SMALL FIRMS AND FEDERAL R&D

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For at least the past decade, there have been growing and general concerns that the United States has failed to maintain its record of innovation, especially as compared to the rest of the world. The Federal Government has been increasingly concerned that its policies may, in certain instances, adversely affect innovation in the private sector. In particular, there has been an intensifying uneasiness, frequently concomitant with the overall concerns, that Federal research and development (R&D) procurement policies may not be taking appropriate advantage of the innovative capacities of small firms. This report considers the question of whether small firms have an appropriate share of Federal R&D procurements.

The report first addresses small firm performance in terms of Federal interests regarding R&D contracts, concluding that small firms have compiled a striking record of innovation in the private sector, especially given their share of the economy and the resources expended by them on R&D. Data collected by the Office of Federal Procurement Policy on the current small firm share of Federal R&D awards are then described, with the conclusion that small firms should probably be receiving more than their present 8% share of Federal R&D awards to industry, even allowing for contracts that cannot feasibly be broken into parts sufficiently small and allowing for subcontracts. This conclusion is then both verified and explained by identifying a number of impediments to small business participation in the Federal R&D process which are not found in the private sector. The identification of impediments produces a number of recommendations concerning stability and efficiency of R&D funding, administrative requirements, nature and timing of Requests for Proposals, treatment of proposals, and contact between small firms and technical personnel.

This report is based upon a synthesis of approximately 75 documents; the bibliography has about 200 items. Citations are in the form of author and, where appropriate, page number; the volume number or date is also given if necessary for identification in the bibliography.

THE APPROPRIATE SMALL FIRM SHARE

The question of whether small firms have an appropriate share of Federal R&D procurements is not amenable to anything resembling precise measurement. In discussing the "fair proportion" language of small business legislation, the U.S. Commission on Government Procurement said that "Fair proportion can be a rigidly defined or a fluid concept. A rigid definition, such as awarding a fixed percentage of Government procurement to small business, would not be in the Government's interest, even though the percentage might be adjusted from year to year. We believe fair proportion should be recognized as a working concept that expands or contracts from year to year with the types of procurement by the Government, state of the economy, and fluctuations of particular industries" (v.1, p.127-128). To address this working concept, it is necessary to examine the performance of small firms in the context of what can be accomplished by Federal R&D contracts with industrial firms.

In the first instance, there is the work for which the Government has contracted. How do small firms perform? This is part of the larger question of small firm innovative capacity vs. resources expended, which is discussed below. But Waterman addressed this particular part of the question in his 1971 survey of 568 technical and procurement personnel "who have any influence on the selection of sources for R&D procurement" (p.181) in 47 offices in the Department of Defense, National Aeronautics and Space Administration, and the Department of Transportation. These offices were estimated to be 71% of the number of offices procuring R&D in these three agencies. Waterman asked how effectively small firms have performed on R&D contracts, as compared to large firms. Of the 485 respondents with an opinion on this question, 82% felt that small firms had performed adequately or better as compared to large firms, 29% felt that small firms had performed fairly effectively or better, and 9% felt that small firms had performed highly effectively.

The second aspect of what can be accomplished by Federal R&D contracts with industrial firms is business use of the R&D performed. This is also part of the larger question of small firm innovative capacity addressed below. This particular aspect of the question may not be of major importance, for as Arthur D. Little, Inc. put it in a recent study for the Experimental Technology Incentives Program of the National Bureau of Standards, "Federally-funded civilian research and development is not sufficient to bring about technological change in the private sector to any significant extent" (p.1).

The third aspect of what can be accomplished by Federal R&D contracts with industrial firms is that the recipients of the contracts, particularly if they are small firms, are financially strengthened by the contracts in that certain costs can be spread over more work. Note that this aspect does not necessarily contradict the arguments that will be cited below that small firms are more efficient in conducting R&D; it only indicates that there are economies of scale in some aspects of performing R&D.

First, a caveat. There is no necessary connection between strengthening a firm by a Government contract and enhancing that firm's innovative capacity in the private sector. As Arthur D. Little (p.1) put it, "many U.S. companies with proven records of developing and marketing new products often shun federal R&D funds...." As for the firms which do not shun Federal funds, "a firm doing contract R&D will find that its knowledge and skills will in time become increasingly specialized to government interests and more and more removed from the commercial area" (Danhof, p.248).

With this in mind, what are the differences between small and large firms in innovative capacity vs. size and resources expended? Note the stress on innovation rather than invention. The difference is aptly illustrated by the following story told by Brown (p.713): "In January 1971 the New York Times published an announcement about a most important U.S. invention; in February, the London Times noted the importance of the U.S. invention but clarified the record by stating that British scientists had made the invention 15 years earlier as published in a British patent (the number was cited); in March, Izvestia agreed with the importance of the invention but claimed Russian credit for it based on a publication by two Russians 25 years earlier in a Russian journal; and in April, Japan announced the export to the U.S. of the new product, based on the U.S. invention" (emphasis deleted).

There are many differences between small and large firms relevant to a discussion of innovative capacity. These differences can be grouped, somewhat arbitrarily, in terms of incentives and capabilities, and in terms of individuals vs. the firms as a whole. The differences are discussed below in the following order: firm incentives, firm capabilities, and individual incentives and capabilities.

Firm Incentives

By definition, the small firm begins with a smaller share of the market than the large firm and therefore has more to gain from innovation, unless the large firm is entering a new market. This comparison must be tempered by two considerations. First, if the large firm can affect price by changing its output, it can capture more of the benefits accruing to the users of the product by keeping output restricted, thereby keeping the price higher. Second, the larger firm has an incentive to innovate to forestall being preempted. As Schumpeter (p.85) put it: "The business man feels himself to be in a competitive situation even if he is alone in his field." But potential competition will not, in general, be as compelling as existing competition, particularly as felt by the small firm.

The small firm has relatively more to lose from an unsuccessful innovation in the sense that it is more likely to go bankrupt. But the large firm has a greater potential absolute loss to the extent that the innovation would make productive equipment obsolete. This leads to a difference in the kinds of innovations valued: "The largest company, which obtains the biggest economies of scale and hence high profits from existing products, has a strong interest in cost-reducing improvements in production techniques which further strengthen its position. Small companies which are having difficulty in competing in the big league for existing products have a bigger incentive to try to enlarge their market share by innovating radically new products" (Layton, Harlow, and De Hoghton; p.72).

Overall, the small firm would seem to have a greater incentive to innovate, particularly in the form of new products, and particularly if the driving force of the firm is not adverse to taking a risk.

Firm Capabilities

The second group of differences between small and large firms are the capabilities of the firms as a whole. The first point to be made is that the average size of the R&D establishments in large firms is roughly 100 times the average size of small firm R&D establishments. According to National Science Foundation data (May 1975, Tables B-13 and B-25), the average company which had less than 1,000 employees and which performed R&D in 1973 had three R&D scientists and engineers. The corresponding figure for companies with 1,000 employees or more was 281 R&D scientists and engineers. This means, of course, that certain projects are simply beyond the scope that small

firms can handle in terms of manpower, facilities, or other resources. The greater resources of the large firm also means that it can reduce R&D risk by undertaking a number of projects, either alternative approaches to the same goal or entirely different undertakings. Further, the large firm will tend to produce more products, making it somewhat more likely that it will be able to use any serendipitous results of its R&D. However, according to Kamien and Schwartz (1975, p.27), "the role of diversification of products in fostering or retarding innovation has been examined statistically, but without a clear conclusion."

The lesser resources of the small firm may mean that it can perform research but not the later stages of innovation (development, production, marketing, and distribution). According to the National Science Foundation (Hogan and Chirichiello, p.322), companies with less than 1,000 employees spent 61% of their R&D funds in 1971 on development, as opposed to 78% for all companies. The U.S. Panel on Invention and Innovation estimated (p.9) that research and development represents only 5-10% of the costs of a successful product innovation. One way of obtaining the necessary capital is for the entrepreneur to have the ability to make a convincing presentation to a venture captialist with, at best, some general technical knowledge. An alternative is that "Some larger companies or groups with holdings in a smaller enterprise have been valuable sources of capital and management skill without destroying the entrepreneurial qualities of the small concern" (Layton, Harlow, and De Hoghton; p.7). Failing this, the entrepreneur can try to license his invention. But this not infrequently runs into the "not invented here" syndrome cited by a number of authors.

Even to the extent the small firm feels it has the necessary resources, it may suffer from a lack of depth in certain areas, particularly in the later stages of innovation. Charpie (p.7) comments on the innovator: "Ordinarily, he has a stronger technical background than he does an administrative or management backgound." Litvak and Maule (1972, p.10-11) add: "A general deficiency in the area of marketing has been a recurring theme in our studies of entrepreneurship in small firms... Lack of a management orientation is frequently the reason for the failure of entrepreneurs to commercialize their product ideas." But the U.S. Panel on Invention and Innovation (p.27) referred to "the problem that a new market represents to the large company's established marketing staff. Indeed, there is no question that good innovative opportunities often are not exploited because the company lacks the requisite market familiarity" (emphasis added). Mansfield and Wagner studied 20 major firms and concluded (p.197) that "Apparently, the rate of technological change could be increased significantly - without substantial increases in R and D expenditures - if firms could make fuller use of the R&D results that they are already turning out."

This leads into an advantage of small companies, "where communications between development, production and marketing are easy and a common objective, with strategies to implement it, can be understood by all concerned" (Layton, Harlow, and De Hoghton; p.5). This must be qualified by the realization that "there is a tendency on the part of the small company to contract out more of its specialized R&D work... about one-third of all industrial R&D contracting is done by small companies" (Hogan and Chirichiello, p.312). Also, some large firms partially replicate small firm ease of communications by instituting small project teams for new products.

Schmookler (1957) found that about 20% of inventions patented in 1953 came from employees in the operating end of industry who were, almost without exception, employed by small and medium-sized firms. His explanation of this phenomenon in 1965 (p.44-45) is worth quoting at length, for it has broad implications: "I would suggest that there is a marked difference in both opportunity and incentive between an operating man in a small firm and one in a large firm...

(a) A simple increase in size of the enterprise tends to make the productive process less comprehensible to the men who engage in it, simply because each man sees less of it.

(b) Big firms tend to be more than mere scaled-up versions of small ones: they cut the work up finer and narrow each man's responsibility, thereby further reducing his range of vision. Understanding less of what is going on, each man is less able to contribute to its improvement...

(c) ... The extreme division of labor and the larger numbers of individuals involved create a greater need for coordination and control by management, and of one tier of managers by another above it. Each man's influence is watered down, and his suggestions have less chance of acceptance... The channels of communication tend to become clogged if only because they are so long...

(d) As the organization becomes more formal, engineering and research men who are supposed to do the thinking tend to resent and discount suggestions by production and sales men who are supposed to do the doing..."

As Schmookler points out, innovation requires more approvals in the large firm, which may not be forthcoming: "In a complex organization the overriding problem often is maintaining an

adequate commitment to a new idea in the face of internal obstacles to change. There is an understandable reluctance to depart from what has been a successful pattern of business" (U.S. Panel on Invention and Innovation, p.28).

The lack of specialization in the small firm may have a positive effect on the creative process. Citing Shockley's hypothesis that superior inventors are able to relate a greater number of previously unrelated concepts, Rabinow (1968, p.92) says: "When one narrows his specialization, he probably comes up with fewer ideas. If one loads the dice in favor of a certain art, one cuts off analogous arts, which I think are important. The more an inventor can pull out of related and unrelated arts, the more original his ideas are likely to be."

On the question of firm capabilities, then, the large firm has the advantage of greater resources, particularly in the later stages of innovation, while the small firm has the advantage of easier communications with its implications for acceptance and attainment of change.

Individual Incentives and Capabilities

The third group of differences between small and large firms are the incentives and capabilities of the individuals comprising the firms. Large firms offer greater salaries, fringe benefits, security, support in facilities and staff, and contact with colleagues having related professional interests. "Another supposed advantage of the large firm in innovation is that it attracts and retains the best entrepreneurial talents by offering the greatest challenges and opportunities" (Kamien and Schwartz, 1975, p.27).

The larger the firm, however, the more likely there is a divergence between the interests of the individual and the firm. Rotondi's empirical work leads him to conclude that "organizational climates may effectively emphasize either creativity or organizational identification, but not both" (1974, p.54). Rabinow points out that "Many of our corporations are no longer managed by their founders. The present day 'professional manager' is often motivated by short-term interest only. He does not have any emotional involvement in his company's product, nor is he going to leave his business to his children" (1976, p.4).

The small firm offers its employees "the opportunity to influence their own environments to a greater extent... many small companies offer a more powerful appeal to those technical people who are particularly confident of their own abilities.... Many large firms typically hire great numbers of men just out of college, many of whom are relatively unproductive until they have acquired some 'seasoning.' It is extremely difficult to appraise a young, technically trained person.... By contrast, small firms typically hire men who have already demonstrated technical competence in larger organizations.... It is difficult to evaluate performance in the large development organization... and large-company personnel policies often make it extremely unlikely that he will be fired for mediocre performance" (Cooper, p.79).

Summary of Differences between Small and Large Firms

The differences described above between the incentives and capabilities of small and large firms and the individuals comprising them do not, as a whole, clearly favor either the small firm or the large firm. It becomes necessary then, as it would in any event, to look at the empirical evidence.

Empirical Evidence

In 1975, Kamien and Schwartz surveyed the empirical work that had been done on the innovative capacities of small and large firms. These studies were characterized by a limited number of innovations and/or industries considered. Taking the studies as a whole, Kamien and Schwartz (p.11) found that "There generally appear to be economies of scale in the innovation production function up to a modest size...", that is, innovation appears to be more efficiently accomplished as firm size increases up to a modest size. Concerning the output of innovations vs. firm size, they found that "the evidence indicates that research output intensity does tend to increase and then decrease with increasing firm size" (p.3).

Since then Gellman Research Associates have completed a study for the National Science Foundation (NSF, December 1975) on 500 major innovations which were introduced into the market during 1953-73 in the United States, the United Kingdom, Japan, West Germany, France or Canada. "The innovations were selected by an international panel of experts as representing the most significant new industrial products and processes, in terms of their technological importance and economic and social impact" (p.100). Of the 319 innovations produced by U.S. industries, 24% were produced by companies with less than 100

employees. Another 24% were produced by companies with 100 to 999 employees. Manufacturing companies contributed 277 of the 319 U.S. innovations. The number of manufacturing innovations per $10 billion in sales were (p.222):

Manufacturing Innovations per $10 Billion in Sales

	Less than 100 employees	100-999 employees	1,000 or more employees
1953-59	3.1	3.2	2.4
1960-66	3.0	2.6	1.9
1967-73	2.0	2.0	1.5

These ratios use manufacturing sales and receipts during 1958, 1963, and 1967, respectively. The average lag between invention and innovation was 7.4 years for all U.S. innovations. The innovations can be related to NSF data (May 1975, p.41) on R&D scientists and engineers seven years earlier for firms with less than and more than 1,000 employees. The corresponding years in the available data are 1964-65 and 1970-73 for innovations and 1957-58 and 1963-66 for R&D employment. The results per 10 thousand R&D scientists and engineers are 1.7 innovations for firms with less than 1,000 employees and 0.4 innovations for firms with more than 1,000 employees. This comparison may overstate the differences in that it credits the R&D scientists and engineers with any major innovations stemming from inventions made by operating men, but it also understates the differences in that it overlooks the disparities in costs per R&D scientist or engineer which in 1973 were $32 thousand for a company with less than 1,000 employees and $61 thousand for a company with 1,000 employees or more (p.46).

The evidence is that small firms have compiled a striking record of innovation in the private sector, especially given their share of the economy and the resources expended by them on R&D.

THE PRESENT SMALL FIRM SHARE

In March 1976, the Office of Federal Procurement Policy (OFPP) requested data on small firm participation in Federal R&D from a number of agencies significant in this process. The Small Business Administration definition of a small business is basically a firm of less than 500 employees, with the addition of larger firms in certain industries. Very few of the awards included in the data received were made to firms with more than 500 employees.

TABLE 1

FEDERAL R&D AWARDS TO BUSINESS, FY 1975
(Millions of Dollars)

Agency	Awards to Business: Small Business Amount	Awards to Business: Small Business %	Awards to Business: Total Business	Obligations to Industrial Firms: Total R&D	Research: Basic	Research: Applied	Development
Defense	316.4	5.6%	5601.5	5606.837	1%	14%	85%
NASA	216	9.6%	2255	1791.797	2%	9%	90%
ERDA	16.773	6.5%	258.166	501.588	*	12%	88%
Transportation	25.304	31.9%	79.224	161.911	-	16%	84%
NIH	25.188	25.9%	97.073	97.073	-	54%	46%
Interior	12.904	21.0%	61.499	63.766	2%	53%	45%
EPA	44.360	37.2%	119.264	51.878	-	55%	45%
NSF	7.946	45.6%	17.420	17.744	37%	50%	13%
Agriculture	.5	100.0%	.5	1.635	27%	57%	16%
Total Above	665	7.8%	8490	8294.229	1%	14%	85%
All Agencies				8385.317	1%	14%	85%
Coverage: Total Above as % of All Agencies				99%	94%	97%	99%

Sources: Awards from agencies; obligations from National Science Foundation (forthcoming).

The amounts going to small business range from $1/2 million for the Dept. of Agriculture to over $300 million for DOD. The percentages of total business awards going to small business range from 5.6% for Defense to 100% of the small Agriculture amount. For the nine agencies as a whole, small business receives $665 million, or 7.8% of total business awards.

Agencies with a high proportion of development in their R&D obligations to industrial firms have a relatively low rate of small business participation. Defense, NASA, and ERDA have the highest proportions of development in their R&D industrial obligations and the lowest proportions of small business awards to total business awards. Transportation is a notable exception with a large element of development but a high rate of small business participation. NIH, Interi and EPA all have approximately 45% development in their R&D obligations to industrial firms; their small business participation rates range from 21% for Interior to 37% for EPA. NSF and Agriculture have the smallest emphasis on development and the highest small business participation rates.

The R&D business awards reported to OFPP are not always consistent with the R&D industrial obligations reported to the National Science Foundation (NSF). There are four possible sources of the numerous differences: the NSF data may be more recent; there may be intra-agency differences in the definitions of research and development, awards vs. obligations, and/or business vs. industry. Based upon extensive discussions with a number of agencies, the most important explanation of the differences seems to be that the offices with data on small business participation do not generally use the same definitions of research and development as the offices which supply data on R&D industrial obligations to NSF. This leads to the following recommendation.

RECOMMENDATION ONE. Data on small firm participation in Federal R&D should be reported annually to the Small Business Administration. Each reporting activity should use the same definitions of basic research, applied research, and development. These definitions should be a reconciliation of the definitions of the National Science Foundation and the Securities and Exchange Commission.

The agencies which responded to the OFPP request for data represent 99% of fiscal 1975 Federal R&D obligations to industrial firms and 94% of obligations to all R&D performers, including in-house performers of research and development. These agencies awarded $665 million in contracts to small business, or 7.8% of approximately $8.5 billion in awards to all business. Industrial obligations were about 45% of obligations to all performers. Thus, small business received about 8% of obligations to industry and about 3 1/2% of obligations to all performers.

Even allowing for contracts that cannot feasibly be broken into parts sufficiently small and allowing for subcontracts, the small firm share seems low in view of the striking record of innovation that small firms have compiled in the private sector. In addition, other NSF data (May 1975, Tables B-6 and B-9) indicate that the 1973 share of companies with less than 1,000 employees in total company R&D funds, including subcontracts, was one-third greater than their share of Federal R&D funds. On the other hand, Mansfield, Rapoport, Schnee, Wagner and Hamburger surveyed 22 small R&D firms in the Philadelphia area and found only six firms that "think that they are getting less than they should... With regard to age of firm and percent of sales accounted for by the federal government, there is little difference between these firms and the others" (p.59).

TABLE 2

FEDERAL R&D OBLIGATIONS TO ALL PERFORMERS, FY 1975
(Millions of Dollars)

Agency	Obligations to All Performers: Industrial Firms Amount	Industrial Firms %	All Performers	Total R&D	Research: Basic	Research: Applied	Development
Defense	5606.837	62%	9012.472	9012.472	3%	17%	80%
NASA	1791.797	58%	3064.413	3064.413	8%	18%	74%
ERDA	501.588	24%	2072.252	2072.252	12%	17%	71%
Transportation	161.911	52%	311.563	311.563	*	17%	83%
NIH	97.073	5%	1845.518	1845.518	28%	59%	13%
Interior	63.766	23%	280.810	280.810	39%	38%	23%
EPA	51.878	20%	257.657	257.657	7%	48%	45%
NSF	17.744	3%	595.021	595.021	82%	14%	4%
Agriculture	1.635	*	420.082	420.082	37%	59%	4%
Total Above	8294.229	46%	17859.788	17859.788	11%	23%	65%
All Agencies	8385.317	44%	19044.260	19044.260	11%	25%	64%
Coverage: Total Above as % of All Agencies				94%	94%	87%	97%

Source: National Science Foundation (forthcoming).

The percentage of R&D obligations going to industrial firms varies from less than 1/2% for Agriculture to 62% for Defense, with an overall percentage of 44% for all agencies. The percentage breakdown of R&D obligations to all performers into basic research, applied research, and development again indicates a basic pattern with respect to development: agencies with a greater percentage of development in their R&D use industry more. The notable exception to this is ERDA, which had 71% of its R&D in the form of development but 64% of the total in the form of obligations to Federally Funded Research and Development Centers.

Overall rates of small business participation in obligations to all performers can be calculated by multiplying the small business percentage of total business awards (from Table 1) by the ratio of industrial obligations to obligations to all performers. In descending order, these overall rates are: Transportation 16.6%, EPA 7.5%, NASA 5.6%, Interior 4.8%, Defense 3.5%, ERDA 1.6%, NIH 1.4%, NSF 1.4%, and Agriculture 0.4%. The overall rate for all nine agencies is 3.6%. These calculations assume that the differences between the business awards data and the industrial obligations data are distributed to small and large firms in the same manner as the business awards data.

The suggestion that small firms should be receiving a greater share of Federal R&D can be both verified and explained by identifying impediments to small business participation in the Federal R&D process which are not found in the private sector.

IMPEDIMENTS TO SMALL FIRM PARTICIPATION

The preceding discussion suggests that small firms face impediments in the Federal R&D procurement process, above and beyond the impediments they face in the private sector. A general indication of such impediments is the lack of influence of small firms: "the track record during the recent 4-year leveling of R&D has demonstrated clearly that in-house government laboratories have succeeded best in protecting their budgets, followed in order by universities, non-profit organizations, big business, and small business" (Research and Development Study Group of the U.S. Commission on Government Procurement, v.2, p.89). Waterman adds: "The procurement practices of the government are not well designed to facilitate small business participation" (p.49).

For purposes of identifying specific impediments to small firms in the Federal R&D process, it is convenient to divide the process into six parts in a somewhat arbitrary order: identification of needs, administrative requirements, treatment of unsolicited proposals, proposal evaluation, contract size, and stability of overall funding.

Identification of Needs

The first step for the small firm is to not only identify Government needs but when they will be needed. This is more difficult than in the private sector for two reasons: the Government need stems from a decision to have R&D performed or, more generally, an interest in a certain kind of R&D. Such a decision or interest is more difficult to indentify than a need for an improved product (for example), because the Government need is for R&D rather than a product. It could be argued that the Government interest in R&D itself stems from another more basic need which could be identified as private sector needs are identified. But the Government interest in R&D also involves the decision that it is worth doing R&D on that basic need; the small firm is thus in the position of identifying not only the basic need as it does in the private sector, but also someone else's interest in R&D on that need, a determination it makes for itself in the private sector. Further, the involvement of other decision makers in establishing an R&D need introduces the question of when that need will be established. This is at least as difficult to determine as the R&D need itself.

The second reason why it is more difficult to identify Government needs and their timing is that the overall needs are established by a bureaucratic and political process which is not as orderly and therefore harder to predict than the market process of the private sector. At this overall level, it is easier to identify the Government needs once they are established, but their timing is harder to predict.

Identifying Government needs takes the forms of interpreting a Request for Proposals, identifying the context of an RFP so as to better understand the work desired, anticipating the issuance of an RFP to avoid the rush of preparing a proposal in the time allowed, and identifying Government interests in R&D which will not be expressed in an RFP but might include interest in an unsolicited proposal. As the system now operates, all of these forms of identifying Government needs can best be accomplished by contact with technical Government personnel, an activity in which the large firm has an advantage of scale. As the U.S. Commission on Government Procurement put it, "small business firms...are at a disadvantage in pursuing sales opportunities...since they usually have limited resources" (v.1, p.132). Danhof (p.237) adds: "The firm that first becomes aware of an agency's interest in an area through the receipt of a Request for Proposal will normally find itself severely if not impossibly handicapped should it wish to submit a proposal.... A staff experienced in dealing with the government also offers the advantage of interpreting an agency's expression of a specific interest by considering it against a broad background." Mansfield et al found in their sample that "40 percent of the firms said that there was often insufficient time to respond to requests for proposals" (p.60).

These impediments to small firm participation are not found to the same extent in the private sector; they lead to the following recommendations.

RECOMMENDATION TWO. The period during which responses are accepted to a Request for Proposals should be lengthened in not a few cases.

RECOMMENDATION THREE. "... agencies should clearly specify in RFPs as precisely as possible the limits of what they are prepared to accept...." (Biderman and Sharp, p.40).

RECOMMENDATION FOUR. "... indications of the problems for which an agency proposes to seek contract resources should be widely disseminated as soon as possible. Everything should be done to try to let potential performers know what kinds of work the government expects to be contracting for and when RFPs for this work will be issued. In this way, research organizations can plan the allocation of their proposal preparation resources and plan as well for optimal use of the research resources that will be committed by the proposals...." (Biderman and Sharp, p.40).

RECOMMENDATION FIVE. RFPs should be written to provide for broad areas in which proposals would be entertained and which would amount to publicizing some of the interests in unsolicited proposals.

RECOMMENDATION SIX. Contact between technical personnel and small firms should be promoted by:

A. Regular open workshops where technical personnel describe agency needs and

B. Announcements in the Commerce Business Daily of lists which give the names of technical liaison personnel.

Administrative Requirements

The second step for the small firm in the Federal R&D process is to prepare a proposal. A necessary part of any full proposal is the compilation and presentation of a substantial amount of non-technical information concerning overhead rates, etc. These requirements and other administrative requirements such as periodic reporting do not have a counterpart in the private sector. Because familiarization with these requirements is in part a fixed cost of doing business with the Government, large firms again have an advantage of scale. It is ironic that many of these requirements were instituted in an effort to compensate for the lack of market competition, but their unwitting effect has been to discourage small firms from participating, with the result of reducing competition in this manner.

Waterman (p.113) asked his sample of 568 procurement and technical personnel to what extent the administrative requirements impaired the ability of small firms to compete for R&D contracts. Of the 485 with an opinion, 75% felt that small firms were impaired; half of those felt that small firms were

impaired greatly rather than slightly. Waterman also asked how difficult it would be to reduce these administrative requirements sufficiently to remove the impediments to small business in competing for R&D procurements. Of the 370 with an opinion, 53% felt that it would be impossible or very difficult, 30% felt that it would be somewhat difficult, and 18% felt that it would be fairly or very easy.

The Office of Federal Procurement Policy is currently integrating and unifying the various procurement regulations. This will be an aid to small business, after small firms have adjusted to the new regulations. When the synthesis has been completed, the following recommendation will be in order.

RECOMMENDATION SEVEN. All administrative requirements should be scrutinized with a view to determining which requirements are not cost-effective when applied to small business, that is, which requirements incur costs to small business greater than the benefits resulting from the application of the requirements.

Treatment of Unsolicited Proposals

If the small firm has identified an interest in R&D which will not be expressed in an RFP, it can prepare an unsolicited proposal. There is frequently a reluctance to fund unsolicited proposals because of the lack of competition. Consequently such proposals are often rejected and/or result in the issuance of an RFP based on the need addressed by the unsolicited proposal. (Using any innovative ideas from the unsolicited proposal would constitute a violation of proprietary information.)

Waterman (p.126) asked how often unsolicited proposals were received from large or small firms which resulted in the initiation of R&D procurements. Of the 528 with an opinion, 17% said very often, 74% said occasionally, and 9% said never. Waterman also asked how frequently small firms submitted unsolicited proposals. Of the 480 with an opinion, 12% said very often, 78% said occasionally and 10% said never.

As recognized by the Research and Development Study Group of the U.S. Commission on Government Procurement, unsolicited proposals are an important governmental method of obtaining creative innovations from the outside world (v.1, p.165). Also according to the Group, "The predominant method by which small businesses achieve support is the unsolicited proposal" (v.2, p.101). Consequently, it seems in order to repeat a Commission recommendation being implemented by the executive branch.

RECOMMENDATION EIGHT. "Eliminate restraints which discourage the generation and acceptance of innovative ideas through unsolicited proposals" (v.2, p.25).

Proposal Evaluation

After a proposal is submitted, it is evaluated by technical and procurement personnel. The evaluation will include a judgment on the capability of the firm. Waterman found "a number of observations that small firms... frequently lose key people in the course of contract performance and are compelled to rely on less competent ones" (p.140). Such an evaluation is more important than in the private sector because the product is less well-defined and there is consequently a greater possibility of effective default without legal recourse due to ambiguities in the definition of the work product. Part of this impediment can be met by more precise specification of the product as in Recommendation Three. Another approach would be the following recommendation.

RECOMMENDATION NINE. Greater use should be made of contract provisions requiring the participation of key personnel.

Another impediment faced by small firms is that many small firms are not known to technical personnel; this impediment is addressed in Recommendation Six. The importance of this impediment is underlined by Waterman's finding (p.127) that when the technical agency recommends a source, the contract is awarded to that source more than 75% of the time according to 56% of the 507 respondents with an opinion, and 25% to 75% of the time according to 37% of the respondents with an opinion.

Contract Size

Large contracts preclude small firms from competing as prime contractors. A large firm is paid in such cases to break a contract down. However, there may be instances where a contract could be broken down more efficiently by Government technical personnel.

RECOMMENDATION TEN. Greater attention should be paid to overall expenditures (including in-house expenses) in determining the size of contracts.

Stability of Overall Funding

Federal R&D funding is less stable than the situation faced by the small firm in the private sector. The small firm share is even less stable than the overall funding, according to the Research and Development Study Group of the U.S. Commission on Government Procurement, cited above. The following recommendation is taken from Section 102(c)(3) of Title I of the National Science and Technology Policy, Organization, and Priorities Act of 1976.

RECOMMENDATION ELEVEN. "Federal promotion of science and technology should... recognize the singular importance of stability in scientific and technological institutions...", considering small firms as a whole to be an institution.

Advocacy and Quotas

The above recommendations will do much to remove the impediments faced by small firms in the Federal R&D procurement process. In the event they are insufficient, broader measures will be necessary. Quotas, goals, and increased set-asides are compelling but relatively rigid measures which involve a presumption that a proper and specific amount of small business participation can be established before the innovative ideas of both small and large firms are known. The establishment of quotas or goals would also precede the knowledge of the specific R&D needs. Advocacy, on the other hand, is less compelling but avoids these rigidities, since it operates on a case-by-case basis.

RECOMMENDATION TWELVE. If necessary, the advocacy and/or quotas for small business participation in the R&D procurement process should be increased.

The above measures should ensure that small firms will make a contribution to the Federal R&D process comparable to their contributions in the private sector.

Bibliography

1. Adams, William J., "Firm size and research activity: France and the United States," Quarterly Journal of Economics, v.84, n.3, August 1970, p.386-409.

2. Allen, B.T., "Concentration and economic progress: note," American Economic Review, v.59, n.4, part 1, September 1969, p.600-604.

3. Allison, David (editor), The R&D Game: Technical Men, Technical Managers, and Research Productivity (Massachusetts Institute of Technology, 1969) 330p.

4. Ames, E., "Research, invention, development, and innovation," American Economic Review, v.51, n.3, June 1961, p.370-381.

5. Angilley, A.S., "Returns to scale in research in the ethical pharmaceutical industry: some further empirical evidence," Journal of Industrial Economics, v.22, n.2, December 1973, p.81-93.

6. Arrow, Kenneth J., "Economic welfare and the allocation of resources for invention" in The Rate and Direction of Inventive Activity: Economic and Social Factors (Princeton University for National Bureau of Economic Research, 1962).

7. Arthur D. Little, Inc., Federal Funding of Civilian Research and Development: Volume 1, Summary (U.S. National Bureau of Standards, 1976) 60p.

8. Baldwin, William L., Contracted Research and Development for Small Business: Potential and Pitfalls (Dartmouth College, 1962).

9. Baldwin, William L. and G.L. Childs, "The fast second and rivalry in research and development," Southern Economic Journal, v.36, n.1, July 1969, p.18-24.

10. Barzel, Y., "Optimal timing of innovations," Review of Economics and Statistics, v.50, n.3, August 1968, p.348-355.

11. Battelle Memorial Institute, Interactions of Science and Technology in the Innovative Process: Some Case Studies (U.S. National Science Foundation C667, March 1973).

12. Ben-Porath, Y., "Some implications of economic size and level for investment in R&D," Economic Development and Cultural Change, v.21, n.1, October 1972, p.96-100.

13. Biderman, Albert D. and Laure M. Sharp, "The evaluation research community: RFP readers, bidders, and winners," Evaluation, v.2, n.1, 1974, p.36-40.

14. Blair, John M., Economic Concentration: Structure, Behavior and Public Policy (Harcourt Brace Jovanovich, 1972) 759p.

15. Bock, B. and J. Farkas, Concentration and Productivity: Some Preliminary Problems and Findings (National Industrial Conference Board Studies in Business Economics 103, 1969).

16. Boore, William F., Contract Research and the Small Manufacturer (Washington State University, 1963).

17. Bourgault, Pierre L., Innovation and the Structure of Canadian Industry (Information Canada, 1973) 135p.

18. Branch, Ben, "Research and development and its relation to sales growth," Journal of Economics and Business, v.25, n.2, Winter 1973, p.107-111.

19. Branch, Ben, "Research and development activity and profitability a distributed lag analysis," Journal of Political Economy, v.82, n.5, October 1974, p.999-1011.

20. Brock, Gerald W., The U.S. Computer Industry: A Study of Market Power (Ballinger, 1975) 264p.

21. Brown, Alfred E., "Invention and innovation - who and how," Chemtech, December 1973, p.709-713.

22. Brumm, Harold J., Jr. and John M. Hemphill, Jr., The Role of Government in the Allocation of Resources to Technological Innovation (U.S. National Science Foundation RDA 74-23122, February 1976).

23. Caldwell, Lynton K., William B. DeVille and Hedvah L. Shuchman, Science, Technology, and Public Policy; A Selected and Annotated Bibliography (U.S. National Science Foundation, 1969).

24. Cardon, Samuel Z., Survival and Growth (II): The Small R&D Firm (U.S. Government Printing Office, 1972) 215p.

25. Carter, C.F. and Bruce R. Williams, Industry and Technical Progress; Factors Governing the Speed of Application of Science (Oxford University, 1957).

26. Caty, Gilbert, Gabriel Drilhon, Georges Ferné, Norman Kaplan and Salomon Wald, The Research System: Volume III, Canada, United States and General Conclusions (Organisation for Economic Co-operation and Development, 1974) 226p.

27. Chakrabarti, A.K., "The role of champion in product innovation," California Management Review, v.17, n.2, Winter 1974, p.58-62.

28. Charpie, Robert A., "Technological innovation and the international economy" in Maurice Goldsmith (editor), Technological Innovation and the Economy (Interscience, 1970) 309p.

29. Comanor, William S., "Research and technical change in the pharmaceutical industry," Review of Economics and Statistics, v.47, n.2, May 1965, p.182-190.

30. Comanor, William S., "Market structure, product differentiation, and industrial research," Quarterly Journal of Economics, v.81, n.4, November 1967, p.639-657.

31. Cooper, Arnold C., "R&D is more efficient in small companies," Harvard Business Review, v.42, n.3, June 1964, p.75-83.

32. Dalrymple, D.G., "The process of an innovation cycle: a comment," American Journal of Agricultural Economics, v.56, n.3, August 1974, p.652-653.

33. Danhof, Clarence H., Government Contracting and Technological Change (Brookings Institution, 1968) 482p.

34. Demsetz, Harold, "Information and efficiency: another viewpoint," Journal of Law and Economics, v.12, n.1, April 1969, p.1-22.

35. Duetsch, L.L., "Research performance in the ethical drug industry," Marquette Business Review, v.17, n.3, Fall 1973, p.129-143.

36. Dusenberry, James S., "Small business in the American economy" in U.S. Board of Governors of the Federal Reserve System, Financing Small Business (U.S. Government Printing Office, 1958).

37. Elderd, Raymond K., A Literature Survey: How the Defense Department Awards Contracts and Grants for Basic Research (Georgia Institute of Technology AD 664-797, December 1967).

38. Elliott, J.W., "Funds flow vs. expectational theories of research and development expenditures in the firm," Southern Economic Journal, v.37, n.4, April 1971, p.409-422.

39. Enos, John L., "Invention and innovation in the petroleum refining industry" in The Rate and Direction of Inventive Activity: Economic and Social Factors (Princeton University for National Bureau of Economic Research, 1962).

40. Evans, Michael K., The Economic Impact of NASA R&D Spending (Chase Econometric Associates, 1975).

41. Fisher, Franklin M. and Peter Temin, "Returns to scale in research and development: what does the Schumpeterian hypothesis imply?", Journal of Political Economy, v.81, n.1, February 1973, p. 56-70.

42. Freeman, C., "The plastics industry: a comparative study of research and innovation," National Institute Economic Review, November 1963.

43. Freeman, C., "Chemical process plant: innovation and the world market," National Institute Economic Review, n. 45, August 1968, p.29-57.

44. Freeman, C., The Role of Small Firms in Innovation in the United Kingdom since 1945 (London, Committee of Inquiry on Small Firms Research Report 6, 1971).

45. Freeman, C., "A study of success and failure in industrial innovation" in Bruce R. Williams (editor), Science and Technology in Economic Growth (Halsted for International Economic Association, 1973) 464 p.

46. Galbraith, J. Kenneth, Economics and the Public Purpose (Houghton Mifflin, 1973) 334 p.

47. Gellman Research Associates, Inc., Indicators of International Trends in Technological Innovation (U.S. National Science Foundation, April 1976).

48. Globerman, Steven, "Market structure and R&D in Canadian manufacturing industries," Quarterly Review of Economics and Business, v. 13, n.2, Summer 1973, p. 59-67.

49. Grabowski, Henry G., "The determinants of industrial research and development: a study of the chemical, drug, and petroleum industries," Journal of Political Economy, v. 76, n.2, April 1968, p. 292-306.

50. Grabowski, Henry G. and Nevins D. Baxter, "Rivalry in industrial research and development: an empirical study," Journal of Industrial Economics, v. 21, n. 3, July 1973, p. 209-235.

51. Grasley, Robert H., The Availability of Risk Capital for Technological Innovation and Invention in Canada (Information Canada, 1975) 86 p.

52. Grether, David M., Market Structure and R&D (California Institute of Technology Social Science Working Paper 58, October 1974).

53. Hall, D. T. and B. Schneider, "Correlates of organizational identification as a function of career pattern and organizational type," Administrative Science Quarterly, 1972, p. 340-350.

54. Hamberg, Daniel, "Invention in the industrial research laboratory," Journal of Political Economy, v. 71, n.2, April 1963, p. 95-115.

55. Hamberg, Daniel, "Size of firm, oligopoly and research: the evidence," Canadian Journal of Economics and Political Science, v.30, February 1964, p.70-74.

56. Hamberg, Daniel, R&D: Essays on the Economics of Research and Development (Random House, 1966) 183p.

57. Hamberg, Daniel, "Size of enterprise and technical change," Antitrust Law Economics, v.1, n.1, August 1967, p.43-51.

58. Helms, Robert B. (editor), Drug Development and Marketing (American Enterprise Institute for Public Policy Research, 1975) 300p.

59. Hennipman, P., "Monopoly: impediment or stimulus to economic progress?" in E. H. Chamberlin (editor), Monopoly and Competition and Their Regulation (Macmillan, 1954).

60. Hiestand, Dale L., High Level Manpower and Technological Change in the Steel Industry: Implications for Corporate Manpower Planning (Praeger, 1974) 105p.

61. Hodgins, J. W., Entrepreneurship in High Technology (Chromlech Press, 1972).

62. Hogan, Thomas J. and John R. Chirichiello, "The role of research and development in small firms" in Deane Carson (editor), The Vital Majority: Small Business in the American Economy (U.S. Government Printing Office, 1974) 512p.

63. Horowitz, Ira, "Firm size and research activity," Southern Economic Journal, v.28, n.1, January 1962, p.298-301.

64. Horowitz, Ira, "Research inclinations of a Cournot oligopolist," Review of Economic Studies, v.30, n.3, June 1963, p.128-130.

65. Horowitz, Ira and James A. Alcott, Small Business and Government Research and Development (U.S. Small Business Administration Small Business Management Series 28, 1962).

66. Howe, J. D. and D. G. McFetridge, "The determinants of R&D expenditures," Canadian Journal of Economics, v.9, n.1, February 1976, p.57-71.

67. Hower, Ralph M. and Charles D. Orth III, Scientists and Managers (Harvard University, 1963).

68. Hu, S. C., "On the incentive to invent: a clarificatory note," Journal of Law and Economics, v.16, n.1, April 1973, p.169-177.

69. Jewkes, John, David Sawers and Richard Stillerman, The Sources of Invention (Norton, Second Edition, 1969).

70. Johannisson, B. and C. Lindstroem, "Firm size and inventive activity," Swedish Journal of Economics, v.73, n.4, December 1971, p.427-442.

71. Johnson, Jimmy D. (editor), Survival and Growth: The Small R&D Firm (U.S. National Science Foundation, Small Business Administration, and Department of Commerce; 1972) 311p.

72. Johnson, P.S., Co-operative Research in Industry: An Economic Study (Wiley, Robertson, 1973) 240p.

73. Johnston, R. E., "Technical progress and innovation," Oxford Economic Papers, v.18, n.2, July 1966, p.158-176.

74. Kamien, Morton I. and Nancy L. Schwartz, "Market structure, elasticity of demand and incentive to invent," Journal of Law and Economics, v.13, 1970.

75. Kamien, Morton I. and Nancy L. Schwartz, "Expenditure patterns for risky R&D projects," Journal of Applied Probability, n.8, March 1971, p.60-73.

76. Kamien, Morton I. and Nancy L. Schwartz, "Timing of innovations under rivalry," Econometrica, v.40, n.1, January 1972, p.43-60.

77. Kamien, Morton I. and Nancy L. Schwartz, "Risky R&D with rivalry," Annals of Economic and Social Measurement, v.3, n.1, January 1974, p.267-277.

78. Kamien, Morton I. and Nancy L. Schwartz, "Market structure and innovation: a survey," Journal of Economic Literature, v.13, n.1, March 1975, p.1-37.

79. Kefover, G. B., "Small business in Government sponsored research and development problems," Law and Contemporary Problems, v.24, Winter 1959.

80. Kirzner, Israel M., Competition and Entrepreneurship (University of Chicago, 1973) 256p.

81. Kislev, Y., "The process of an innovation cycle: reply," American Journal of Agricultural Economics, v.56, n.3, August 1974, p.654.

82. Kitti, Carole and Charles L. Trozzo, The Effects of Patent and Antitrust Laws, Regulations, and Practices on Innovation: Volume I, A State-of-the-Art Review (U. S. National Science Foundation DA 39595, February 1976) 345p.

83. Lange, O., "A note on innovations," Review of Economics and Statistics, v.25, n.1, February 1943, p.19-25.

84. Langrish, J., Michael Gibbons, W.G. Evans and R.F. Jevons, Wealth from Knowledge: Studies in Innovation in Industry (Macmillan, 1972).

85. Layton, Christopher, Christopher Harlow and Charles De Hoghton, Ten Innovations: An International Study on Technological Development and the Use of Qualified Scientists and Engineers in Ten Industries (George Allen & Unwin, 1972) 211p.

86. Levin, R., "Endogenous technical change and barriers to entry," American Economist, v.18, n.2, Fall 1974, p.42-53.

87. Litvak, I. A. and C. J. Maule, "Science policy, innovation, and the small firm," Science Forum, v.5, n.6, December 1972, p.9-11.

88. Litvak, I.A. and C. J. Maule, "Government-business interface: the case of the small technology-based firm," Canadian Public Administration, v.16, 1973, p.96-109.

89. Machlup, F., The Production and Distribution of Knowledge in the U. S. (Princeton University, 1962).

90. Maclaurin, W. R., "Technological progress in some American industries," American Economic Review, v.44, n.2, May 1954, p.178-189.

91. Mansfield, Edwin, "Size of firm, market structure,and innovation," Journal of Political Economy, v.71, December 1963, p.556-576.

92. Mansfield, Edwin, "Industrial research and development expenditures: determinants, prospects, and relation to size of firm and inventive output," Journal of Political Economy, v.72, August 1964, p.333-337.

93. Mansfield, Edwin, "The economics of research and development: a survey of issues, findings, and needed future research" in W. Alderson, V. Terpstra and J. Shapiro (editors), Patents and Progress: The Sources and Impact of Advancing Technology (Irwin, 1965).

94. Mansfield, Edwin, The Economics of Technological Change (Norton, 1968) 267p.

95. Mansfield, Edwin, Industrial Research and Technological Innovation: An Econometric Analysis (Norton, 1968) 253p.

96. Mansfield, Edwin, "Innovation and size of firm" in Edwin Mansfield (editor), Monopoly Power and Economic Performance: The Problem of Industrial Concentration (Norton, Third Edition, 1974) 244p.

97. Mansfield, Edwin and Richard Brandenburg, "The allocation, characteristics, and outcome of the firm's research and development portfolio: a case study," Journal of Business, v.39, n.4, October 1966, p.447-464.

98. Mansfield, Edwin and John Rapoport, "The costs of industrial product innovations," Management Science, August 1975.

99. Mansfield, Edwin and Samuel Wagner, "Organizational and strategic factors associated with probabilities of success in industrial R&D," Journal of Business, v.48, n.2, April 1975, p.179-198.

100. Mansfield, Edwin, John Rapoport, Jerome Schnee, Samuel Wagner and Michael Hamburger, Research and Innovation in the Modern Corporation (Norton, 1971) 249p.

101. Marcson, S., The Scientist in American Industry (Harper & Row, 1960).

102. Markham, Jesse W., "Market structure, business conduct, and innovation," American Economic Review, v.55, n.2, part 2, May 1965, p.323-332.

103. Markham, Jesse W., "Concentration: a stimulus or retardant to innovation?" in Harvey J. Goldschmid, H. Michael Mann and J. Fred Weston (editors), Industrial Concentration: The New Learning (Little, Brown, 1974) 478p.

104. Mathematica, Inc., Quantifying the Benefits to the National Economy from Secondary Applications of NASA Technology (Mathematica, June 1975).

105. McConnell, C. R. and W. C. Peterson, "Research and development: some evidence for small firms," Nebraska Journal of Economics and Business, 1968, p.356-364.

106. McConnell, C. R. and I. N. Ross, "An empirical study of research and development in small manufacturing firms," Nebraska Journal of Economics and Business, Spring 1964, p.37-46.

107. McGee, John S., In Defense of Industrial Concentration (Praeger, 1971) 178p.

108. McKie, James W., Concentration in Military Procurement Markets: A Classification and Analysis of Contract Data (Rand Corporation RM-6307-PR, June 1970).

109. McNulty, P. J., "On firm size and innovation in the Schumpeterian system," Journal of Economic Issues, v.8, n.3, September 1974, p.627-632.

110. Mestre, E. R. and A. M. Lubell, "Mergers and technological change in the garment industry," Antitrust Bulletin, v.20, n.3, Fall 1975, p.521-542.

111. Meyboom, P., Technological Innovation in Canada (Canadian Department of Finance, December 1970).

112. Morison, Elting E., From Know-How to Nowhere: The Development of American Technology (Basic Books, 1974) 212p.

113. Morse, Richard S., The Role of New Technical Enterprises in the U. S. Economy (U.S. Department of Commerce Technical Advisory Board, January 1976) 16p.

114. Mueller, Dennis C., "The firm decision process: an econometric investigation," Quarterly Journal of Economics, v.81, n.1, February 1967, p.58-87.

115. Mueller, Willard F., "The origins of the basic inventions underlying Du Pont's major product and process innovations, 1920 to 1950" in The Rate and Direction of Inventive Activity: Economic and Social Factors (Princeton University for National Bureau of Economic Research, 1962).

116. Myers, Sumner and Donald G. Marquis, Successful Industrial Innovations: A Study of Factors Underlying Innovation in Selected Firms (U.S. Government Printing Office, May 1969).

117. National Security Industrial Association, The Impact of Government Research and Development Expenditures on Industrial Growth (U.S. Government Printing Office, 1963).

118. Needham, Douglas, "Market structure and firms' R&D behavior," Journal of Industrial Economics, v.23, n.4, June 1975, p.241-255.

119. Nelson, Richard R., "The simple economics of basic scientific research," Journal of Political Economy, v.67, n.3, June 1959, p.297-306.

120. Nelson, Richard R., Merton J. Peck and Edward D. Kalachek, Technology, Economic Growth and Public Policy (Brookings Institution, 1967).

121. Nordhaus, William D., Invention, Growth, and Welfare: A Theoretical Treatment of Technological Change (Massachusetts Institute of Technology, 1969) 182p.

122. Norris, K. and J. Vaizey, The Economics of Research and Technology (George Allen and Unwin, 1973).

123. Nutter, G. W., "Monopoly, bigness and progress," Journal of Political Economy, v.64, n.6, December 1956, p.520-527.

124. Parker, William A., "The competitive aspects of the research and development market," National Contract Management Journal, v.1, Spring 1967.

125. Pavitt, Keith and Salomon Wald, The Conditions for Success in Technological Innovation (Organisation for Economic Co-operation and Development, 1971) 169p.

126. Peck, Merton J., "Inventions in the post-war American aluminum industry" in The Rate and Direction of Inventive Activity: Economic and Social Factors (Princeton University for National Bureau of Economic Research, 1962).

127. Peck, Merton J. and Frederic M. Scherer, The Weapons Acquisition Process: An Economic Analysis (Harvard University, 1962) 768p.

128. Pellicanò, G., "Research, technological innovation and management in Italy," Review of the Economic Conditions in Italy, v.27, n.6, November 1973, p.381-396.

129. Pelz, Donald C. and Frank M. Andrews, Scientists in Organizations: Productive Climates for Research and Development (Wiley, 1966).

130. Phillips, Almarin, "Concentration, scale and technological change in selected manufacturing industries 1899-1939," Journal of Industrial Economics, v.4, June 1956, p.179-193.

131. Phillips, Almarin, "Market structure, innovation, and investment" in W. Alderson, V. Terpstra and J. Shapiro (editors), Patents and Progress: The Sources and Impact of Advancing Technology (Irwin, 1965).

132. Phillips, Almarin, Technology and Market Structure: A Study of the Aircraft Industry (Lexington, 1971).

133. Phlips, L., Effects of Industrial Concentration: A Cross Section Analysis for the Common Market (North-Holland, 1971).

134. Rabinow, Jacob, "The process of invention" in David V. De Simone (editor), Education for Innovation (Pergamon, 1968) 189p.

135. Rabinow, Jacob, Statement to the House Subcommittee on Domestic and International Scientific Planning and Analysis of the Committee on Science and Technology (29 April 1976).

136. Ray, G. F. and D. T. Jones, "The innovation process in the gas industry," National Institute Economic Review, n.72, May 1975, p.47-56.

137. Roberts, B. and B. Holdren, Theory of Social Process: An Economic Analysis (Iowa State University, 1972).

138. Roberts, Edward B., The Dynamics of Research and Development (Harper & Row, 1964).

139. Roberts, Edward B., "Facts and folklore in research and development management," Industrial Management Review, v.8, n.2, Spring 1967.

140. Roman, Daniel D., Research and Development Management: The Economics and Administration of Technology (Appleton, Century, Crofts, 1968).

141. Rotondi, Thomas, Jr., "Personality implications of organizational identification," Personnel Administration, 1972, p.24-28.

142. Rotondi, Thomas, Jr., "Creativity and organizational identification in research and development environments," Public Personnel Management, v.3, n.1, February 1974, p.53-58.

143. Rovelstad, James M., Marketing R&D to the Government (University of Michigan, 1971) 142p.

144. Ruff, L. E., "Research and technological progress in a Cournot economy," Journal of Economic Theory, v.1, n.4, December 1969, p.397-415.

145. Ruttan, V. W., "Usher and Schumpeter on invention, innovation and technological change," Quarterly Journal of Economics, v.73, n.4, November 1959, p.596-606.

146. Sanders, Barkev S., "Patterns of commercial exploitation of patented inventions by large and small companies," Patent, Copyright, and Trademark Journal, Spring 1964.

147. Sanders, Barkev S., "Comparative patent yields from Government versus industry financed R&D," Idea, v.9, Spring 1965.

148. Sanders, Barkev S., Joseph Rossman and L. James Harris, "Patent acquisition by corporations," Patent, Copyright, and Trademark Journal, Fall 1959.

149. Scherer, Frederic M., The Weapons Acquisition Process: Economic Incentives (Harvard University, 1964).

150. Scherer, Frederic M., "Size of firm, oligopoly, and research: a comment," Canadian Journal of Economics and Political Science, v.31, n.2, May 1965, p.256-266.

151. Scherer, Frederic M., "Firm size, market structure, opportunity, and the output of patented inventions," American Economic Review, v.55, n.5, December 1965, p. 1097-1125.

152. Scherer, Frederic M., "Market structure and the employment of scientists and engineers," American Economic Review, v.57, n.3, June 1967, p.524-531.

153. Scherer, Frederic M., "Research and development resource allocation under rivalry," Quarterly Journal of Economics, v.81, n.3, August 1967, p.359-394.

154. Scherer, Frederic M., Industrial Market Structure and Economic Performance (Rand McNally, 1970) 587p.

155. Schmookler, Jacob, "Invention, innovation, and competition," Southern Economic Journal, April 1954, p.380-385.

156. Schmookler, Jacob, "Inventors past and present," Review of Economics and Statistics, v.39, n.3, August 1957, p.321-333.

157. Schmookler, Jacob, "Bigness, fewness, and research," Journal of Political Economy, December 1959, p.628-632.

158. Schmookler, Jacob, "Technological progress and the modern American corporation" in Edward S. Mason (editor), The Corporation in Modern Society (Harvard University, 1959).

159. Schmookler, Jacob, "The size of firm and the growth of knowledge," Statement to the Senate Subcommittee on Anti-trust and Monopoly of the Committee on the Judiciary (26 May 1965) in Zvi Griliches and Leonid Hurwicz (editors), Patents, Invention, and Economic Change: Data and Selected Essays (Harvard University, 1972).

160. Schmookler, Jacob, Invention and Economic Growth (Harvard University, 1966).

161. Schrage, Harry, "The R&D entrepreneur: profile of success," Harvard Business Review, v.43, December 1965.

162. Schrieber, Albert N., Sumner Marcus, Robert A. Sutermeister and Edward G. Brown, Defense Procurement and Small Business: A Survey of Practices and Opinions of Small Business Firms Selling to Defense Programs (University of Washington, 1961).

163. Schumpeter, Joseph A., Capitalism, Socialism and Democracy (Harper and Row, Third Edition, 1950) 431p.

164. Shapero, Albert and Cary Hoffman, An Initial Examination of the Role of Small Business in Federal Research and Development (U.S. Small Business Administration, 1970).

165. Sherman, Roger, The Economics of Industry (Little, Brown, 1974) 438p.

166. Sinclair, George, "Perpetuating fallacies about innovation in Canadian industry," Science Forum, v.5, n.3, June 1972.

167. Smith, William J. J. and Daniel Creamer, R&D and Small-company Growth: A Statistical Review and Company Case Studies (National Industrial Conference Board Studies in Business Economics 102, 1968) 175p.

168. Smyth, David J., William J. Boyes and Dennis E. Peseau, "The measurement of firm size: theory and evidence for the United States and the United Kingdom," Review of Economics and Statistics, v.57, n.1, February 1975, p.111-114.

169. Smyth, David J., J. M. Samuels and J. Tzoennos, "Patents, profitability, liquidity and firm size," Applied Economics, v.4, n.2, June 1972, p.77-86.

170. Stekler, Herman O., "Technological progress in the aero-space industry," Journal of Industrial Economics, v.15, n.3, July 1967, p.226-236.

171. Stigler, G. J., "Industrial organization and economic progress" in L. D. White (editor), The State of the Social Sciences (University of Chicago, 1956).

172. Thompson, Charles W. N., Small Business Participation in Government R&D (U.S. Small Business Administration, 1970).

173. Thompson, Victor A., Bureaucracy and Innovation (University of Alabama, 1969).

174. Townsend, H., Scale, Innovation, Merger and Monopoly (Pergamon, 1968).

175. Trippi, R. R. and D. R. Wilson, "Technology transfer and the innovative process in small entrepreneurial organizations," Journal of Economics and Business, v.27, n.1, Fall 1974, p.64-68.

176. Tybout, Richard A. (editor), Economics of Research and Development (Ohio State University, 1965) 478p.

177. U.S. Commission on Government Procurement, Report (U.S. Government Printing Office, December 1972).

178. U.S. Commission on Government Procurement, Research and Development Study Group, Final Report (U.S. Commission on Government Procurement, February 1972).

179. U.S. Government, Public Law 94-282, National Science and Technology Policy, Organization, and Priorities Act of 1976 (11 May 1976).

180. U.S. House Subcommittee on Government Procurement of the Select Committee on Small Business, The Position and Problems of Small Business in Government Procurement (1971): Hearings (U.S. Government Printing Office, 1972) 826p.

181. U.S. Interagency Committee on Small Business in Research and Development, Small Business Participation in Research and Development Prime Contracting (U.S. Small Business Administration, May 1969).

182. U.S. National Science Foundation, Science and Engineering in American Industry, Final Report on a 1953-54 Survey (U.S. Government Printing Office, 1956).

183. U.S. National Science Foundation, Research and Development in Industry, 1973: Funds, 1973; Scientists and Engineers, January 1974 (U.S. Government Printing Office, May 1975) 85p.

184. U.S. National Science Foundation, Science Indicators, 1974 (U.S. Government Printing Office, December 1975) 250p.

185. U.S. National Science Foundation, Federal Funds for Research, Development,and Other Scientific Activities, Fiscal Years 1975, 1976, and 1977, Volume XXV: Detailed Statistical Tables, Appendixes C and D (U.S. National Science Foundation, forthcoming).

186. U.S. Panel on Invention and Innovation, Technological Innovation: Its Environment and Management (U.S. Government Printing Office, January 1967) 90p.

187. U.S. Small Business Administration, Federal Research and Development Expenditures: Problems and Prospects for Small Business (U.S. Small Business Administration, March 1964).

188. Van Hoa, T., "Technical change and returns to scale in Australian manufacturing: a reply," Economic Record, v.50, n.130, June 1974, p.300-304.

189. Vernon, J. M., Market Structure and Industrial Performance (Allyn and Bacon, 1972).

190. Vernon, J. M. and P. Gusen, "Technical change and firm size: the pharmaceutical industry," Review of Economics and Statistics, v.56, n.3, August 1974, p.294-302.

191. Villard, Henry H., "Competition, oligopoly and research," Journal of Political Economy, v.66, n.6, December 1958, p.483-497.

192. Von Hippel, Eric, The Dominant Role of Users in the Scientific Instrument Innovation Process (Massachusetts Institute of Technology School of Management Working Paper, January 1975).

193. Waterman, Bernard S., Small Business in Federal Government Research and Development - The Government Perception (George Washington University Doctoral Dissertation, 1971) 228p.

194. Watson, Spencer C., "A vote for R&D profit centers," Management Accounting, v.56, n.10, April 1975, p.50-52.

195. Weidenbaum, Murray L., "Concentration and competition in the military market," Quarterly Review of Economics and Business, v.8, n.1, Spring 1968, p.7-17.

196. Weiss, L., "Average concentration ratios and industrial performance," Journal of Industrial Economics, v.11, n.3, July 1963, p.237-254.

197. Weiss, L., "Quantitative studies of industrial organization" in M. D. Intriligator (editor), Frontiers of Quantitative Economics (North-Holland, 1971).

198. Williamson, Oliver E., "Innovation and market structure," Journal of Political Economy, v.73, n.1, February 1965, p.67-73.

199. Williamson, Oliver E., Markets and Hierarchies: Analysis and Antitrust Implications (Free Press, 1975) 303p.

200. Wilson, Andrew H., Background to Invention (Information Canada, 1970).

201. Wilson, Andrew M.,Governments and Innovation (Information Canada, 1973).

202. Worley, J. S., "Industrial research and the new competition," Journal of Political Economy, v.69, n.2, April 1961, p. 183-186.

203. Xander, J. A., "Technical change and returns to scale in Australian manufacturing: a comment," Economic Record, v.50, n.130, June 1974, p.296-299.

204. Yamey, B. S., "Monopoly, competition and incentive to invent: a comment," Journal of Law and Economics, v.13, 1970.

205. Yovits, M. C., D. M. Gilford, R. H. Wilcox, E. Staveley and H. D. Lerner (editors), Research Program Effectiveness (Gordon and Breach, 1966) 559p.

206. Zerbe, Richard O., Jr., "Research and development by smaller firms," Journal of Contemporary Business, v.5, n.2, Spring 1976, p.91-113.