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Regional Specialization and
Technology in Manufacturing

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I. Introduction and Summary

Human capital and technology intensive products have been strongly identified as the nation's comparative advantage in world trade. And in observing the ties between rapid regional growth and high technology industries, states in every region of the United States have now focused much attention on their own technology base. Despite almost universal attention on technology, this paper finds that there are significant regional differences in technological intensity. (Technological intensity is measured herein by the activities of a region's manufacturing workers—the proportion of workers listing engineering, science and other technical fields as their primary occupation, “SET labor force”). Further, technology intensive regions are twice blessed. First, high tech regions are home to the nation's high tech industries to a much greater extent. Secondly, on a pairwise industry-by-industry basis, these same regions tend to employ greater shares of SET personnel, strongly indicating a pervasive tech intensity across all industries within high tech regions.

Despite the fact that regional specialization with regard to tech intensity is very marked, one notable counter-trend is uncovered. As a general tendency, all regions—both high and low tech—tend to hold greater technological edge in those manufacturing industries that are most concentrated there. This finding accords with a dynamic theory of regional factor specialization as posited by John Rees and Howard Stafford (1986). Regions develop first as hinterlands, supplying raw materials to industrialized regions and serving as branch plant locales for manufacturing companies who are headquartered elsewhere. Over time, as necessary infrastructure, labor force skills, and indigenous industries are developed, technological specializations associated with indigenous industries are developed in parallel fashion. In the process, a region's overall factor intensity and comparative advantage can be transformed from backwardness to technological prowess.

II. Factor Intensity, Trade and Development

The Heckscher-Ohlin theory has been the dominant theory of international trade and specialization in the 20th century. This theory posits that a na-

tion will specialize in producing and exporting those goods that are produced intensively with the factor of relative abundance in the nation—e.g. labor or capital.

The first round of empirical tests of the theory for the United States yielded the paradoxical finding that, despite the U.S. capital abundance, the nation tended to export those goods which were relatively labor intensive (Leontif 1956; 1964) (Minhas 1962) (Belassa 1963). Subsequently, this “paradox” was resolved by considering an additional factor of production—human capital (Leontif 1956; 1964) Keesing (1965; 1966; 1968) (Baldwin 1971) (Weiser & Jay 1972) (Hufbauer in Vernon 1970). Evidence was strong that the U.S. exported goods which were *technology* or skill intensive. In fact, a perusal of the U.S. trade balance for such goods today strongly bears out this assertion (National Science Board 1986).

A dynamic context in explaining the U.S. trade pattern was introduced by Raymond Vernon who believed that the U.S. comparative advantage lies in providing an environment conducive to innovation of new products (1966). These innovative products are initially produced in the U.S. in small batches employing highly skilled personnel. Over time, as the production process of new products becomes standardized and routinized, the location of production favors countries of lower labor costs. Consequently, in Vernon’s “product cycle” theory, it becomes profitable to move production offshore as a product matures.

In explaining U.S. inter-regional rather than international growth and trade, Leontif’s paradox arose once again in statistical studies. Joe Persky found that, despite low wages and abundant labor, the South paradoxically employed more capital intensive production methods in certain industries such as paper and chemicals (1978). He explained this away as a type of technological “dualism” between industry sectors. In some sectors, the new plants in the South were of more recent vintage—using more recent technology which was “labor saving” and inflexibly capital intensive. The resolution of this finding was apparently provided by appealing to the labor skill content of interregional exports. A 1979 study by Y. Horiba and R. Kirkpatrick found that labor skill differences at the regional level accounted for the overall pattern of interregional commodity flows, although the empirical regularity was not so dramatic as in the international trade literature. Niles Hansen directly responded to Persky by once more appealing to Raymond Vernon’s product cycle theory (1980). According to Hansen, new products were initially conceived and produced in the North in small batches using large amounts of highly skilled labor. Over time as products could be routinized in production, low-cost capital-intensive processes could be employed in combination with lower skill employees. Geographically, such production was most advantageous in the South

Table 1**Employed scientists and engineers by region: 1986**

Region	Number of SE	Share of Regional Total Employment (percent)	Concentration ¹ Index
New England	360,200	5.8	1.26
Mid-Atlantic	771,600	4.8	1.04
South Atlantic	675,400	3.9	.84
East North Central	795,400	4.6	1.00
West North Central	302,000	4.2	.91
East South Central	191,700	3.5	.75
West South Central	440,600	4.4	.95
Mountain	255,500	4.9	1.07
Pacific	834,100	5.6	1.23
U.S.	4,626,500	4.6	1.00

¹ Concentration index is the ratio of regional SE share of total employment to national SE share of total employment.

SOURCE: SE, National Science Foundation, *U.S. Scientists and Engineers: 1986*; total employment, U.S. Bureau of Labor Statistics, *Employment & Earnings*, monthly.

where low skill labor was cheap and abundant. Evidence to this effect was apparent from well-publicized studies which were able to distinguish branch plants from parent firm headquarters across U.S. regions (Allaman and Birch 1975; Jusenius and Ledebur 1978; Malecki 1985). These studies illustrated the marked characteristics of the South among U.S. regions as domicile to a branch plant economy.

Implicit in this regional specialization by corporate function lies geographic differences in innovative capacity. At least in early stages of growth, branch plant activity is not noted for innovative activities but rather for routinized production using lesser skilled labor force.

The technology intensity or specialization of U.S. regions has recently regained attention among regional analysts and policy makers. In the current national debate, technology investment to produce new products, create new processes, and to adapt new processes more rapidly than competing firms has become one of the watchwords in regaining competitiveness for U.S. manufacturing (e.g. National Research Council 1986) (Dewar 1988). So too, states in every region have focused on encouraging technology dif-

fusion and investment within their borders as a parallel “spatial strategy” to remain competitive *vis a vis* neighboring regions and the world. The following section reviews the technological differences of U.S. manufacturing across U.S. regions using occupational indicators. The inquiry centers on whether tech intensity is a distinguishing feature of regional specialization and, further, how pervasive are the technological advantages of certain regions.

III. Regional Dispersion of Scientists and Engineers in Manufacturing

A region’s technological intensity in manufacturing can be measured in one of several ways. In this study, we examine the propensity of a state’s industries to employ scientists, engineers, and technicians (SET) as a broad indicator of tech orientation. Elsewhere, we have argued that, in assessing a region’s overall tech intensity, the SET measure is more inclusive than the often-used alternative of industrial R&D expenditures in accounting for the various ways in which technology can be important to a firm or industry. SET personnel will account not only for the presence of research activity but also for those firms which adopt new process technologies which may have been developed elsewhere (Giese and Testa 1987). A further advantage of the SET information set over others is that it was reported by region for each individual industry during the 1980 Census. For this reason, we can carefully examine differences in tech intensity for individual industries across regions.

The size of U.S. Census regions varies widely. Accordingly, standardizing a regional measure of SET personnel by regional size enables us to compare tech concentration in a meaningful fashion. These comparisons are made still more accessible by converting our standardized measures into index form which compare each region to the nation. That is, each standardized measure is reported as a ratio relative to the U.S. standardized measure. For example, column 1 in Table 2 reports each region’s SET personnel per employed person *relative to the nation’s SET personnel per employed person*.

$$(1) \quad index = (SET_i / totemp) / (SET^{U.S.} / totemp^{U.S.})$$

where SET = Scientists, engineers, and technicians in
region i

A wide range in SET intensity is evident across regions. On this scale, the New England Region reports far and away the highest relative employment of scientists and engineers in its manufacturing sector as a proportion of total labor force (both manufacturing and nonmanufacturing labor force).

The New England region is accompanied by the Mid-Atlantic, East North Central, and Pacific regions in having above-average industrial SET intensity. In contrast, the southern regions emerge as much below average—especially the South Central Regions. The West North Central region reports an SET intensity only modestly below the nation's average.

The index measure can be further modified by examining the SET intensity of each region's manufacturing labor force rather than the industrial SET intensity of total labor force. The latter measure is more relevant to assessing the tech intensity of a region's manufacturing sector—not being distorted by overall size of the region's manufacturing sector.¹

In considering the SET intensity of each region's *manufacturing* labor force alone, some revealing differences emerge (column 2, Table 2). Index values for the New England, Mid Atlantic, and East North Central Regions lie significantly below the index(s) using total labor force in the denominators. The relatively larger manufacturing labor force in these regions tends to raise the overall concentration of industry SET personnel when measured on the former basis. Using this revised index, the East North Central Region's SET intensity actually lies below the nation. In contrast, the Mountain and Pacific Regions are seen as much more SET intensive when viewing this latter index which is based on manufacturing labor force.

Decomposing regional differences

By means of simulation, we can “decompose” the index of industrial SET concentration into two effects; an “industry mix” and a “tech intensity effect”. First, for the “tech intensity” effect, the index is recast “as if” the distribution or mix of manufacturing industries in each region were identical. In doing so, differing tech intensity for each industry is uncovered as it contributes to the region's overall tech intensity. Second, the industry mix effect illustrates the polar opposite effect. The region's mix of industries is allowed to vary while the industry-by-industry SET labor force intensities are held identical (to national averages) for each region.

Consider first the tech intensity effect and its influence on overall regional SET concentration. If industry composition were the same, it is seen that the Northeast, Mid-Atlantic, and Pacific regions would stand out as more tech intensive than other regions. Either the most creative activities of U.S. industries, such as R&D activities, tend to locate in these regions; or, the plants in these regions tend to employ more skilled labor which is needed to adopt advanced production processes. Using this scheme, a second tier tech intensity is displayed by the North Central region and the South Atlantic region as only moderately less tech intensive. In contrast, and

Table 2

Regional—U.S. ratios of SET concentration manufacturing across industries¹

Region	Total	Actual ²	Industry Mix ³ Effect	Tech-Intensity ⁴ Effect
Northeast	1.50	1.21	1.19	1.03
Mid Atlantic	1.09	1.03	1.01	1.01
South Atlantic	.70	.73	.75	.90
East North Central	1.14	.90	.91	.92
West North Central	.87	.95	1.02	.89
East South Central	.65	.54	.69	.68
West South Central	.55	.70	1.02	.62
Mountain	.75	1.34	1.27	.99
Pacific	1.31	1.50	1.34	1.05

¹Ratio with manufacturing employment (with total employment, MFGE is replaced by TOTE) =

$$\frac{(SET_i^A \cdot SHR_i^B \cdot MFGE^R) / MFGE^R}{(SET_i^{US} \cdot EMP_i^{US}) / MFGE^{US}}$$

A value above (below) one indicates that the region's SET concentration is above (below) average.

where i = industry (77 industries, mainly 3 digit SIC)

R = region (9 census divisions)

US = United States

A and B = defined below as either R (region) or US depending upon scenario

SET_i = SET share of industry employment

EMP_i = employment in industry i

SHR_i = industry's share of total manufacturing employment

MFGE = total manufacturing employment

² Actual: A=R B=R.

³ Industry Mix: A=US B=R.

⁴ Tech-Intensity: A=R B=US.

consistent with their reputation as "branch plant" economies, the South Central regions display a significantly lower tendency to employ SET personnel for any given industry.

Suppose the labor force composition of each region for any given industry were the same. What is the impact on differing industry mix *alone* on the geographic dispersion of scientists and engineers? High tech industries tend to gravitate to the regions commonly associated with high tech (Column 3). SET concentration in the New England, Mountain States, and the Pacific Regions all register a strong simulated impact of industry mix as it reflects the geographic incidence of high tech occupations.

Industry Mix and Tech Intensity: Twice Blessed Regions

The geographical correlation between the two aforementioned effects is also evident. Regions with more tech intensive industry mixes also tend to lead other regions in their tendency to host creative activities or to employ advanced processes industry-by-industry.

The bicoastal geography of technology is also evident in that the New England, Mid Atlantic, and Pacific regions tend to both host tech intensive industries and to operate with more tech intensive labor forces across all industries. For three other regions, the trend is opposite—both tech intensity and industry mix tend to work against them.

In interpreting these findings, there is an element of simultaneous causality in these two effects which helps to explain the fact that they vary in the same direction for most regions. A region's ability to attract or host a high tech industry will not be independent of its ability to attract scientists and engineers. For example, perhaps the location of the aircraft industry owes part of its location in the Pacific region to the region's attractiveness to scientists and engineers. The regional heterogeneity of labor in explaining the geography of high tech industry has been widely noted by Edward Malecki and others (1985;1988).

"The locational needs of the firm revolve around ensuring both that professional labor will be able to be attracted to R&D locations and that communication (especially face-to-face communication) will be facilitated."²

Scientists and engineers are geographically mobile but they have strong druthers in their choice of location, preferring attractive climate, good schools, access to universities, and recreation/cultural amenities.

By the same token, a region with a significant "agglomeration" or concentration of high tech industries will be generally attractive to scientists and engineers because of wider job mobility and opportunity. This, in turn, may drive down the skill-adjusted wage. Consequently, all types of firms, both high tech and low tech, will find it all the more attractive to hire SET types of employees in greater proportion than elsewhere.

The tendency of regions with greater concentrations of high tech industry to maintain technological edge on an industry-by-industry basis is also consistent with the hypothesis that technology is diffused outward in space over time from "growth pole" industries or regional hubs of creativity and innovation (Rees and Stafford 1986). Perhaps the innovative techniques

of high tech industries "spill over" more easily into nearby industries of every ilk. Or perhaps the propulsive "growth pole" of technology is not an industry at all, but rather an innovative, technology producing institution such as MIT in Massachusetts.

But whatever the reason, high tech regions are twice-blessed: their mainstay industries are the more innovative among the array of manufacturing industries and, second, all industries apparently employ more highly skilled personnel in their operations. If technology is a synonym for success, then success breeds success for such regions. Indeed, this effect is the hallmark of the so-called "agglomeration"; a critical mass of innovative people and institutions has been amassed which permeates the underlying manufacturing processes and products of the regions' industrial economy.

IV. Low Tech Regions and Technology Strategies

It would seem that low tech regions would have little recourse but to accept their fate to remain as backward and lagging in technology. In the framework of specialization and trade, they would do better to capitalize on a different "competitive advantage"—that is, for example, pursuing nonmanufacturing employment bases or attracting the low-skilled operations of manufacturing industries. Certainly, portions of the South Atlantic region have grown rapidly quite aside from high tech industry growth.

However, evidence suggests that there are also technology niches for low tech regions to cultivate. An earlier study suggested that, despite a mediocre overall concentration in technology, the Seventh District of the Federal Reserve System, encompassing most of the East North Central region, held a technology edge in its "mainstay industries"—i.e. those industries which were most concentrated in the region (1987).

Does this result generalize to all regions? To test this hypothesis, the pairwise differences in SET intensity for each industry between each region and the national average were taken as the units of observation to be explained by OLS regression estimations. These deviations were regressed on the regional location quotient for each industry (i.e. a concentration index of each industry's employment in the region relative to the nation).

Why would one expect that a region's concentrated industries tend to be tech intensive? The intuition centers on the so-called "product cycle" of products and regions. At the initial stages of a product's development, production volume will be low and highly concentrated in the home region. This is so because the process of production is not yet well-suited for standardized production; process technology is continually being trans-

ferred from the headquarters or R&D facility to the fledgling production line. Communication between company headquarters personnel and production line personnel is paramount.

So too, the market for the industry's product may not have reached sufficient volume for application of mass-production techniques. At later stages, once production has reached an ample volume, it is not unusual for the company to establish plants in peripheral regions so as to take advantage of lower factor costs or to save on transportation costs of shipping the product to regional markets. Nonetheless, the industry may still tend to concentrate in the home region. To some extent, technology activities remain behind in the home region, perhaps in the form of R&D centers and corporate headquarters establishments. Of course, this need not be the case for all industries. For some, technology activities are best located nearer to production plants in order to facilitate the transfer of new production technologies onto the factory floor. For other industries, technology activities locate in proximity to corporate headquarters so as to facilitate communication between product development and overall firm strategy (Howells 1984).

In recognizing these intra-firm linkages as a possible influence on technology location, a concentration index of the nonproduction employees of each industry (defined at the two-digit industry level) was also included in the estimation. These are the employees of so-called auxiliary establishments—i.e. corporate headquarters, data processing facilities, R&D labs, warehouses, and sales offices of manufacturing firms. So too, to the extent that the location of auxiliary establishments represents corporate headquarters activity, the industry's region of origin would be indicated by this variable.

Looking at the broad empirical results across 74 industries and 9 regions, any tendency for SET personnel to consistently locate close to auxiliary/corporate headquarters facilities is not apparent from the statistical estimation (Table 3). This result may follow because different industries behave differently with regard to siting of SET personnel. Some industries may locate such personnel close to corporate headquarters and other auxiliary facilities. Others may locate technology activities closer to production plants so that, on net across all industries, the effect is a "wash" in our estimations.³

Nonetheless, it can be seen that there is a positive and significant relation between an industry's overall employment concentration in a region and the extent that a regional industry tends to employ relatively greater scientific and technical personnel in its operations (i.e. SET intensity) in comparison to the national average (statistically significant at the 1 percent level). As

Table 3

Regression results: Percentage difference in SET between regions and the nation (all industries)

$$\text{Dependent Variable: } \left(\frac{\% \text{ SET}_i^R - \% \text{ SET}_i^{US}}{\text{SET}_i^{US}} \right) \cdot 100$$

where % SET_i = percent of scientists, engineers, and technicians in industry *i* (3-digit SIC).

R = region (Census regions).

US = United States

Independent Variables	Parameter Estimates	Level of Significance
Intercept	-9.99	.0376*
<i>CIME_i^R</i>	4.60	.0046*
<i>ADMEMP_j^R</i>	2.13	.8762
REG1	6.04	.2903
REG2	5.98	.2918
REG3	-8.67	.1278
REG4	8.88	.1186
REG5	1.37	.8098
REG6	-15.27	.0077*
REG7	-28.20	.0001*
REG9	5.83	.3080
$\bar{R}^2 = .12 \quad n = 666$		

*Variable has a significant impact on the dependent variable (5% level of significance or below).

where

CIME_i^R = regional concentration index of industry *i* using manufacturing employment in the denominator.

ADMEMP_j^R = percent of industry *j* (2-digit SIC) employment in auxiliary establishments (i.e., administrative activities).

REG1-9 = regional dummy variables, 1 = New England, 2 = Mid-Atlantic, 3 = South Atlantic, 4 = East North Central, 5 = West NC, 6 = East South Central, 7 = West SC, 9 = Pacific (8 = Mountain is in the intercept).

SOURCE: SET - Bureau of the Census, 1980 Census of Population, Occupation by Industry data.

CIME - U.S. Department of Labor, ES 202 Employment data.

DMEMP - Bureau of the Census, County Business Patterns, Auxiliary Establishment data.

a matter of general tendency, then, a region's mainstay industries tend to fair relatively better than the region's other industries in technological competition with the rest of the nation.

Such industries can be specifically identified by region with the "industry-occupation data matrix" which cross-classifies industries and occupations by state from the 1980 Census. In Table 4, each region's most concentrated manufacturing industries (by employment) are listed. Corresponding SET shares of the labor force in each region are also displayed along with the ratio of the region's SET personnel to the national average for each industry. More recent data (with only a two-year lag) for individual states are typically available through programs of state employment security bureaus. Rather than more recent data, the 1980 Census data are displayed here by region because these data were collected annually and in a consistent manner across the entire U.S. landscape.

For these "mainstay" industries, the overall correlation between regional employment concentration and technology intensity is not overwhelming and there are significant differences in the tendency from region to region. High tech regions including New England, Mountain States, and the Pacific Region tend to display relatively greater technology intensity in mainstay industries. In contrast, the previously identified low tech regions tend to display lower technological intensity across the range of their most concentrated industries. This illustrates that it is correct to bear in mind the more general finding from the preceding analytical section. High tech regions are twice blessed, both with regard to high tech industries and also in employing a more tech oriented labor force on an industry-by-industry basis.

Nonetheless, several individual industries in low tech regions significantly contribute to the overall correlation between industry concentration and technological edge which was previously evidenced in the statistical equations. For example, in the West South Central Region, petroleum refining and agricultural chemicals industries are more technology intensive than their national counterpart industries. In the South Atlantic, fabrics, clothing, and textiles are being produced with more highly skilled personnel (relative to the nation) according to the data. So too, wood products and plastics and synthetics industries emerge in this region as technologically superior to national counterparts. Similarly, the East South Central Region apparently holds technology edge in pulp, paper, and paperboard mills; plastics and synthetics; apparel and accessories; and even household appliances. The latter industry was once concentrated in the North Central Region but has gradually shifted to the South. And apparently, the plants there now operate with skilled personnel relative to the nation.

The North Central regions display a sharp tendency in their mainstay industries to employ SET at a greater rate than the national counterpart industries. Mainstay industries such as motor vehicles and equipment,

metalworking machinery, construction and material handling equipment, steel mills, railroad locomotives and equipment, food processing industries and paperboard continue to be technological leaders in these niches. Here in the nation's premier manufacturing hub, one can only speculate concerning cause and effect for this tendency. Partly, these industries may have retained their regional concentration to date by staying ahead of the nation in employing advanced technologies in their production activities. Alternatively, the region has partly succeeded in retaining its corporate headquarters/R&D facilities even while production plants have branched out into other regions.

V. Conclusions

Looking to the future, all regions will be concerned that their region's mainstay industries remain (or regain) competitive through investments in new technology. Information presented herein covering the geographic dispersion of SET personnel suggests that a region's technology prowess is self-enforcing. High tech regions contain a favorable industry mix while, at the same time, their industries tend to operate with more skilled labor force processes than national counterparts.

Nonetheless, low tech regions can look to their mainstay industries for some respite from the self-reinforcing trend of technological advancement. Regional mainstay industries of greater concentration tend to hold technological edge over national counterparts. Accordingly, in encouraging technology transfer, adoption, and development, states and regions would do well to look toward the production processes and products of their mainstay industries for maximum probability of payoff in the home economic base.

Footnotes

¹ However, the size of the overall manufacturing sector is surely not independent of tech intensity in a dynamic sense. For this reason, both index values are reported.

² E. J. Malecki, "The R&D Location Decision of the Firm and 'Creative' Regions--A Survey", *Technovation*, 6, 1987, p. 205.

³ A further problem lies with inadequate data. While our industries of observation are often defined at the three digit level according to the U.S. Dept. of Commerce SIC system, the data on employees of auxiliary establishments are only defined at the two-digit level.

Table 4

Top 20 dominant regional industries and their tech-intensity compared with US average

New England				Mid Atlantic			
Industry	CI ¹	Regional Set ²	Relative Set ³	Industry	CI ¹	Regional Set ²	Relative Set ³
Footwear, x. rubber and plastics	4.01	.5	.73	Photographic equipment and supplies	4.06	16.9	1.11
Leather tanning and finishing	3.55	1.3	.94	Drugs*	2.56	16.8	1.04
Ship and boat building and repairing	3.39	9.4	1.54	Railroad and locomotive equipment	2.54	4.5	1.01
Office and accounting machines*	3.05	11.7	.87	Soaps and cosmetics*	1.97	8.4	1.05
Misc. manufacturing industries	3.01	2.9	1.34	Glass and glass products	1.84	.8	.81
Misc. textile mill products	2.71	4.1	1.22	Pottery and related products	1.68	3.4	1.18
Cutlery, hand tools, and other hardware	2.52	4.1	1.44	Watches, clock, and clockwork devices	1.63	2.8	.69
Electronic computing equipment*	2.43	22.1	.84	Misc. manufacturing industries	1.63	1.8	.82
Scientific and controlling instruments*	2.41	6.2	1.28	Apparel and accessories, x. knit	1.60	.2	.54
Electrical machinery, n.e.c.*	2.34	12.7	1.07	Sugar and confectionery products	1.57	3.4	1.04
Optical and health service suppliers*	2.32	10.6	1.21	Printing and publishing, x. newspapers	1.56	1.6	.93
Toys, amusement, and sporting goods	2.02	2.1	.29	Leather, tanning and finishing	1.54	1.3	.94
Dyeing and finishing textiles	2.00	3.1	1.11	Misc. paper and pulp products	1.40	3.6	1.00
Aircrafts and parts*	1.96	15.3	.88	Bakery products	1.32	1.3	1.37
Pulp, paper, and paperboard mills	1.91	1.1	.56	Misc. fabricated textile products	1.30	2.5	.75
Radio, T.V., and communication equipment*	1.90	18.2	1.12	Optical and health service supplies*	1.29	8.8	1.00
Watches, clock, and clockwork devices	1.87	5.7	1.41	Office and accounting machines*	1.25	10.2	.76
Metalworking machinery	1.78	5.1	1.19	Electrical machinery, n.e.c.*	1.23	11.1	.94
Screw machine products	1.76	2.0	.79	Misc. nonmetallic mineral and stone products	1.22	3.9	1.47
Ordnance*	1.73	6.5	.61	Knitting mills	1.20	.6	.68

*High tech industry.

¹ Dominant industries are those with a concentration index (CI) greater than one.

² Tech intensity is measured by the percent of scientists, engineers, and technicians (SET) in the industry's labor force.

³ Relative SET is the ratio of regional SET to US SET; values greater than one indicate greater tech-intensity in the region's industry.

SOURCE: U.S. Bureau of the Census, 1980 Census of Population, Occupation by detailed industry; Bureau of Labor Statistics (E.S. 202).

Table 4

Top 20 dominant regional industries and their tech-intensity compared with US average

East North Central				West North Central			
Industry	CI ¹	Regional Set ²	Relative Set ³	Industry	CI ¹	Regional Set ²	Relative Set ³
Motor vehicles and equipment	3.59	6.5	1.25	Ordnance*	3.62	13.9	1.29
Metal forgings and stampings	3.56	2.5	.96	Grain mill products	3.17	5.2	1.30
Metalworking machinery	2.88	4.6	1.08	Footwear, x. rubber and plastic	2.71	.9	1.40
Iron and steel foundries	2.69	3.5	1.02	Meat products	2.38	1.2	1.05
Screw machine products	2.62	2.4	.95	Misc. paper and pulp products	2.35	2.8	.80
Blast furnaces, rolling and finishing mills	2.60	4.1	1.05	Dairy products	1.95	4.3	1.41
Engines and turbines*	2.47	6.7	.76	Electronic computing equipment*	1.81	28.5	1.08
Cycles and misc. transportation equipment	2.41	5.7	1.48	Aircrafts and parts*	1.59	15.6	.90
Household appliances	2.23	4.9	1.09	Printing and publishing, x. newspapers	1.48	2.0	1.18
Not specified electrical machinery*	2.01	11.6	.83	Beverage industries	1.37	3.6	1.09
Railroad locomotives and equipment	1.99	4.7	1.04	Optical and health services supplies*	1.31	7.9	.91
Paints, varnishes, and related products*	1.94	12.3	1.08	Misc. petroleum and coal products	1.27	5.2	.96
Cutlery, handtools, and other hardware	1.89	3.2	1.12	Agricultural chemicals*	1.26	10.3	.98
Misc. nonmetallic mineral and stone products	1.88	5.4	1.14	Scientific and controlling instruments*	1.26	12.1	.84
Misc. plastic products	1.84	4.4	1.07	Structural clay products	1.21	5.0	1.33
Other rubber products and plastics	1.83	8.9	1.57	Leather tanning and finishing	1.19	1.3	.92
Construction and material handline equipment*	1.80	7.0	1.10	Newspaper printing and publishing	1.14	.8	1.03
Misc. fabricated metal products	1.79	3.3	.94	Cement, concrete, gypsum, and plastic products	1.12	2.7	1.01
Machinery n.e.c., x. electrical	1.77	5.3	1.07	Soaps and cosmetics*	1.08	5.8	.73
Tires and inner tubes	1.73	6.8	1.57	Paperboard containers and boxes	1.05	2.3	1.17

*High tech industry.

¹Dominant industries are those with a concentration index (CI) greater than one.²Tech intensity is measured by the percent of scientists, engineers, and technicians (SET) in the industry's labor force.³Relative SET is the ratio of regional SET to US SET; values greater than one indicate greater tech-intensity in the region's industry.SOURCE: U.S. Bureau of the Census, *1980 Census of Population*, Occupation by detailed industry; Bureau of Labor Statistics (E.S. 202).

Table 4

Top 20 dominant regional industries and their tech-intensity compared with US average

East South Central				West South Central			
Industry	CI ¹	Regional Set ²	Relative Set ³	Industry	CI ¹	Regional Set ²	Relative Set ³
Household appliances	4.13	4.5	1.01	Petroleum refining*	3.66	12.8	1.02
Tires and inner tubes	3.29	3.9	.90	Construction and material handling equipment*	2.49	4.7	.74
Apparel and accessories, knit	3.25	.5	1.09	Agricultural chemicals*	1.79	11.6	1.10
Tobacco	2.78	2.3	.67	Industrial and misc. chemicals*	1.76	14.2	.92
Knitting mills	2.77	.9	.95	Office and accounting machines*	1.62	3.7	.27
Ordnance*	2.48	6.1	.57	Cement, concrete, gypsum, and plastic products	1.56	2.1	.80
Structural clay products	2.27	3.0	.81	Structural clay products	1.52	1.2	.31
Plastics, synthetics, and resins*	2.21	13.2	1.38	Meat products	1.48	.9	.81
Misc. wood products	2.18	.9	.73	Fabricated structural metal products	1.38	3.3	.86
Office and accounting machines*	2.15	18.4	1.36	Tires and inner tubes	1.34	3.3	.76
Logging	2.11	.5	.62	Misc. petroleum and coal products	1.28	2.8	.53
Sawmills, planing mills, and millwork	2.11	1.2	.94	Misc. food preparation	1.25	1.7	.49
Furniture and fixtures	2.10	.7	.69	Beverages industries	1.14	.9	.28
Misc. textile mill products	2.10	2.7	.82	Wood building and mobile homes	1.13	4.8	.54
Iron and steel foundries	2.03	2.4	.71	Sawmills, planing mills, and millwork	1.07	1.4	1.16
Wood buildings and mobile homes	1.97	.9	1.00	Misc. nonmetallic mineral and stone products	1.06	1.3	.29
Pulp, paper, and paperboard mills	1.95	6.0	1.16	Grain mill products	1.00	1.1	.27
Watches, clock, and clockwork devices	1.87	1.7	.23				
Ship and boat building and repairing	1.85	5.7	.93				
Footwear, x. rubber and plastic	1.79	.5	.74				

*High tech industry.

¹Dominant industries are those with a concentration index (CI) greater than one.

²Tech intensity is measured by the percent of scientists, engineers, and technicians (SET) in the industry's labor force.

³Relative SET is the ratio of regional SET to US SET; values greater than one indicate greater tech-intensity in the region's industry.

SOURCE: U.S. Bureau of the Census, *1980 Census of Population*, Occupation by detailed industry; Bureau of Labor Statistics (E.S. 202).

Table 4

Top 20 dominant regional industries and their tech-intensity compared with US average

Mountain				Pacific			
Industry	CI ¹	Regional Set ²	Relative Set ³	Industry	CI ¹	Regional Set ²	Relative Set ³
Electronic computing equipment*	1.80	25.6	.97	Guided missiles, space vehicles, and parts*	2.69	37.3	1.05
Cement, concrete, gypsum, and plastic products	1.72	3.3	1.24	Aircrafts and parts*	2.65	19.6	1.13
Guided missiles, space vehicles and parts*	1.70	36.2	1.02	Canned and preserved fruits and vegetables	2.28	3.1	1.01
Office and accounting machines*	1.48	21.0	1.56	Logging	2.24	1.7	2.04
Photographic equipment and supplies*	1.45	17.5	1.14	Radio, T.V. and communication equipment*	2.20	20.7	1.28
Sawmills, planing mills, and millwork	1.33	1.1	.91	Electronics computing equipment*	1.78	26.4	1.00
Logging	1.30	1.0	1.18	Sawmills, planing mills and millwork	1.77	1.4	1.16
Wood building and mobile homes	1.20	1.1	1.18	Scientific controlling instruments*	1.72	18.5	1.29
Pottery and related products	1.13	5.7	2.00	Electrical machinery equipment n.e.c.*	1.53	16.9	1.42
Beverage industries	1.12	4.9	1.50	Optical and health services supplies*	1.43	10.8	1.24
Electrical machinery equipment n.e.c.*	1.11	18.6	1.56	Petroleum refining*	1.41	14.7	1.17
Newspaper publishing and printing	1.09	.7	.93	Cycles and misc. transportation equipment	1.34	4.5	1.18
Dairy products	1.07	2.3	.76	Misc. food preparation	1.19	2.1	.62
Canned and preserved fruits and vegetables	1.06	3.2	1.04	Toys, amusement, and sporting goods	1.18	2.5	.34
Scientific and controlling instruments*	1.00	21.4	1.50	Ship and boat building and repairing	1.07	7.2	1.18
				Screw machine products	1.02	3.7	1.49
				Paints, varnishes, and related products*	1.00	8.7	.76
				Beverage industries	1.00	4.0	1.22

*High tech industry.

¹Dominant industries are those with a concentration index (CI) greater than one.

²Tech intensity is measured by the percent of scientists, engineers, and technicians (SET) in the industry's labor force.

³Relative SET is the ratio of regional SET to US SET; values greater than one indicate greater tech-intensity in the region's industry.

SOURCE: U.S. Bureau of the Census, *1980 Census of Population*, Occupation by detailed industry; Bureau of Labor Statistics (E.S. 202).

Table 4

**Top 20 dominant regional industries and their tech-intensity
compared with US average**

South Atlantic

Industry	CI ¹	Regional Set ²	Relative Set ³
Yarn, thread and fabric mills	4.54	2.5	1.18
Floor covering, x. hard surfaces	4.41	2.0	.82
Tobacco	4.15	4.0	1.17
Dyeing and finishing textiles	3.80	3.4	1.22
Knitting mills	3.36	1.1	1.18
Plastics, synthetics, and resins*	2.87	12.4	1.29
Misc. textile products	2.18	4.0	1.19
Ship and boat building and repairing	1.96	5.8	.94
Wood building and mobile homes	1.82	.6	.72
Agricultural chemicals*	1.67	9.7	.92
Furniture and fixtures	1.65	.8	.77
Apparel and accessories, x. knits	1.50	.6	1.30
Logging	1.45	.6	.70
Misc. fabricated textile products	1.39	1.4	1.52
Meat products	1.32	.8	.70
Cement, concrete, gypsum, and plastic products	1.27	2.3	.86
Structural clay products	1.17	2.4	.65
Sawmills, planing mills, and millwork	1.17	1.1	.87
Glass and glass products	1.13	2.3	.65
Misc. wood products	1.10	1.7	1.30

*High tech industry.

¹Dominant industries are those with a concentration index (CI) greater than one.

²Tech intensity is measured by the percent of scientists, engineers, and technicians (SET) in the industry's labor force.

³Relative SET is the ratio of regional SET to US SET; values greater than one indicate greater tech-intensity in the region's industry.

SOURCE: U.S. Bureau of the Census, 1980 Census of Population, Occupation by detailed industry; Bureau of Labor Statistics (E.S. 202).

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Appendix I

The industries composing the sample for the regression reported in Table 3 are drawn from those used in the Census industry-occupation matrix for 1980. These groupings are as follows:

Industry Grouping	Inclusive of SIC Codes
Manufacturing nondurable goods, food and kindred products:	
Meat products	201
Dairy products	202
Canned and preserved fruits and vegetables	203
Grain mill products	204
Bakery products	205
Sugar and confectionery products	206
Beverage industries	208
Miscellaneous food preparation and kindred products	207 & 209
Tobacco manufactures	21
Textile mill products:	
Knitting mills	225
Dyeing and finishing textiles, except wool and knit goods	226
Floor coverings, except hard surface	227
Yarn, thread, and fabric mills	221-224, 228
Miscellaneous textile mill products	229
Apparel and other finished textile products:	
Apparel and accessories, except knit	231-238
Miscellaneous fabricated textile products	239
Paper and allied products:	
Pulp, paper, and paperboard mills	261-263 & 266
Miscellaneous paper and pulp products	264
Paperboard containers and boxes	265
Printing, publishing, and allied industries:	
Newspaper publishing and printing	271
Printing, publishing, and allied industries, except newspapers	272-79

Industry Grouping	Inclusive of SIC Codes
Chemicals and allied products:	
Plastics, synthetics, and resins	282
Drugs	283
Soaps and cosmetics	284
Paints, varnishes, and related products	285
Agricultural chemicals	287
Industrial and miscellaneous chemicals	281, 286, & 289
Petroleum and coal products:	
Petroleum refining	291
Miscellaneous petroleum and coal products	295, 299
Rubber and miscellaneous plastics products:	
Tires and inner tubes	301
Other rubber products, and plastics footwear and belting	302-304, 306
Miscellaneous plastics products	307
Leather and leather products:	
Leather tanning and finishing	311
Footwear, except rubber and plastic	313, 314
Leather products, except footwear	315-17, 319
Durable goods:	
Lumber and wood products, except furniture:	
Logging	241
Sawmills, planing mills, and millwork	242, 243
Wood buildings and mobile homes	245
Miscellaneous wood products	244, 249
Furniture and fixtures	25
Stone, clay, glass, and concrete products:	
Glass and glass products	321-323
Cement, concrete, gypsum, and plastic products	324, 327
Structural clay products	325
Pottery and related products	326
Miscellaneous nonmetallic mineral and stone products	328, 329
Metal industries:	
Blast furnaces, steelworks, rolling and finishing mills	331
Iron and steel foundries	332
Primary aluminum industries & other primary metal industries	333-339

Industry Grouping	Inclusive of SIC Codes
Cutlery, handtools, and other hardware	342
Fabricated structural metal products	344
Screw machine products	345
Metal forgings and stampings	346
Ordnance	348
Miscellaneous fabricated metal products	341, 343, 347, 349
Machinery, except electrical:	
Engines and turbines	351
Farm machinery and equipment	352
Construction and material handling machines	353
Metalworking machinery	354
Office and accounting machines	357 exc. 3573
Electronics computing equipment	3573
Machinery, except electrical, n.e.c.	355, 356, 358, 359
Electrical machinery, equipment, and supplies:	
Household appliances	363
Radio, TV, and communication equipment	365, 366
Electrical machinery equipment, and supplies, n.e.c.	361, 362, 364, 367
Not specified electrical machinery, equipment, and supplies	369
Transportation equipment:	
Motor vehicles and motor vehicle equipment	371
Aircraft and parts	372
Ship and boat building and repairing	373
Railroad locomotives and equipment	374
Guided missiles, space vehicles, and parts	376
Cycles and miscellaneous transportation equipment	375, 379
Professional and photographic equipment, and watches:	
Scientific and controlling instruments	381, 382
Optical and health services supplies	383-385
Photographic equipment and supplies	386
Watches, clock, and clockwork operated devices	382
Toys, amusement, and sporting goods	394
Miscellaneous manufacturing industries	39 exc. 394