and Nevada because separate values for gold and silver were not presented for gold- and silver-bearing ore. For Idaho, the value of gold and silver quartz was set at 57 per cent and 43 per cent silver. This is a rough estimate based on value relationships in Idaho deep mines as given in the *Tenth Census, 1880*, Vol. XV, p. 356. Gold value for Nevada was set at the 1869–70 relationship of gold and silver in the Comstock lode, 40 per cent gold and 60 per cent silver (*Mines and Quarries, 1902*, p. 255).

1879: Value of gold contents of ore raised during year computed as follows: Total of deep mines (tons of ore raised times average yield in dollars per ton of ore raised) plus placer mines (value of crude bullion). Source: *Tenth Census, 1880*, Vol. XIII, *Precious Metals*, 1885, pp. 354–355 for deep mines, p. 353 for crude placer gold.

1889: Eleventh Census, 1890, Vol. VII, *Mineral Industries*, p. 53, excludes Alaska.

1902: Mines and Quarries, 1902, p. 534, excludes Alaska.

1909: Mineral Resources, 1909, Pt. 1, p. 130, excludes Alaska, the Philippines, and Puerto Rico.

Silver

All years except 1869: See notes to annual production series.

1869: See notes on regional distribution of gold production for method and sources. California silver output has been calculated by the method described in *Economic Paper 3*, notes to Table 6, p. 14. Gold and copper output are found in *Economic Paper 3*, Table 10, p. 20; lead output in Ingalls, *Lead and Zinc*, p. 145.

Source of Silver	*Ounces*
Gold, placer, and quartz	98,400
Copper	14,375
Lead	150,000
Total	262,775

All silver output values converted into ounces at the coining rate of $1.29.

TABLE A-4

EMPLOYMENT IN MAJOR METAL MINING, BY REGION AND COMMODITY, 1839-1909
(thousands)

Region and Commodity	1839[a]	1849[a]	1859	1869	1879	1889	1902	1909
New England								
Iron ore	.224	.256	.224	.218	.617	.426	0	0
Copper	0	.009[b]	.075	.355	.619	0	0	0
Lead and zinc	0	0	0	.005	0	0	0	0
Gold and silver	0	0	0	.008	0	0	0	0
Major metals	.224	.265	.299	.586	1.236	.426	0	0
All minerals				5.32	7.27	9.42	8.14	9.08
All employment				1,299	1,572	2,006	2,377	2,914
Middle Atlantic								
Iron ore	2.320	4.030	6.300[c]	13.100[d]	18.219	9.481	4.193	5.549
Copper	0	.007[b]	.065	.007	.010	0	0	0
Lead and zinc	.397	.270	.192	.437	.405	.233	.119[e]	.208[f]
Gold and silver	0	0	0	0	0	0	0	0
Major metals	2.717	4.307	6.557	13.544	18.634	9.714	4.312	5.757
All minerals				58.87	98.30	154.67	232.70	346.25
All employment				2,807	3,738	4,966	6,203	8,209
South Atlantic								
Iron ore	.380	.780	.475	.815	1.970	3.497	3.855	4.168
Copper	0	.034	.300	.189	.334	0	0	0
Lead and zinc	.064	.058	.040	.175	.153	.810	.420[e]	0
Gold and silver	1.030	1.400	1.055[g]	.833[h]	1.660	1.435	.836	.191
Major metals	1.474	2.272	1.870	2.012	4.117	5.742	5.111	4.359
All minerals				7.46	12.87	26.99	48.67	95.32
All employment				1,996	2,678	3,118	4,001	5,188
Eastern north central								
Iron ore					7.340	16.604	16.876	18,487
Copper					5.011	6.765	14.315	19.575
Lead and zinc					.530	1.145	.583	2.043
Gold and silver					0	.097	0	0
Major metals					12.881	24.611	31.774	40.105
All minerals					38.75	95.78	135.82	189.24
All employment					3,615	4,687	5,888	7,258

(continued)

TABLE A-4 (continued)

Region and Commodity	1839[a]	1849[a]	1859	1869	1879	1889	1902	1909
Western north central								
Iron ore					1.893	2.499	9.010	18.409
Copper					.041	0	0	0
Lead and zinc					6.253	4.100	7.661	19.590
Gold and silver					1.090	1.899	3.071	3.568
Major metals					9.277	8.498	19.742	41.567
All minerals					19.17	38.64	62.26	81.13
All employment					2,009	2,987	3,693	4,447
South central								
Iron ore	.650	.747	.706	.388	1.615	5.134	6.596	7.767
Copper	0	.046[b]	.405	.620	0	0	0	0
Lead and zinc	0	0	0	.005	.142	0	0	.943
Gold and silver	0	0	0	0	0	.357	.045	0
Major metals	.650	.793	1.111	1.013	1.757	5.491	6.641	8.710
All minerals				3.62	6.46	25.35	59.56	93.97
All employment				2,096	3,023	3,636	5,210	7,108
Southwest								
Iron ore	0	0	0	0	0	0	0	0
Copper	0	0	.580	.045	.110	1.097	4.395	13.608
Lead and zinc	0	0	0	.006	0	0	0	.066
Gold and silver	0	.044	.277	4.250[1]	11.600	8.213	3.632	7.383
Major metals	0	.044	.857	4.301	11.710	9.310	8.027	21.057
All minerals				10.24	15.32	13.19	17.41	31.54
All employment				62	95	103	139	254
North central								
Iron ore	.128	.268	.603	4.556	9.233	19.103	25.886	36.896
Copper	0	.560	3.639	4.188	5.052	6.765	14.315	19.575
Lead and zinc	1.080	1.430	1.023	1.086	6.783	5.245	8.244	21.633
Gold and silver	0	0	0	0	1.090	1.996	3.071	3.568
Major metals	1.208	2.258	5.265	9.830	22.158	33.109	51.516	81.672
All minerals				36.60	57.92	134.42	198.08	270.37
All employment				3,896	5,624	7,674	9,581	11,705

(continued)

TABLE A-4 (concluded)

Region and Commodity	1839[a]	1849[a]	1859	1869	1879	1889	1902	1909
Rocky Mountain								
Iron ore	0	0	0	0	0	.545	1.224[j]	1.600[k]
Copper	0	0	0	0	0	1.958	7.407	17.947
Lead and zinc	0	0	0	0	0	0	.008	0
Gold and silver	0	0	.963	8.960[i]	14.300	27.450	23.100	23.542
Major metals			.963	8.960	14.300	29.953	31.739	43.089
All minerals				18.76	49.58	50.43	77.23	72.26
All employment				72	188	397	525	855
Pacific								
Iron ore	0	0	0	0	.014	.047	0	0
Copper	0	0	0	0	.020	0	.541	2,674
Lead and zinc	0	0	0	0	0	0	0	0
Gold and silver	0	9.800	42.762	18.700[i]	22.700	17.466	10.716	15.827
Major metals		9.800	42.762	18.700	22.734	17.513	11.257	18.501
All minerals				45.75	50.06	32.55	52.57	46.39
All employment				280	474	836	1,039	1,935
United States[l]								
Iron ore	3.702	6.081	8.308	19.077	31.668	38.233	41.754	55.980
Copper	0	.656	5.064	5.404	6.145	9.820	27.783	53.804
Lead and zinc	1.541	1.758	1.255	1.714	7.483	6.288	8.791	22.850
Gold and silver	1.030	11.244	45.057	32.751[i]	51.350	56.917	41.560	50.511
Major metals	6.273	19.739	59.684	58.946	96.646	111.258	119.888	183.145
All minerals				186.62	297.78	447.00	694.35	965.17
All employment				12,506	17,392	22,736	29,073	38,167

Note: 1859-1909 are Census data with adjustments as described. In the Censuses of 1850, 1860, 1870, 1880 (precious metals), and 1890, the Census forms asked for the "average number employed." In 1902 the form asked for the "average during the year," but this was reduced by the fraction of a 300-day year that the establishment was idle. This adjusted figure appears in this table. The 1909 figures are the number employed as of Dec. 15 or some date which would be reasonably representative thereof. In the 1840 and 1880 (nonprecious metals) Censuses, the form simply asked for the "number employed."

See Table A-5 for 1902 and 1909 data adjusted to the 1889 concept of employment.

[a]All employment for 1839 and 1849 is estimated regionally on the assumption that employment moves proportionately with output from 1859. The employment figures in the Census for 1840 and 1850 include large amounts of manufacturing activity.

[b]Estimated on basis of ratio for 1849/1859 of copper not allocated by state 0.31/2.7. The same states are in the "not allocated" group in both years.

[c]Iron ore employment per Census has been changed by the ratio of our estimate of regional output to the Census figure. The Census gives data on iron ore mining only for noncaptive mines. These accounted for 38 per cent of the output (see notes on 1859 output). If we take employment/output by region for the noncaptives and multiply by our estimated total output for each region (both captive and noncaptive), we get the figures for 1859 which are used in the tables. However, the employment/output ratios for noncaptives in the 1860 Census are far below the same ratios for 1869.

[d]Census figure of 9,036 multiplied by ratio of our estimate of output to Census output (2.57 L.T./1.77 L.T.). Census says Pennsylvania was undercounted. See output notes on 1869 iron ore.

[e]Unallocated employment is 539 in Census. This is distributed between New Jersey and Virginia on basis of 1889 employment in lead and zinc.

[f]Extrapolated from 1902 by output.

[g]Census figure of 573 increased by ratio of our estimate of output to Census output ($413t/224t).

[h]Census figure of 385 increased by output ratio of 331/153, as in footnote g.

[i]It appears that output of gold and silver was greatly underestimated in the 1870 Census. The table which follows compares Resources for the Future and Census value of gold and silver output in 1879 prices for Censuses of 1860 and later. Correspondence is good, except for 1869.

CORRECTION OF CENSUS, GOLD AND SILVER OUTPUT

	1859	1869	1879	1889	1902	1909
	CHANGE OF VALUE FIGURES FROM CURRENT PRICES TO 1879 PRICES (THOUS. DOLLARS)					
${}_sP_i$, Census silver price	1.36	1.325	1.29	1.29	0.522	0.515
$r_i = {}_sP_i / {}_sP_{79}$	1.21	1.18	115.0	115.0	0.47	0.46
Rocky Mountain						
1. Value of gold	1,860	9,488	6,408	9,612	36,503	31,501
2. Value of silver	--	1,042	23,251	47,074	53,189	44,845
3. Index $1+2/1+2r_i$	1.00	0.98	0.89	0.89	1.46	1.46
Southwest						
4. Value of gold	--	5,085	5,168	5,126	4,692	19,678
5. Value of silver	45	9,038	14,336	8,692	6,406	15,658
6. Index $4+5/4+5r_i$	0.83	0.90	0.90	0.91	1.44	1.31
Pacific						
7. Value of gold	44,854	18,975	18,603	13,766	18,086	21,269
8. Value of silver	349	314	1,165	1,242	1,792	2,464
9. Index $7+8/7+8r_i$	1.00	1.00	0.99	0.99	1.05	1.06
	CENSUS VALUE GOLD + SILVER IN 1897 PRICES = CENSUS VALUE IN CURRENT PRICES (MILL. DOLLARS) x INDEX					
Rocky Mountain						
10. Census	2.00	6.8	29.6	56.8	74.5	70.1
11. RFF	1.9	10.5	29.6	56.7	89.7	76.3
Southwest						
12. Census	0.20	10.4	19.4	13.9	9.9	27.0
13. RFF	0.04	14.1	19.5	13.8	11.1	35.3
Pacific						
14. Census	45.7	7.9	19.6	15.0	18.6	20.4
15. RFF	45.2	19.3	19.8	15.0	19.9	23.7
Total West						
16. Census	47.90	25.1	68.6	85.7	103.0	117.5
17. RFF	47.14	43.9	68.9	85.7	120.7	135.3

NOTES TO TABLE A-4 (concluded)

Census employment data for the western regions for 1869 have been increased by the ratio of our output value to Census value of output. Thus:

Rocky Mountain	5,810 x 10.5/6.8 = 8,960
Southwest	3,137 x 14.1/10.4 = 4,250
Pacific	7,668 x 19.3/7.9 = 18,700

See notes on gold and silver output for details on output.

[j] Includes Colorado, 451, and "all other" which I believe is mainly Rocky Mountain. Other states mentioned are Connecticut, Kentucky, Massachusetts, New Mexico, North Carolina, Texas, Utah, Vermont, and West Virginia.

[k] Includes Utah, 81, and 1,519 "all other." I believe this is mainly Rocky Mountain, but other states mentioned in the Census (p. 259) are Connecticut, Kentucky, Massachusetts, Nevada, New Mexico, North Carolina, Texas, and West Virginia.

[l] U.S. totals include unallocated.

TABLE A-5

EMPLOYMENT IN MAJOR METAL MINING, BY REGION AND COMMODITY, 1889, 1902, AND 1909 WITH 1902 AND 1909 ADJUSTED TO THE 1889 DEFINITION OF EMPLOYMENT

Region and Commodity	1889	1902[a]	1909[b]	1902[c] (1902 Definition Divided by 1889 Definition)	1909[d] (1902 Definition Divided by 1909 Definition)
New England					
Iron ore	426	0	0	.894	
Total	426				
Middle Atlantic					
Iron ore	9,481	5,040	5,720	.832	.859
Lead and zinc	233	121	182	.983	
Total	9,714	5,161	5,902		
South Atlantic					
Iron ore	3,497	5,490	5,040	.702	.851
Lead and zinc	810	697	0	.602	
Gold and silver	1,435	1,396	244	.598	.765
Total	5,742	7,583	5,284		
East north central					
Iron ore	16,604	19,840	20,150	.850	.928
Copper	6,765	14,315	19,575	1.00	1.00
Lead and zinc	1,145	877	2,100	.664	.683
Gold and silver	97	0	0	1.00	
Total	24,611	35,032	41,825		
West north central					
Iron ore	2,499	10,900	20,300	.827	.913
Lead and zinc	4,100	8,510	17,550	.900	.807
Gold and silver	1,899	3,420	3,540	.897	.890
Total	8,498	22,830	41,390		
North central					
Iron ore	19,103	30,740	40,450		
Copper	6,765	14,315	19,575		
Lead and zinc	5,245	9,387	19,650		
Gold and silver	1,996	3,420	3,540		
Total	33,109	57,862	83,215		
South central					
Iron ore	5,134	8,640	9,170	.763	.902
Lead and zinc	0	0	943		.563
Gold and silver	357	83	0	.540	
Total	5,491	8,723	10,113		
Southwest					
Copper	1,097	4,600	13,450	.954	.944
Lead and zinc	0	0	66		.515
Gold and silver	8,213	4,510	7,920	.806	.863
Total	9,310	9,110	21,436		
Rocky Mountain					
Iron ore	545	1,680	1,950	.730	.890
Copper	1,958	7,890	18,400	.939	.965
Lead and zinc	0	8	0		
Gold and silver	27,450	27,800	24,160	.832	.854
Total	29,953	37,378	44,510		
Pacific					
Iron ore	47	0	0	.810	
Copper	0	566	2,674		.954
Gold and silver	17,466	18,300	22,150	.584	.818
Total	17,513	18,866	24,824		
United States					
Iron ore	38,233	51,590	62,330		
Copper	9,820	27,371	54,099		
Lead and zinc	6,288	10,213	20,841		
Gold and silver	56,917	55,509	58,014		
Total	111,258	145,968[e]	195,284		

NOTES TO TABLE A-5

[a]Factor described in note c applied to Table A-4.

[b]Factors described in notes c and d applied to Table A-4.

[c]Equals

$$\frac{\Sigma\ (\text{employment})_i \text{ times } \frac{(\text{days worked})_i}{300}}{\Sigma\ (\text{employment})_i}$$

where i is the skill level or occupational group. This correction is suggested in *Mines and Quarries, 1902*, p. 90.

[d]Equals average monthly employment in 1909 per Census divided by 1909 Census employment on Dec. 15.

[e]Includes 1,125 for unallocated copper and 160 for unallocated gold and silver.

Note: Reported employment in 1902 was reduced by the fraction of a 300-day year that an establishment was not operating. This adjustment was thought to yield a result approximately equal to average monthly employment (see *Mines and Quarries, 1902*, p. 90).

Census employment in 1909 was the employment of Dec. 15 or for "the nearest representative date" if the mine was not in operation. Fortunately, data were collected also for the 15th of each month.

COMMENT

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The Herfindahl paper provides a survey of the Census and other sources of metal mining production, employment, prices, and numbers of mines in production over the period from 1839 to 1909, by region and commodity. There are problems of comparable industry definition in the early Censuses where smelting was included with mining and concentrating, but the current convention of treating smelting as a manufacturing activity was soon adopted after regional and company distribution of smelting became more concentrated. Data distinctions between current mineral production and mining development were not available during the period (and are still not available despite the fact that such distinctions are made annually for tax purposes and the data are regularly submitted to the Internal Revenue Service—which does not tabulate or publish them).

Dramatic shifts in regional concentrations of metal mining took place during the period and were extremely important in the economic history of the eleven western states. It is remarkable to note that employment in metal mining was greater during that period than it is today; and, therefore, the relative importance of these industries has shrunk drastically since then, while the population has increased tenfold.

Herfindahl examines the effect of these industries on regional development and notes that metal mining rather than agriculture was the primary source of export of major commodity production and employment for many of the western states for several decades. These statistics, therefore, justify the preoccupation of historians of these eras with the varying success of metal mining and remind us that this emphasis, despite the violence in these localities, is not based on nostalgic romanticism. For a number of states, such as the Rocky Mountain group between 1870 and 1880, metal mining provided over 25 per cent of all employment. This means that metal mining contributed more than one-half of the income-generating exports from these areas and thus was responsible for more than one-half the economic activity in these states.

Herfindahl discusses the relationship between transportation, markets, and location of mining activities. By the end of the Civil War with the expansion of railroads, transportation no longer had such a crucial bearing on regional distribution of metal mining, which had by that time decisively shifted to the eleven western states region for nonferrous mining, and to the Great Lakes states for iron. On the other hand, the shift from precious metals to base nonferrous metals was accomplished only as transportation resources were increased within these states, and such deposits could then be profitably exploited.

Growth in metal mining production roughly equals that of all manufacturing during the period but was considerably greater in iron and copper mining where ingenious, large-scale production methods were introduced steadily after 1870. Production increases were smaller for other metals not amenable to large-scale expansion. (It would have been helpful if Herfindahl had reported on Census data for open-pit and underground copper and iron operations in this respect.) His tables show that the ratios of employment to output in mining the same metal differ sharply among states. Such drastic differences are still evident today—although to a lesser extent among states—and reflect substantial differences in the characteristics and riskiness of ore bodies and in the extent to which entrepreneurs are skilled in the introduction of efficient techniques. Greater differences among states in that early period were no doubt due to the inferior communication and dissemination of the more advanced practices compared with those of this century.

The "net rent" question in metal mining is a famous one in economic discussion, but almost no serious quantitative research has been undertaken. The necessary data, of course, are not present in any Census publication but might be derived from different tabulations of mining operations ranked by Census data on cost, such as those which have become available in the *Census of Minerals Industries* since 1954 (and were prepared by the Census for 1939). These retabulations could be made from archival materials and would provide greater insight into the profitability of mining operations in different areas.