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FISHING OUT OR CROWDING OUT?:

AN ANALYSIS OF THE RECENT DECLINE IN U.S. PATENTING

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In recent years there has been a decline in the number of patents granted to U. S. inventors by the U. S. Patent Office. Since 1914, the number of such patents granted per year had averaged around 40,000, except for a dip during World War II. But during the late seventies and eighties, the number of patents obtained by U.S. inventors has fallen from an average 45,000 patents per year in the sixties to 35,000 patents per year, in spite of a rise in real corporate research and development expenditures of around fifty per cent during the same period. At the same time, the number of U. S. patents granted to inventors in the rest of the world has risen from around 4,000 per year in the twenties to 10,000 in the sixties and 27,000 in the eighties. Why has this happened? Has the R&D done within U. S. corporations become less effective, or perhaps directed toward different ends? Is there a "fishing out" of patentable inventions or has the incentive to patent

1. University of California at Berkeley and the National Bureau of Economic Research. I am grateful to Zvi Griliches for supplying me with some unpublished Patent Office data.

continued to fall for the reasons suggested by Schmookler in 1966?² Or is the rise in foreign patent applications simply crowding out the U. S. patentors so that the patents which are being issued are of higher quality although fewer in number?

Several competing hypotheses which would explain this phenomenon suggest themselves: first, during the same period, the nature and locus of invention has shifted from the individual to the corporation to a great extent, implying a greater increase in corporate patenting than the aggregate figures suggest. This can be made precise by an examination of the patent assignment statistics, which are available. It turns out not to help much in explaining the decline. Second, the fall in the yield of patents from industrial research and development may be due to a shift in the industry mix of R&D away from industries which are heavy patentors towards those which are not (such as the computer and semiconductor industries). The reasons that these industries do not patent much are themselves of interest, and somewhat linked to changes in the process of patenting which I will discuss here.

Finally, the rise in foreign patenting may simply reflect the increasing importance of the industrial R&D by other countries (particularlyly Japan) in the world's economy and hence in the United States. If this is all that is happening, the patent application rate of U. S. corporations and individuals should not have been affected as

2. Jacob Schmookler, Invention and Economic Growth (Cambridge, Mass.: Harvard University Press, 1966), Chapter 2.

much (except by changing expectations of the probability of receiving a patent), and this can be verified in the data.

This paper uses long run historical data on U. S. and foreign patenting behavior and data on the patent office workload to see if the existing slowdown in U. S. patenting activity can be explained simply as due to a rise in foreign patenting coupled with a fixed patent office workload. In so doing, it makes some attempts to correct for the changing industrial mix of R&D expenditures over the time period in question and for the changing mix of patent applications between individuals and corporations.

1. Patent Applications and Grants

The first step in investigating the decline in U.S. corporate patenting is to assemble the data on foreign and domestic patent applications and grants. Data on total applications and grants have been published every year (with a few exceptions) in the Annual Report of the Patent Commissioner.³ Since the computerization of the Patent Office during the sixties, detailed data have been available in machine-

3. U.S. Patent Office, Annual Report of the Patent Commissioner (Washington, D.C.: Government Printing Office). This report has been published continuously from 1841 to the present, with the omission of the years 1846 and 1875. Prior to 1841, reports on the Patent Office activities were included in those of the Department of Agriculture, to which it then belonged. From 1933 until 1949, the report was included in U.S. Dept of Commerce, Annual Report of the Secretary of Commerce (Washington, D.C.: Government Printing Office)

readable form which allows anyone to assemble series on the number of patents granted to individuals, corporations, and governments by country of inventor. Prior to this time, the Patent Commissioner occasionally reported manually collected statistics on patenting by foreign inventors in his Annual Report.⁴

Data on applications are harder to find, since statistics on the country of origin of applications were not regularly collected until 1960. However, an internal Patent Office memo does exist which contains counts made manually from slips recording the country of origin for applications filed from 1940 to 1960, and from this I was able to obtain data on foreign applications back to 1940.⁵ From 1880 until 1950, the U.S. share of patent grants hovered around ninety percent, while during the forties, the first period for which I have data, the U.S. share of patent applications was at the same level. It not unreasonable to guess that this share was also around ninety percent prior to the period for which I have data. In any case, foreign patenting activity is a small part of the story up until the time when more complete statistics become available.

Figure 1 shows the basic trends in patenting activity in the United

4. U.S. Patent Office, Annual Report of the Patent Commissioner, 1947 and 1956.

5. P.J. Federico, "Applications filed in the United States by residents of foreign countries" (Washington, D.C.: U.S. Patent Office, internal memorandum, 1961).

States in this century. Applications by U.S. inventors have remained relatively constant over the whole period, although fluctuating from year to year, while grants have risen slowly until around 1970-1973, when they drop off sharply. Applications submitted by foreign inventors show a steady rise throughout the period, as do the patents granted to foreigners, with the possible exception of the post-1973 period.

Figure 2 shows the same information in a different way: the U.S. share of both grants and applications declines steadily during the period from over ninety per cent to almost fifty per cent. Until 1975, an application from a U.S. inventor is slightly more likely to be granted, but after that the probabilities are identical.

Historically the mean lag time between filing a patent application and having it granted has fluctuated quite a bit due to changes in application rates coupled with fluctuations in the number of patent examiners employed by the Patent Office. The number of applications handled per year by each examiner has changed much more slowly (see Figure 4). Therefore the number of patents granted per year has tended to be somewhat fixed relative to applications. When applications rise dramatically, there are only a limited number of examiners available to process them, and so the mean lag between application and grant rises, leaving the grants to increase much more slowly until the backlog has been exhausted.

Thus if there is an exogenous increase in patent application activity, such as an increase in applications by foreign entities, one expects that the patents actually granted to U.S. applicants will decline because of an increasing lag between the time of filing and the

time of granting (or denying) the patent. Of course, this slowdown will undoubtedly decrease the utility of the patent, causing firms not to file for some patents when they otherwise might have. Note that in Figure 1 something like this could be exactly what happened during the seventies: there is a fall in the U.S. patents granted which is not matched by a corresponding decline in applications. Before I try to quantify this phenomenon, however, I must attempt to say something about the expected yield of patents from corporate R&D during this period.

2. Schmookler Redux: The Historical Relationship between Patenting and R&D Expenditures

In Invention and Economic Growth⁶, Jacob Schmookler gives a convincing series of arguments on the question of why the patenting yield of industrial Research and Development fell during the first half of this century, at the same time that industrial R&D programs were growing rapidly. These reasons are the following "(1) the shift of inventive attention away from the more empirical toward the more scientific fields....; (2) a growing amount of industrial research is oriented more toward the creation of techniques and formulas for designing whole classes of products,....so that the inventive process tends to be bypassed; (3) the effort expended in development has probably expanded; and (4) whereas corporate R&D expanded rapidly, the other three sources of corporate patents (non-R&D employees and assignment of patents which were not developed within the firm) probably

6. Schmookler, op. cit., Chapter 2.

decreased absolutely."⁷

Schmookler then goes on to argue that although these reasons for a fall in yield will not affect the utility of patent statistics as indicators of inventive activity, other reasons for the decline of patenting may. These other reasons he gives as a change in political and judicial climate which adversely affected the corporate patent during the thirties, the rising backlog in the patent office which lead to a lengthening of time from application to issue from one to two years to four years. The two combined, he thinks, to discourage corporate patenters, who then found that "doing without patents was a far less trying experience than many companies had feared."

What has happened to these trends in the roughly twenty years since Schmookler identified them? First, the decline in the patent productivity of corporate R&D has continued (see Figure 5): in real terms, the number of patents generated per million dollars of corporate R&D has fallen by two-thirds (if we use only R&D funded by private industry) or by one-half (if we use all R&D performed by private industry). Of the reasons he suggests, (1) and (3) now seem the most persuasive, at least for the recent decline. Reason (4) may have helped to account for the sharp decline which occurred between 1920 and 1953, when industrial R&D rose by a factor of ten, while corporate patenting

7. Schmookler, op. cit. p. 29.

only doubled,⁸ but it is doubtful that it has much to do with the decline since then.

Reasons (1) and (3) imply an increase in both the research and the development required for a particular invention. It is now possible to look at the trends in the share of corporate R&D devoted to basic and applied research and development to verify this hypothesis. Presumably what Schmookler had in mind was that basic scientific research done in the corporate laboratory provided a background for invention, and that development expenditures were used to bring a newly invented product or process to commercial availability. The shares of corporate R&D devoted to these three activities in 1953 were 4, 20, and 76 percent respectively. These shares have varied little over the years, with development rising very slightly throughout the seventies to 78 percent, and then falling during the eighties to 72 percent. Basic research fell

8. Data on patenting during the earlier period is quite reliable and easily obtained from patent office records. The converse is true of data on industrial R&D; the number reported is derived from the sources cited in the Data Appendix, which are the reports of various studies conducted during and after World War II concerning the (potential) increased government role in science and R&D policy. These studies in fact led to increased government involvement in R&D and in the collection of data about it, which led ultimately to the establishment of the National Science Foundation and the NSF surveys of industrial R&D which began in 1951-1953. Thus the quality of the data prior to the fifties is low, due to incomplete sampling and a lack of a common system for collection. In fact, there is a factor of two difference between two of the sources (Bush and Steelman) in the estimates of industrial R&D during the twenties and thirties, where they can be compared. The fact remains, however, that the data is sparse because the number is small, and therefore, the order of magnitude of the increase is large no matter what measure is used.

from four to three percent and then rose again to five percent.⁹ There is little evidence here of a wholesale shift of emphasis in the corporate R&D effort either towards or away from development. This is not really inconsistent with his argument, since 75-80 percent of R&D is devoted to activities he sees as generating little patenting, and the remainder could easily have increased along with the rest in a non-patenting dimension.

Another way to ask whether the composition of corporate R&D has changed in such a way as to reduce the propensity to patent per R&D dollar is to ask whether the mix of industries has shifted towards those with lower patenting rates. Again, Schmookler reported the ratio of patents pending to company-funded R&D by two-digit industry in 1953, where the patents were applications from the company in question. These numbers are shown in Table 1, with the R&D deflated so it is in millions of 1972 dollars. In the same table, I show a comparable set of numbers for 1981, although here the patents figure is patents granted in the closely related product fields, which is not strictly comparable to Schmookler's number.¹⁰

The last column shows the number of patent grants we would have expected in 1981 if firms patented at the same rate as in 1953 (counting

9. These numbers are from the National Science Foundation, Basic Research, Applied Research, and Development in Industry (1966) and Science Indicators (1985). They pertain to company funded industrial R&D.

10. The earlier data is from Schmookler, op. cit., page 45, and the later data is from Science Indicators (1985), Tables 1-18, 1-19.

two patents pending as one patent grant, which is roughly correct for the period). Only four industries do not show a substantial decline in patenting rates: textiles, rubber products, stone, clay, and glass, and fabricated metals, and these are hardly highly inventive fast-growing industries. Most of the industries show a very substantial decline, which seems too large to be explained by anything other than a great increase in R&D which is unaccompanied by and unrelated to patenting activity. Consider chemicals and drugs, for example: if the industry had yielded patents at the same rate as in 1953, it would have generated 35,000 patents granted in 1981, whereas in fact it only generated 4400. Since there has not been a real change in the patenting standard for new chemical entities or in the desirability of a patent, most of this decline must be attributable to an increase in R&D directed to other ends (such as cost reduction), and possibly to the considerable increase in the cost of bringing a new drug to the market. This reasoning suggests that some fishing out may have occurred in this industry.

Machinery is another interesting example: the 1981 figures include the computer industry, since it belongs in machinery. This industry accounts for about two-thirds of the R&D shown but only about one-seventh of the patents. It is well-known that the tremendous technical advance in this industry since 1953 has been largely unaccompanied by significant patenting activity for reasons of secrecy and speed of development. In this industry, it is more likely that the propensity to patent is simply not very great, for reasons having to do with the nature of innovations and the speed of technical progress.

In 1966, Schmookler concluded that corporate patenting before World

War II serves as a good indicator of the inventive activity of corporations and that after World War II it is highly correlated with R&D activities of particular corporations. However, he sees a sharp decline in the propensity to patent by corporations between the two periods, which he attributes to changed antitrust policies, prolonged pendency, and a political atmosphere hostile to patents.¹¹ Some of this argument does not ring true today, since if anything, there has been an increase in the desire of the public to grant inventors the rights to intellectual property arising partly from the perception that overseas competition will take that property if it is not so secured. From this perspective, making an invention available to manufacturers in the United States without restriction may have been desirable, but if that means that it is also available to competing manufacturers from other countries, the public (and hence, the politicians) may have second thoughts.

There remains the pendency issue. At the time of Schmookler's writing, the average time that a patent spent in the patent office before disposition had risen from less than one year in 1920 to over two years in the sixties.¹² Since then, the lag has fallen again to about

11. Schmookler, op. cit., page 55.

12. These estimates of the Patent Office processing lag were obtained using a simple FIFO inventory model with two assumptions: the first patent to have arrived is the first to be disposed of at any given time, and the rejection rate is a function of calendar time, not the age of the patent. Using these assumptions together with the application, grant, and patents pending series, it is possible to compute the age distribution of patents in process in any year, and from that the mean lag. The numbers have been checked against other numbers quoted by the Patent Office, Schmookler, and some recent statistics from OTAF. Although my method underestimates the lag slightly (due to the FIFO assumption, which is not completely realistic because of problem

one and one half years, although there are signs that it is rising again during the eighties, partly because of budget cuts during the Reagan administration. So although firms may have permanently withdrawn from the patent business as they saw the lag rising in the forties and fifties, the situation today is really not much worse in the aggregate than it was between the wars. However, the pace of technical change and information flow does seem to have speeded up considerably since then, and one could argue that the time a patent spends pending today is longer when measured in the correct time units (with a higher discount rate) than it was then. Possibly this provides some slight disincentive to patenting, but it does not seem a large enough effect to explain the decline completely.

From this updated review of the reasons which Schmookler cited for the secular decline in U.S. corporate patenting as an output of R&D, I conclude that the continued decline since his time is primarily due to an increase in the real cost of obtaining a patentable innovation, and the increasing importance of what he called "the creation of techniques and formulas for designing whole classes of products,"¹³ as well as a choice by corporations to rely on a "head start" or trade secret protection. The other reasons he cites seem of less relevance today.

patents), I thought it best to construct a consistent series from 1921 to 1985 using the same methods rather than mixing estimates.

13. Schmookler, loc. cit..

3. Modelling the Patent Granting Process

We have seen that the decline in the yield of corporate patents from R&D which Schmookler documented persisted until today, but this is a longrun trend which cannot be responsible for the decline in patents granted to U. S. corporations since the sixties. I now must return to question the possibility that crowding out in the Patent Office by foreign patentors has reduced the yield of U.S. patents.

4. Discussion and Conclusion

It seems inescapable that some fishing out has taken place in some industries. It is also true an increase in foreign patenting which is not accompanied by an increase in the number of examining assistants in the Patent Office will inevitably lead to a reduction in the number of patents granted per year to U.S. applicants. Both possibilities are supported by the data, with fishing out happening earlier and over a longer period than crowding out.

TABLE 1
Corporate R&D and Patenting by Industry

Industry	1953			1981			Predicted Patents
	R&D (\$M)	Patents Pending	P/R	R&D (\$M)	Patents Granted	P/R	
Food & kind prod	52.0	1.5	29	326	0.28	0.9	4.7
Textiles & app.	23.4	0.9	38	59	0.2	3.4	1.1
Paper & all. prod.	29.1	0.7	24	290		0.0	3.5
Chem & all. prod.	461.7	12.2	26	2667	4.42	1.7	35.2
Petroleum ref&ex	192.6	8.1	42	912	0.65	0.7	19.2
Rubber prod.	28.9	0.3	10	306	1.57	5.1	1.6
Stone, clay, & glass	37.2	1.3	35	211	0.73	3.5	3.7
Primary metals	78.9	2.3	29	360	0.27	0.8	5.2
Fabricated metals	52.3	2.1	40	279	3.17	1.4	5.6
Machinery	295.7	11.0	37	3138	7.55	2.4	58.4
Elec. equip.	288.8	8.4	29	3284	6.15	1.9	47.8
Aircraft & parts	165.8	3.7	22	1763	0.33	0.2	19.7
Prof & sci. eq.	141.0	3.3	23	1526	4.52	3.0	17.9
Other manufacturin	113.7	7.8	69	2498	4.38	1.8	85.7
Construction	21.1	0.6	28				0.0
Telecommunications	89.0	0.2	2				0.0
Transportation	19.5	0.4	21				0.0
Other nonmfg.	18.3	0.4	22				0.0
Total	2108.9	65.2	31	17619	34.22	1.9	304.5

Notes:

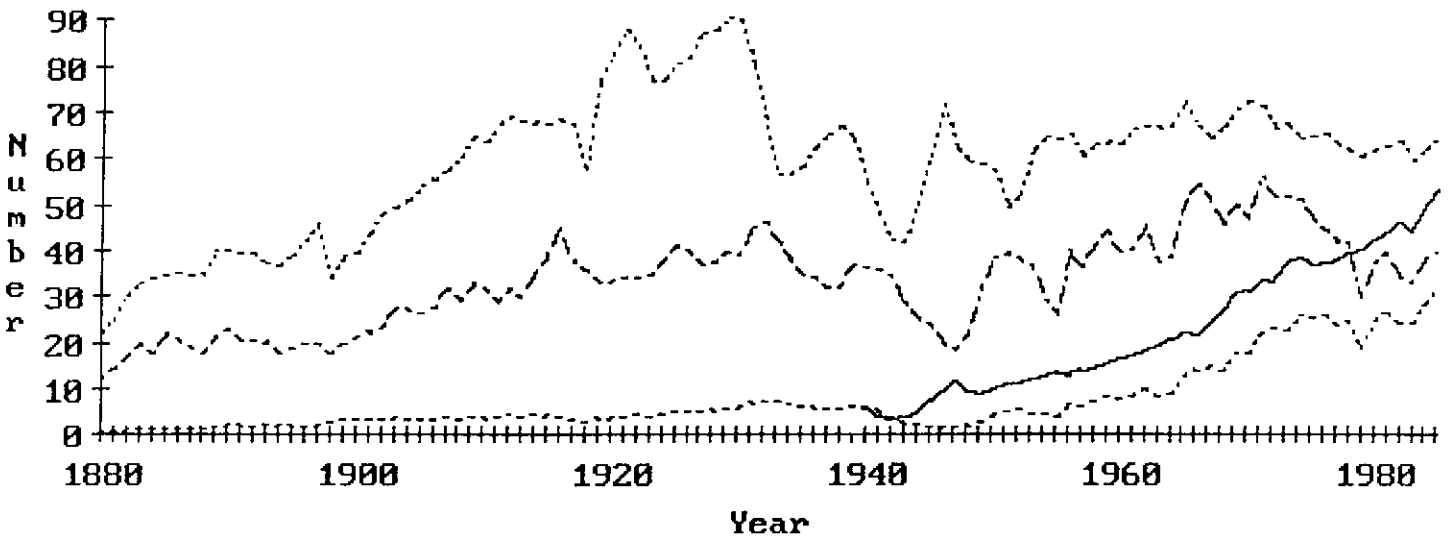
All dollar figures are in millions of 1972 dollars. All patent counts are in thousands. The columns labelled P/R are the ratio of the previous two columns in units of patents per million dollars of R&D.

The source for the 1953 data is Schmoekler (1966), Chapter II, Table 3.

The source for the 1981 data is Science Indicators (1985).

Figure 1

Trends in Patenting Activity by U.S. and Foreign Inventors



— Patents Applied for by Foreigners	··· Patents Applied For by U. S. Inventors	--- Patents Granted to Foreigners	-·- Patents Granted to U.S. Inventors
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Figure 2

U.S. Patent System - Applications and Grants

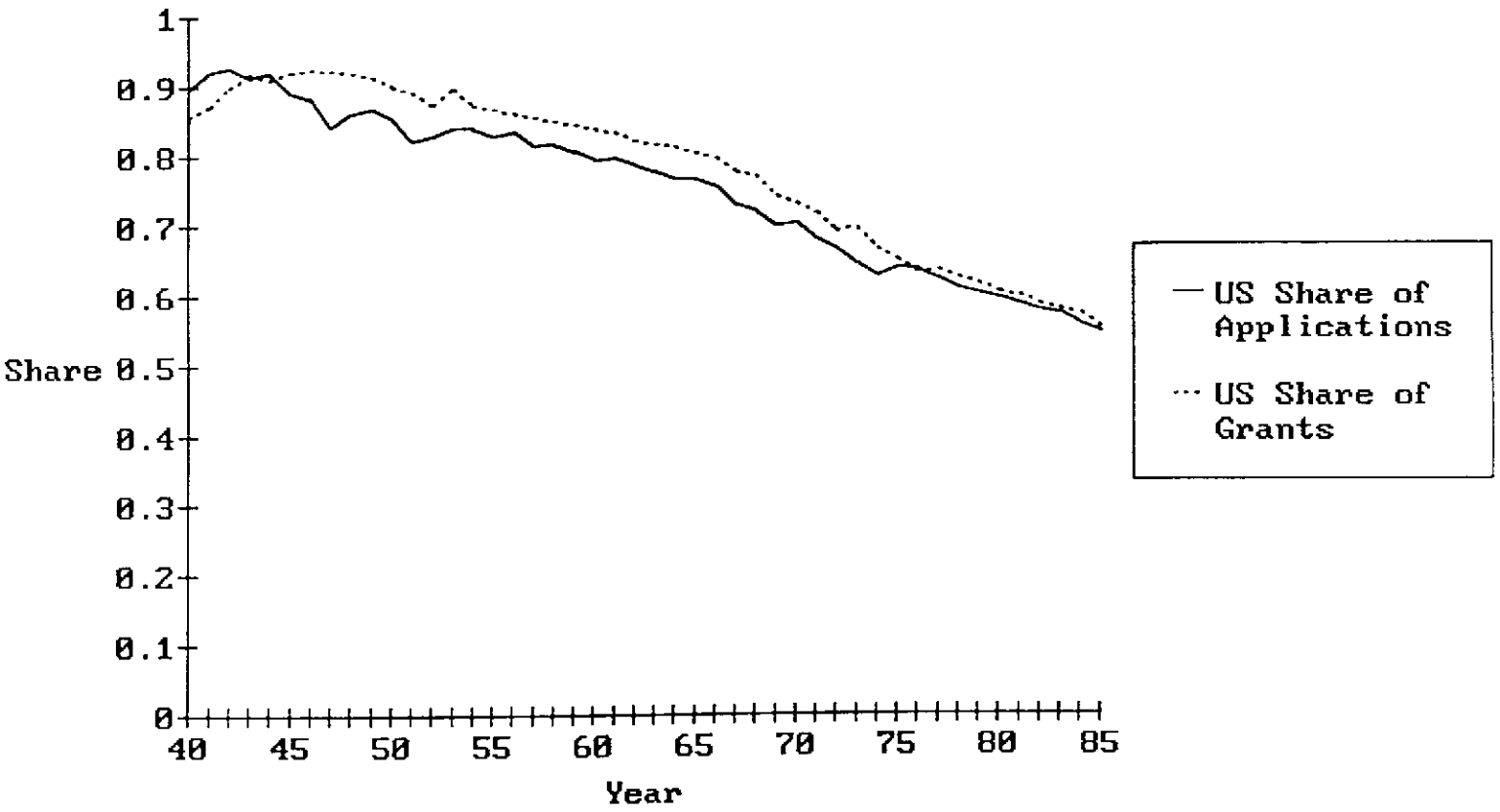


Figure 3

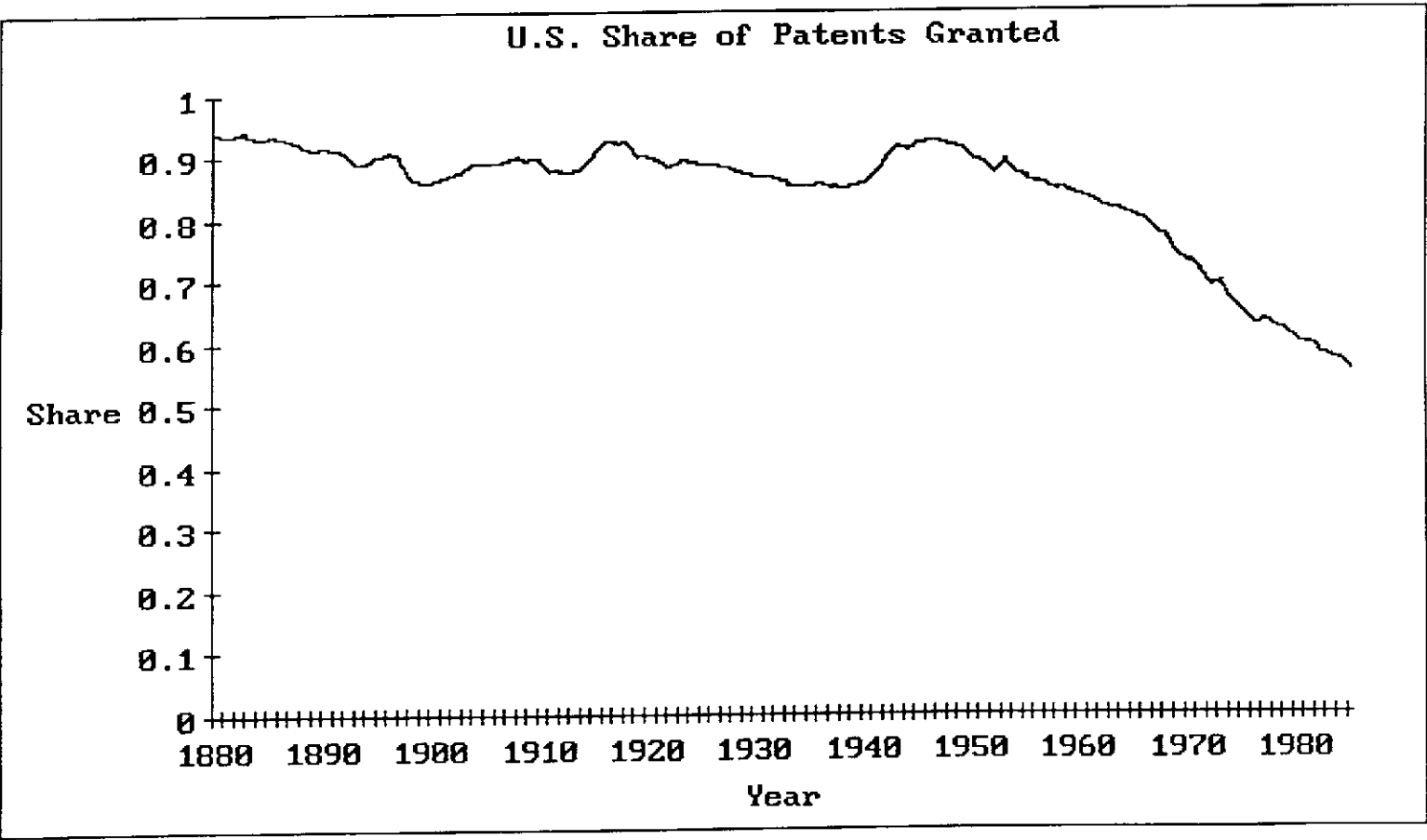


Figure 4

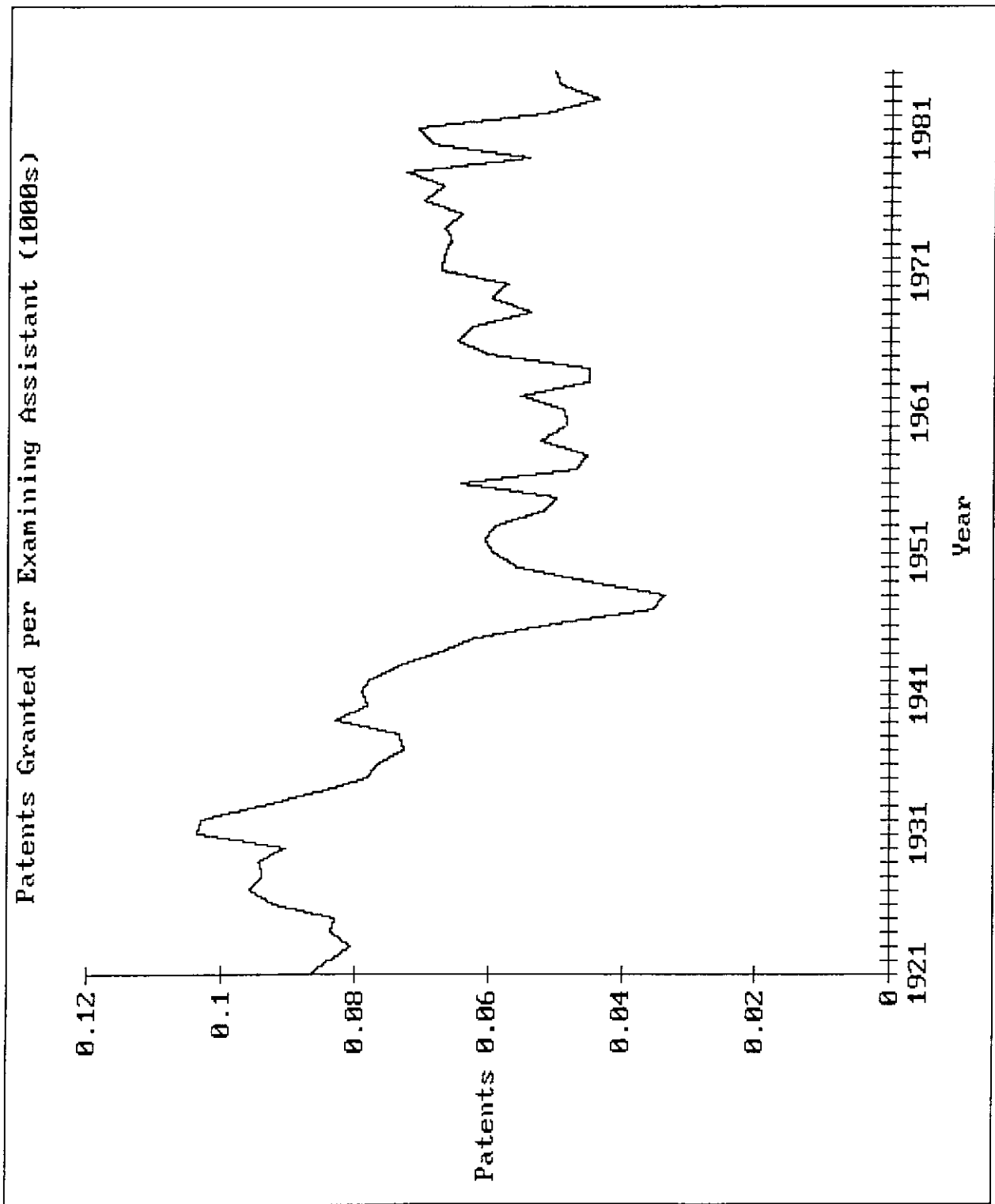
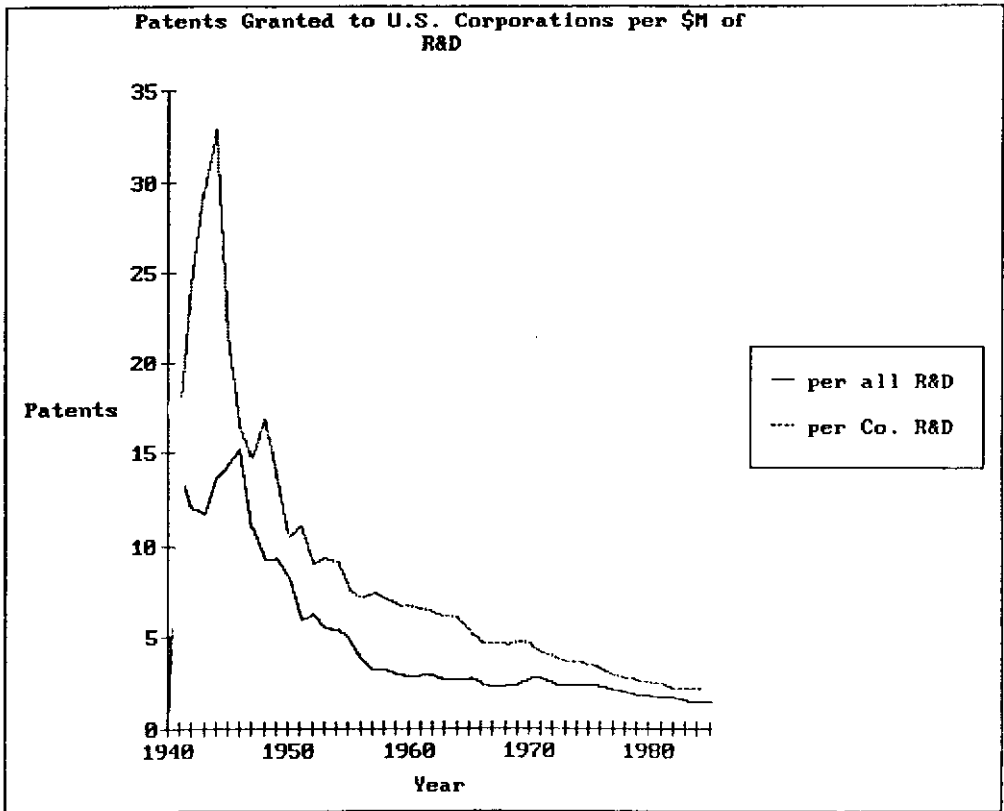
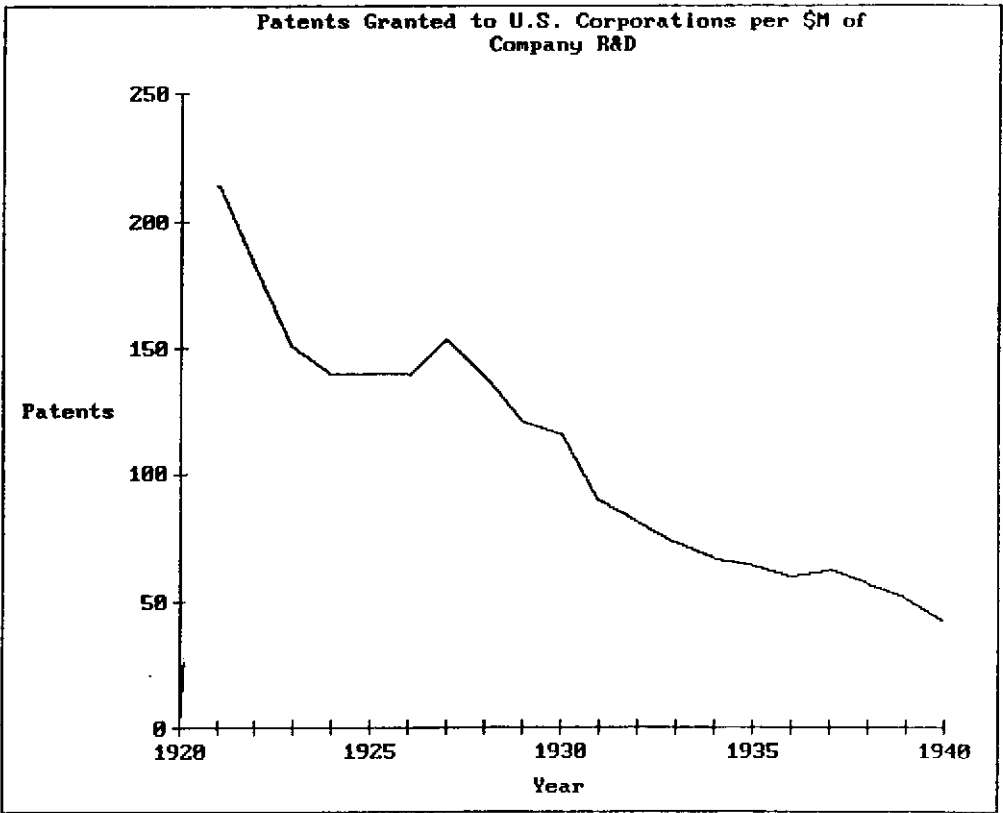


Figure 5



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DATA APPENDIX

(All patent counts are in thousands of patents.
All \$ figures are in millions of dollars.)

TOTAPP (1880-1985): Total number of patents applications filed.

<u>Source</u>	1880-1919	OTAF (1977), Table A-1
	1920-39	U.S. Patent Office, 1920-39 Reports
	1940-59	P.J. Federico (1961)
	1960-69	OTAF (1977), Table A-1
	1970-85	U.S. Patent Stat. Table (1986)

FORAPP (1940-85): Number of patent applications filed.

<u>Source</u>	1940-59	P.J. Federico (1961)
	1960-69	OTAF (1977), Table A-1
	1970-85	U.S. Patent Stat. Table (1986)

TOTGRNT (1880-1985): Total number of patents granted.

<u>Source</u>	1880-1939	OTAF (1977), Table A-1
	1940-69	OTAF (1977), Table A-1
	1970-85	U.S. Patent Stat. Table (1986)

FORGRNT (1880-1985): Number of patents granted to foreigners.

<u>Source</u>	1880-1969	OTAF (1977), Table A-1
	1970-85	U.S. Patent Stat. Table (1986)

USCGRNT (1965-84): Number of patents granted to U.S. corporations.

<u>Source</u>	1965-84	National Science Board (1982,1985)
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USCGRNTA (1965-84): Number of applications granted to U.S. corporations by date applied for.

<u>Source</u>	1965-84	National Science Board (1985), Table 4-9
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BACKLOG (1920-83): Number of applications awaiting first action at the end of the year.

<u>Source</u>	1920-83	U.S. Patent Office, 1925-83 Reports
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PATPEND (1934-83): Number of patents pending at the end of the year.

<u>Source</u>	1934-46	U.S. Patent Office, 1947 Report
	1947-55	U.S. Patent Office, 1954 Report
	1956-63	U.S. Patent Office, 1975 Report
	1964-83	U.S. Patent Office, 1983 Report

EXEMPLY (1921-87): Number of patent examining assistants.

<u>Source</u>	1921-24	Kursh (1959), interpolation
	1925-29	U.S. Patent Office, 1925-29 Reports
	1930-39	U.S. Patent Office, 1930-39 Reports; estimate based on # divisions
	1940-87	Private communication, U.S. Patent Office

OTEXEMP (1955-78): Number of patent examining assistants corrected for overtime.

<u>Source</u>	1955-78	Private communication, U.S. Patent Office
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PATPROF (1961-83): Number of patent professionals at the end of the year.

<u>Source</u>	1961-85	U.S. Patent Office, 1961-85 Reports
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POSAL (1925-83): Patent office salaries in current M\$.

<u>Source</u>	1925-83	U.S. Patent Office, 1925-83 Reports
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PINDROD (1920-85): Industrial R&D expenditures funded by industry.

<u>Source</u>	1920-29	Vannevar Bush (1945)
	1930-40	John R. Steelman (1947)
	1941-52	U.S. Dept. of Defense, R&D Board (1952)
	1953-64	National Science Foundation (1966)
	1965-75	NSF (1981)
	1976-85	National Science Board (1985), Table 4-4

INDROD (1941-85): Total industrial R&D expenditures.

<u>Source</u>	1941-75	U.S. Dept. of Defense, R&D Board (1952)
	1976-85	National Science Board (1985), Table 2-5

GNPDEF (1920-85): GNP deflator for 1972 constant dollars.

<u>Source</u>	1920-52	Historical Statistics, Part 1, Table F1-5
	1953-59	Economic Report of the President (1982)
	1960-85	National Science Board (1985), Table 2-1