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Appendix C

The Statistical Treatment of Stone Quarrying

THE PROBLEM of measuring output, employment and productivity in stone quarrying is complicated by a number of defects in the statistical record which call for comment. The chief of these derives from a failure to distinguish between mining and manufacturing as separate stages in the productive process whenever a single establishment carries production through both stages. The difficulty occurs with enterprises that quarry and also cut dimension stone; and with enterprises that quarry limestone and convert it into cement or lime. Other problems are the segregation of noncommercial output in the case of crushed stone, and the need to adjust for undercoverage in the employment data. The methods we developed to handle these various matters are described in the following sections. Details of the actual construction of the estimates of stone output will be found in notes to Table A-1, and of the estimates of quarry employment in notes to Table A-3.

Mining and Manufacturing

Let us first draw a line of separation between the operations we wish to include in "mining," and those which we regard as a form of manufacture and therefore outside the scope of this report. Our definition is of course conditioned by the purpose it is intended to serve,[1] in this case the construction for stone quarrying of indexes of output and employment which do not overlap the statistics of manufactures. Since the basis of the distinction is essentially statistical in character, and since the basic data are those collected by the Bureau of the Census, we shall use the definitions adopted by that agency.[2]

[1] To one who is interested solely in distinguishing between extraction and fabrication from a purely technical standpoint, "mining" ends as soon as the stone is extracted from the quarry bed: all further processing is considered "manufacturing." Another whose interests lie only in industrial organization need merely note the distinction between mining and manufacturing when extraction and fabrication are performed by separate establishments; when the two activities are undertaken by the same establishment an interesting example of integration occurs, but no special problems arise.

[2] The National Bureau of Economic Research has already constructed index numbers of physical output in manufacturing which include the Census of Manufactures classification "Marble, granite, slate, and other stone, cut and shaped." See Solomon Fabricant, *The Output of Manufacturing Industries, 1899–1937* (1940); also the same author's *Employment in Manufacturing, 1899-1939: An Analysis of Its Relation to the Volume of Production* (1942).

The distinction between mining and manufacturing made by the Bureau of the Census is indicated in the following quotation from the 1929 Census of Mines and Quarries:

> Relatively little stone is used rough as obtained from the quarry but at most quarries the stone is broken, crushed, shaped, dressed, ground, or otherwise prepared. The breaking of stone into rubble and riprap, and the crushing of stone for road work, ballast, concrete, or for other construction purposes are quite general and are closely connected with the quarrying operation, and data for these operations are included in the statistics for the several stone industries. On the other hand, the cutting, sawing, finishing, and polishing of stone for monumental, building, or other purposes, are considered as manufacturing operations and fall within the scope of the census of manufactures.[3]

To conform strictly to the definition of mining implicit in this quotation we should evidently have to exclude all fabricational processes from our statistics of production and employment in dimension stone, while the processing of nondimension or crushed stone would be considered a form of mining activity.[4] In general, definitions of mining followed in other Censuses were similar to that employed in 1929.[5] Nevertheless, it can readily be shown that the distinction in question is not definitive. Indeed it cannot be so, in view of the mixed character—extractive and fabricational—of many of the enterprises in the quarrying industry. The line of separation drawn by the Census Bureau is admittedly an ideal at which to aim in collecting statistics, rather than a touchstone of universal application.

Thus a certain amount of duplication is inevitable, especially in the

[3] *Fifteenth Census,* "Mines and Quarries, 1929," pp. 328-29.

[4] A minor difficulty of classification arises from the fact that, following the practice of the Bureau of Mines, we have found it convenient to regard rubble as a form of dimension stone. (Rubble consists of irregularly shaped pieces of stone, with perhaps one good face, used for building purposes, especially in foundations.) Theoretically, at least, the breaking of stone into rubble is excluded from our indexes, even though the Census Bureau regards it as a mining operation.

[5] The distinction between mining and manufacturing is not drawn as clearly in the Census of 1909 as it is in the Censuses of 1902, 1919 and 1929. From preliminary releases, it appears that the Census of 1939 used definitions similar to those of 1929, although there are references, for example in the report on sandstone, to "rough dimension stone trimming operations" which are included as a form of quarrying, i.e. mining, activity. These operations probably refer to "scabbling," the process whereby blocks are trimmed to uniform rectangular shape before shipment, in order to avoid freight charges on waste. See Oliver Bowles, *The Stone Industries* (McGraw-Hill, 1934), p. 53.

statistics for nondimension or crushed stone.[6] So far as possible, however, the definition of "mining" utilized in this analysis will conform to the practice of the two most recent Censuses of Mines and Quarries —1929 and 1939—and will exclude only the processing of dimension stone. The processing of crushed stone (but not the manufacture of cement or lime) will be considered a form of mining activity.[7] The methods whereby Bureau of Mines figures for dimension stone are made to conform to this definition will be discussed first with regard to physical output and then with regard to employment.

Dimension Stone—Output

Bureau of Mines statistics on quantity and value of dimension stone are cross-classified according to two criteria. (1) Figures for stone are divided according to variety: granite, marble, sandstone (including bluestone), limestone, slate, and a miscellaneous category whose composition may vary somewhat from year to year. (2) Each of these varieties is then classified according to use: rough building stone, cut building stone, monumental stone, paving blocks, curbing, etc. It follows that various degrees of detail may be adopted in computing an index of physical output. Since the formula we use (see Appendix A) involves essentially a comparison in constant prices, and since prices or unit values differ markedly both as between varieties and as between uses of stone, it follows that different breakdowns will yield differing measures of output. In principle, one of three alternatives may be selected:

[6] For example, we read that "in the stone-quarrying industries the establishments included in both the mining and manufacturing statistics were chiefly producers of crushed and ground stone and were classified by the census of manufactures as in the roofing and paving-material industries" (*Fourteenth Census*, Vol. XI, "Mines and Quarries, 1919," p. 13). It is easy to see, too, that an establishment which quarries, cuts and polishes dimension stone would find it difficult to place a valuation on the quarried product before fabrication when such a product never enters the market, and might be unable to segregate its employment records. Censuses of Mines and Quarries have in the past included substantial amounts of manufacturing operations in the statistics they report, but the Bureau of the Census has achieved progressively greater success in its attempt to exclude manufacturing from the statistics of mining.

[7] It is difficult to determine to what extent our indexes of crushed stone will duplicate the indexes of manufacturing. It is certainly true that only a portion of stone crushing is included in the statistics of manufactures whereas all dimension stone processing is so covered. This is because the Census of Manufactures classifies dimension stone processing as a manufacturing industry, but includes stone crushing only when it is incidental to manufacturing industries covered in the manufactures data. In this sense the inclusion of stone crushing is similar to the inclusion of quarrying in the manufacturing statistics for dimension stone processing. (See discussion under "Marble, granite, slate, and other stone, cut and shaped," in the 1937 Census of Manufactures.)

I A breakdown by variety without regard to use.
II A breakdown by use without regard to variety.
III A simultaneous breakdown both by variety and by use.

Table C-1, relating to four of the dimension stone industries, indicates the different results yielded by the alternative methods of combination of products.

TABLE C-1

DIMENSION STONE
Alternative Indexes of Physical Output[a]
1929:100

Industry	*Single Production Series (in short tons)*			*Breakdown According to Use (all uses converted to short tons)*		
	1919	1929	1937	1919	1929	1937
Granite	65.5	100.0	43.9	89.0	100.0	60.6
Marble	55.5	100.0	29.5	57.0	100.0	29.4
Limestone	42.8	100.0	41.9	31.8	100.0	44.5
Sandstone	66.3	100.0	35.3	59.3	100.0	33.5
TOTAL	57.0	100.0	39.0	61.0	100.0	45.3

[a] Comparisons are made throughout with the Edgeworth formula (see Appendix A).

The total index numbers secured correspond to those described under alternatives I and III. Alternative II yields the following indexes on the 1929 base: 1919:61.9; 1937:48.2. These correspond quite closely with the results under alternative III. The only index of dimension stone output published to date, so far as the authors are aware, is that given by Vivian E. Spencer, *The Mineral Extractive Industries, 1880–1938* (National Research Project, Philadelphia, 1940), pp. 88-91, in which method II is adopted.

Results will, of course, differ according to the degree of detail in the breakdown utilized. Also, it can be seen that differences may be obscured in the total because of the diverse movements of the individual components. This is particularly clear in 1919—the total indexes diverge slightly because even though those for granite, limestone and sandstone diverge considerably, the directions of the divergences differ.

It might be thought that method III, which uses the greatest detail and the largest amount of information, would give the best result. But this is not necessarily the case, for some of the detail may establish distinctions irrelevant to our purpose. What we desire is an index of output which takes full account of differences in the grade of stone quarried, but gives no weight to "quality" differences wrought by manufacturing processes.

The various enterprises from which the Bureau of Mines collects statistics of production and value are described as follows:

> Dimension-stone producers fall in three main groups upon the basis of plant operation: (1) those who quarry stone and sell it as rough blocks or slabs; (2) those who quarry stone and manufacture it

into finished products; and (3) those who have no quarries but who buy their rough stock and manufacture it into finished products. The Bureau of Mines statistical canvass covers the first and second groups, but as the third group comprises manufacturers rather than quarrymen it is canvassed by the Bureau of the Census. Bureau of Mines statistics are compiled from reports of tonnages and values of original sales, hence they include some material sold as rough blocks and some sold as finished products.[8]

It is clear that producers in the second group report a fabricated product, and that the value of a block of stone produced by them exceeds its value as taken from the quarry. In fact, for these producers, differences in value per short ton among uses of a given variety of stone probably arise in good part from variations in value added by manufacture to a relatively constant "mine" value of mineral (i.e. value as it leaves the quarry), and are not the result of any considerable differences in the grade of stone quarried.[9]

These considerations imply that, at least for the part of the industry reporting fabricated products, the breakdown of dimension stone output by use is not one that it is desirable to employ if we are interested in measuring quarrying rather than manufacturing output. Only by using a single production series for each variety of stone, even though a detailed breakdown by use is available, can the pull which fabrication might otherwise exert on the index of physical output be avoided. For this reason method 1 has been used in the construction of our indexes of the physical output of dimension stone.

While this method—the adoption of a breakdown by variety but not by use—appears to approximate most closely what we actually wish to measure, it also has certain defects which we must briefly notice. Thus the use of a single output series (in short tons) effectively eliminates the influence of manufacturing, but it also obscures actual quality differences in stone quarried. Such differences exist, even though we can take no account of them. For example, first class monumental granite in unfinished blocks commands a premium over other unfinished granite.[10] Similarly, price differentials for sandstone derive from the nature of the cementing material between the grains, and from the

[8] *Minerals Yearbook, 1940,* p. 1164.

[9] This point is substantiated in a letter from Mr. Oliver Bowles of the United States Bureau of Mines. Commenting on the fact that in 1929 among the several uses of granite the unit values per short ton were: building stone, $15.86; paving blocks, $10.22; monumental stone, $43.39, etc., he states that "the differences in value . . . are due chiefly to differences in the degree of fabrication" and not to differences in the quality of the stone.

[10] Bowles, *The Stone Industries,* pp. 156-57.

degree of cementation.[11] Accordingly, the assumption that rough stone is uniform in quality within a single variety represents a shortcoming of our indexes.[12]

When we combine the series for individual varieties a further defect becomes apparent, for the prices of each variety include value added by manufacture in varying degrees. Judged by evidence of the extent to which finishing is done by mills attached to quarries, the degree of fabrication included in our data is greatest in slate (with marble and sandstone next), and least in granite and limestone. It seems likely, therefore, that in the output index for dimension stone slate is accorded too great a weight, and granite and limestone are given too small a weight. Although the evidence quoted is for recent years, conditions in this regard do not seem to have changed materially.[13]

We may summarize as follows. (1) Although manufacturing is eliminated from the indexes for the several varieties, this is achieved only by adopting the unreal assumption of uniform quality of stone within a single variety. (2) The values used in combining individual varieties into an index for stone output as a whole include substantial amounts of value added by manufacture. It follows (3) that the value of quarry products (Table A-2) is somewhat overstated, and therefore also the importance of quarrying in relation to other forms of mining in the computation of indexes for mining output as a whole.

Dimension Stone—Employment

Although the problem here is basically the same as in the measurement of production, the data seem to allow a simpler approach. The quarry accident totals[14] for number of persons employed, mandays and manhours (the latter since 1931 only) are divided for each variety of stone into two groups—quarries and "outside works." This breakdown fortunately provides a ready-made approximation to the distribution of employment between mining and manufacturing.

In constructing our indexes of employment for the several varieties of dimension stone and for the total, we have excluded all employment outside of quarries. Such treatment of the data is subject to the ob-

[11] *Ibid.*, p. 68.

[12] Nor is this all. The quantity data relate to stone that has already been cut and shaped. Since some stone is wasted in the process, this quantity is smaller than that which would have been reported by the quarry had it shipped stone to an independent mill for finishing. The difference is minimized where scabbling is practiced (see footnote 5 above).

[13] Bowles, *op. cit.*, p. 31. Additional information was received through correspondence with Mr. Bowles.

[14] U. S. Bureau of Mines annual publication, "Quarry Accidents in the United States."

vious criticism that "outside" employees include truckmen, shippers, construction workers and others engaged in similar capacities, who are not clearly associated with either the manufacturing or the mining end of an integrated establishment. To exclude such employment entirely is, therefore, to underestimate the actual numbers engaged in mining.[15]

It is of course impossible to determine exactly the magnitude of the understatement in the employment figures arising from our exclusion of all outside workers. For the period beginning in 1931, however, there are available data that permit us to determine the maximum possible error. This can be done by comparing employment in rock dressing for 1931–39 (which is a minimum figure for manufacturing in the sense that it includes the basic manufacturing employment but excludes employment common to both mining and manufacturing) with employment in outside dimension works (the total of which was excluded from our employment indexes). This comparison and other pertinent figures are summarized in the Table C-2.

TABLE C-2

EMPLOYMENT AT ALL DIMENSION STONE QUARRIES, 1931–39
Thousand mandays

Year	(1) *Outside Works*[a]	(2) *Rock Dressing Plants*[b]	(3) *Difference* (1) — (2)	(4) *Quarries*[a]	(5) *Ratio* (3) ÷ (4)
1931	2,619	2,483	136	1,905	.071
1932	2,012	1,925	87	1,123	.077
1933	1,609	1,583	26	1,023	.025
1934	1,202	1,175	27	841	.032
1935	1,224	1,195	29	946	.031
1936	1,979	1,885	94	1,329	.071
1937	1,992	1,919	73	1,497	.049
1938	1,688	1,643	45	1,238	.036
1939	1,882	1,837	45	1,403	.032

[a] Includes employment actually listed under dimension stone in the accident bulletins and estimated dimension employment included under "all other and not stated." The employment shown for quarries (column 4) is included in Table A-3; that shown for outside works (column 1) is excluded. The totals for the dimension industry in Table A-3 also include nondimension marble and slate quarries, and therefore exceed the figures shown here.

[b] U. S. Bureau of Mines, "Quarry Accidents in the United States."

The table shows that in all years total employment in outside works exceeds total employment in rock dressing by only a small margin.

[15] That too many employees are excluded becomes most apparent when one considers quarries which produce only rough stone. They too have outside employees (engaged in the type of work indicated above) who clearly should be included under mining, in contrast to such workers in integrated establishments whose status in this regard is uncertain. However, when industry totals alone are available, it is impossible to treat these establishments separately.

What this means essentially is that, at the most, quarry employment should be increased by 7.1 percent in 1931, 7.7 percent in 1932, 2.5 percent in 1933, and so on, if mining is to be completely covered. Actually, of course, the amount of understatement is considerably less (and probably more stable) than these maximum figures indicate.

Limestone for Cement and Lime—Output

All but a small fraction of the limestone used in cement and lime manufacture is quarried by the cement and lime companies for use in their own plants. Hence it becomes necessary to define the limits of manufacturing and mining, as in the case of dimension stone. The problem of defining the respective spheres is relatively simple here, since the actual production of the stone for manufacture into cement and lime is, broadly speaking, part of the crushed stone industry. This means that we may consider as pertaining to mining all fabrication preliminary to the burning of crushed limestone into lime, or preliminary to the addition of crushed limestone to the other components of the mixture to be manufactured into cement. In other words, quarrying and crushing of the stone are considered mining, while operations in the cement mill and the limekiln are included under manufacturing.

Adequate data on quantity of physical output are available from 1915 onward. For these years the Bureau of Mines presents quantity data for both limestone manufactured into cement and limestone manufactured into lime. For years prior to 1915 quantity figures have been estimated by us according to the methods indicated in footnotes to Table A-1. Since a single production series seems adequate for each industry, no problem of weighting arises and a suitable index of physical output may be derived in each case.

The weighting factor assumes importance when these two industries are combined with the other stone industries into an index of physical output for the total. Here lack of a unit value for mine or quarry gives rise to a problem identical with that encountered in combining the indexes for the several varieties of dimension stone. In the case of limestone for cement and lime, the difficulty is more serious because the only unit values available are for the final products—cement and lime—and therefore relate specifically to manufacturing. Under such circumstances it becomes necessary to attempt to approximate the unit mine values.

Since limestone for lime and cement are varieties of crushed limestone, the question which naturally arises is whether their unit values are sufficiently like the average unit value for the remainder of crushed limestone (for which a mine value is available) to allow the use of that

value. This appears to be the case in lime, but not in cement.[16] We have, therefore, added quantity data on limestone for lime to those for regular crushed limestone, and used a unit value derived from quantity and value figures for the latter (before the inclusion of limestone for lime) as the price coefficient for the total.

In the case of cement we employed a far more dubious procedure, which nevertheless seemed the most adequate method available. In the 1929 Census of Mines and Quarries there are quantity and value data relating to limestone quarried by cement manufacturers and used in the manufacture of cement.[17] The unit value derived from these figures was used as the 1929 price; for all other years this price was extrapolated by the Bureau of Mines unit value for total cement produced during the year.

Limestone for Cement and Lime—Employment

The employment figures for both limestone for lime and limestone for cement (referred to as limestone, chief product lime, and cement rock, respectively, in the accident bulletins) include limekilns and cement mills when these are attached to quarries. The two stages of production are usually combined in a single establishment and it is to be expected, therefore, that the bulk of manufacturing employment is included in the statistics.

The breakdown between quarries and outside works which approximated the distribution of employment between mining and manufacturing in the case of dimension stone cannot be similarly utilized in these two industries. It will be remembered that crushers are included in our definition of mining and a good percentage of the outside workers are employed at crushers. Only that portion of outside employment accounted for by cement mills and limekilns is excluded from our data.

[16] Oliver Bowles deals with this point in the following paragraph quoted from a letter in response to the above question: "As to unit values, it is difficult to arrive at a value per ton of stone used for cement and lime manufacture because the material does not enter the market except in the form of finished lime and cement. The cost of quarrying and crushing limestone for cement manufacture is in general lower than the cost of preparing similar stone for crushed stone uses because for the latter uses the stone must be crushed to produce a minimum of fines and the crusher product must be screened and possibly washed, whereas for cement manufacture the object is to secure a product as fine as dust. For lime burning the stone is selected carefully and is prepared in specified sizes, therefore, the quarrying costs are about the same as though the stone were prepared for crushed stone uses."

[17] Table 26, p. 363. The unit value of limestone used for cement in 1929 was $0.42 per short ton. In Table 27 on the same page there are similar data relating to limestone for lime. Here the unit value was $0.84 per short ton. The unit value for the remainder of crushed limestone (Table 28, p. 364) was $0.88 per short ton. It will be seen that these results are in general agreement with the statement in the preceding footnote.

For some of the more recent years (since 1931 for limekilns and since 1929 for cement mills) data relating to such employment are available; for all other years the numbers employed at limekilns and cement mills (which we need to deduct) have been estimated according to methods described in the footnotes to Table A-3.[18]

Undercoverage of the Employment Data—Crushed Stone

The employment data collected by the Bureau of Mines in connection with the annual survey of accidents extend back to 1911. However, the Bureau's descriptions of the data throughout this period suggest that the canvass of the industry has not been complete. The 1911 report states that replies were received from 88 percent of the names on the list (the list did not necessarily include all producers) but that all of the large producers replied, so that the statistics are highly representative when measured by production.[19] In subsequent years the same general note of caution concerning coverage is repeated, although no attempt to estimate undercoverage is made. It seems certain that the data are to some extent incomplete over the entire period. Since the coverage may have changed, we are naturally concerned as to both the year-to-year and the long-time comparability of the series. This problem can be handled best if crushed stone, limestone for cement and lime, and dimension stone are considered separately.

In the case of crushed stone (other than limestone for cement or lime), the first real attempt to approximate 100 percent coverage was made by the National Research Project. Since the Project had access to the original production and employment schedules filed by producers with the Bureau of Mines, they were able to derive productivity measures from matched reports for representative samples. Employment (manhours) was then estimated from production for the remaining operations by use of figures for average productivity of quarries,

[18] In the discussion of the dimension stone statistics it was pointed out that employment in rock dressing is adequate only as an approximation to total manufacturing employment in dimension stone. The same point must be made with regard to the cement mill and limekiln data. The miscellaneous employees who cannot be clearly classified in either mining or manufacturing are automatically included with mining when only the numbers employed in cement mills and limekilns proper are deducted from total employment, whereas in dimension stone they were automatically included with manufacturing (since total outside employment was excluded). Data that provide some indication of the size of this group of employees are available only for workers in limestone for cement (*Minerals Yearbook, 1940,* pp. 1142-43). The mandays (in thousands) of all such employees were about 138 in 1934, 114 in 1935, and 116 in 1936; total employment at quarries and crushers (including these miscellaneous workers) for the same three years was 1,034, 1,042 and 1,425 respectively, which indicates a maximum error of small proportions.

[19] Albert H. Fay, "Quarry Accidents in the United States, 1911," U. S. Bureau of Mines, *Technical Paper 46,* p. 3.

similar in both size and location, for which the matched data were available.[20] Although the Kantor-Saeger estimates are available only for the years 1929–36, a comparison of their figures with the accident data for employment discloses marked changes in the coverage of the latter even over so short a period. This may be seen from Table C-3

TABLE C-3

CRUSHED STONE EMPLOYMENT, 1929–36[a]
Comparison of Accident Bulletin and Kantor-Saeger Figures
Thousand manhours

Year	(1) *Accident Bulletins*[b]	(2) *Kantor-Saeger*[c]	(3) *Ratio (2) ÷ (1)*
1929	52,759[d]	95,873	1.82
1930	41,159[d]	84,496	2.05
1931	32,548	64,591	1.98
1932	27,028	47,535	1.76
1933	28,232	42,220	1.50
1934	31,419	43,911	1.40
1935	36,451	39,838	1.09
1936	47,165	50,390	1.07

[a] See p. 337 above.
[b] Includes nondimension granite, sandstone, basalt (trap rock) and limestone (manhours actually listed under nondimension and estimated nondimension included under "all other and not stated"). For the years 1929–34 limestone had to be adjusted to exclude limestone for lime and for 1929–31 it had to be adjusted to exclude also some cement rock incorrectly classified under limestone in the accident bulletins: see pp. 334-36 above.
[c] Kantor and Saeger, *op. cit.*, Table 4, p. 18 (average number of men employed at commercial operations multiplied by average hours per man per year at such operations).
[d] Derived as mandays and converted to manhours.

Evidently the coverage of the Bureau of Mines data increased sharply during the years shown in the table, but we have no information as to coverage in other years. Accordingly, our indexes of crushed stone employment for the years 1929–36 are based upon the Kantor-Saeger estimates. For years after 1936 the Bureau of Mines data were adjusted to total coverage according to the procedure described in footnotes to Table A-3 above. For years prior to 1929 no adequate method of adjustment seemed possible.

There is reason to suspect that employment figures for other sections of the stone industry are also defective in coverage. In the case of limestone for cement, there are available data that permit a quantitative

[20] H. S. Kantor and G. A. Saeger, *Crushed-Stone Industry* (National Research Project, Philadelphia, 1939), p. 129, note 4. This note fails to mention that the estimates were based on limestone (by far the most important component of the total) and that the results were applied to total crushed stone (not including limestone for cement and lime). This procedure, noted by Mr. Kantor in a letter to us, was prompted by lack of adequate data for the other varieties.

evaluation of the undercoverage. Thus employment for the entire cement industry can be derived for the years 1928–38.[21] These figures cover 100 percent of the industry only in 1934, 1937 and 1938. For other years we have assumed, in deriving column (2) of Table C-4, that output per manday was the same in those establishments for which production data alone are available and those in which production and employment data are available.[22] These data of course include employment in cement manufacture as well as in quarrying operations, but it is possible to approximate the latter by deducting cement-mill employment (given separately) from the total. Figures thus derived from *Minerals Yearbook* are compared with the accident bulletin figures in Table C-4. It will be seen that *Yearbook* data exceed the bulletin figures for the 1928–33 period, while for all later years the relationship is reversed. The varying nature of the relationship is apparently explained by two factors. (1) Since 1933 both the accident bulletin and the *Yearbook* figures represent complete coverage. The excess of the former is accounted for by the fact that accident bulletin data include employment in the production of natural cement, and also some employment in construction work, both of which are excluded from the *Yearbook* figures for all years.[23] (2) In 1928–33 the *Yearbook* figures are complete, while the accident bulletin figures fall short of total coverage for two reasons. First, and most important, is the fact that a number of quarries producing limestone for cement were incorrectly classified under crushed limestone; since we present no separate employment indexes for limestone for cement, this causes us no concern. Second is the actual failure to include all producers within the scope of the canvass—the same weakness encountered in the case of the regular crushed stone data.[24]

Our employment data for limestone for cement are derived from both sources. For years since 1934 we have used the accident bulletin data, for 1929–33 the *Yearbook* figures, and for all years prior to 1929 we used accident bulletin figures in the absence of more reliable data.[25] Our employment figures are clearly most reliable for the period since 1929. Even during this period a minor difficulty is encountered because

[21] *Minerals Yearbook, 1940,* pp. 1142-43.

[22] Coverage is fairly high in all years. In 1935 and 1936 it is slightly less than 100 percent and in 1928–33 it varies between 87.3 percent and 89.0 percent.

[23] Construction work is very often reported under miscellaneous, in which case it is included in the *Yearbook* figures. Construction is excluded only when separate figures are available.

[24] This information was supplied by Mr. W. W. Adams of the U. S. Bureau of Mines.

[25] See pp. 338-39 above. Since the data have to be spliced in 1929, it is not feasible to use the available *Yearbook* figure for 1928 in the construction of the employment index.

of the exclusion of employment in natural cement and in some construction work from the *Yearbook* totals, but it appears unlikely that these omissions have had any noticeable effect on the movement of the index.[26] For years preceding 1929 little more than guesswork can be used as a guide to the adequacy of the index. There is no doubt that under-

TABLE C-4

LIMESTONE FOR CEMENT
Employment at Quarries and Crushers, 1928–38
Thousand mandays

	(1) *Accident Bulletins*[a]	(2) *Estimates Derived from* Minerals Yearbook[b]	(3) *Ratio* (2) ÷ (1)
1928	1,445	2,009	1.39
1929	1,296	1,745	1.35
1930	1,139	1,639	1.44
1931	995	1,186	1.19
1932	745	826	1.11
1933	764	819	1.07
1934	1,034	1,031	.997
1935	1,042	998	.96
1936	1,425	1,365	.96
1937	1,523	1,339	.88
1938	1,256	1,173	.93

[a] See p. 334 above.
[b] See text.

coverage is severe; however, nothing is known of changes in the degree of undercoverage. Table C-4 suggests a tapering off in the degree of undercoverage after the violent change between 1930 and 1931. If the level of coverage in 1928–30 is representative of earlier years, the movement of the index may be a fairly faithful reflection of the true movement of employment, although it cannot be proved that this is the case. If the coverage of the data varied, it seems more likely on general grounds that an improvement in coverage followed the passage of time than that a deterioration occurred: in which case our measures (Table A-5) understate the rise in the productivity of stone quarrying prior to 1929.

[26] Examination reveals that the importance of the employment excluded from the *Yearbook* totals is slight in 1934, 1935 and 1936, and becomes greater in 1937 and 1938. (See Table C-4, col. 3.) Since natural cement is relatively unimportant in all these years the variation is most probably due to differences in the reporting of construction workers. (See footnote 23 above.) If, as the trend suggests, construction was reported under miscellaneous in the earlier years, it is safe to conclude that undercoverage is very slight from 1929 to 1933, the years for which we use *Yearbook* figures.

Since limestone for lime has been included under crushed limestone no separate index of employment has been constructed for it. It should be noted, however, that our estimates of undercoverage in crushed stone exclude limestone for lime because the Kantor-Saeger figures do not include it. An independent estimate of the adequacy of the employment data in this branch of quarrying is called for, but there are no means by which such an estimate may be assembled. As in the case of limestone for cement, the chief difficulty connected with the employment figures on limestone for lime is obviated by its inclusion with crushed limestone. Under such circumstances the incorrect classification, under crushed limestone, of an enterprise quarrying limestone for lime, is of no consequence. Nevertheless the problem that arises from actual deficiencies in the scope of the canvass still remains, and we are ignorant of its effect on the index for crushed limestone.

Undercoverage of the Employment Data—Dimension Stone

We may suppose that employment data for dimension stone are subject to the same weaknesses as employment figures for the other stone industries. Unfortunately, in the case of dimension stone, data similar to the Kantor-Saeger figures mentioned above, which would enable us to derive a more or less precise measure of the degree of undercoverage, are lacking. Nevertheless, we can say something about the adequacy of the data in this part of the field.

It was pointed out above that in the dimension stone industry employees who are reported under the heading "outside works" are largely engaged in manufacturing. Therefore such employment was not included by us, with the result that our employment indexes for dimension stone relate solely to quarry workers. The exclusion of outside employment now assumes added importance because the problem of changing coverage in the "Quarry Accident" figures for dimension stone is especially pronounced with regard to such outside employment. This is not to say that the reported employment at quarries represents complete industrial coverage, but rather that changes in coverage for quarries and outside works as a whole are attributable mainly to the lack of uniformity in reporting employment in stone dressing over a period of years.[27]

[27] Miss Vivian E. Spencer of the Census of Mines and Quarries suggested that this was the case in a letter explaining the treatment of stone employment by the National Research Project (see Spencer, *The Mineral Extractive Industries, 1880–1938*, Philadelphia, 1940). She stated, in part, "Dimension-stone quarrying data as collected by all agencies (at least prior to taking the present Census [1939]) are fairly nebulous. All of them included some, but did not completely cover, dimension-stone dressing at plants operated in conjunction with the quarries."

The data at our disposal permit a rather simple demonstration of changing accident bulletin coverage of outside works since 1922 (the year when total stone employment was for the first time divided into dimension and nondimension). If the relationship between employment at outside works (which we exclude) and total employment is examined for this period (see Table C-5) a very definite rise in the percentage of total employment accounted for by outside works is indicated. Such a result must certainly stem from changing coverage, since

TABLE C-5

DIMENSION STONE QUARRIES
Ratio of Mandays at Outside Works to Total Mandays, 1922–1939[a]

Year	*Marble*	*Granite*	*Limestone*	*Sandstone*
1922	.51	.33	.33	.28
1923	.55	.27	.22	.29
1924	.55	.27	.21	.19
1925	.59	.37	.37	.23
1926	.61	.43	.44	.24
1927	.58	.40	.53	.45
1928	.61	.43	.55	.44
1929	.64	.46	.53	.42
1930	.64	.50	.52	.45
1931	.66	.53	.59	.55
1932	.74	.52	.67	.54
1933	.73	.50	.66	.67
1934	.73	.52	.61	.69
1935	.71	.45	.62	.62
1936	.77	.45	.66	.50
1937	.69	.50	.58	.47
1938	.66	.51	.65	.45
1939	.66	.51	.63	.43

[a] U. S. Bureau of Mines, "Quarry Accidents in the United States." Total mandays comprise mandays at quarries and at outside works. The ratios were computed from the data as published, and take no account of employment reported as "All other and not stated," i.e., not distributed between dimension and nondimension.

there has been no tendency toward a greater degree of fabrication by quarry companies during this period. The changes in coverage, in turn, are at least partially accounted for by the fact that accident bulletin coverage of outside employment has increased considerably during the period, whereas there has been no similar change with regard to quarry workers. Such changes as have taken place in the coverage of quarry statistics must have been of a much lower order of magnitude. In addition, it is possible that in the accident reports the segregation of employment between quarries and outside works has tended to improve over the period. To the extent that this has happened, our indexes suffer from lack of comparability over time.

Crushed Stone Output—Noncommercial Production

During the past decade increasing amounts of crushed stone have been quarried by local government units, mainly for highway construction and repair. These amounts are included in the output data for crushed stone shown in Table A-1. The employment statistics collected by the Bureau of Mines cover only commercial enterprises.[28] To make our measure of output comparable with employment we therefore have to exclude noncommercial production for years after 1929. For this purpose we have used over-all value data, for no segregation in terms of physical output is available for individual varieties. For years since 1929, according to Bureau of Mines figures, the percentage contribution of commercial to total crushed stone production (excluding limestone for cement, which is produced only commercially) ran as follows, in value terms:

1929	95.1
1930	94.3
1931	92.3
1932	87.1
1933	88.3
1934	81.7
1935	81.2
1936	77.2
1937	78.6
1938	71.0
1939	69.3

Accordingly, the index for crushed stone (excluding limestone for cement) computed from the data in Table A-1 was adjusted for 1930 and later years as follows: for 1930 it was multiplied by 94.3/95.1, for 1931 by 92.3/95.1, and so forth. The resulting index was then combined with an index for limestone for cement to yield an index for total commercial crushed stone; this was in turn combined with the index for dimension stone to provide an index of the output of commercial stone quarrying as a whole (Table A-5).

Conclusion

We have examined the adequacy both of the output and of the employment data in stone quarrying, and have indicated the choices we

[28] Since 1936 the Bureau of Mines has begun to collect employment data for noncommercial crushed stone operations, but the figures are incomplete and of unknown coverage.

made and the kinds of adjustment we found necessary. We have also mentioned the remaining weaknesses of the data, for which no adjustments could be devised. The defects in the figures for output appear to be much less serious than the weaknesses of the employment data. Any reservations we may have concerning the productivity measures for the stone industries (Table A-5) relate chiefly to the adequacy of the latter and for this reason we have devoted considerable space to the subject. It is probable that our indexes understate rather than overstate the rise which has occurred in the productivity of stone quarrying.