# Conditions Favoring Major Advances in Social Science

Analysis of 62 advances since 1900 shows that most come from a few centers and have rapid effects.

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The environmental group conditions for creative success in the social sciences are a frequent subject for debate. It is not generally realized how much information about these creative conditions can be obtained from a statistical analysis of creative instances. To examine this question, we made a list of some 62 leading achievements in the social sciences in this century (see Table 1). With this list we have tried to explore the following major groups of questions.

1) Which were the major achievements, or advances, or breakthroughs in the social sciences from 1900 to 1965? Are there publicly verifiable criteria by which they can be recognized? Can such advances be called cumulative in the sense proposed by J. B. Conant—that is, have successive advances been built upon earlier ones?

2) In what fields did such breakthroughs occur?

3) Did major advances relate mainly to theory, or to method, or to matters of substance? In what fields did such advances occur most often?

4) Are there any changes and trends over time in the incidence and characteristics of these breakthroughs?

5) Who accomplished such advances most often—individuals or teams?

6) What were the ages of the contributors at the time of their achievements? Did they have any special personality characteristics?

7) Were the results quantitative, explicitly or by implication?

8) Did such breakthroughs require much capital? Manpower? Other resources?

9) Where were they accomplished? At what geographic locations? At what types of institutions? Under what social and political conditions?

10) Where did the ideas come from? Were most advances made primarily within existing disciplines, or were they mainly interdisciplinary in character?

11) Did the major advances have any close relation to social practice? Were they inspired or provoked by practical demands or conflicts? Were they applied to practice? If so, were they applied by or to individuals, small or middle-sized groups, or national governments and states?

12) How long was the delay between each major breakthrough and its first major impact on social science or social practice, or both?

Some of the evidence bearing on these questions is summarized in Table 1 in relation to the 62 achievements in the years 1900–65. The achievements themselves were selected on the basis of our personal judgment as to their importance for social science in this century. We also called upon the opinions and advice of a number of colleagues in other fields, and we checked each contribution against the relevant entries of the recent edition of the *International Encyclopedia of the Social Sciences* (*1*).

The full range of answers to our questions, including various kinds of statistical analyses, will be given elsewhere (*2*), but some of the broad results of more general interest are summarized here. There are three principal findings from this study. (i) There *are* such things as social science achievements and social inventions, which are almost as clearly defined and as operational as technological achievements and inventions. (ii) These achievements have commonly been the result of conscious and systematic research and development efforts by individuals or teams working on particular problems in a small number of interdisciplinary centers. (iii) These achievements have had widespread acceptance or major social effects in surprisingly short times; median times are in the range of 10 to 15 years, a range comparable with the median times for widespread acceptance of major technological inventions.

## Criteria for Recognizing Major Advances in Social Science

The major achievements or breakthroughs selected for this study were defined as having the following characteristics. First, they either had to involve a new perception of relationships or they had to result in new operations, including scientific operations. That is, they had to help people see something not perceived before, as represented by new discoveries (statements of the form "there is . . .") or new verifiable propositions (statements of the form "if . . . then . . ."); or else they had to create the possibility of doing something that had not been done before.

A second essential condition for any major contribution, whether of perceptions or of operations, was that it should have proved fruitful in producing a substantial impact that led to further knowledge. Impacts simply upon social practice were treated as interesting but nonessential.

We believe that the 62 contributions listed in Table 1 are among the most significant achievements in social science that satisfy these criteria in the years 1900–65. We should emphasize that there is no intent to use this list for any invidious bestowal of professional recognition and that other achievements might well be chosen by other criteria of significance or for other purposes.

We omitted purely technical achievements such as television, in spite of their great impact on society, in the belief that they have thus far not contributed to social science in the way, for instance, that computers have. We also omitted the more purely political and organizational achievements, such as the National Aeronautics and Space Administration (NASA), the Manhattan Project, the British National Health

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Table 1. Basic innovations in social science, 1900–65. Abbreviations in column 1: An, anthropology; Ec, economics; Math, mathematics; Phil, philosophy, logic, and history of science; Pol, politics; Psy, psychology; Soc, sociology. In column 6, + N indicates a larger number of collaborators with a less crucial share in the work. Abbreviations in column 7: QFE, quantitative findings explicit; QPE, quantitative problems explicit; QPI, quantitative problems implied; Non-Q, predominantly nonquantitative.

| Contribution<br>1 | Contributor<br>2 | Time<br>3 | Place<br>4 | Type of support<br>5 | No. of workers<br>6 | Quantitative aspects<br>7 | Years until impact<br>8 |
|---|---|---|---|---|---|---|---|
| 1. Theory and measurement of social inequalities (Ec) | V. Pareto<br>C. Gini | 1900<br>1908 | Lausanne, Swit.<br>Cagliari, It.<br>Padua, It.<br>Rome, It. | University chairs | 1 + N | QFE | 25 |
| 2. Sociology of bureaucracy, culture, and values (Soc) | M. Weber | 1900–21 | Freiburg, Ger.<br>Heidelberg, Ger.<br>Munich, Ger. | University chair with research support | 1 | QPI | 20 ± 10 |
| 3. Theory of one-party organization and revolution (Pol) | V. I. Lenin | 1900–17 | Shushenskoe, Siberia<br>London, Eng.<br>Munich, Ger. | Underground party | 1 + N | QPI | 10 ± 5 |
| 4. Psychoanalysis and depth psychology (Psy) | S. Freud<br>C. G. Jung<br>A. Adler | 1900–25<br>1910–30<br>1910–30 | Vienna, Aus. | University institute of psychology | 1 + N | Non-Q | 30 ± 10 |
| 5. Correlation analysis and social theory (Math) | K. Pearson<br>F. Edgeworth<br>R. A. Fisher | 1900–28<br>1900–30<br>1920–48 | London, Eng.<br>Oxford, Eng.<br>Cambridge, Eng.<br>Harfenden, Eng. | University chairs | 1 + N | QFE | 25 ± 15 |
| 6. Gradual social transformation (Pol) | B. Webb<br>S. Webb<br>G. B. Shaw<br>H. G. Wells | 1900–38 | London, Eng. | Fabian society | 4 + N | QPE | 35 ± 5 |
| 7. Elite studies (Soc) | G. Mosca<br>V. Pareto<br>H. D. Lasswell | 1900–23<br>1900–16<br>1936–52 | Turin, It.<br>Lausanne, Swit.<br>Chicago, Ill. | University institutes | 1 + N | QFE | 40 ± 10 |
| 8. Unity of logic and mathematics (Phil) | B. Russell<br>A. N. Whitehead | 1905–14 | Cambridge, Eng. | University institute | 2 | QPE | 30 |
| 9. Pragmatic and behavioral psychology (Psy) | J. Dewey<br>G. H. Mead<br>C. Cooley<br>W. I. Thomas | 1905–25<br>1900–34<br>1900–30<br>1900–40 | Ann Arbor, Mich.<br>Chicago, Ill.<br>Ann Arbor, Mich.<br>Chicago, Ill.<br>New York, N.Y. | University chairs | 1 | Non-Q | 20 ± 10 |
| 10. Learning theory (Psy) | E. L. Thorndike<br>C. Hull *et al.* | 1905–40<br>1929–40 | New York, N.Y.<br>New Haven, Conn. | Teachers college, Institute of human relations | 1 + N | QFE | 20 ± 5 |
| 11. Intelligence tests (Psy) | A. Binet<br>L. Terman<br>C. Spearman | 1905–11<br>1916–37<br>1904–27 | Paris, Fr.<br>Stanford, Calif.<br>London, Eng. | Testing organizations | 1 + N | QFE | 15 ± 5 |
| 12. Role of innovations in socioeconomic change (Ec) | J. A. Schumpeter<br><br>W. F. Ogburn<br>A. P. Usher<br>J. Schmookler | 1908–14<br>1946–50<br>1922–30<br>1924<br>1966 | Vienna, Aus.<br>Cambridge, Mass.<br>New York, N.Y.<br>Cambridge, Mass.<br>Minneapolis, Minn. | University chair and research program | 1 + N | QPI | 40 |
| 13. Conditioned reflexes (Psy) | I. Pavlov | 1910–30 | Leningrad, U.S.S.R. | Imperial medico-surgical academy | 1 + N | QPI | 20 ± 10 |
| 14. Gestalt psychology (Psy) | M. Wertheimer<br>K. Koffka<br>W. Koehler | 1912–32 | Berlin, Ger. | University chairs | 3 + N | Non-Q | 25 ± 5 |
| 15. Sociometry and sociograms (Soc) | J. L. Moreno | 1915<br>1934–43 | Innsbruck, Aus. | University chair | 1 | QFE | 10 |
| 16. Soviet type of one-party state (Pol) | V. I. Lenin *et al.* | 1917–21 | Leningrad, U.S.S.R. | Politburo | 1 + N | QPI | 5 ± 5 |
| 17. Large-scale nonviolent political action (Pol) | M. K. Gandhi | 1918–34 | Ahmedabad, India | Political movement and institute (ashram) | 1 + N | Non-Q | 15 ± 10 |

| Contribution 1 | Contributor 2 | Time 3 | Place 4 | Type of support 5 | No. of workers 6 | Quantitative aspects 7 | Years until impact 8 |
|---|---|---|---|---|---|---|---|
| 18. Central economic planning (Ec) | Q. Krassin<br>G. Grinko | 1920–26 | Moscow, U.S.S.R. | Government institute | 1 + N | QFE | 7 ± 6 |
| 19. Social welfare function in politics and economics (Ec) | A. C. Pigou<br>K. Arrow | 1920–56<br>1951 | London, Eng.<br>Stanford, Calif. | University chairs | 1 + N | QPE | 40 ± 10 |
| 20. Logical empiricism and unity of science (Phil) | M. Schlick<br>R. Carnap<br>O. Neurath<br>P. Frank<br>L. Wittgenstein<br>H. Reichenbach<br>C. Morris | 1921–38<br><br><br><br><br>1921<br>1936–50 | Vienna, Aus.<br><br><br><br>Cambridge, Eng.<br>Berlin, Ger.<br>Chicago, Ill.<br>Cambridge, Mass. | Vienna circle and university chairs<br><br><br><br><br>University chairs | 3 + N | QPI | 20 ± 5 |
| 21. Quantitative mathematical studies of war (Pol) | L. F. Richardson<br>Q. Wright | 1921–55<br>1936–66 | London, Eng.<br>Chicago, Ill. | University chair and research program | 1 + N | QFE | 25 ± 10 |
| 22. Projective tests (Psy) | H. Rorschach<br>H. Murray | 1923 | Herisau, Swit.<br>Cambridge, Mass. | Cantonal mental institute<br>University chair | 1 | Non-Q | 15 ± 5 |
| 23. Sociology of knowledge and science (Soc) | K. Mannheim<br><br>R. K. Merton<br>D. deS. Price | 1923–33<br><br>1937<br>1950–60 | Heidelberg, Ger.<br>Frankfurt, Ger.<br>Princeton, N.J.<br>New Haven, Conn. | University chairs, institutes, and programs | 1 + N | Non-Q | 10 |
| 24. Quantitative political science and basic theory (Pol) | C. Merriam<br>S. Rice<br>H. Gosnell<br>H. D. Lasswell | 1925–36 | Chicago, Ill. | University chairs | 3 + N | QFE | 15 ± 5 |
| 25. Functionalist anthropology and sociology (An) | A. R. Radcliffe-Brown<br><br><br><br>B. Malinowski<br>T. Parsons | 1925<br><br><br><br>1925–45<br>1932–50 | Cape Town, S. Afr.<br>Sidney, Aus.<br>Chicago, Ill.<br>Oxford, Eng.<br>London, Eng.<br>Cambridge, Mass. | University chairs and travel grants | 1 + N | Non-Q | 20 ± 10 |
| 26. Ecosystem theory (Soc) | R. Park<br>E. W. Burgess | 1926–38 | Chicago, Ill. | University chairs | 2 + N | QFE | 25 ± 5 |
| 27. Factor analysis (Math) | L. Thurstone | 1926–48 | Chicago, Ill. | University chair | 1 + N | QFE | 15 ± 10 |
| 28. Operational definitions (Phil) | P. W. Bridgman | 1927–38 | Cambridge, Mass. | University chair | 1 | QPI | 15 ± 5 |
| 29. Structural linguistics (Math) | R. Jakobson and Prague circle<br>N. Chomsky | 1927–67<br><br>1957– | Brno, Czech.<br>Cambridge, Mass.<br>Cambridge, Mass. | University chairs and programs | 1 + N | QPE | 20 ± 10 |
| 30. Economic propensities, employment, and fiscal policy (Ec) | J. M. Keynes | 1928–44 | Cambridge, Eng. | University chair | 1 + N | QFE | 6 ± 4 |
| 31. Game theory (Math) | J. v. Neumann<br>O. Morgenstern | 1928–44<br>1944–58 | Berlin, Ger.<br>Princeton, N.J. | University chairs and institute | 2 + N | QFE | 10 ± 5 |
| 32. Peasant and guerrilla organization and government (Pol) | Mao Tse-tung | 1929–49 | Kiangsi, P. R. China<br>Yenan, P. R. China<br>Peking, P. R. China | Political movement | 1 + N | QPI | 15 ± 10 |
| 33. Community studies (Soc) | R. Lynd<br>H. Lynd<br>L. Warner<br>C. Kluckhohn | 1929–62<br><br>1941 | New York, N.Y.<br><br>Chicago, Ill. | University chairs | 2 | QFE | 20 ± 5 |

| Contribution 1 | Contributor 2 | Time 3 | Place 4 | Type of support 5 | No. of workers 6 | Quantitative aspects 7 | Years until impact 8 |
|---|---|---|---|---|---|---|---|
| 34. Culture and personality and comparative child rearing (An) | R. Benedict<br>M. Mead<br>G. Gorer<br>A. Kardiner<br>J. Piaget<br>E. Erikson<br>J. Whiting<br>I. Child | 1930<br>1930<br><br>1939<br>1940–60<br>1950<br>1953 | New York, N.Y.<br><br><br><br>Geneva, Swit.<br>Cambridge, Mass.<br>Cambridge, Mass.<br>New Haven, Conn. | University chairs, research projects, and travel grants | 3 + N | Non-Q | 20 ± 10 |
| 35. Economics of monopolistic competiton (Ec) | E. H. Chamberlin<br>J. Robinson | 1930–33 | Cambridge, Mass.<br>Cambridge, Eng. | University chairs | 1 | QPE | 10 ± 5 |
| 36. Authoritarian personality and family structure (Psy) | M. Horkheimer<br>H. Marcuse<br>E. Fromm<br>T. Adorno *et al.*<br>A. Mitscherlich | 1930–32<br><br><br>1950<br>1962 | Frankfurt, Ger.<br><br><br>Stanford, Calif.<br>Frankfurt, Ger.<br>Heidelberg, Ger. | Institute for social research and university | 3 + N | QPI | 20 ± 5 |
| 37. Large-scale sampling in social research (Math) | M. Hansen | 1930–53 | Washington, D.C. | Government office | N | QFE | 5 |
| 38. Laboratory study of small groups (Psy) | K. Lewin<br>R. Lippitt<br>R. Likert<br>D. Cartwright | 1932–36 | Cambridge, Mass. | University and research institutes | 1 + N | QPI | 10 ± 5 |
| 39. National income accounting (Ec) | S. Kuznets<br>C. Clark<br>U.N. Statistical Office | 1933–40<br><br>1953 | Philadelphia, Pa.<br>Cambridge, Eng.<br>Washington, D.C.<br>New York, N.Y. | Public research institutes and university chairs | 1 + N | QFE | 10 ± 5 |
| 40. General systems analysis (Phil) | L. v. Bertalanffy<br>N. Rashevsky<br>J. G. Miller<br>A. Rapoport<br>R. W. Gerard<br>K. Boulding | 1936<br><br>1956 | Vienna, Aus.<br>Chicago, Ill.<br>Ann Arbor, Mich. | University research institutes | 4 + N | QPI | 15 ± 5 |
| 41. Attitude survey and opinion polling (Psy) | G. Gallup<br>H. Cantril<br>P. F. Lazarsfeld<br>A. Campbell | 1936<br>1937–52<br>1940<br>1942 | Princeton, N.J.<br><br>New York, N.Y.<br>Ann Arbor, Mich. | University and research institutes, commercial organizations | 3 + N | QFE | 5 |
| 42. Input-out analysis (Ec) | W. Leontief | 1936–53 | Cambridge, Mass. | University chair | 1 + N | QFE | 15 |
| 43. Linear programming (Ec) | L. Kantorovich<br>J. B. Souto<br>G. B. Dantzig<br>R. Dorfman | 1938–50<br>1941<br>1948<br>1958 | Leningrad, U.S.S.R.<br>Buenos Aires, Arg.<br>Washington, D.C.<br>Berkeley, Calif. | University research institutes and government office | 1 + N | QFE | 10 ± 5 |
| 44. Content analysis (Pol) | H. Lasswell<br>I. deS. Pool<br>B. Berelson<br>P. Stone | 1938–56<br><br><br>1961–66 | Chicago, Ill.<br><br><br>Cambridge, Mass. | University institute | 2 | QFE | 10 |
| 45. Operant conditioning and learning; teaching machines (Psy) | B. F. Skinner | 1938–58 | Bloomington, Ind.<br>Cambridge, Mass. | University chairs | 1 + N | QPE | 15 |
| 46. Statistical decision theory (Math) | A. Wald | 1939–50 | New York, N.Y. | University chair | 1 + N | QPE | 15 ± 5 |
| 47. Operations research and systems analysis (Math) | P. M. S. Blackett<br>P. Morse<br>R. Bellman | 1941–50<br>1941–58 | London, Eng.<br>Cambridge, Mass. | Government research institutes | N | QPE | 5 |
| 48. Scaling theory (Psy) | L. Guttman<br>C. Coombs | 1941–54 | Ithaca, N.Y.<br>Ann Arbor, Mich. | University chairs | 3 + N | QFE | 10 ± 5 |

| Contribution 1 | Contributor 2 | Time 3 | Place 4 | Type of support 5 | No. of workers 6 | Quantitative aspects 7 | Years until impact 8 |
|---|---|---|---|---|---|---|---|
| 49. Quantitative models of nationalism and integration (Pol) | K. Deutsch<br>B. Russett<br>R. L. Merritt | 1942–67 | Cambridge, Mass.<br>New Haven, Conn. | University chairs | 1 + N | QFE | 20 ± 5 |
| 50. Theories of economic development (Ec) | P. Rosenstein-Rodan<br>R. Prebisch<br>R. Nurkse<br>W. A. Lewis<br>G. Myrdal<br>A. O. Hirschman<br>R. F. Harrod<br>E. Domar<br>H. Chenery | 1943–58 | London, Eng.<br>Santiago, Chile<br>New York, N.Y.<br>Manchester, Eng.<br>Stockholm, Swed.<br>New Haven, Conn.<br>Oxford, Eng.<br>Baltimore, Md.<br>Stanford, Calif. | Government offices, U.N. regional commission, university chairs | 6 + N | QFE | 10 ± 5 |
| 51. Computers (Math) | V. Bush<br>S. Caldwell<br>D. P. Eckert<br>J. W. Mauchly | 1943–58 | Cambridge, Mass.<br><br>Philadelphia, Pa. | University and government research laboratories | N | QFE | 10 ± 5 |
| 52. Multivariate analysis linked to social theory (Soc) | S. Stouffer<br>T. W. Anderson<br>P. Lazarsfeld | 1944–54 | Washington, D.C.<br>Cambridge, Mass.<br>New York, N.Y. | Government and university research institutes | 3 + N | QFE | 5 |
| 53. Information theory, cybernetics, and feedback systems (Math) | C. Shannon<br>N. Wiener | 1944–58 | Cambridge, Mass.<br>Orange, N.J. | University research institute and Bell Laboratories | 2 + N | QFE | 10 ± 5 |
| 54. Econometrics (Ec) | J. Tinbergen<br>P. Samuelson<br>E. Malinvaud | 1935–40<br>1947<br>1964 | The Hague, Neth.<br>Cambridge, Mass.<br>Paris, Fr. | Government institute and university chairs | 1 + N | QFE | 10 ± 5 |
| 55. Cognitive dynamics of science (Phil) | J. B. Conant<br>I. B. Cohen<br>T. Kuhn<br>D. deS. Price | 1946–64 | Cambridge, Mass.<br><br>Berkeley, Calif.<br>New Haven, Conn. | University chairs | 3 + N | Non-Q | 15 |
| 56. Computer simulation of economic systems (Ec) | L. Klein<br>G. Orcutt | 1947–60 | Philadelphia, Pa.<br>Madison, Wis. | Research institutes | 2 +N | QFE | 5 |
| 57. Structuralism in anthropology and social science (An) | C. Levi-Strauss | 1949–66 | Paris, Fr. | Museum (government) | 1 +N | QPI | 15 ± 5 |
| 58. Hierarchical computerized decision models (Math) | H. Simon | 1950–65 | Pittsburgh, Pa. | University research institute | 1 +N | QPE | 10 |
| 59. Cost-benefit analysis (planned programming and budgeting) (Pol) | C. Hitch | 1956–63 | Santa Monica, Calif. | Government-related research institute | 3 +N | QFE | 7 |
| 60. Computer simulation of social and political systems (Pol) | W. McPhee<br>H. Simon<br>A. Newell<br>I. Pool<br>R. Abelson | 1956–66<br><br><br>1958–64 | Pittsburgh, Pa.<br><br><br>Cambridge, Mass.<br>New Haven, Conn. | University chairs and research institutes | 2 +N | QPE | 5 ± 3 |
| 61. Conflict theory and variable sum games (Psy) | A. Rapoport | 1960– | Ann Arbor, Mich. | University research institute | 1 +N | QFE | 2 |
| 62. Stochastic models of social processes (Math) | J. S. Coleman | 1965 | Baltimore, Md. | University and research institute | 1 +N | QFE | 5 |

Service, the European Common Market, the Tennessee Valley Authority, credit cards, "think tanks," the great public and private foundations, the Peace Corps, and the partial Nuclear Test Ban Treaty, although all these have intellectual components that would justify their inclusion in a broader list. On the same grounds, we omitted such primarily practical innovations as Henry Ford's development of the assembly line; the time and motion studies by F. W. Taylor and his followers; the studies of human relations in industry by F. J. Roethlisberger and his associates; the development of such rural organizations as the *kibbutzim* in Israel and the *kolkhozy* in the Soviet Union; B. Ruml's invention of the "pay-as-you-go income tax"; the development of high-information teaching by J. Zacharias and associates; man-and-computer designs as developed by C. E. Shannon, R. Fano, and others; and the proposal for a guaranteed annual income, or a negative income tax, by J. Tobin, M. Friedman, and other economists. By contrast, the innovations by Lenin, Mao, Gandhi, and the Webbs were included because they were connected with explicit theories.

Several contributions seemed to us to constitute borderline cases. In social psychology, these include the frustration-aggression hypothesis by J. Dollard, N. Miller, and their collaborators (New Haven, Connecticut, 1940); the theory of cognitive dissonance developed by L. Festinger, R. Abelson, and others (Stanford, California, and New Haven, 1956–57); the development of cognitive anthropology by F. Lounsbury and others (New Haven, 1956–68); the concept and measurement of the semantic differential by C. Osgood, G. J. Suci, and P. H. Tannenbaum (Urbana, Illinois, 1957); and the concept and partial measurement of achievement motivation by D. E. McClelland (Middletown, Connecticut, 1953, and later Cambridge, Massachusetts, 1961). At the borderlines of psychology, we find the discovery of a wider range of mind-influencing drugs; the works of K. Lorenz and others on "imprinting" in young animals; the broader explorations in the chemistry of memory; and the work on the electric stimulation on brain centers directing larger sequences of behavior, by J. Delgado and others. None of these have been included in our present list, primarily because we were not sure that the impact of any of these contributions on broader areas of the social sciences has been as large and lasting, so far, as the impact of the contributions that we did include. A future tabulation may well have to include some or all of these present-day borderline cases. In any case, a comparison with our tables in this article will show that an inclusion of these borderline cases would have strengthened rather than weakened the trends indicated by our major findings.

Table 2. Major social science contributions by field and focus, 1900 to 1965.

| Field | Total | Major contributions | | Focus on theory | | Focus on method | | Focus on results | |
|---|---|---|---|---|---|---|---|---|---|
| | 1900 to 1965 | 1900 to 1929 | 1930 to 1965 | 1900 to 1929 | 1930 to 1965 | 1900 to 1929 | 1930 to 1965 | 1900 to 1929 | 1930 to 1965 |
| Psychology | 13 | 7 | 6 | 6 | 3 | 6 | 6 | 6 | 6 |
| Economics | 12 | 5 | 7 | 4 | 5 | 4 | 6 | 5 | 7 |
| Politics | 11 | 7 | 4 | 7 | 2 | 2 | 4 | 4 | 4 |
| Mathematical statistics | 11 | 4 | 7 | 2 | 5 | 4 | 7 | 4 | 6 |
| Sociology | 7 | 6 | 1 | 4 | 1 | 5 | 1 | 6 | 1 |
| Philosophy | 5 | 3 | 2 | 3 | 2 | 2 | 2 | 0 | 1 |
| Anthropology | 3 | 1 | 2 | 1 | 2 | 0 | 2 | 1 | 2 |
| Total | 62 | 33 | 29 | 27 | 20 | 23 | 28 | 26 | 27 |

Clearly, other individuals and other schools of thought would have a different ranking for particular achievements, but one would hope that within our chosen boundaries there would be a considerable amount of overlap within the academic community in evaluating the top 50 to 70 contributions in this century.

An inspection of our list shows that many of the later contributions were clearly building on the earlier ones, and that they resulted in clear increases in the powers of social scientists to recognize relationships and to carry out operations. Many of the advances had a substantial impact on the subsequent development of several social sciences and on social practice as well. Together these advances add up to unmistakable evidence of the cumulative growth of knowledge in the social sciences in the course of this century. Today, statements such as "we know no more about human psychology and politics than Aristotle did" mainly express the ignorance of those who utter them.

## Main Fields of Advances

The assignment of major social science innovations to particular fields is indicated in column 1 of Table 1, and their distribution among fields is shown in column 1 of Table 2. Table 2 reveals the leading position of psychology, economics, and politics with 13, 12, and 11 major contributions, respectively. On the average, therefore, a major advance was made every 5 or 6 years in *each* of these three fields.

Several contributions that involve the applications of mathematical and statistical methods to these subject fields are included in these numbers; thus linear programming and the computer simulation of economic systems were each coded as contributions to economics.

There were 11 major contributions that were primarily mathematical or statistical in nature but that were coded in a separate category, even though they may have had applications in various substantive fields. Factor analysis and information theory are two examples of this category. Although these coding rules tend to underrepresent the number of major advances in social science methods, it still appears that a major advance in mathematical or statistical method was made on the average at least once every 6 years.

Substantive advances in sociology seemed to have occurred once per decade, and in anthropology about once every 20 years. These calculations somehow underrepresent, however, the actual rate of progress in these fields, particularly with regard to sociology. Several of the advances in social psychology, political science, and even economics were almost as important for the progress of sociology as they were in their fields of origin.

Another five contributions resemble those in mathematics and statistics in that their primary impact was not in any substantive fields of social science. Since they were not primarily quantitative, however, we coded them in a separate category as philosophy, logic, and history of science. Russell and

Table 3. Capital requirements and quantitative results, 1900 to 1965. "High" and "low" refer to the level of capital required.

| Type of result | 1900 to 1929 | | 1930 to 1965 | | 1900 to 1965 | |
|---|---|---|---|---|---|---|
| | High | Low | High | Low | High | Low |
| Nonquantitative results | 1 | 6 | 0 | 2 | 1 | 8 |
| Applications to quantitative problems explicit and/or implied | 3 | 9 | 4 | 5 | 7 | 14 |
| Quantitative findings explicit | 4 | 10 | 14 | 4 | 18 | 14 |
| Total | 8 | 25 | 18 | 11 | 26 | 36 |

Whitehead's demonstration of the unity of logic and science, the work of the Vienna circle on the unity of science, and Kuhn's work on the role of paradigms in scientific revolutions are examples of such entries.

### Theory, Method, or Substance?

Important advances typically combine theory, methods, and results, rather than choosing one of these elements as a focus of interest. Our analysis of these factors is summarized in Table 2. Most often such advances have cut across at least two of these aspects of social science and have often crossed all three of them. In the light of these findings the long-standing quarrel about whether to emphasize theory, methodology, or empirical results seems ill-conceived and obsolete. All three seem to form part of one production cycle of knowledge, and substantial advances in any one of these three phases are likely to lead to advances in the other two.

### Trends with Time

Substantial social science advances at the level of importance examined here have been surprisingly frequent, averaging close to one advance per year. When we take into account the greater difficulty of estimating the full impact of social science contributions after 1950, which drastically reduces the number of such contributions in our count, it seems that this high frequency has remained at least undiminished since 1930. Social science investigators who need to keep informed in several disciplines thus face serious problems in the partial obsolescence of their information.

A more detailed analysis indicates that the distribution of advances shows a certain amount of clustering in time. Particular fields show "great periods" of 5 to 15 years during which substantial advances were frequent, and two such great periods, 1925–29 and 1940–44, are common to many fields. (If several promising contributions that we considered but did not include in our count should prove to be fundamental, then the decade 1955–65 may yet prove to have been another period of greatness.) Since great periods often last several years, whereas 10 to 15 years may be required for working out the implications of particular achievements or for applying them to practice (Table 1, column 8), it would seem rational to organize 10- or 15-year programs of support in any social science field after a few initial breakthroughs have occurred.

### Individuals or Teams?

Individual researchers produced nearly two-thirds of all major advances over the entire 1960–65 period, but our study indicates that their share declined from about three-quarters of all contributions before 1930 to less than one-half thereafter (Table 1, column 6). Teams of social scientists, by contrast, increased their contributions from less than one-quarter before 1930 to more than one-half thereafter. Teams of social scientists seem likely to be the main source of major advances during the next decade, but individual social scientists operating in the traditional "great man" or "lone wolf" styles will continue to be a significant, though secondary, source of new ideas.

### Ages of the Contributors

The ages of the contributors at the time they made their breakthroughs have also been examined. Details of the analysis will not be given here, but for the entire period 1900–65, the median age group among 160 contributors was between 35 and 39 years, with a mean of 37 years. The modal age group, with 40 contributors, was a little older, in the range of 40 to 44 years. Slightly more than 40 percent of all contributors were more than 40 years old at the time of their contribution, but only 6 percent were over 50 years. The psychologists tend to be somewhat younger, the sociologists and anthropologists somewhat older, than the contributors in the other fields.

Since 1930 the contributors tend to be younger, with the modal age moving to the 30 to 34 age group. However, this could be an artifact, due to our better knowledge of the earlier stages of more recent developments. It also seems that the youngest contributors are in the fields with the largest number of contributors. Conceivably some fields are intrinsically more difficult today and require more experience for any successes.

It is worth emphasizing that older scientists are necessarily less numerous in any rapidly growing field, as D. Price has noted (*3*). Since the number of social scientists grew between 1900 and 1965 at a rate of about 5 percent per

Table 4. Geographic locations of major social science advances, 1900–65 (by continents and by countries in Europe).

| | By continents | | | | By countries in Europe | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Europe | North America (U.S.A.) | Other | Total | England | Germany | Russia | Austria | France | Switzerland | Other | Total |
| 1900–29 | 33 | 12 | 4 | 49 | 13 | 8 | 4 | 3 | 1 | 2 | 2 | 33 |
| 1930–65 | 11 | 41 | 0 | 52 | 4 | 2 | 1 | 1 | 1 | 0 | 2 | 11 |
| 1900–65 | 44 | 53 | 4 | 101 | 17 | 10 | 5 | 4 | 2 | 2 | 4 | 44 |

year, doubling every 14 years, the proportion of scientists in the age groups 20 to 34, 35 to 49, and 50 to 64 at any given time is roughly as 4 : 2 : 1. When the creativity curves are normalized to take account of these differences in numbers, the creativity of men over 50 for social science achievements of this sort is comparable to that of the men under 35, but the mode is still in the 35- to 49-year range.

Our findings on the ages of peak creativity in these fields are in fair agreement with those of H. C. Lehman for the fields of architecture, psychology, economics, and education theory (*4*).

Our biographical information is uneven and incomplete, but it suggests that the key members of the post-1930 teams were not colorless cogs in an anonymous machine. Usually we find among them strong and highly individualistic personalities, with some of the strengths and weaknesses found in the personalities of artists. Often they have appeared to some of their contemporaries as "rude and overbearing men," impatient with disagreement and obtuseness and unwilling to suffer fools or critics gladly. The decisive difference from the past is that today these creative individuals nonetheless know how to work with other people, how to support others, and how to elicit their cooperation and support in turn. Indeed, a surprising number of them founded significant organizations or institutes to carry on their work.

## Are the Great Achievements Quantitative or Nonquantitative?

Quantitative problems or findings (or both) characterized two-thirds of all advances, and five-sixths of those were made after 1930 (Table 1, column 7). Completely nonquantitative contributions—the recognition of new patterns without any clear implication of quantitative problems—were rare throughout the period and extremely rare since 1930. Nonetheless, they include such substantial contributions as psychoanalysis, Rorschach tests, and the work on personality and culture; thus, their potential for major contributions in the future should not be underrated. Certainly both types of scientific personalities, the quantifiers and the pattern-recognizers—the "counters" and the "poets"—will continue to be needed in the social sciences.

## Requirements in Capital, Manpower, and Time

The making and testing of any new discovery require some kind of investment in the form of capital equipment, manpower, or the principal investigator's time. Libraries represent relatively low capital requirements per investigator, but special laboratories, computing facilities, and organizations for survey or implementation represent high capital requirements.

In manpower, the extremes are represented by a single scientist working at a desk, or by the need for large numbers of laboratory assistants, polltakers, or tabulating clerks. In time, some achievements may require relatively short periods of insight and working out, whereas others require years of the principal investigator's time and thought, as did Max Weber's historical and sociological studies or Freud's development of psychoanalysis. We have coded each contribution in terms of these three types of requirements and analyzed their distributions.

Of particular interest was the difference in high and low capital requirements for the quantitative and the nonquantitative contributions, as summarized in Table 3. Here we find that out of 26 high capital contributions during the entire period, 18 produced explicit quantitative findings, whereas out of 36 contributions with low capital requirements only 14 produced such explicit quantitative results. There was already a tendency toward higher capital requirements for quantitative work in the 1900–29 period, but it becomes considerably stronger after 1930 as high capital work has become more frequent.

The perception of social science work as cheap—a notion that is widespread among laymen and some university administrators—seems based on the experiences before 1930, when only one-fourth of all major social science contributions required major amounts of capital. Since 1930 more than three-fifths of all contributions have required relatively large amounts of capital, particularly for survey research and large-scale tabulations (see Table 3), and this proportion seems likely to increase in the future. If explicit quantitative results are desired, the requirement for capital support becomes still stronger. Low-budget research, the work of lone individuals, or work on nonquantitative topics may play a smaller and smaller role. The industrial revolution in the production of knowledge has not only reached a large part of the natural sciences but has reached the social sciences as well.

Table 5. Geographic locations of major social science advances, 1900 to 1965 (by cities).

| | 1900 to 1929 | 1930 to 1965 | 1900 to 1965 |
|---|---|---|---|
| | *England* | | |
| London | 7 | 2 | 9 |
| Cambridge | 4 | 1 | 5 |
| Oxford | 2 | 0 | 2 |
| Manchester | 0 | 1 | 1 |
| Total | 13 | 4 | 17 |
| | *Germany* | | |
| Berlin | 3 | 1 | 4 |
| Heidelberg | 2 | 0 | 2 |
| Frankfurt | 1 | 1 | 2 |
| Munich | 1 | 0 | 1 |
| Freiburg | 1 | 0 | 1 |
| Total | 8 | 2 | 10 |
| | *Austria* | | |
| Vienna | 3 | 1 | 4 |
| | *Russia* | | |
| Leningrad | 2 | 1 | 3 |
| Moscow | 1 | 0 | 1 |
| Shushenskoe, Siberia | 1 | 0 | 1 |
| Total | 4 | 1 | 5 |
| | *Others in Europe* | | |
| Paris | 1 | 1 | 2 |
| Turin | 1 | 0 | 1 |
| Lausanne | 1 | 0 | 1 |
| Herisau | 1 | 0 | 1 |
| Brno | 1 | 0 | 1 |
| Rotterdam | 0 | 1 | 1 |
| Stockholm | 0 | 1 | 1 |
| Total | 5 | 3 | 8 |
| | *United States* | | |
| Chicago | 7 | 3 | 10 |
| Cambridge | 1 | 9 | 10 |
| New York | 2 | 5 | 7 |
| Washington | 0 | 5 | 5 |
| Ann Arbor | 1 | 3 | 4 |
| New Haven | 1 | 3 | 4 |
| Ithaca | 0 | 2 | 2 |
| Pittsburgh | 0 | 2 | 2 |
| Philadelphia | 0 | 2 | 2 |
| Princeton | 0 | 1 | 1 |
| Orange | 0 | 1 | 1 |
| Baltimore | 0 | 1 | 1 |
| Madison | 0 | 1 | 1 |
| Bloomington | 0 | 1 | 1 |
| Berkeley | 0 | 1 | 1 |
| Santa Monica | 0 | 1 | 1 |
| Total | 12 | 41 | 53 |

## Where the Pioneers Were

An analysis of major social science contributions by location is difficult because many investigators moved during the course of their work and because many advances involved the work of several investigators with changing institutional affiliations. Also, our own greater familiarity with some countries, institutions, and fields of social science may have distorted our assignments of

Table 6. Types of institutions where major social science advances were initiated, 1900 to 1965.

| Type | 1900 to 1929 | 1930 to 1965 | 1900 to 1965 |
|---|---|---|---|
| 1. University chair or lectureship | 19 | 10 | 29 |
| 2. Institute or project | 6 | 12 | 18 |
| 3. Government research organization | 2 | 7 | 9 |
| 4. Combined items 2 and 3 | 8 | 19 | 27 |
| 5. Nongovernmental political organization | 5 | 0 | 5 |
| 6. Other | 1 | 0 | 1 |
| Total | 33 | 29 | 62 |

location. Nevertheless, some relationships in the data come out so strongly that it seems unlikely that they could have been produced by errors of this kind, and they raise some interesting questions about the conditions for creativity in the social sciences.

The results of the geographical analysis of the data in column 4 of Table 1 are shown in Tables 4 and 5. In this coding we have counted all locations where any of our 62 important advances appear to have been initiated, which gives a total of 101 locations. However, the continuation of an advance initiated elsewhere was not counted separately, even if the initiator had moved to the new location to carry on his work. Thus, the work of the Vienna circle in the philosophy of science was credited both to Vienna and Berlin (H. Reichenbach) but not to Chicago, where the work was continued after 1936.

Tables 4 and 5 show that in the period 1900–29 Europe produced three-fourths of the contributions, but after 1930 the United States produced more than three-fourths, even though our method of coding tended to favor the assignment of contributions to their first origins in Europe. (Of the American contributions in the second period, only five could be credited in the main to European-born Americans.)

Two countries, the United States and Britain, produced more than 50 percent of all major social science contributions in the 1900–29 period, and almost 90 percent in the 1930–65 period. After 1930 contributions made in the United States greatly exceeded those from the rest of the world.

Within countries, a very few capital cities or university centers accounted for the great majority of all contributions; other cities and university centers of comparable size contributed little or nothing (see Table 5). Of the British contributions, one-half or more came from London and one-third from Cambridge, but the social science contribution of Oxford was minor. In the United States, one-half of all contributions before 1930 came from Chicago (7 out of 12). For 1900–65 as a whole, three centers—Chicago, Cambridge, and New York—provided more than one-half of all American contributions, with Washington, Ann Arbor, and New Haven providing another one-quarter. Since these six centers represent only a small minority of American social scientists [20 percent in the 1968 edition of *American Men of Science* (5)], they evidently achieved an increase in effectiveness by an order of magnitude for the men working in these centers, with one-fifth of the scientists producing about three times as many contributions as the remaining four-fifths. By contrast, centers like Berkeley and Princeton, so eminent in other scientific fields, each initiated only one major social science contribution during these 65 years, and a metropolis like Los Angeles made no contribution at all.

These concentrations of social science achievements in particular countries and particular centers seem to be even more marked than the concentrations in modern physics and biology, and they do not seem directly related to any general factors such as increased war funding or science funding in the fields involved. We surmise that contributions to social science may be extremely sensitive to external economies, such as the presence of local subcultures with other first-rate investigators and facilities in other fields, as well as to an intellectual climate specifically favorable to social science in the country and in the local community.

More than three-quarters of all contributions were made under democratic regimes. The remnant were made under authoritarian regimes and under communist dictatorships. Anticommunist totalitarian dictatorships such as Italian Fascism, German National Socialism, and Japanese militarism produced no major social science contributions at all.

In institutional terms, universities have been the prime source of intellectual advances (Table 1, column 5), but in the later period it is the university and government interdisciplinary institutes and "think tanks" that have accounted for about two-thirds of all contributions, as shown in Table 6.

## Disciplinary or Interdisciplinary?

Interdisciplinary work has been a major intellectual source of contributions throughout the period; responsible for nearly one-half of all advances from 1900 to 1929, it produced nearly two-thirds of the total thereafter. This growing importance of interdisciplinary work reinforces our finding of the great importance of locating social science work at major intellectual centers, in proximity to many kinds of information and expertise from many disciplines. Locating a highly specialized social science enterprise at a small town or college, "far away from all distractions," seems, on the contrary, to be a very promising prescription for sterility.

## Relation to Social Practice, Demands, and Conflicts

Details will be omitted here, but our analysis indicates that practical demands or conflicts *stimulated* about three-fourths of all contributions between 1900 and 1965. In fact, as the years went on, their share rose from two-thirds before 1930 to more than four-fifths thereafter. The contributions of "ivory-tower" social scientists in the future seem apt to be minor indeed.

Major social science advances were *applied* to social practice in almost exactly the same proportion as they were stimulated by it, and they showed considerable practical importance. Applications were most frequent at the level of social groups. Applications to problems of individuals occurred in about one-quarter of the cases in both periods. Applications to national policy increased from about one-third before 1930 to about two-thirds thereafter.

Increasingly, however, the same social science contributions produced applications at more than one level of the social system. Applications to individuals and groups, to groups and states, or to all three levels together rose from less than one-half of all advances before 1930 to more than two-thirds of all advances between 1930 and 1965.

On the record, major advances in social science have been highly usable

in practice and increasingly more so in the recent past. In all likelihood, such advances will be still more usable in the years ahead, if we take the trouble to make them so.

### Time Delay in the Impact of Major Social Science Advances

Like all advances in any science, social science advances take time before they have any identifiable impact on a broader field of scientific activity or on the practical affairs of society. Our estimates of this delay for each of the advances on our list are given in the last column of Table 1.

For the period 1900–65 as a whole, the minimum delay of the impact for nearly three-quarters of the major advances was less than 10 years, the median delay was about 10 years, and the maximum delay was in the neighborhood of 15 years. These figures may understate the true length of the delay because for the recent period, as for any time-limited study, the achievements with longer delays are less likely to be recognized and are underrepresented. As a practical rule of thumb it may be safer, therefore, to expect the first major impact of a social science advance to be delayed by 10 to 15 years after its inception.

Nevertheless, the delays in the recent period seem to have been decreasing, as might be expected in a society with greatly increased higher education and faster communications networks. The most frequent median delay time dropped from between 11 and 20 years in the years 1900–29 to less than 10 years in the years 1930–65; and the most frequent maximum delay time declined from about 25 years before 1930 to about 15 years in the more recent period. If one wishes to extrapolate from these data, one might surmise that the time lags of impact may be further shortened in the future. However, part of this decrease in the time delay may be due to the tendency of research institutions or governments today to support research that is expected to have an early impact on practical affairs, and it may not be characteristic of more fundamental contributions.

These time data suggest the desirability of extending the support of fundamental social science research efforts in the form of 10- or 15-year programs at clearly favorable locations. This more sustained support might encounter political and bureaucratic difficulties, but it would seem to be the most promising strategy for making and consolidating advances like those described here in our basic understanding of social relationships and in our ability to solve pressing social problems.

The radical increase in natural science knowledge and in its application has produced a radical increase in the problems of coordination in all industrialized societies. To cope with this radical increase in urgent problems it seems essential to produce an early and large increase in social science knowledge and its constructive applications. The evidence here suggests that the intellectual and organizational means for such an increase are at hand if we care to use them.

#### References and Notes


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**NEWS AND COMMENT**

# '72 Budget: Nixon Proposes Modest Increases for Science

President Nixon's budget for fiscal year (FY) 1972 proposes selective increases for research and development which would start the federal science budget upward again after several years of virtually static financing.

The impact on actual spending in FY 1972—which roughly covers the 1971–72 academic year—would not be dramatic since there is a lag of as much as 2 or 3 years between the obligation and actual spending of funds for science, but the budget does serve as a declaration of intentions by the Administration.

Since the Nixon Administration has now been through the budget-making process twice, it has had the opportunity to leave its imprint clearly on the budget, and the new one does reveal some identifiable marks of a Nixon policy in science. In general, the Administration shows an inclination to maintain high-quality capabilities for research but to restrain expansion of research and, particularly, of manpower training except in areas judged to contribute to the solution of major national problems.

Administration priorities are indicated by the choices of agencies and programs for major increases:

- The National Science Foundation (NSF) budget would go over the $600 million mark for the first time. A major portion of the increase would go into additional support of research grants, and there would be further cutbacks in traineeship and fellowship programs.
- A new cancer research program would be in line for $100 million in funding; an additional $95 million would be directed into support of financially hard-pressed medical schools and other institutions that train health professionals.
- Substantial percentage increases would be provided in funds for research on environmental problems, highway safety, air traffic control, and reduction of crime.
- Defense Department spending on research and development would be substantially increased. The additional funds would be split roughly between work on strategic and on tactical weapons. Expenditures on basic research would remain about level.

In discussing the new budget, Administration officials have stressed funds to be obligated but not necessarily spent in the coming fiscal year. Under the Nixon FY '72 budget, obligational authority for the total federal