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DEFINING HIGH-TECHNOLOGY INDUSTRIES

by Amy K. Glasmeier, Ann R. Markusen and Peter G. Hall

Introduction

The term "high technology" is being tossed about in a variety of contexts and with a variety of meanings -- in both with questionable precision. Within the context of state and local economic development, high technology is associated with emerging growth industries thought to be the solution for areas with high unemployment. In the context of industry, high technology is associated both with new products and with labor-saving production processes. In political contexts, high technology is seen both as a basis of economic recovery and as a constituent of America's competitive "edge," an edge which some officials argue requires protection from foreign competition. And within the context of academia, high technology is often associated with esoteric forms of research and development.

The lack of clarity in the connotations of "high technology" growth is because high technology is being asked to perform a multitude of roles: provide jobs, improve the productivity of the nation's industry, protect and maintain America's economic competitiveness, and lead society on the path of progress.

Amid this confusion, we wish to shed some light on the problem by examining a number of measures used by other researchers to define high-technology industries. In our opinion, any measure used to identify high technology industries must be precise, comparable, and objective. By precise we mean the definition should be based on a measure that is as disaggregated as possible. By comparable we mean the measure should treat all industries in the same manner. And by objective, we are concerned that subjective judgement in the selection of industries is minimized. According to this criteria then, we argue for a more comprehensive definition of high-technology industries based on the degree of sophistication and competence embodied in the technical occupations within the industry, that is, on the human capital component of the labor process. Although we are concerned here with manufacturing industries, the same measure can be used for other non-manufacturing industries such as services and the transportation, communications and utilities industries.[1]

Our definition of high technology will not include those industries which use high-tech processes per se. For example, the use of robotics in the auto industry does not mean the industry is high tech in its own right but that it uses a variety of technologies including some advanced, as well as more standardized, assembly techniques. We make this distinction for two reasons. First, in a majority of cases, "high technology processes" originate as a another industry's product. If we included processes as well as products double counting could occur. Second, since discussions of high technology industries are primarily

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[1] Other researchers using similar occupational classifications have identified service industries which, according to our classification, would be considered high-technology industries.

associated with prospective job generation, including high tech processes would be somewhat contradictory given many of them are labor-displacing in application.

Competing Notions of High Technology

The literature contains three frequently cited measures of high technology industries: (1) the perceived degree of technical sophistication of the product produced by an industry; (2) the rate of growth in employment within the sector; and (3) research and development expenditures as a percent of sales. As we will show, all of these measures lack operational precision and have been employed at too high a level of aggregation, using primarily 2-digit industry classifications.

(1) Perceived degree of technical sophistication of products produced by the industry. The Massachusetts Division of Employment Security (MDES) developed this measure on the basis of industries classified in the Standard Industrial Classification (SIC) Manual.[2] Essentially, MDES staff analysed the SIC manual and industries were selected -- literally -- without more objective criteria than perceived product sophistication. The "list of 20 industries" as referred to in a report prepared by the staff of the Massachusetts Department of Manpower Development, generated some consensus among MDES staff, but lacked precision and failed to differentiate between high tech users and producers.[3]

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[2] Vinson, Robert and Paul Harrington, Defining "High Technology" Industries in Massachusetts Department of Manpower Development Boston, Massachusetts, September, 1979.

An industry typically selected according to this measure is Office, Computing and Accounting Machines, SIC 357. This industry group includes such products as computers, typewriters, scales and balances, except laboratory -- and calculating and accounting machines. On the basis of a 3-digit classification SIC 357, is in fact, a mix of both high tech and less sophisticated products.

While this measure provides a first cut at what might constitute high-technology industries, it fails as a measure of high tech on the basis of our criteria. Moreover, in order to rigorously operationalize such a definition more detailed and up-to-date knowledge of individual firm product and production technology, as well as a comprehensive accounting of firm-level production inputs would be needed.

(2) Growth in employment. A second, and more widely-used notion of high tech industries, is based on industry employment growth rates. It is primarily used in conjunction with other "measures" of high tech such as: percent R&D, real growth rates, productivity, inflation, etc.[4] The rationale for using this measure is largely economic -- high tech industries have been growing while the basic industries have declined.[5] As seen in Table I, according to the National Science Foundation, between 1965 and 1977, employment in industries such as Petroleum, Chemicals,

[3] Massachusetts was not alone in adopting a "high tech list" of industries as Weiss points out, California developed a similar list.

[4] Technical Marketing Associates, Inc. -- Management Consultants High Technology Enterprise in Massachusetts -- Its Role and Its Concerns October 1979

[5] Marc Weiss, High Technology Industries and the Future of Employment, Introduction to unpublished book, December, 1982.

Electrical Equipment, Scientific Instruments and Machinery, increased on average 16.6 percent. While employment in more traditional industries such as Textiles Food and Kindred Products, Stone, Clay and Glass, grew by only 4.2 percent over the same period.

Rapid growth rates in new industries are not entirely unexpected, given that many are just entering the market and are at an early point in their product life cycle with considerable room for expansion. This measure, however, overlooks intra-industry differences among more mature and more stable products such as chemicals, as well as newly emerging products that have yet to develop on a large scale.

While employment growth would identify industries such as reclaimed rubber SIC 303, and measuring and controlling instruments SIC 380 -- which would be considered high tech on the basis of other measures such as R&D and industry occupational structure -- it also identifies other non-high tech industries such as furniture manufacturing which according to Table I, experienced high employment growth between 1965 and 1977.

Employment as a measure of high tech would also exclude industries that are on the cutting edge of research, such as biotechnology, which has yet to produce widely commercialized products and attendant employment growth. Defense-related industries would also be eliminated given the sporadic nature of that industry's growth, while on other measures, such as the degree of product sophistication and R&D, aerospace and defense industries would score very high indeed.

Finally, this measure discriminates against industries which are capital-intensive in nature. Conceivably, according to this measure, as

TABLE I

2-Digit Industry Employment Growth 1965-1977
(Industries ranked in descending order)

Industry	SIC	Percent Total Employment Change (1965-1977)
2-Digit Industry Average		10.8
Rubber & Plastic Products	30	43.4
Scientific Instruments	38	35.5
Machinery	35	26.0
Furniture & Futures	25	18.4
Electrical Equipment	36	16.6
Chemicals	28	16.5
Petroleum Refining	29	14.5
Fabricated Metals	34	14.4
Printing & Publishing	27	13.3
Paper & Products	26	9.4
Textiles	22	6.1
Lumber & Wood Products	24	5.8
Stone, Clay & Glass	32	3.8
Transportation Equipment	37	3.2
Miscellaneous Mfg.	39	-0.2
Food & Kindred Products	20	-2.1
Apparel	23	-4.8
Primary Metals	33	-7.4
Leather Products	31	-25.1

Source: National Science Foundation, 1977, as cited in High Technology Enterprise in Massachusetts, Technical Marketing Associates, Cambridge, MA, October, 1979.

products became more standardized and employment growth stablized they would lose their "high tech" status. Thus this measure falls short on the basis of comparability and precision.

(3) R&D as a percentage of sales. High-technology industries are most often identified on the basis R&D expenditures as a percent of total industry sales. Despite its widespread use, only an handful of authors provide more than a rudimentary explanation of the term "R&D". Since our concern, here, is with the definition of high tech industries, an explanation of what constitutes R&D is appropriate.

The "R" in R&D consists of two components: basic and applied research. Basic research refers to scientific exploration for the sake of advancing knowledge. Most of this work is undertaken by scientists within universities and private research institutions. Only a small portion of industrial research fits into this category. Applied research, on the other hand, makes up the majority of industrial research, and is loosely defined as the application of scientific and technical principles with the anticipation of economic returns for the effort.

Finally, in the development stage, processes and products identified in the earlier research phase as having market potential, are further tested and may eventually become commercial products/processes. Engineering skills are primarily utilized in the latter phases of R&D where known scientific principles are applied to technical problems. Development is usually more costly, risky, and time-consuming than either basic or applied research. This measure of high tech then, is based on the amount of effort, in terms of technical staff and financial resources, allocated for the development of new products and processes. It is not based on technical capacity as measured by the concentration of technical occupations in the workforce, however, but rather on the basis of categorical expenditures which constitute R&D.

If used as a definition of high tech, R&D is likely to be a good predictor of industries in the early stages of product development where the enhancement of products through technological innovation has significant economic payoffs. It is less likely to identify more mature and stable industries. As Table II illustrates, according to this measure petroleum and chemicals fall relatively far down on the list -- chemicals are only slight above the industry average for R&D -- if defined by R&D expenditures. This measure is particularly misleading for industries such as petroleum, with huge sales figures making up the denominator of the research indicator. Because some industries would be excluded on the basis of this measurement problem, R&D appears technically flawed.

<u>Summary of Competing Notions of High Tech</u>

None of these measures truly defines high-tech industries. Rather, each considers a single characteristic ascribed to high-tech industries. Where these measures are used, as Tables I and II illustrate, each identifies a selection of industries which are not necessarily comparable and are not of the same rank order. None of these measures, though capable in most cases of identifying new industries made popular by the press, offers a good basis for identifying high-tech industries.

TABLE II

Selected Industries' Research and Development Expenditures as a Percent of Sales, 1976

Industry	SIC	R&D as % of Sales
Industry Average		3.0
Aircraft/Missile	372/376	12.2
Office Machines	357	11.6
Communication Equipment	366	7.4
Electronic Components	367	7.4
Drugs	283	6.3
Optical, Surgical & Photographic Instruments	383-7	6.3
Scientific & Measuring Instruments	381-2	5.3
Chemicals	28	3.6
Fabricated Metals	34	1.2
Paper	26	0.9
Petroleum	29	0.8
Primary Metal	33	0.8
Wood/Furniture	24,25	0.7
Textiles/Apparel	22,23	0.4
Food	20	0.4

Source: National Science Foundation, 1976, as cited in *High Technology Enterprise in Massachusetts*, Technical Marketing Associates, Cambridge, MA, October, 1979.

Given the lack of precision, comparability, and objectivity of the previous indicators, we argue that a more precise and more generalizable definition of high-technology industries is made on the basis of an industry's occupational profile. The percent of technical occupations as a portion of the total workforce indicates the technical capacity of an industry to employ scientific and technical practices in the development of new products. We therefore define high technology industries on the basis of the percent of engineers, engineering technicians, computer scientists, life scientists, and mathematicians exceeding the manufacturing average for these occupational categories.

The Occupational Structure as an Indicator of High Technology Industries

The use of occupational data to identify high-tech industries is superior to other measures in several respects. First, primary occupational categories are standardized across industries. That is, distinctions are made among technical, professional, managerial, skilled, and unskilled work.

Second, occupational definitions are based on standards of competence that are particularly well-defined in relation to technical occupations requiring advanced academic training such as engineers and scientists. In addition, most of these professions are certified by national boards, insuring some degree of consistency across occupational categories. Third, 3-digit occupational data are collected on a state basis by the federal government, using "job definition" rather than individual self-selection for determining occupational categories.

In the following section we compare and contrast existing occupational data bases. The results form the basis of our classification scheme. We conclude with a discussion of our methodology for choosing high-tech industries.

Industry Occupation Data

There are two comprehensive sources of national industry occupational data, the 1970 census-based industry occupation matrix and the 1980 Occupational Employment Statistics (OES) survey-based matrix. The OES survey is a federal-state cooperative effort undertaken on a three-year cycle. States receive the technical specifications for the survey from the Labor Department. After the completion of a full three-year cycle the data are forwarded to the Department of Labor, which then compiles the data into the Industry-Occupational Employment matrix. As far as we know, we are the first researchers to use this national data base for the present purposes.

For a number of reasons, the OES-based matrix proves to be a more reliable and comprehensive source of occupational data than the census. First, the census is a survey of individuals, whereas the OES survey is a survey of employers. In the census, individuals self-select the occupational category they consider most closely fitting a description of their job, with little or no capacity for listing multiple occupations if the individual holds more than one job. The OES survey, on the other hand, is a survey of jobs within establishments and thus avoids the problem associated with secondary employment.

Second, the OES uses specific occupational definitions based on skill levels. In the census, occupational titles form a category which often includes individuals with widely differing skill levels. Third, similar occupational titles used in the census and the OES are not necessarily comparable because the census titles usually take the name of the most prominent occupation within that group.

Fourth, the OES reports individuals performing one or more jobs on the basis of the job requiring the highest skill level. The census reports individuals on the basis of the occupation in which the greatest number of hours are spent working.

Fifth, the OES survey questionnaires are tailored to specific industries. Each questionnaire includes a maximum of 200 occupations; residual categories are used so that establishments can report total employment. Employers are requested to specify newly emerging occupations if they are not already found on the questionnaire.

Sixth, coding procedures are substantially more accurate for the OES survey. The OES survey is filled out by an official within the firm whereas the census is filled in usually by one individual on behalf of the household. Another source of coding error in the census stems from the lack of sufficiently detailed occupational categories. NSF estimates that the range of error in the census survey is as high as 50%. The OES, on the other hand, provides detailed titles as well as specific definitions of activities performed and skills required.

Finally, the census covers 201 industries at varying levels of two, three, and four-digit disaggregation, based on the 1967 SIC categories.

The OES uses the 1972 3-digit SIC classification for 378 industries. In the census, inclusion of four-digit industries is solely based on response rates whereas the OES is systematic in reporting all industries at the 3-digit level. The census reports 377 occupations while the OES reports 1,678 occupational categories. For these reasons the OES provides more systematic descriptions of individual industry occupational profiles.

Identifying High Technology Industries

We employed a two-step process to identify high-tech industries at the national level. The first cut was made on the basis of industries that had greater than the overall manufacturing average of engineers, engineering technicians and computer scientists as a percentage of total industry occupations. Table III lists the 26 industries in descending order which exceed the manufacturing average of 5.51 percent of engineers, engineering technicians and computer scientists.

The second step involved adding two additional occupational categories, scientists and mathematicians. Within the category of "scientist" are geologists, physicists, and other life scientists. Scientists and mathematicians were added because of their primary role in basic research. They were also added to see whether their inclusion significantly changed the distribution of industries or altered the original rank ordering. Although adding the two categories only increased the total manufacturing percentage of technical occupations to 5.82, as seen in Table IV, this addition significantly changed the rank ordering and increased the number of industries exceeding the industry average.

TABLE III

Defining High Technology Industries

Rank	SIC	Title	Engineering/ Engineering Technicians Computer Scientists	Life and Physical Scientists	Mathematicians	Engineers/ Eng.Tech./Compt/Sci. Sci and Math	Percent all Professional and Technical
		Manufacturing	5.51	.26	.05	5.82	16.11
1	376	Missiles	40.90	.21	.08	41.19	55.70
2	357	Office Computing Machines	26.62	.05	.03	26.70	32.48
3	381	Engineering, Laboratory Instruments, and Scientific Instruments	25.67	.73	.05	26.45	32.70
4	366	Communication Equipment	21.30	.26	.30	21.86	32.26
5	383	Optical Instruments and Lenses	18.73	1.03	.04	19.80	24.10
6	372	Aircraft and Parts	17.95	.24	.34	18.53	25.39
7	286	Industrial Organic Chemicals	14.51	4.85	.24	19.60	24.91
8	382	Measuring and Controlling Instruments	13.93	.12	.09	14.14	17.28
9	367	Electronic Components and Assembly	12.72	.10	.02	12.84	15.70
10	291	Petroleum Refining	11.76	2.42	.44	14.62	19.71
11	351	Engines and Turbines	10.16	.48	.01	10.65	16.67
12	281	Industrial Inorganic Chemicals	9.46	3.14	.05	12.65	15.52
13	282	Plastics and Synthetic Resins	9.38	1.81	.17	11.36	14.86
14	348	Ordnance	9.37	.99	.06	10.42	15.80

15	362	Electrical Industrial Apparatus	9.24	.03	.03	9.30	12.35
16	283	Drugs	8.86	8.59	.22	17.67	23.77
17	386	Photographic Equipment	8.67	.80	.01	9.48	13.26
18	361	Electrical Transmission Equipment	8.55	.03	.01	8.59	10.72
19	353	Construction Equipment	8.34	.05	.04	8.43	12.24
20	356	General Industry Machinery	7.21	.04	.02	7.27	11.44
21	365	Radio and TV Receiving Equipment	6.62	.06	.04	6.72	10.04
22	374	Railroads	6.58	.08	.09	6.75	9.60
23	289	Misc. Chemicals	6.35	3.70	.05	10.10	12.98
24	354	Metal Working Machinery	6.27	.01	.00	6.28	8.78
25	369	Electrical Equipment and Supplies	5.58	.15	.04	5.77	8.27
26	344	Fabricated Metal Products	5.55	.08	.01	5.64	8.38

TABLE IV

Defining High Technology Industries

Rank	SIC	Title	Engineering/ Engineering Technicians Computer Scientists	Life and Physical Scientists	Mathematicians	Engineers/ Eng.Tech./Compt/Sci. Sci and Math	Percent all Professional and Technical
		Manufacturing	5.51	.26	.05	5.82	16.11
1	376	Missiles	40.90	.21	.08	41.19	55.70
2	357	Office Computing Machines	26.62	.05	.03	26.70	32.48
3	381	Engineering, Laboratory Instruments, and Scientific Instruments	25.67	.73	.05	26.45	32.70
4	366	Communication Equipment	21.30	.26	.30	21.86	32.26
5	383	Optical Instruments and Lenses	18.73	1.03	.04	19.80	24.10
6	286	Industrial Organic Chemicals	14.51	4.85	.24	19.60	24.91
7	372	Aircraft and Parts	17.95	.24	.34	18.53	25.39
8	283	Drugs	8.86	8.59	.22	17.67	23.77
9	291	Petroleum Refining	11.76	2.42	.44	14.62	19.71
10	382	Measuring and Controlling Instruments	13.93	.12	.09	14.14	17.28
11	367	Electronic Components and Assembly	12.72	.10	.02	12.84	15.70
12	281	Industrial Inorganic Chemicals	9.46	3.14	.05	12.65	15.52
13	282	Plastics and Synthetic Resins	9.38	1.81	.17	11.36	14.86
14	351	Engines and Turbines	10.16	.48	.01	10.65	16.67

15	348	Ordnance	9.37	.99	.06	10.42	15.80
16	289	Misc. Chemicals	6.35	3.70	.05	10.10	12.98
17	386	Photographic Equipment	8.67	.80	.01	9.48	13.26
18	362	Electrical Industrial Apparatus	9.24	.03	.03	9.30	12.35
19	361	Electrical Transmission Equipment	8.55	.03	.01	8.59	10.72
20	353	Construction Equipment	8.34	.05	.04	8.43	12.24
21	285	Paints	3.22	4.97	.01	8.20	10.73
22	303	Reclaimed Rubber	5.26	2.27	--	7.53	7.53
23	356	General Industry Machinery	7.21	.04	.02	7.27	11.44
24	374	Railroads	6.58	.08	.09	6.75	9.60
25	365	Radio and TV Receiving Equipment	6.62	.06	.04	6.72	10.04
26	287	Agricultural Chemicals	4.58	1.79	.11	6.48	9.59
27	354	Metal Working Machinery	6.27	.01	.00	6.28	8.78
28	384	Medical & Dental Supply	5.42	.57	.04	6.03	9.94
29	284	Soap	3.14	2.71	.06	5.91	9.03

Two industries, reclaimed rubber (SIC 303) and paints (SIC 285), moved up in rank from 30th and 32nd to 21st and 22nd respectively.

Other minor changes in ranking occurred as well. Including life scientists and mathematicians enlarged the pool of high-tech industries to include SIC 384, 303, 287, 285, and 284, while eliminating two other industries, SIC 369 and 344, thus increasing the total number of industries to 29.

In a similar study defining high tech industries conducted by the Massachusetts Manpower Development Department, industries were defined on the basis of the percent of technical occupations exceeding the durable manufacturing average for industries in the state. From our results it is clear that Massachusetts' industry occupational configuration does not mirror the nation's.

Their results using both the state manufacturing average of 8.7% for technical occupations, and the durable average of 13.7% differed substantially from ours. Much of this difference can be explained by the fact that Massachusetts has a high proportion of high tech industries in general and hence a high overall proportion of technical occupations represented in the workforce. Their justification for using the durable as opposed to the manufacturing average for technical occupations is on the basis of industries represented in the state. This cut-off point however, seems to lack justification. If their intent was to eliminate processes versus products a better measure would have been to distinguish industries on the basis of whether its products were intermediate inputs versus final products.

In an effort to test for significant variation between general manufacturing versus durable industries, we examined the distribution of industries selected on the basis of the percent of engineers, engineering technicians and computer scientists in only durable manufacturing industries. This reduced the pool of industries to 19, as seen in Table V, with the deletion of SIC's 284, 285, 287, 289, 303, 354, 356, 365, 369, 374, and 384. Sectors eliminated by this procedure included assorted chemicals, metal working machinery and medical equipment industries.

In conformance with the first procedure we included scientists and mathematicians in the durable manufacturing occupational profile to see if this would substantially alter the pool of industries selected. As seen in Table VI, with the inclusion of the additional technical occupations, the pool increased to 21 industries adding Miscellaneous Chemicals (SIC 289) and Paints (SIC 285). The rank order changed somewhat with SIC 289 moving up from 25th to 16th and SIC 283 moving up from 16th to 8th.

After examining the group excluded using the national durable manufacturing average of technical occupations of 7.86, we felt on the basis of the employment of the rejected industries as a percent of the total high-tech industry employment that there was no objective reason for using the durable average to define the pool of industries. The seven rejected industries would diminish the high-tech employment base by 26 percent. We decided it would be better to include rather than exclude them, since their presence is so substantial. We plan to undertake sensitivity analyses to determine if our spatial results are

TABLE V

Defining High Technology Industries

Rank	SIC	Title	Engineering/ Engineering Technicians Computer Scientists	Life and Physical Scientists	Mathematicians	Engineers/ Eng.Tech./Compt/Sci. Sci and Math	Percent all Professional and Technical
	Manufacturing	5.51	.26	.05	5.82	16.11	
1	376	Missiles	40.90	.21	.08	41.19	55.70
2	357	Office Computing Machines	26.62	.05	.03	26.70	32.48
3	381	Engineering, Laboratory Instruments, and Scientific Instruments	25.67	.73	.05	26.45	32.70
4	366	Communication Equipment	21.30	.26	.30	21.86	32.26
5	383	Optical Instruments and Lenses	18.73	1.03	.04	19.80	24.10
6	372	Aircraft and Parts	17.95	.24	.34	18.53	25.39
7	286	Industrial Organic Chemicals	14.51	4.85	.24	19.60	24.91
8	382	Measuring and Controlling Instruments	13.93	.12	.09	14.14	17.28
9	367	Electronic Components and Assembly	12.72	.10	.02	12.84	15.70
10	291	Petroleum Refining	11.76	2.42	.44	14.62	19.71
11	351	Engines and Turbines	10.16	.48	.01	10.65	16.67
12	281	Industrial Inorganic Chemicals	9.46	3.14	.05	12.65	15.52
13	282	Plastics and Synthetic Resins	9.38	1.81	.17	11.36	14.86
14	348	Ordnance	9.37	.99	.06	10.42	15.80

15	362	Electrical Industrial Apparatus	9.24	.03	.03	9.30	12.35
16	283	Drugs	8.86	8.59	.22	17.67	23.77
17	386	Photographic Equipment	8.67	.80	.01	9.48	13.26
18	361	Electrical Transmission Equipment	8.55	.03	.01	8.59	10.72
19	353	Construction Equipment	8.34	.05	.04	8.43	12.24

TABLE VI

Defining High Technology Industries

Rank	SIC	Title	Engineering/ Engineering Technicians Computer Scientists	Life and Physical Scientists	Mathematicians	Engineers/ Eng.Tech./Compt/Sci. Sci and Math	Percent all Professional and Technical
		Manufacturing	5.51	.26	.05	5.82	16.11
1	376	Missiles	40.90	.21	.08	41.19	55.70
2	357	Office Computing Machines	26.62	.05	.03	26.70	32.48
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11	367	Electronic Components and Assembly	12.72	.10	.02	12.84	15.70
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15	348	Ordnance	9.37	.99	.06	10.42	15.80
16	289	Misc. Chemicals	6.35	3.70	.05	10.10	12.98
17	386	Photographic Equipment	8.67	.80	.01	9.48	13.26
18	362	Electrical Industrial Apparatus	9.24	.03	.03	9.30	12.35
19	361	Electrical Transmission Equipment	8.55	.03	.01	8.59	10.72
20	353	Construction Equipment	8.34	.05	.04	8.43	12.24
21	285	Paints	3.22	4.97	.01	8.20	10.73

changed by their elimination. If we chose the smaller pool to begin with, the comparison between the two pools of industries would not be possible. Finally, industries such as medical and dental supplies and agricultural chemicals are known to produce high-technology products. Thus our definition of high-technology industries as seen in Table IV, includes 29 industries which exceed the manufacturing average of engineers, engineering technicians, computer scientists, life scientists and mathematicians.