FEDERAL R & D EXPENDITURES AND THE GEOGRAPHIC CONCENTRATION OF R & D ACTIVITY

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In recent years the proposition has been advanced and generally accepted in Congress than an increasingly unequal distribution of federal R&D funds among regions has increased the geographic concentration of R&D activity in the United States.

The Senate Subcommittee on Employment, Manpower, and Poverty concludes in a December, 1966 report:

> ... The existing patterns and flows, the testimony of various witnesses, the experience of individual members of the subcommittee, and the dictates of common sense all point in one direction: whatever may be the original reasons that funds and men began to accumulate and concentrate in given regions, in recent years the tremenous inflows of federal dollars to these regions has strengthened existing tendencies and concentrations. The rich have gotten richer, both in terms of dollars and men; the scientific manpower resources of these regions have been both enhanced and developed. In relation to favored regions, others have languished. Federal funds have played a major role in this process.
>
> [19, p. 36]

On the basis of these findings, the Subcommittee recommended that the National Science Foundation be authorized and directed to develop a ten-year plan to redistribute federal R&D funds.

This is not an isolated observation. The proposition that the geographic concentration of R&D activity has increased largely because of the geographic distribution of federal R&D funds has been one of the main props for Congressional discussions about the equitableness of the distribution of federal R&D funds among regions. Regional equity was raised as an issue in hearings before the House Subcommittee on Science, Research, and Development in 1963 [15] and subsequently explored in a series of Congressional hearings and reports.[1] The entire series of hearings and reports appear to accept, in general, the notions that R&D activity and, in turn, economic activity, and higher higher education among regions are strongly responsive to the regional allocation of federal R&D funds. The relationship and responsiveness of regional economic activity and higher education to changes in federal R&D funds has been discussed in [2].

This paper examines the proposition that an increased geographic concentration of federal R&D funds has caused an increased geographic concentration of R&D activity. I first consider whether existing empirical evidence supports the conventional wisdom and then turn to possible weaknesses in my analysis.

THE DATA AND INDICES OF REGIONAL INEQUALITY

In order to examine changes that have taken place in the geographic concentration of federal R&D funds and regional R&D activity, data are required as measures of the regional expenditures of federal R&D funds and the regional performance of R&D.

FEDERAL R&D FUNDS

R&D obligations are used as the measure of regional expenditures of federal

R&D funds. This information is available by states for the extramural obligations in fiscal years 1961-1962 and the intramural and extramural obligations in fiscal years 1963-1965 of the eight agencies that account for virtually all federal R&D activity [11, 12]. The obligations are also classified by four types of recipient organizations: Industrial firms, educational institutions, other non-profit institutions, and other performers. R&D obligations are an imperfect measure of the actual expenditures of federal R&D funds; there is no assurance that the actual expenditures of R&D funds will be limited to the same year or the same state in which the obligations are incurred.

R&D obligations are likely to precede the actual expenditures by varying lengths of time. However, there is evidence that the actual expenditures are more likely to coincide with R&D obligations than is the case with procurement obligations [4].

The state distribution of R&D obligations does not reflect the influence of subcontracting and intrafirm transfers of R&D funds on R&D expenditures. Partial information available for 1963 and 1965 indicates that the subcontracting process tends to reduce the concentration of federal R&D funds. [11, pp. 34-37 and 15, pp. 17-19].

R&D Activity

The most often used measures of R&D performance are R&D expenditures and R&D employment. Data for R&D expenditures by industrial organizations are available for 1962-1964 for most states [9], but they are not available for other organizations or for total R&D expenditures. The state distribution of scientists and engineers is available from the 1960 Census [14, p. 194]. Different data from the National Science Register on the state distribution of scientists are also available for the even years 1960-1966 from the National Science Foundation. [8, 13]. The latter data are used as a measure of R&D performance in the years 1962, 1964, and 1966. They have the advantage of showing greater detail about the type of work and the institution in which scientists are employed. An obvious shortcoming is that they exclude engineers and other technical personnel, who are particularly important for development as opposed to basic and applied research.

Indices of Regional Inequality

This analysis requires a summary measure of the extent of inequality or concentration in the state distributions of R&D activity and federal R&D funds. Various indices of inequality exist in the economics, political science, and sociology literature.[2] I have used the Gini coefficient which is defined as the ratio of the area between the Lorenz curve of a distribution and the 45 degree line of equality and the total area under the line of equality.[3] It can vary in value between zero, indicating absolute equality, and one, indicating absolute inequality. The coefficient is used here in two ways: to indicate the extent of inequality in the distribution of various categories of federal R&D obligations and scientists among states and to indicate the extent of inequality in the state distribution of particular R&D obligations relative to particular groups of scientists. In the latter case, a positive or negative valued Gini coefficient would indicate that R&D obligations are, respectively, less or more equally distributed among states than scientists.

REGIONAL INEQUALITY

Gini coefficients for the distribution of federal R&D funds obligated among states are shown in Table 1. The coefficient in 1961 for extramural obligations is .77 and in 1963 and 1965 for extramural obligations and intramural obligations is .72. This suggests a fairly high concentration of R&D funds for the period of 1961-1965.

Similar results are shown in Table 2 for the state distribution of R&D

TABLE 1

GINI COEFFICIENTS OF THE DISTRIBUTION OF FEDERAL R&D OBLIGATIONS AMONG STATES BY AGENCY AND PERFORMER FISCAL YEARS 1961, 1963, and 1965

	1961[1] Extramural	1963[2] Extramural and Intramural	1965[3] Extramural and Intramural
Total	.772	.723	.722
Agencies			
DOD	.831	.776	.771
HEW	.650	.678	.664
AEC	.882	.827	.815
NASA	.872	.848	.831
NSF	.624	.657	.635
Agriculture	.262	.515	.494
Commerce	.809	.891	.900
Interior	.513	.507	.496
Performers			
Intramural	---	.759	.734
Educational Institutions			
excluding Research Centers	.626	.614	.612
including Research Centers	.726	.717	.675
Profit Organizations	.796	.760	.780
Other Non-profit	.827	.834	.821
Other Performers	.471	.521	.559

[1](12), pp. 44-47, 68-71, 92-95, 116-119, 140-141.
[2](12), pp. 24-25, 36-37, 80-83, 128-131, 148-149.
[3](11), pp. 46-47.

TABLE 2

GINI COEFFICIENTS FOR THE DISTRIBUTION
OF SCIENTISTS AND ENGINEERS AMONG STATES

	1960	1962	1964	1966
Scientists and Engineers[1]	.612	---	---	---
Scientists[2]				
Total	.552	.553	.556	.551[3]
R&D as Primary Work Activity	---	.609	.605	---
Federally Employed	---	.576	.605	---
Employed by Educational Institutions	.537	.536	.534	---
Employed by Industry	---	.642	.648	---
Employed by Other Non-profit Institutions	---	.732	.734	---

[1] (14), p. 194.
[2] (4).
[3] (3).

activity as measured by the distribution of scientists. The coefficients for the state distribution of scientists have a value of .55 in each of the even years from 1960-1966. The same degree of inequality persists for 1960-1966, and scientists are more equally distributed among states than R&D funds.

This measure of overall R&D performance is somewhat narrow, however, because it does not include other types of scientific manpower. Data on the state distribution of scientists and engineers in 1960 offer an indication of the relative inequality of a distribution with additional types of scientific manpower. The Gini coefficient is .61, suggesting a more unequal distribution than for scientists. This result is not unexpected; engineers are more likely to be engaged in development than basic and applied research, and development, which accounts for approximately two-thirds of the total R&D performance, is more concentrated reginally than applied and basic research. In this sense, scientists are likely to be a better measure of research than of development. The surprising thing is that the difference between the two distributions is so small.

The data used above include all scientists whether or not they are engaged in R&D. Data on the state distribution of scientists primarily engaged in R&D are available for 1962 and 1964. Gini coefficients for the two years are shown in Table 2 as .609 and .605. R&D scientists are somewhat more concentrated among states than total scientists, but they show approximately the same degree of concentration as total scientists and engineers.

A somewhat different perspective about the data is gained by determining the extent of inequality in the state distribution of R&D funds relative to the state distribution of R&D activity. The two sets of data are reported for different years; so the distributions of federal R&D funds in fiscal years 1961, 1963, and 1965 have been matched with the corresponding 1962, 1964, and 1966 distributions of scientists.[4] The Gini coefficients are indicated in Table 3 as .50, .44, and .43 respectively, for FY1961/1962, FY1963/1964, and FY 1965/1966. These results suggest that federal R&D funds are more concentrated than scientists and that the extent of concentration has remained constant or perhaps declined slightly during this time period.

Similar results are suggested in Table 4 when the state distribution of R&D obligations is compared with the distribution of scientists primarily engaged in R&D activity. The coefficients are .47 and .42, respectively, for FY1961/1962 and FY 1963/1964.

A further comparison of the distribution of R&D obligations in fiscal year 1961 with the distribution of scientists and engineers in 1960 yields a Gini coefficient of .485. Although the time periods are not quite comparable, this suggests that R&D obligations in 1961 are slightly more concentrated relative to total scientists and engineers than R&D scientists but less concentrated relative to total scientists.

Because geographic data on R&D obligations for intramural performers are only available after 1962, Gini coefficients involving R&D obligations for 1961 are not directly comparable with the coefficients for later years. I have attempted to adjust the FY 1961/1962 coefficients of the distributions of R&D obligations relative to scientists and R&D scientists in order to consider the influence of intramural obligations.

The relative positions of individual states in the distribution of intramural obligations remained generally unchanged between 1963 and 1965 [11, p. 14], and the Gini coefficients for intramural obligations (Table 1) have essentially the same value in each year. Therefore, it is assumed that the state distribution of intramural obligations did not change between 1961 and 1963. Total intramural obligations in 1961 are allocated among states according to their percentage shares of total intramural funds in 1963. The adjustment reduces the FY1961/1962 coefficient for R&D obligations relative to total scientists (Table 3) from .50 to .46 and the coefficient for R&D obligations relative to R&D scientists (Table 4) from .47 to .43. However, it does not alter the previous results.

TABLE 3

GINI COEFFICIENTS OF THE STATE DISTRIBUTION OF R&D OBLIGATIONS IN FISCAL YEARS 1961, 1963, 1965, BY AGENCY, RELATIVE TO THE RESPECTIVE STATE DISTRIBUTIONS OF TOTAL SCIENTISTS IN 1962,1964,1966

	FY1961/1962	FY1963/1964	FY1965/1966
Total Agencies	.500	.441	.429
DOD	.578	.482	.439
HEW	.278	.345	.310
AEC	.666	.691	.707
NASA	.678	.665	.627
NSF	.285	.315	.313
Agriculture	.481	.482	.469
Commerce	.525	.795	.812
Interior	.536	.592	.533

TABLE 4

GINI COEFFICIENTS OF STATE DISTRIBUTIONS OF R&D OBLIGATIONS RELATIVE TO STATE DISTRIBUTIONS OF SCIENTISTS

	FY1961/1960
Total Extramural Obligations - Total Scientists and Engineers	.485

	FY1961/1962	FY1963/1964
Total Extramural R&D Obligations -R&D Scientists	.471	----
Total R&D Obligations -R&D Scientists	----	.417
R&D Obligations to Educational Institutions- Scientists Employed by Educational Institutions	.422	.403
R&D Obligations to Educational Institutions Excluding Research Centers- Scientists Employed by Educational Institutions	191	.183
R&D Obligations to Industry-Industrial Scientists	579	.536
R&D Obligations to Other Non-profit Institutions- Scientists Employed by Other Non-profit Institutions	.347	.315
Intramural R&D Obligations -Federally Employed Scientists	----	.416

This paper examines the hypothesis than an increasing geographic concentration of federal R&D funds has caused an increasing geographic concentration of R&D activity in the United States. I have attempted to determine whether federal R&D funds are less equally distributed among states than R&D activity and whether the two have in fact become more concentrated during the time period for which data are available.

The findings indicate that federal R&D obligations are more concentrated than R&D activity as measured by the distribution of scientists. This result appears both in comparisons of the relative inequality of the separate state distributions of federal R&D funds and scientists and in the estimates of the extent of inequality in the distribution of R&D funds relative to the distribution of scientists. The substitution of R&D scientists for total scientists as the measure of R&D activity reduces the inequality between the two distributions but does not change the overall result.

The same amount of concentration in the state distribution of R&D funds and R&D activity persists throughout the period for which data are available. There appears to be no support for the contention that both federal R&D funds and R&D activity are becoming more concentrated. In fact, if there is any hint at all of changes in the distributions, it is that R&D funds may be becoming less concentrated relative to scientists. However, this is not a conclusion I would be willing to assert with any confidence.

QUALIFICATIONS

These conclusions may be criticized, and perhaps rightfully so, as depending on a time period that is too short to catch all the effects of the distribution of federal R&D funds on the geographic pattern of R&D activity. It should be noted however, that the proposition that an increasingly unequal distribution of federal R&D funds has caused a greater geographic concentration in R&D activity is advanced for the same time period. In fact, much of the statistical justification given for the hypochesis in Congressional hearing and reports is based on the same data on federal R&D obligations and scientific manpower than are used in this paper. The geographic data on federal R&D obligations were first published by the National Science Foundation as a report to the House Subcommittee on Science, Research, and Development [11, p. ix; 12] and were used by the Subcommittee to establish the geographic unevenness of federal R&D funds [15].

Similar conclusions are also reached by Ira Horowitz for the 1950's in a study [5] using data on Department of Defense R&D obligations by state for 1954-1956 and 1960 and state distributions of scientific manpower in 23 scientific and engineering fields for varying time periods between 1951 and 1963 based on data from the National Science Foundation and membership rosters of various professional societies. Horowitz found stable or lessening concentration in the state distributions of scientific manpower in individual fields [5, p. 244]. The state distribution of R&D expenditures by the Department of Defense was also fairly stable [5, p. 244]. However, he did find evidence in the case of a few technical fields, particularly aeronautical engineers, of greater concentration effected by the geographic distribution of R&D funds by DOD [5, p. 250].

Questions may also be raised about the meaningfulness of a summary measure of regional concentration. A Gini coefficient of a given value may represent quite different distributions among states; so that, a coefficient that is stable over time may conceal considerable redistribution among states. This is an inherent difficulty of a summary measure of concentration like the Gini coefficient. I have tried to gain some perspective about this problem by examining the data from several directions.

Some evidence has already been presented. Gini coefficients were estimated individually for the state distributions of R&D obligations and scientists and for state distributions of R&D obligations relative to state distributions of scientists. Evidence of changing concentration was not indicated in either case.

In addition, we can look at the geographic distributions of disaggregations of federal R&D obligations, by agency and performer, and of scientists, by type of employer.

Gini coefficients for agency R&D obligations are shown in Table 1. Although the coefficients for 1961 are again not directly comparable with those for 1963 and 1965, definite patterns do appear. Stable or lessening concentration is indicated for DOD, AEC, NASA, and the Interior Department, while increasing concentration appears for the Departments of Agriculture and Commerce, HEW, and perhaps NSF. Agencies with stable or lessening concentration account for more than 90 percent of total R&D obligations [11, p. 51]. Only HEW, NSF, and the Departments of Agriculture and Interior, which together account for less than 10 percent of the total obligations, have Gini coefficients smaller than those for total R&D obligations. In general, agencies with increasing concentration are less concentrated than total R&D obligations and at the same time account for a very small part of the total.

Similar results are shown for the distributions of R&D funds received by R&D performers (Table 1). In this case, extramural and intramural performers are reported separately, so that the coefficients are comparable for 1961. Increasing concentration is only indicated clearly for other performers, which accounts for less than 1 percent of total obligations. The other coefficients have stable or decreasing values. R&D obligations of educational institutions and other performers are less concentrated than total R&D obligations, but these two classes of R&D performers account for approximately 12 percent of total obligations [11, p. 50].

Gini coefficients for the state distributions of scientists by type of employer (Table 2) are shown for 1962 and 1964.[5] In this time period, increasing concentration is shown for federally-employed scientists, who account for approximately 10 percent of the total. Stable concentration is indicated for scientists employed in educational institutions, industry, and other non-profit institutions. In this case, all classes of scientists, except those employed in educational institutions, are more concentrated than total scientists. Scientists employed by educational institutions account for one-third of total scientists; another one-third are employed in industry. [13, p. 1].

Gini coefficients in Table 3 for the state distributions of agency R&D obligations relative to the state distribution of total scientists measure the inequality between the two distributions for each agency between FY1961/1962 and FY 1965/1966. Increased inequality is suggested only for AEC and the Department of Commerce; stable or declining inequality is shown for the other agencies.

Similarly, the distributions of R&D obligations for educational institutions, industry, and other non-profit institutions are compared in Table 4 to the distribution of scientists employed in the corresponding institutions. Greater equality between R&D obligations and scientists is clearly indicated for each of the three types of R&D performers.

CONCLUSIONS

These findings do not support the contention that there has been an increasing concentration of federal R&D funds and R&D activity. Instead there is evidence that the overall level of concentration among states has remained stable or, perhaps, a faint indication that it has declined.

The results might have been different for smaller regions; however, the available data do not permit conclusions about regions other than states. The conclusions are also contingent on the extent to which state data on federal R&D obligations and scientists represent actual federal R&D expenditures and R&D activity in states.

We have established neither the existence, or lack of it, of the responsiveness

of R&D activity in general to the geographic distribution of federal R&D funds. If the question of the geographic effects of federal R&D funds is sufficiently important to require its consideration in the R&D policies of federal agencies, then the whole issue should be drawn more narrowly to examine the regional effects of specific R&D programs on particular types of scientific activity.

The conclusions may not apply after 1965-1966 during a time in which existing priorities in federal expenditures have changed because of the Vietnam war and federal R&D expenditures have increased more slowly. Whereas increased R&D expenditures do not appear to have caused a greater regional concentration of federal R&D funds, the slower growth of R&D expenditures since 1965-1966 may have had that effect.

FOOTNOTES

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The expression "R&D" is used in this paper for "research and development."

[1]The concept of an equitable distribution of federal R&D funds among regions and the evolution of Congressional concern with the issues involved are discussed in [2]. Also, see [16], [17], and [18].

[2]See, [20], [1], and [3]. The choice of any one index is arbitrary. Most of the indices appear to yield approximately equivalent results.

[3]The Gini coefficient and alternative indices are discussed in [5], pp. 243-244, [6], pp. 160-167, and [7]. The mechanics of computing the value of the Gini coefficient are discussed in [6], pp.162-163.

[4]In view of the hypothesis about causation between the state distribution of federal R&D funds and R&D activity and the presumption that such causation would be lagged, there is some justification for matching the data in this fashion in addition to convenience.

[5]State data on industrial R&D expenditures [9] offer additional support for the concentration of industrial R&D activity that is indicated by Table 2 by the Gini coefficients for scientists employed by industry. Coefficients for the R&D expenditures are .696 and .693 for 1962 and 1964 which correspond both in magnitude and stability to the coefficients for industrial scientists.

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