V. LIMITATIONS ON THE USE OF THE INDEXES

A. General Limitations.

In discussing the limitations of the various indexes, it may be useful to begin by listing certain general limitations which apply to all the indexes, before investigating in detail the qualifications and cautions surrounding the use of individual indexes. Four general limitations common to all the indexes may be listed as follows:

1. The indexes do not measure changes in the "real" cost of discovery, *i.e.,* the actual returns per unit of exploratory effort. While the indexes have been adjusted for increases in the average depth of wells drilled, no adjustments have been made for changes in the volume of reserves found per successful well or for changes in the success rate of exploratory drilling.

2. The indexes do not attempt to provide any estimates of the replacement costs of oil and gas produced, owing to the lack of the necessary basic data.

3. The indexes do not reflect the full effect of technological changes on costs. The necessity for using the weights applicable to a fixed time period fails to allow for the effects of technological change in altering the pattern of resource inputs. The effects of trends toward such developments as slim-hole drilling, tubingless completions, multiple completions, etc., are not reflected in the indexes. The use of 1959 weights more nearly reflects present technology and drilling practices than the 1947 weights previously used, but ideally an annual set of weights should be developed for and applied to each year of the period 1947-1961.

4. The indexes are primarily designed to measure the cost of drilling and completing onshore wells drilled by the rotary method. In selecting the sample of wells used to compute the weights employed in the composite price index of direct operator cost, it is true that offshore wells in Louisiana were included, and no distinction was made between rotary and cable drilling, so that some of the wells included in the sample are likely to have been drilled by cable tools. Nevertheless, the price indexes were not designed to include items specifically used in offshore or cable tool drilling, primarily because of the difficulty of obtaining representative price data on such inputs. It is not known to what extent the input price indexes are valid in their application to cable tool and offshore wells. For

example, no price indexes have been developed for offshore drilling rigs, barges, or helicopters.

B. Limitations on the Use of Individual Indexes.

1. The Index of Direct Operator Cost Unadjusted For Depth Changes. A major limitation on the use of the index of direct operator cost unadjusted for depth changes is the circumstance that the weights applied to the individual price index series are based upon the experience of operators drilling wells included in the survey in the single year 1959. This is the sort of limitation common to all index numbers of the Laspeyres type—the necessity of selecting a fixed base period for the determination of quantity weights. The present comments are, however, intended to emphasize the fact that the application of the weights of a particular year to the prices of a number of different years implies the holding constant of all factors influencing costs except the level of prices. Perhaps the most important of the other factors influencing costs is the state of technology; the use of 1959 weights implicitly assumes that the ratios of factor inputs appropriate to the state of technology in 1959 can be applied to all other years in the cost index time series.

The index of direct operator cost unadjusted for depth changes differs from the usual Laspeyres price index in that the latter generally employs base-year weights with the base year selected as the initial year (or as the average of two or more consecutive initial years) of the period covered by the series, while 1959 is the thirteenth year covered by the particular index in question. It will be recalled that economic statisticians distinguish between the direction of bias in the Laspeyres (base-year weights) and the Paasche (current-year weights) price indexes in accordance with the implications of the downward slope of the demand curve, *i.e.,* that at lower prices more will be purchased and vice versa. In the case of the Laspeyres index, with constant base-year weights assumed for quantities purchased, more weight will be given to those items which have increased in relative price than would be justified unless the demand for such items is completely inelastic. This follows from the assumption that relatively less will be purchased of those goods the prices of which have increased since the base period, while the use of the Laspeyres index constant base-year weights assumes constant relative quantities purchased of all inputs, regardless of price changes. This feature of the Laspeyres index has been responsible for the Laspeyres index being considered a measure of the "upper limit" of price change since the base period. In the contrary case of

the Paasche price index, employing current-year weights, more weight will correspondingly be given to those items which have decreased in relative price than would be called for unless the demand for such items is, again, completely inelastic. If relatively more will be purchased of those goods the prices of which have declined since the initial period, the use of current-year weights gives greater prominence to those items the prices for which have declined (relatively as well as absolutely) since the initial period. The Paasche price index is therefore considered as a measure of the "lower limit" of price change since the initial period included in a price index time series.

It must be noted, however, that this traditional problem does not exist in the present instance between the choice of 1947-1949 and 1959 weights. The index with the base period 1947-1949 = 100 is a simple Laspeyres index; the index with the base period 1959 = 100 is of the Laspeyres type, except that the base year is not the initial year of the index time series, but neither of these is a Paasche index, since there are no current-year weights. There are only weights for 1959. (For 1959, but for 1959 only, will the index with the base year 1959 = 100 be the conceptual equivalent of a Paasche index.) If we take the quasi-Laspeyres index with 1959 = 100 as the base, we find that, since 1959 is not the initial year in the period covered by the index, it is not correct to say that the value of this index, for the years before 1959, as compared with 1959, gives an upper limit of the probable actual price change during the interval. On the contrary, during a period of generally rising prices (such as the period 1947-1959), movements backward in time from the base year will tend to understate, rather than overstate, the probable movement in price levels. Only for movements forward in time beyond 1959 will the index values be an estimate of the upper limit of the probable actual impact of price changes.

Neither is the alternative version of the index, with the base period 1947-1949 = 100, a conventional Laspeyres index with base-period weights for the initial period covered by the index. If this were the case—*i.e.,* if the quantity weights had actually been computed on the basis of experience during the period 1947-1949—then this series would be a true Laspeyres index with the necessity for the usual caution as to the probable overestimation of the cost inpact of price increases. However, this is not the case. The index computed on the base 1947-1949 = 100 is merely a transposed version of the index with the base 1959 = 100; *i.e.,* the weights employed are 1959 weights in both indexes. If one desires to present an index number with the base 1959 = 100 in such a way that the period 1947-1949 = 100 becomes the basis for price index

measurement, the procedure is merely to divide the index number for any particular year i on the basis 1949 = 100, by the index number for the average of the years 1947-1949 on the basis 1959 = 100. Denoting prices by p, quantity weights by q, and the relevant year by numerical subscripts, we then have:

$$\frac{\Sigma p_i \quad q_{59}}{\Sigma p_{59} \quad q_{59}} \Big/ \frac{\Sigma p_{47\text{-}49} \quad q_{59}}{\Sigma p_{59} \quad q_{59}},$$

which reduces to:

$$\frac{\Sigma p_i \quad q_{59}}{\Sigma p_{47\text{-}49} \quad q_{59}}.$$

Despite the (nominal) change in the base period for index number calculation, the series with 1947-1949 = 100 retains all the characteristics of relative understatement of the effect of price increases from 1947-1949 to 1959 and relative overstatement of the effect of price increases after 1959 that characterized the series with the base 1959 = 100.

A further limitation on the use of this index is the absence of any price index data on oilwell tubing, resulting in the weighting of the category of casing and tubing (34.1 per cent of the index by weight) solely by a price index applicable to casing alone. Other examples than tubing (tool rentals, various testing methods, etc.) could be cited in this context, but tubing is probably the most important omission.

2. The Index of Cost Adjustment for Changes in The Depth Distribution of Wells. The choice of a single interval of time as the base period for computing changes in the cost of drilling within different depth ranges is of necessity an arbitrary one. Data for such a computation are available for four years (1953, 1955, 1956, and 1959) as a result of the efforts of the Joint Association Surveys. The year 1959 was chosen as the base year because the most recent survey is regarded as the most complete and statistically reliable study. It can be argued that the year 1953, being in the middle of the time period covered by the indexes, would give a more appropriate indication of typical drilling technology during the entire

period covered to date by the indexes. An average of the years 1953, 1955, and 1956 might conceivably give a still better approximation to the average state of technology, but aside from the fact that the averaging of a number of nonconsecutive years would tend to obscure both the nature of the base period and the measurement of changes relative to such a period, the objection remains that the data for the earlier years are not as reliable as those for the year 1959. A further advantage of the choice of 1959 as the base year is that it coincides with the year for which the sample survey of drilling and completion costs was made by the Committee.

3. The Index of Total Payments to Contractors Per Foot Drilled. The chief difficulty with the index of total payments to contractors per foot drilled is the question of its reliability. Is it representative of the entire universe of total payments to contractors for all footage drilled in each year? Data from individual companies are very likely to be erratic because of the changing areas of concentration of drilling from year to year. A weighted average of the data obtained from a fairly large number of individual companies begins, however, to become more meaningful. For example, the composite data from only three companies, when combined with the *Oil and Gas Journal* data, demonstrated considerable stability from year to year. The firms which contributed data were large to medium in size, with no real representation of small operators. This fact is very likely to introduce a certain bias toward the selection of more of the deeper wells, since the large companies average deeper drilling. If deeper wells are relatively overrepresented, the average total payments per foot drilled to drilling contractors will be somewhat overstated; however, it is not the absolute value of such payments, but their time trend, which is of importance for the calculation of index numbers. It may perhaps be assumed that the time trend will not be affected by the year-by-year inclusion of a greater number of deeper wells in the sample, but this is by no means certain. It is also to be assumed that a representative selection of wells drilled by geographical area has been obtained by virtue of the relatively large number of wells included in the data reported for each year, although this, too, is far from certain.

4. The Indexes of Drilling and Completion Costs Per Well and Per Foot. One qualification which must be pointed out in connection with the uses of the index of drilling and completion costs per well is that this index represents the costs of both productive wells and dry holes. This fact is misleading to the extent that the costs of productive wells are typically considerably greater than the cost of

dry holes, the difference being largely comprised in the cost of completing and equipping successful wells with the necessary producing apparatus. The indexes of drilling and completion costs per well therefore apply to the anomalous case of a "typical" well which is partly productive and partly dry! It would be highly desirable to compute separate indexes for dry and for productive wells, but this cannot readily be done. The defense is to some extent relevant that the purpose of the indexes is not to measure the absolute cost of drilling either a dry or a productive well, but to measure the time trend of changes in the average cost of drilling the statistical average well. The defense fails, however, in that the ratio of dry holes to productive wells is by no means constant over the years, but varies from 30 to 40 per cent. This same qualification applies to the index of drilling and completion costs per foot.

A further qualification applicable to both the index of drilling and completion costs per well and the index of drilling and completion costs per foot is implicit in the method of combining direct operator and contractor costs by using the weights of 61.0 per cent for the direct operator segment and 39.0 per cent for the contractor segment on the basis of the 1959 drilling cost survey conducted by the Committee. The assumption is that the functions performed by operators directly and by contractors were the same in 1959 as in any other year. There is some evidence, however, that the drilling contractor is tending to perform an increasing number of functions, as is shown by the increase in the number of turnkey arrangements.

A final qualification affecting both indexes is that they measure year to year changes in costs per foot and per well for the average foot or well drilled in the United States, but they do not necessarily measure year to year changes in the costs of drilling wells in any particular geographical area of the country. The 1959 sample upon which the cost weights are based was drawn from all areas in the country, but in being representative of all producing areas, it is necessarily typical of no single geographical area or geological province individually. In practice, any differences between national average costs and those pertaining to a single region will perhaps only seldom be a serious source of error. For certain areas, however, actual costs will differ significantly from the national average cost. Ideally, one should compute different cost indexes for every producing area in the country, but this would prove formidably burdensome in practice.

APPENDIX A.

REQUEST FOR INFORMATION PERTAINING
TO CONTRACT RATES PER FOOT OF HOLE DRILLED
(Contractor Report)

It is requested that one of these sheets be completed for *each major area* in which you have drilled holes in the years 1957, 1958, 1959, and 1960. For the purposes of this study "holes" include onshore oil wells, gas wells, and dry holes drilled by the rotary method. Offshore wells, wells drilled by cable tools, and input and salt water disposal wells should be *excluded.*

1. Area of drilling:

   Basin _____

   State or states _____

2. Average footage rates, average depth, and total number of holes in this area.

Year	Average Footage Rate Specified in Contract ($/foot) Development	Exploratory	Average Depth of Holes Drilled Development	Exploratory	Total Number of Holes Drilled Development	Exploratory
1957						
1958						
1959						
1960*						

* Report 1960 data on the basis of experience to date.

INSTRUCTIONS:

Area of drilling—Use the standard industry nomenclature to indicate the area in which the drilling occurred (Permian Basin, Delaware Basin, San Juan Basin, etc.) and also show the state or states. Our objective is to obtain representative contract rates in areas in which the substantial part of your onshore drilling was done.

Average footage rates—An average of the footage rates specified in rotary drilling contracts. A weighted average is preferred, computed as follows: total dollar receipts for footage drilled at a footage rate ÷ number of feet drilled at a specified rate per foot. If this calculation cannot be made conveniently, the average rate per foot for a *typical* hole will be satisfactory.

Average depth of holes—A weighted average for all holes you drilled in this area is preferred, but the depth of a *typical* hole is acceptable.

Total number of holes reported—The actual number of holes you drilled in this area.

APPENDIX B.

SURVEY OF THE DISTRIBUTION OF EXPENDITURES IN DRILLING AND EQUIPPING WELLS IN 1959

QUESTIONNAIRE

A. This questionnaire is for recording data, including the *total* cost of drilling the following well:

1. Operator _____
2. Area _____
3. Well _____

B. The depth of this well was _____ feet.

C. This well was classified as an:

(a) Exploratory well _____
(b) Development well _____

D. This well was drilled by

(a) Cable tools _____
(b) Rotary _____

E. If the well was drilled *by a contractor*, please enter the total payments to the drilling contractor as follows:

1. Payment at the contract footage rate $ _____
2. Payment at day rate $ _____
3. Payment under turnkey contract $ _____
4. Total payments to drilling contractor (sum of Items 1, 2, and 3) $ _____

F. The name of the drilling contractor was

G. If the well was drilled *by the operator*, enter the following costs *in drilling hole* incurred by the operator.

1. Depreciation on drill pipe and rig, prorated to this well $ _____
2. Labor in drilling operation $ _____
3. Rig maintenance and supplies $ _____
4. All other costs *in drilling hole* (please identify major items) $ _____

H. *Direct expenditures made by operator*

This part of the questionnaire covers the costs incurred by the operator in addition to drilling hole which is covered by Parts E and G.

Instructions

1. See definitions of items on next page.
2. Enter expenditures made directly by the operator, including payments to third parties, in dollars, in Column *a* only.
3. If an expenditure for any item is included in the drilling contract, please *check* this item in Columns *b* or *c* or *d*. If a part of any item is included in the drilling contract, please *check* Columns *b*, *c* or *d* as appropriate and enter dollar expenditures paid to other than the drilling contractor in Column *a*.
4. If combination of items is required on reporting expenditures, please specify all combinations.

Item	Direct Expenditure Made by Operator	Please *check* Column (b), (c), or (d) for any item included (in whole or part) in payments made to drilling contractor: Footage Rate Payments	Day Rate Payments	Turnkey Payments
	(a)	(b)	(c)	(d)
1. Road & site preparation	$			
2. Transportation	$			
3. Fuel	$			
4. Water	$			
5. Drilling mud & additives	$			
6. Well site logging	$			
7. All other physical tests	$			
8. Logs	$			
9. Directional drilling service	$			
10. Perforate	$			
11. Formation treating	$			
12. Cement and cementing service	$			
13. Casing and tubing	$			
14. Special tool rentals	$			
15. Drill bits and reamers	$			
16. Wellhead equipment	$			
17. Other equipment and supplies	$			
18. Plugging	$			
19. Supervision and overhead assigned this well	$			
20. All other expenditures (please specify major items)	$			
21. Total direct expenditures made by operator (sum of items 1. through 20.)	$			
I. Total expenditures in drilling and equipping this well (sum of Part H, line 21, plus Part E if drilled by a contractor, or Part G if drilled by the operator)	$			

INSTRUCTIONS AND DEFINITIONS

a) The operator should report the total expenditures for this well regardless of the percentage of the operator's interest.

b) Expenditures as reported should be the total expenditures of the wells completed in 1959 regardless of the year in which the charges were recorded on the books.

c) *No* expenditures should be reported which pertain to
   1) Surface equipment beyond wellhead.
   2) Pumps and other artificial lift equipment even if such equipment is installed during the initial completion of the well.
   3) Production testing after completion of the well.

d) Secondhand equipment should be included in costs at condition value; material transferred or salvaged should be credited at condition value.

e) Equipment salvaged or to be transferred shortly after well completion should be credited to cost at condition value.

Definitions for Part H

1. Road and site preparation. This item should include the costs of preparing locations and access roads and canals. Such costs should include labor, transportation, supplies, contract expense, fuel, caliche, shell, gravel, board road lumber, cattle guards, pilings, etc. Also clearing location, cost of permit to drill well, damage to property, drive pilings for derrick foundation (includes pilings), engineering expense (making location, etc.), dikes or levees, reserve pit, rental on road or right-of-way, digging slush pit and filling of pit.

Also comparable expenditures for offshore drilling. If offshore drilling platform is included, report only the cost-prorated to this well.

2. Transportation. This item should include cost of transportation of personnel, materials and supplies, tools, casing and other subsurface equipment up to and including wellhead connections, etc. However, exclude transportation included in other items such as fuel, water, drilling fluids, cement and cementing service, etc.

3. Fuel. Fuel should include the total cost of fuel, including transportation, whether furnished from a company system or facility or by an outsider; also, costs in connection with laying and recovering temporary fuel lines.

4. Water. Water should include the total cost of fresh water, including transportation and treating expense, and cost of water wells drilled.

5. Drilling mud and additives. This item should include the cost of mud materials, mud conditioners, and additives such as chemicals, weighting materials, crude or fuel oil, salt water, etc., as well as their transportation costs. It should include the cost of rental and transportation of mud house, where applicable. Also lost circulation material.

6. Well site logging. This item should include the cost of well site sample and core analysis and mud logging operations.

7. All other physical tests. This item should include drill stem testing, caliper logs, side wall testing and sampling, etc., but exclude production testing.

8. Logs. This item should include temperature surveys and all types of well logs performed for the purpose of formation evaluation such as electric, radioactive, and sonic.

9. Directional drilling service. This item should include directional drilling services and directional surveys.

10. Perforate. This item should include the cost of perforating casing, whether by gun, shaped charge, casing cutter, or otherwise.

11. Formation treating. This item should include formation treating such as formation fracturing, acidizing, shooting, open hole formation perforating, gravel packing, sand control, surface tension control, etc.

12. Cement and cementing service. This item should include the cost of cement including transportation of cement and equipment and the cost of cementing service.

13. Casing and tubing. This item should include casing, tubing, tubing packers, liners, casing and liner couplings, screens, liner packer and lead seals, liner hangers, etc.

14. Special tool rentals. This item should include rental of equipment and tools (company and outside) for all purposes other than transportation, e.g.—special fishing tools not normally supplied by drilling contractor, core barrels, special casing tools, etc.

15. Drill bits and reamers. This item should include the cost of all drill bits, reamers and services.

16. Wellhead equipment. This item should include casing and tubing hangers, flow line connections at the wellhead, pressure gauges, valves, flow beans or chokes, etc. *Do not include* cost of surface equipment beyond the wellhead. These costs are beyond the scope of this questionnaire.

17. Other equipment and supplies. This item should include items *not included in other categories,* such as stabilizers, core heads, casing scratchers, casing centralizers, swab rubbers, non-retrievable cement retainers and plugs, casing float equipment (such as float shoes, guide shoes, float collars, etc.), stage collars, and similar items. However, *do not include* (1) equipment and supplies connected with surface equipment beyond the wellhead, (2) pumps and other artificial lift equipment even if such equipment is installed during the initial completion of the well.

18. Plugging. This item should include the cost to plug back, cut and pull casing, plug and abandon, and clean up location.

19. Supervision and overhead. This item should include supervision, overhead, well sitting and service directly assigned to this well, including geologist, engineer, mud engineer and other personnel assigned to well on part-time or full-time basis.

20. All other expenditures. Please identify other major items which will provide a better understanding of the cost of drilling this well. For instance, special contract services not included in above items.

FOOTNOTES AND REFERENCES

[1]David Siskind, "Drilling Costs," *Petroleum Engineer,* XXIV (January 1952), B-14ff.

[2]The data referred to are from the "Joint Association Survey of Industry Drilling Costs" for the years 1953, 1955, 1956, and 1959. These surveys were conducted jointly by the American Petroleum Institute, the IPAA, and the Mid-Continent Oil and Gas Association of America. In each year extensive surveys were made to determine the cost of drilling wells and the total of industry expenditures on finding, developing, and producing oil and gas reserves. The first survey covered the years 1944, 1948, and 1953. The cost findings were reported in an information release dated December, 1955. The expenditure estimates were reported in an information release dated April 12, 1956. The second survey covered the years 1955 and 1956. The cost findings were reported in an information release dated June 3, 1959. The expenditures were published in a release issued later in 1959. The third survey covered the year 1959, and its findings were reported in information releases during 1961.

[3]P.C. Pope and John Mesaros, "Mud Programs for Deep Wells in Pecos County, Texas," *Proceedings of the American Petroleum Institute, Division of Production,* March, 1959.

[4]C.C. Anderson, "Petroleum and Natural Gas in the United States—Relation of Economic and Technologic Trends," Canadian Sectional Meeting, World Power Conference, September, 1958.

[5]1954 Census of Mineral Industries, "Crude Petroleum and Natural Gas," Bulletin M-13B. 1958 Census of Mineral Industries, "Crude Petroleum and Natural Gas," Bulletin M-14B.

[6]See, for example, F.E. Croxton and D.J. Cowden, *Applied General Statistics,* New York, Prentice-Hall, 1939, pp. 613-616.