High-Tech Clusters in North Carolina

North Carolina Board of Science and Technology

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by

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Executive Summary

Across the country, cities and states are abandoning economic development policies focused on individual industries. It is now widely recognized that every company's success depends on the competitiveness of its key suppliers, service providers, sources of capital equipment, and even direct competitors. Best practice economic development aims to nurture clusters of linked industries and to exploit synergies between clusters and related institutions (universities, colleges, non-profit R&D houses and labs, and business assistance agencies).

Industry clusters are groups of businesses and industries related through their presence in a common product chain, dependence on similar labor skills, or utilization of similar or complementary technologies. Whereas an *industry* is a group of businesses that produce a similar product, a *cluster* includes final market producers, suppliers, related producer services, and other enterprises linked through formal and informal channels. Typical examples are computers and software in Silicon Valley, biotechnology in Boston, automobiles in Detroit, and aircraft in Seattle.

As barriers to international trade fall, it is clear that North Carolina can no longer compete on the basis of low-cost labor. Central to the state's continued economic prosperity is the development of leading industry clusters that seek competitive advantage through continued innovation, highly skilled and productive workers, and the utilization of advanced infrastructure and technology.

High-Tech Clusters in North Carolina was prepared to inform the design and implementation of cluster-based economic development strategies at the state and regional levels. The study uses a systematic methodology to identify major existing, emerging, and high technology clusters in North Carolina and its seven Economic Development Partnership regions. Trends in each cluster are documented using employment and wage data obtained via special request from the North Carolina Employment Security Commission. The report updates and expands the scope of a 1996 study of the state's manufacturing clusters.[1]

[1] See *Targeting North Carolina Manufacturing: Understanding the State's Economy Through Industrial Cluster Analysis* (Chapel Hill, NC, UNC Institute for Economic Development, 1996).

The following are key findings from the study:

- Based on three criteria—absolute size, relative size, and depth (a diversity of underlying sectors)—North Carolina's principal industry clusters include tobacco products, apparel, pharmaceuticals, stone and clay products, fabricated textile goods, and wood products (including furniture).

- Emerging clusters in the state include printing and publishing, hospitals/labs/specialized medical services, transportation/shipping/logistics, construction materials, information technology and instruments, chemicals and plastics, and banking and advertising.

- The core U.S. technology clusters with the strongest relative presence in North Carolina include chemicals and plastics, industrial machinery, and pharmaceuticals and medical technologies. But information technology and instruments (led by activity in the Research Triangle) and motor vehicle manufacturing (led by intermediate supplier sectors and after-market parts industries in the Western and Carolinas regions) are also beginning to attain critical mass.

- The strongest area of overlap between emerging industry clusters and academic R&D in North Carolina is in the area of health sciences (pharmaceuticals and hospitals/medical technologies on the industry side and wide variety of leading health-related research programs at Duke, University of North Carolina at Chapel Hill, and Wake Forest University).

- The state also boasts considerable strength in chemistry and chemicals engineering research (out of NC State University and UNC-Chapel Hill), in some cases with close connections to the growing chemicals and plastics industry cluster.

- On the whole, North Carolina's emerging clusters demand workers considerably more advanced knowledge and skills than its declining clusters, emphasizing the critical importance of a high quality primary, secondary, and post-secondary education and training system in the state.

- The Carolinas region is shifting gradually from an economy dominated by traditional manufacturing to one driven by technology-intensive production (motor vehicles manufacturing, industrial machinery, and chemicals and plastics) and advanced services (banking, printing and publishing, and health). Banking and advertising is the most dynamic cluster in the region, driving growth in other advanced producer and consumer services.

- The Northeast region's strongest existing cluster may be chemicals and plastics. Only a few high tech segments of the cluster are represented in the region, however. The Northeast's packaged food products cluster is not generating a significant number of new jobs.

- Based on trends over the last decade, the Piedmont Triad region's most promising clusters are transportation, shipping and logistics and construction materials. The hospitals, labs and specialized medical services cluster may be emerging, especially in sectors that overlap with research strengths at Wake Forest University, but the cluster remains small relative to national averages. Two technology clusters that are growing at a strong clip nationwide are barely expanding in the Triad: information technology/instruments and communications services/software.

- Top clusters in the Research Triangle are hospitals, labs and specialized medical services, information technology and instruments, and pharmaceuticals. From the perspective of industry trends and leading academic programs, a very broad and deep health sciences cluster is emerging in the region. It includes internationally renowned academic programs in biological and medical sciences and industrial specializations in pharmaceuticals, biotechnology, and advanced medical services.

- Existing clusters in the Southeast include packaged food products and chemicals and plastics, while transportation, shipping, and logistics cluster may be emerging. Two high technology clusters with a significant presence in the Southeast are high tech industrial machinery and high tech chemicals and plastics. Communications services and software activity in the region is growing fast.

- Key clusters in the Transpark region include apparel, packaged food products, fabricated textiles, pharmaceuticals manufacturing, boat building and tobacco products. Of the existing clusters, only packaged food products is adding significant employment. High technology clusters with a sizable relative presence in the region include household appliances and pharmaceuticals/ medical technologies, though the former is dominated by a few large producers.

- Growth clusters in the West include chemicals and plastics, construction materials, and motor vehicle manufacturing. There is some high tech activity expanding in chemicals, motor vehicles, and pharmaceuticals and medical technologies. High-tech information technology and instruments, a growth cluster nationwide, is not expanding in the West.

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CHAPTER ONE
Introduction

In 1995, the North Carolina Alliance for Competitive Technologies commissioned researchers at the Institute for Economic Development at the University of North Carolina at Chapel Hill to conduct a detailed analysis of industry clusters in the state's manufacturing sector. The study, titled *Targeting North Carolina Manufacturing: Understanding the State's Economy through Industrial Cluster Analysis*, was designed to assist in the development of programs for increasing rates of industrial modernization and technology adoption. Various state and local agencies also used the results to guide marketing, recruitment, workforce development, and entrepreneurship activities. In 1997, the UNC team released seven reports documenting manufacturing clusters in each of North Carolina's Economic Development Partnership regions.

The present report, prepared for the North Carolina Board of Science and Technology, updates and expands the scope of the original *Targeting North Carolina Manufacturing* report and seven regional studies. *High-Tech Clusters in North Carolina* defines clusters made up of both manufacturing *and* non-manufacturing "export" sectors, focuses specifically on technology-intensive clusters, and includes a brief economic profile of each Economic Development Partnership region. While the scope of the present study is broader than *Targeting North Carolina Manufacturing*, the analysis is less detailed. Broad trends are summarized as concisely as possible.

Why Industry Clusters?

It is now widely recognized that every company's success depends in part on the competitiveness of its key suppliers, service providers, sources of capital equipment, and even direct competitors. Industry clusters are groups of businesses and industries related through their presence in a common product chain, dependence on similar labor skills, or utilization of similar or complementary technologies. Whereas an *industry* is a group of businesses that produce a similar product, a *cluster* includes final market producers, suppliers, related producer services, and other linked enterprises. Typical examples of clusters are the vehicle manufacturing complex in Detroit, computers, software, and telecommunications services in the Silicon Valley, and commercial aircraft production in Seattle.

The critical feature of an industry cluster is shared benefits associated with the cluster's size and scope; such returns grant member businesses a competitive edge *vis-à-vis* their counterparts in regions with less extensive clusters. Businesses in large, well-developed industry clusters enjoy ready access to supplies and equipment, skilled labor, specialized infrastructure, and top quality technical and scientific personnel. Evidence suggests that businesses in clusters benefit from working jointly to solve collective problems while also engaging in direct competition.[1]

Understanding the state's economy from the perspective of groups of related and supporting industries can reveal economic strengths and opportunities that are not evident from analyses of individual sectors. For example, *Targeting North Carolina Manufacturing* demonstrates that the vehicle manufacturing cluster is significant in the state, though employment in the transportation equipment industry itself (SIC 37) remains small. The reason is that North Carolina is home to a fairly diverse range of transportation equipment suppliers and after-market parts producers. Evidence suggests the state is well poised to benefit from the southern shift in U.S. vehicle production.

Targeting North Carolina Manufacturing also found that in ten of the eleven largest manufacturing clusters in the state, a higher share of NC employment is in low-technology, low-wage sectors than is the case nationwide.[2] North Carolina specializes in the lowest technology segments of the lowest technology clusters. Such a finding is not evident when individual industries are the focus of the analysis.

Objectives

The principal objective of the study is to identify major existing and emerging clusters in the state and in each of the seven Economic Development Partnership regions. We investigate both general industry clusters and clusters comprised of high-tech sectors alone. We also briefly describe specialized enabling infrastructure and programs—research strengths, training initiatives, business assistance, etc.—in each region that might help support or leverage further cluster development.

Scope and Organization

Chapter two describes the methodology. The basic approach is the same as that of *Targeting North Carolina Manufacturing*, though new and more recent sources of data on inter-industry ties are included and the cluster definitions have been revised (not least to include non-manufacturing sectors). Chapter three outlines major existing and emerging clusters in the state. Seven regional profiles follow in chapter four. Detailed data on each cluster in each region and the state are available for downloading at www.governor.state.nc.us/govoffice/science/projects/nc2030.html.

CHAPTER TWO

Finding Industry Clusters: The Benchmark Approach

The most common approach to industry cluster analysis involves two steps. First, measures of size, concentration, and growth are used to identify large or high performing sectors. Second, those sectors are grouped into clusters based on judgment or secondary information about their interdependence.[3] The result is a set of key industry clusters as they exist at the time of the study.

In many states, such an approach has severe limitations. First, it often reveals little about technology-intensive industries of interest (e.g., information technology, health sciences, etc.) simply because such sectors are not yet as large—in relative or absolute terms—as other industries. Second, it ignores the fact that in many industries, local ties are not a significant determinant of competitiveness. The branch plant manufacturer producing a standardized good is an example. Its principal linkages are with its headquarters, suppliers, and equipment vendors, all of which may be located in another region or state. Finding clusters is relatively straightforward in places like Silicon Valley or, for that matter, Research Triangle Park. But cluster analysis that generates real policy implications for less-developed economies like the Northeast, Transpark, and Western regions of North Carolina is more difficult.

The Current Study

In a restructuring economy such as North Carolina's—one in which traditional industries remain dominant and where knowledge-intensive sectors dependent on strong local linkages are only beginning to attain critical mass, a *benchmarking* approach to industry cluster analysis can contribute insights the typical approach cannot. The benchmarking method begins by identifying major industry clusters—groups of interdependent and related sectors—for the U.S. economy as a whole using detailed data on industrial interdependence. Then, the distribution, composition, and performance of such clusters are examined in North Carolina.[4]

While the usual analytical approach focuses mainly on what a state or region *does have* at the current time, the benchmarking method identifies what is emerging and what an economy *could have*, perhaps with properly focused technology policy. It is well known that tobacco, textiles, apparel, and furniture are key clusters in North Carolina. The more important question is whether higher technology and

Defining Industry Clusters

There are three critical dimensions of the industry cluster concept. The first is interdependence or linkage. By definition, clusters comprise interdependent or linked business enterprises. That interdependence may be formal or informal. It may derive from presence in *common value chains* (i.e., end market producers and their suppliers), the *utilization of similar labor* or workforce skills (dependence on joint labor pools), the *adoption of similar technologies*, or the *exchange of knowledge and innovations*. The first order of business in an industry cluster study is determining the appropriate measure of interdependence.

The second dimension is time or stage of development. Industry clusters may be defined as existing, emerging, or potential. *Existing clusters* are those that have obtained critical mass: they are large in both absolute and relative terms and are diverse (multiple elements or sectors of the cluster are present). Existing clusters, which may be expanding or contracting over any given period, are usually easily recognized as the leading industrial specializations in the given state or region. Examples in North Carolina are the declining tobacco products cluster and the growing pharmaceuticals cluster.

Emerging clusters are clusters that will likely attain critical mass if current trends continue. An example in North Carolina is information technology: a powerhouse in the Research Triangle that has only a modest presence in the rest of the state. *Potential clusters* are more speculative than emerging clusters. In a potential cluster, few related industries may be present or the cluster may be dominated by just a few large firms. In a potential cluster, there is opportunity but conditions favorable to the cluster's actual emergence are uncertain. An example is transportation, shipping and logistics, a potential North Carolina cluster that, although small in relative terms, received a considerable boost with the 1998 decision by Federal Express to locate a hub in the Piedmont Triad.

The third dimension of the industry cluster concept is geography. Some clusters are concentrated in particular regions. Others are distributed across multiple regions. Like regional economies, industry clusters rarely follow defined administrative boundaries (e.g., counties or political divisions). In an increasingly global economy, some companies' most important linkages are non-local ones; such businesses are members of global networks of production—worldwide clusters—that are as critical to their competitiveness as any local cluster.

Some cluster studies focus on identifying strictly localized clusters, employing the implicit assumption that local ties are more crucial to the competitiveness of area businesses than non-local ties. Others, *High-Tech Clusters in North Carolina* included, utilize a market logic to identify linked businesses irrespective of location and then search for geographical concentrations of such businesses.

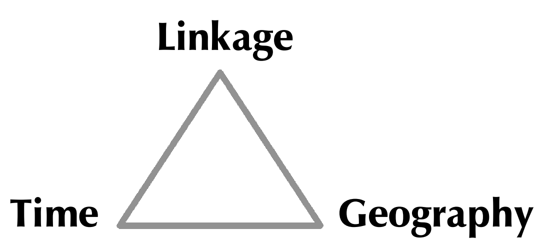

FIGURE 1
Identifying industry clusters: 3 dimensions

higher wage industry segments can be developed within those clusters. But to find the answer one has to know what those segments are. They simply cannot be found by looking in a place where they have not yet developed.

Procedures

The benchmark clusters reported here are based on statistical analysis of two sets of data: the *Benchmark Input-Output Accounts of the United States* and the *U.S. Staffing Patterns Matrix*. Input-output data provide a useful characterization of trading patterns and general technological similarities among all U.S. industries, but with a particular emphasis on manufacturing sectors. Because human capital is the principal input in many non-manufacturing industries, we supplemented the input-output-based analysis by using staffing-patterns information to group sectors according to shared occupational labor requirements. We then used other sources of industry information and judgment to reconcile the results derived from the two data sources.

The clusters are therefore groups of industries that fall within the same broad value chain (final market producers and their first, second, and third tier supplier sectors) or, for industries that do not trade significantly in physical goods, that draw from the same broad labor pool. The latter include legal services, banking and advertising, and transportation services and logistics.

We excluded from the analysis those sectors that are largely local-serving, including personal services, construction (though not construction equipment), retail, wholesale, government, and education. Farming is also excluded, primarily because of lack of appropriate data. In essence, our investigation is restricted to those industries with the greatest potential to export goods or services outside the state or particular region in question.

***Two Sets of Clusters*.** To focus specifically on high-technology businesses while also recognizing other strengths in the North Carolina economy, we developed two sets of benchmark clusters. We derived the first from a statistical analysis of interdependence among *all* potential export sectors in the U.S. economy.[5] That analysis revealed 28 clusters, ranging from metalworking and industrial machinery to pharmaceuticals. Many of the 28 benchmark clusters comprise both high-tech and low-tech sectors while some sectors are members of multiple clusters. For example, the software industry is a member of both the information technology/instruments and hospitals/labs/specialized medical services clusters. Appendix Table 1 reports the detailed makeup of each cluster.

We derived a second set of benchmark clusters by statistically analyzing interdependence only among high-technology industries. That effort identified 8 benchmark technology clusters, where each comprises individual high-tech industries that are most closely linked due to value-chain or labor market relationships. Note that the benchmark technology clusters are not simply direct high-tech subsets of the general industry clusters. For example, the wiring industry is most closely tied to metalworking and industrial machinery when we investigate relationships among all industries. But wiring falls into

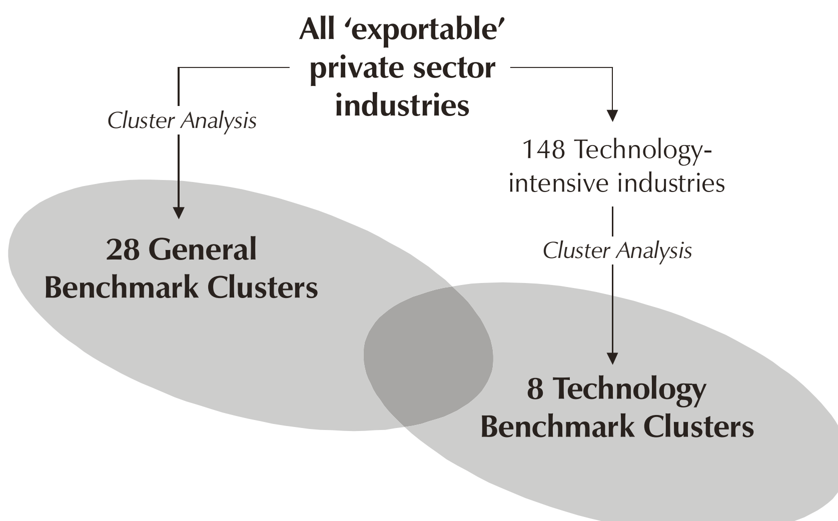

FIGURE 2
Summary of benchmark cluster methodology

an information technology and instruments cluster when we examine only relationships among high-tech sectors.

Some sectors essentially stand alone; that is, they have few significant ties with other industries. An example is the pharmaceuticals industry, which, as defined by the federal government's classification system, is essentially self-contained. Put differently, pharmaceuticals companies tend to interact—at least in terms of trading ties—mainly with other pharmaceuticals companies. Thus the pharmaceuticals "cluster" is made up of only pharmaceuticals industries. Other features of the clusters are the following:

- They differ, sometimes significantly, from clusters reported in *Targeting North Carolina Manufacturing*. They are based on more recent data, are derived from labor market rather than value-chain ties in some cases, and include the influence of some non-manufacturing sectors.

- They comprise industries in detailed four-digit Standard Industrial Classification (SIC) system categories that span two-digit sectors. For example, industries that fall into ten two-digit sectors (from furniture and fixtures, SIC 25, to instruments, SIC 38) are members of the metalworking and industrial machinery cluster.

- They cover less than 50 percent of all employment in the state, given that they exclude primarily local-serving industries, government, mining, and agriculture. However, the industries they do cover are major drivers of North Carolina's economy.

- They are not mutually exclusive; sectors are members of multiple clusters since many industries have ties with a very diverse array of sectors. Mutual exclusivity would contradict the notion of interdependence that is at the heart of the cluster concept.

- The set of revealed clusters is influenced by limitations in the federal government's industry classification system. Some fast growing technology industries—such as biotechnology and specialized information technology—are not easily detected in the analysis since many such sectors did not exist when the last revision of the SIC system was released. Such industries are captured within the pharmaceuticals and hospitals/medical technologies clusters, as well as chemicals and plastics (due to the presence of agricultural chemicals).

- The statistical procedures used to develop the benchmark clusters include factor analysis and hierarchical cluster analysis. A supplementary appendix describing methodological issues in more detail is available.[6] An important feature of the study is that it is based on a systematic rather than arbitrary analysis of observed ties between industries.

General Benchmark Clusters

Table 1 lists the 28 general U.S. benchmark clusters along with basic payroll, wage, and employment information. The largest cluster in the U.S. in terms of employment is printing and publishing. Nearly 9 million Americans work in the various industries that make up the cluster. Its large size can be explained in part by the inclusion of the hospitals and software industries. Hospitals are major consumers of paper products, from printed forms, gowns, and sheets, to sanitary products, packaging, bags, and cleaning supplies. The demands of hospitals and medical services providers have driven the development of some higher value paper goods. The software and computer services industry is a major supplier to the publishing industry and is also closely tied to hospitals and medical services (including via the emerging field of bioinformatics). Thus, the printing and publishing cluster runs the gamut from resource extraction and physical commodity production to informatics

Among other large U.S. clusters are hospitals/labs/specialized medical services, metalworking and industrial machinery, information technology and instruments, banking and advertising, transportation/shipping/logistics, construction materials, motor vehicle manufacturing, chemicals and plastics, and packaged food products.

Table 1

General Benchmark Clusters, U.S.

	Employment			Payroll			
Clusters	1997 (000's)	% Private Sector 1997	Annual % Change '89-'97	1997 (millions)	% Private Sector 1997	Annual % Change '89-'97	Average Wage 1997
Printing and publishing	8,948.9	8.76	2.09	355,541.2	11.57	9.03	39,730
Hospitals, labs, specialized medical services	6,646.5	6.51	3.71	252,558.2	8.22	12.16	37,999
Metalworking and industrial machinery	5,155.3	5.05	0.41	194,332.2	6.33	4.78	37,696
Information technology and instruments	3,935.6	3.85	1.13	208,092.1	6.77	8.63	52,875
Banking and advertising	3,316.7	3.25	0.37	165,189.0	5.38	9.22	49,805
Construction materials	3,266.8	3.20	0.48	121,870.0	3.97	5.22	37,306
Transportation, shipping and logistics	3,110.4	3.04	2.88	102,872.7	3.35	6.64	33,074
Motor vehicle manufacturing	2,881.8	2.82	1.16	113,422.5	3.69	5.71	39,358
Chemicals and plastics	2,771.6	2.71	1.87	106,967.7	3.48	6.80	38,594
Securities and insurance	1,681.0	1.65	1.81	71,585.0	2.33	9.12	42,584
Packaged food products	1,640.9	1.61	0.37	50,290.6	1.64	4.24	30,647
Fabricated textiles	1,320.2	1.29	-2.42	32,016.2	1.04	1.86	24,251
Apparel	1,286.9	1.26	-2.98	30,816.2	1.00	0.75	23,945
Wood products (incl. furniture)	1,000.0	0.98	0.27	31,018.5	1.01	4.02	31,017
Legal services	948.5	0.93	0.76	48,113.4	1.57	5.38	50,725
Aerospace	785.9	0.77	-4.75	42,343.6	1.38	-1.37	53,881
Primary nonferrous metals	579.9	0.57	1.05	20,426.6	0.66	5.42	35,222
Stone and clay products	303.7	0.30	-0.97	14,904.8	0.49	3.26	49,076
Pharmaceuticals	269.8	0.26	2.08	17,040.2	0.55	10.53	63,162
Canned and bottled beverages	200.8	0.20	-1.19	9,108.9	0.30	3.59	45,375
Boat building	198.5	0.19	-1.79	8,021.3	0.26	1.93	40,407
Aluminum	196.3	0.19	-1.87	9,426.1	0.31	1.24	48,027
Petroleum products	141.9	0.14	-1.44	8,453.7	0.28	3.76	59,557
Platemaking and typesetting	89.2	0.09	-1.89	3,973.9	0.13	2.52	44,554
Leather goods	80.1	0.08	-4.62	1,925.4	0.06	-0.99	24,047
Jewelry	68.6	0.07	-2.26	2,137.3	0.07	1.26	31,178
Tobacco products	41.2	0.04	-2.54	2,301.7	0.07	1.57	55,820
Food oil mills	32.5	0.03	0.32	1,244.5	0.04	5.01	38,286
Total Private Sector Employment	102,175.1		1.73	3,071,807.3		6.71	30,064

Source: Minnesota IMPLAN Group, Inc. ES-202 files and authors' calculations. Clusters are not mutually exclusive.

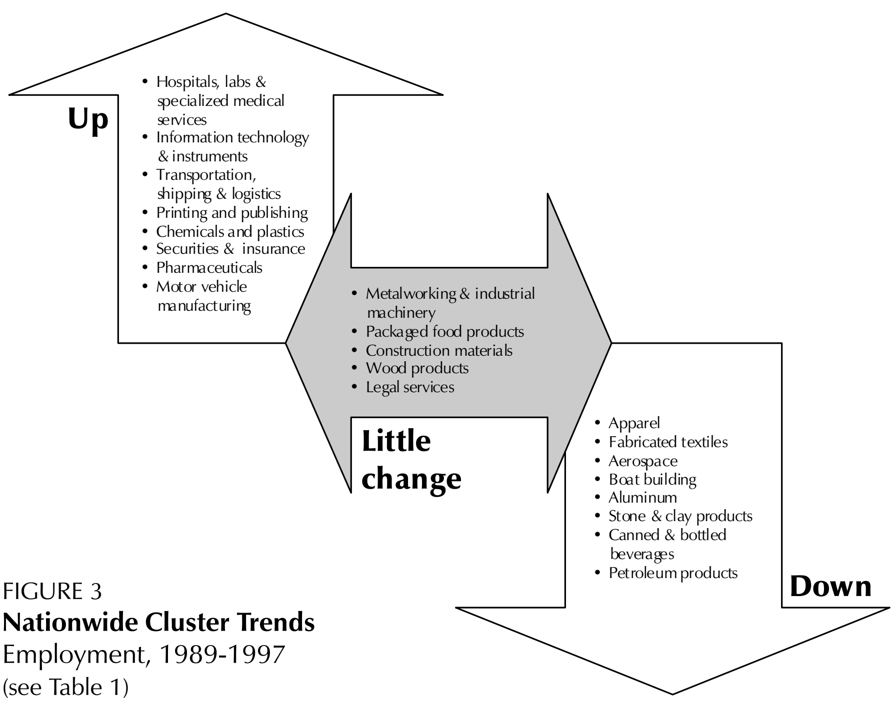

FIGURE 3
Nationwide Cluster Trends
Employment, 1989-1997
(see Table 1)

Figure 3 summarizes broad employment and wage trends in the clusters over the 1989–1997 period. During the 1990s, knowledge-intensive or technology-intensive clusters such as hospitals and labs, information technology, printing and publishing, securities and insurance, and pharmaceuticals have been expanding while lower technology, traditional clusters are growing slowly or declining. A key exception is aerospace, a technology-intensive cluster that posted significant job losses over the period because of reductions in federal defense spending.

Technology Benchmark Clusters

Table 2 lists the 8 benchmark technology clusters.[7] Among largest high-technology clusters in the country are information technology and instruments, communications services and software, motor vehicle manufacturing, and chemicals and plastics. Note that when linkages among all industries—high tech and low tech—are examined, communications services and software do not fall out as a distinct cluster (rather, as enabling technologies, many communications services and software sectors fall into multiple general industry clusters; see Table 1 and Appendix Table 1). The cluster stands alone only when the focus is restricted to technology-intensive sectors. Likewise, medical technologies (which includes surgical instruments and equipment) are joined with pharmaceuticals and testing laboratories when the analysis is limited to high-tech sectors.

Among the fastest growing technology clusters in the country are communications services and software and information technology and instruments. Other clusters posting strong employment gains between 1989 and 1997 are vehicle manufacturing (its technology-intensive segments in engines, electronics, and assembly) and chemicals and plastics. Employment in aerospace and household appliances declined over the period.

Table 2

Technology Benchmark Clusters, U.S.

	Employment			Payroll			
Clusters	1997 (000's)	% Private Sector 1997	Annual % Change '89-'97	1997 (millions)	% Private Sector 1997	Annual % Change '89-'97	Average Wage 1997
Information technology and instruments	3,371.3	3.30	1.83	181,425.4	5.91	10.21	53,815
Communications services and software	2,659.7	2.60	5.51	143,111.9	4.66	15.08	53,808
Motor vehicle manufacturing	1,490.8	1.46	0.96	69,006.2	2.25	5.60	46,289
Chemicals and plastics	1,327.1	1.30	1.23	57,824.1	1.88	6.57	43,573
Pharmaceuticals and medical technologies	948.4	0.93	1.60	47,815.9	1.56	8.81	50,419
Aerospace	809.0	0.79	-3.40	40,410.6	1.32	0.03	49,948
Industrial machinery	562.8	0.55	0.16	23,059.4	0.75	5.28	40,971
Household appliances	86.5	0.08	-1.16	3,061.4	0.10	2.80	35,379
Total Private Sector	102,175.1		1.73	3,071,807.3		6.71	30,064

Source: Minnesota IMPLAN Group, Inc. ES-202 files and authors' calculations. Clusters are not mutually exclusive.

CHAPTER THREE

Industry Clusters in North Carolina

Based on three criteria—absolute size, relative size, and depth (a diversity of underlying sectors)—North Carolina's principal industry clusters include tobacco products, apparel, pharmaceuticals, stone and clay products, fabricated textile goods, and wood products (including furniture). Except for stone and clay products and pharmaceuticals, the existing clusters are all in decline or are failing to generate significant new employment opportunities. Employment in both the tobacco and fabricated textiles clusters declined by 3.8 percent annually between 1989 and 1998. Apparel cluster jobs fell by 3.3 percent each year over the period while there was little net change in employment in wood products.

Output has remained strong in some clusters (particularly textiles and apparel), even as workers have been laid off. Automation is displacing labor in many sectors, producing a pool of workers that require substantial retraining before they can enter higher skilled positions in growing industries. The size and depth of the textile, apparel, and wood products clusters will probably help many North Carolina businesses remain viable even in the face of stiff competition from overseas competitors. But these clusters will not be a significant source of new jobs in the future.

A Summary Measure of Relative Size

To evaluate the *relative* size of each cluster, we use a simple descriptive measure called a location quotient. It is calculated as

$$\frac{\text{Employment, cluster i, NC}}{\text{Total employment, NC}} \div \frac{\text{Employment, cluster i, US}}{\text{Total employment, US}}$$

A location quotient of 1.0 indicates that the share of employment in the cluster in North Carolina matches the comparable share for the U.S. Location quotients significantly above one suggest the state is specialized in the given cluster, i.e. it has a larger share of activity in the cluster than we would expect based on national trends.

Emerging Clusters

Based on employment and wage trends over the 1989-1998 period, several clusters appear to be emerging in North Carolina. They include printing and publishing, hospitals/labs/specialized medical services, transportation/shipping/logistics, construction materials, information technology and instruments, chemicals and plastics, and banking and advertising.[8] In relative terms the emerging clusters remain small. For example, although the printing and publishing cluster employs close to 280,000 people in North Carolina, its share of total private sector employment (7.6 percent) is slightly lower than the comparable share for the U.S. as a whole (8.8 percent). Yet employment in the cluster expanded by nearly 5 percent annually between 1989 and 1998, compared to

Criteria for Identifying Clusters

Existing Clusters. Absolute size, relative size based on location quotient, diversity of underlying cluster sectors.

Emerging Clusters. Absolute size, relative size (location quotient approaching or slightly above 1.0), strong growth relative to national trends, diversity of underlying cluster sectors. Assumes trends over the study period (1989-1998) will continue.

Potential Clusters. Absolute size and strong growth relative to national trends. Potential clusters often lack a diversity of underlying sectors.

Technology Clusters. Data for all eight U.S. benchmark clusters are reported regardless of size, growth or diversity.

annual growth at the national level of 2.1 percent. All of the emerging clusters except transportation/shipping/logistics are significantly outpacing U.S. growth trends. Transportation, shipping and logistics is included as an emerging cluster because of its large relative size, its solid growth, and the fact that the location of the Federal Express hub in the Triad is likely to give the cluster a significant boost.

On average, the seven emerging clusters pay annual wages of $37,087, compared to an average $25,013 for apparel, fabricated textiles, and wood products. However, they also demand better trained and higher skilled workers, emphasizing the critical importance of a high quality and extensive secondary and post-secondary education and training system in the state.

Some Core High Technology Clusters Also Emerging

Table 3 summarizes North Carolina employment and wage trends in the 8 U.S. technology clusters. Examining the relative presence of the clusters in North Carolina gives a sense of major specialized technology strengths in the state. Note that some sub-industries within each technology cluster are also members of the existing and emerging clusters in Table 3. For example, the information technology and instruments cluster in Table 3 includes both high-tech sectors (such as software and electronics) as well as lower-tech industries (computer rental and leasing).[9]

The core technology clusters with the strongest relative presence in North Carolina include chemicals and plastics, industrial machinery, and pharmaceuticals and medical technologies. But information technology and instruments (led by activity in the Research Triangle) and motor vehicle manufacturing (led by intermediate supplier sectors and after-market parts industries in the Western and Carolinas regions) are also beginning to attain critical mass. Aerospace and household appliances each have a very minor presence in the state. The state significantly increased its share of national high-tech chemicals and plastics employment during the 1990s.

The communications services and software cluster is growing at an exceptionally high rate. Em-

Table 3

North Carolina Industry Clusters

	Employment			
Clusters	1998	Annual % Change '89-'98	Location Quotient 1998	Average Wage
Existing general industry clusters				
Apparel	207,698	-3.3	4.46	25,057
Fabricated textiles	128,893	-3.8	2.70	23,538
Wood products (incl. furniture)	77,549	0.0	2.15	26,445
Pharmaceuticals	17,783	3.0	1.82	48,538
Tobacco products	16,151	-3.8	10.84	47,151
Stone and clay products	13,838	5.8	1.26	40,161
Emerging general industry clusters				
Printing and publishing	279,849	4.9	0.87	35,621
Hospitals, labs, specialized medical services	226,117	6.1	0.94	34,657
Transportation, shipping and logistics	118,989	2.6	1.06	32,918
Consruction materials	118,390	2.2	1.00	31,990
Information technology and instruments	105,796	4.4	0.74	47,378
Chemicals and plastics	104,367	3.9	1.04	36,070
Banking and advertising	95,259	5.3	0.79	40,978
U.S. technology clusters, presence in the state				
Information technology and instruments	104,420	4.5	0.86	47,363
Communications services and software	63,660	10.0	0.66	48,241
Chemicals and plastics	53,923	4.1	1.12	38,106
Motor vehicle manufacturing	44,277	4.1	0.82	35,169
Pharmaceuticals and medical technologies	34,629	1.7	1.01	41,915
Industrial machinery	21,464	1.3	1.06	35,870
Aerospace	5,545	5.8	0.19	41,168
Household appliances	1,139	n.a.	0.36	23,492

Source: NC Employment Security Commission and Minnesota IMPLAN Group, Inc. (ES-202 files). Clusters are not mutually exclusive.

ployment in the cluster expanded by 10 percent annually between 1989 and 1998, compared to a national annual growth rate of 5.5 percent. The cluster has the second largest presence in the state of all technology clusters, although it is small in relative terms (accounting for 1.7 percent of private sector employment compared to 2.6 percent at the national level).

Industry Clusters and Academic Research

North Carolina's emerging industry clusters—both general clusters and high-technology clusters—dovetail with some of its leading academic strengths. A 1998 study that evaluated national rankings and performance of science disciplines at all universities in the state identified four leading academic R&D strengths: electronics and related (electrical engineering, materials science, computer science), life sciences and related (biology, biochemistry, pharmacology, biomedical engineering, among others), other chemicals (chemistry and chemical engineering), and environmental (geosciences, oceanography, and ecology).[10]

The strongest area of overlap between emerging industry clusters and academic R&D in North Carolina is in the area of health sciences (pharmaceuticals and hospitals/medical technologies on the industry side and wide variety of leading health-related research programs at Duke, University of North Carolina at Chapel Hill, and Wake Forest University). The state also boasts considerable strength in chemistry and chemicals engineering research (out of NC State University and UNC-Chapel Hill), in some cases with close connections to the growing chemicals and plastics industry cluster.

CHAPTER FOUR
Regional Profiles

The following profiles summarize major cluster trends in each of the state's Economic Development Partnership regions. Criteria for identifying existing, emerging, and (in some cases) potential clusters are as described in chapter three.

Also included in each profile is a very brief description of major university research strengths (based on R&D funding trends by discipline) and programs and initiatives designed to leverage *specific* industries. There are a great many training and business assistance programs across the state, not to mention many local and regional development agencies. The activities of many of those programs and agencies are well-documented elsewhere. We focused on identifying significant and *illustrative* initiatives that are currently targeted to particular industries and that might leverage broader existing and emerging industry clusters identified in the study.

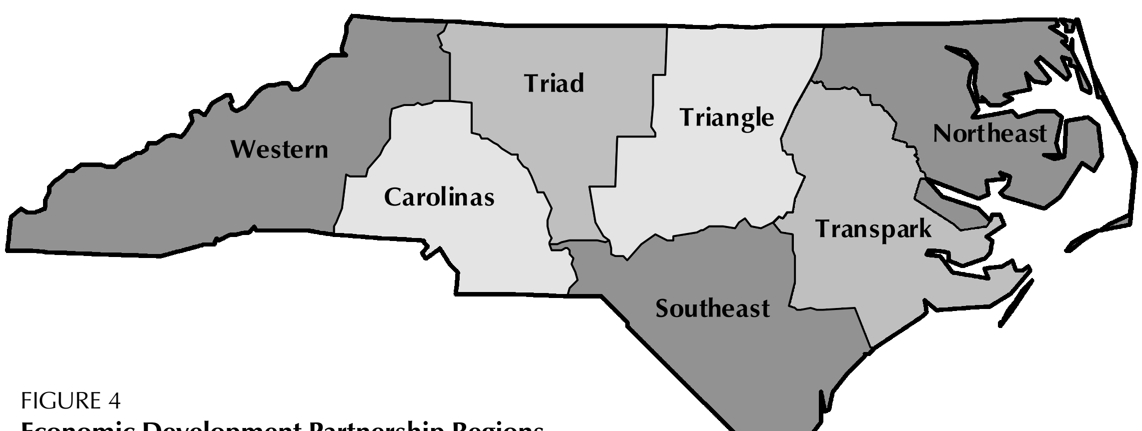

FIGURE 4
Economic Development Partnership Regions

Carolinas Region

Summary

- The Carolinas region is shifting gradually from an economy dominated by traditional manufacturing to one driven by technology-intensive production (motor vehicles manufacturing, industrial machinery, and chemicals and plastics) and advanced services (banking, printing and publishing, and health).

- Banking and advertising is the most dynamic cluster in the region, driving growth in other advanced producer and consumer services. Such knowledge-intensive sectors hold the greatest promise for quality job gains in the Carolinas into the foreseeable future.

- Employment growth has also been solid in metalworking and industrial machinery, transportation/shipping/logistics, motor vehicle manufacturing, and chemicals and plastics.

- Overall, the region is still firmly grounded in traditional, less technology-intensive manufacturing sectors, despite the shift toward producer and consumer services and advanced manufacturing.

Table 4

Carolinas Industry Clusters

Clusters	Employment 1998	Employment Annual % Change '89-'98	Employment Location Quotient 1998	Average Wage
Existing general industry clusters				
Apparel	57,887	-3.6	4.87	24,963
Fabricated textiles	41,073	-3.3	3.37	24,144
Transportation, shipping and logistics	39,227	1.2	1.36	40,166
Banking and advertising	38,618	9.9	1.26	48,365
Motor vehicle manufacturing	33,227	3.9	1.25	34,240
Wood products	14,122	2.3	1.53	24,584
Stone and clay products	3,282	4.3	1.17	40,754
Emerging general industry clusters				
Printing and publishing	72,706	4.7	0.88	38,309
Hospitals, labs, specialized medical services	52,370	7.4	0.85	38,545
Metalworking and industrial machinery	43,662	2.1	0.92	35,520
Construction materials	31,343	3.9	1.04	35,349
Chemicals and plastics	27,418	3.7	1.07	37,140
Primary nonferrous metals	4,749	3.0	0.89	37,584
Potential general industry clusters				
Information technology and instruments	24,731	4.9	0.68	50,284
Securities and insurance	10,338	5.5	0.67	39,688
Legal services	5,147	6.6	0.59	44,250
U.S. technology clusters, presence in the region				
Information technology and instruments	23,309	5.2	0.75	50,840
Communications services and software	21,166	14.9	0.86	53,144
Motor vehicle manufacturing	14,918	6.1	1.08	37,698
Chemicals and plastics	12,096	1.5	0.99	45,318
Industrial machinery	7,845	2.3	1.51	40,326
Pharmaceuticals and medical technologies	2,609	5.7	0.30	32,434
Aerospace	1,561	4.2	0.21	38,779
Household appliances	s	s	s	s

Source: NC Employment Security Commission (ES-202 files). *s* indicates data suppressed to satisfy confidentiality restrictions. Clusters are not mutually exclusive.

Existing Regional Clusters

Based on relative and absolute size measures, seven clusters are major industrial strengths in the Carolinas region (see Table 4). The banking and advertising cluster is the most dynamic. Its industries pay a high average wage and its outstanding growth over the last decade has propelled Charlotte to its status as a national leader in banking and finance. The expansion of the cluster has also fueled growth in several other knowledge-based clusters, including securities and insurance, information technology and instruments, and legal services.

Snapshot: Carolinas Economy

Private sector employment, 1998	944,674
Annual employment growth, '89–'98	2.8%
Share of state private employment growth, '89–'98	25.5%
Average annual private sector wage, 1998	$28,585
Annual real wage growth, '89–'98	1.1%
Net new establishments, '89–'98	9,189
Unemployment rate, 1998	3.2%
Poverty rate, 1990	9.4%
Adults w/college education, 1990	17.6%
Manufacturing employment intensity, 1998	23.4%
Agricultural employment intensity, 1998	0.9%

The Carolinas region is more than Charlotte, however. Much of the region remains dominated by low-tech manufacturing and raw materials processing industries. In general, such clusters tend to be more cost-sensitive, pay lower wages, rely on moderately skilled workers, and, because of the dominance of branch plants, have fewer linkages to the local economy. Apparel and fabricated textiles remain the largest of region's clusters. The resource-intensive wood products (including furniture) and stone and clay products clusters have both added jobs over the past decade despite little growth at the national level.

The motor vehicles cluster expanded rapidly in the region in the 1990s, though it remains dominated by a small number of large employers. The cluster enjoys proximity to the transportation equipment industry developing around BMW in South Carolina and excellent highway access to major vehicle production complexes in Tennessee, Kentucky, and Ohio. The transportation and logistics cluster has been growing at a pace slightly below national averages. The cluster benefits from Carolina's central location along major transportation corridors, increasing local demand for business travel, and the US Airways hub.

Emerging Clusters

Despite sluggish growth nationwide, the metalworking and industrial machinery cluster may be gaining momentum in the region. Other emerging clusters are chemicals and plastics, printing and publishing, primary nonferrous metals, construction materials and hospitals/labs/specialized medical services. The recent growth of the latter two clusters may reflect the region's rapid growth in population and income rather than a core exportable strength.

High-Technology Clusters

High-technology clusters with the largest *relative* presence in the region include industrial machinery and motor vehicle manufacturing. The high-tech industrial machinery cluster is among the most diverse; most segments of the cluster are represented in the region. The high-tech motor vehicle manufacturing cluster, however, is dominated by the motor vehicle parts and accessories industry and comprises just a handful of very large employers. While the high-tech chemicals and plastics cluster is relatively diverse, several key segments of the cluster are under-represented, including medical laboratories, industrial organic chemicals, and plastics materials and resins.

The rise of the knowledge-based economy in the Carolinas is evident in the increasing concentration of employment in the communications services/software and information technology/instruments clusters. Both clusters are outpacing national trends in job growth and pay very high wages. Note that the two clusters share a number of industries; most communications services/software sectors are also

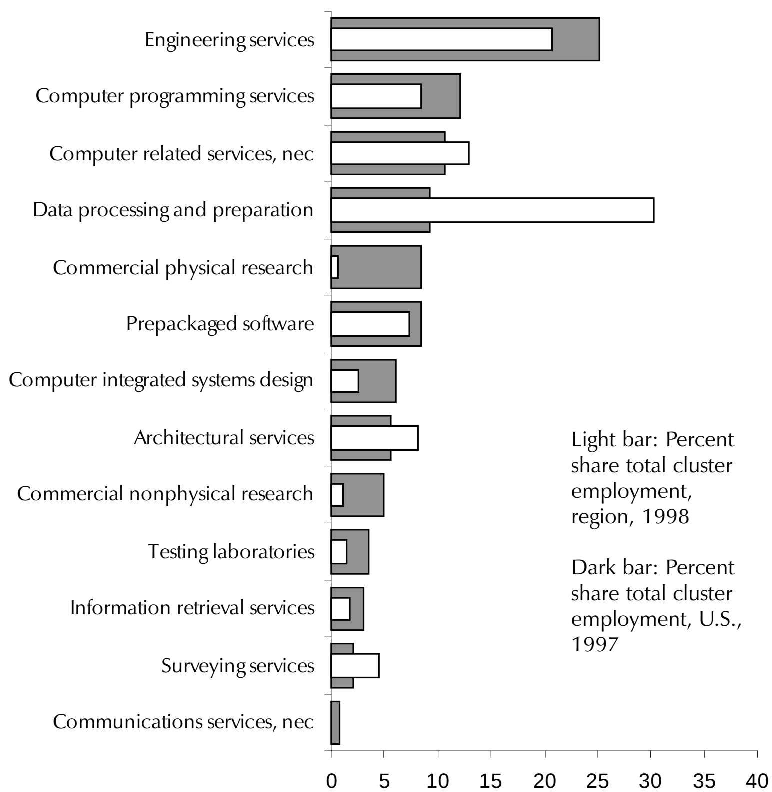

FIGURE 5
Communications services & software cluster
Industry mix, Carolinas region vs. nation

members of the information technology/instruments cluster. The latter includes several advanced manufacturing industries.

In the Carolinas, nearly all job gains in the information technology cluster during the 1990s have occurred in communications services and software (i.e., the sectors it shares with the communications services/software cluster) and not in computer hardware and electronics. Various segments of the communications services and software cluster are very well represented in the region, with a slight concentration of employment in data processing.

Enabling Infrastructure and Programs

The Carolinas region is one of few Economic Development Partnership regions in North Carolina with a significant array of programs targeted to specific regional strengths. Such programs are an important contributing element to the competitiveness of the region's clusters.

The Catawba Valley Community College is home to the Furniture Technology Center and the Hosiery Technology Center, offering technology assistance and training for the apparel and furniture industries. The Cameron Applied Research Center at UNC Charlotte undertakes R&D and technology transfer to support the region's chemicals and plastics, industrial machinery, and information technology industries. The Polymers Center for Excellence conducts R&D and provides training and technical support to the chemicals and plastics industries, while the Ben Craig Center is an incubator that specializes in high-tech firms. The North Carolina Center for Applied Textiles Technology provides training and technology assistance to the fabricated textiles sector.

Northeast Region

Summary

- As one of North Carolina's most sparsely populated regions, the Northeast region's industrial base is highly specialized and dominated by a limited number of larger establishments.

- Chemicals and plastics may be the region's strongest cluster at present; the cluster comprises over 100 establishments and 5,100 workers; its 1989-98 employment growth rate (5.9 percent annually) was over three times the national rate of growth for the period;

- The packaged food products cluster (along with the closely related canned and bottled goods cluster) is also strong, though it is not generating a significant number of new jobs;

- The region's largest technology-intensive cluster is high-tech chemicals and plastics, though at present the cluster has little depth in terms of a diversity of sectors and linkages;

- The expansion of high-tech and knowledge-intensive industry in the region may be hampered by the lack of a dominant metropolitan center with the kinds of amenities and infrastructure (including access by air) many technology companies demand.

Snapshot: Northeast Economy

Private sector employment, 1998	123,518
Annual employment growth, '89–'98	1.8%
Share of state private employment growth, '89–'98	2.3%
Average annual private sector wage, 1998	$21,009
Annual real wage growth, '89–'98	0.04%
Net new establishments, '89–'98	392
Unemployment Rate, 1998	6.3%
Poverty Rate, 1990	20.2%
Adults w/college education, 1990	10.7%
Manufacturing employment intensity, 1998	19.7%
Agricultural employment intensity, 1998	2.9%

Existing Regional Clusters

Industry clusters in the Northeast are relatively small and underdeveloped. Yet employment growth in several clusters has been strong during the 1990s (in part a function of the clusters' small size in 1989). Overall, private sector employment in the region expanded by 1.8 percent between 1989 and 1998, slightly faster than job growth nationwide.

Based on our criteria, there are seven modestly-sized clusters in the Northeast, all of which are resource-intensive or involve mostly traditional manufacturing. Chemicals and plastics and apparel are the largest clusters with over 5,000 workers each, followed by packaged food products (with over 4,500 workers), wood products and furniture, and fabricated textiles. Employment in both the region's fabricated textiles and apparel clusters is declining by nearly 6 percent annually, compared to 3-4 percent annually statewide. Wood products and furniture is also declining significantly in the region.

The region's principal job gains during the 1990s have come in chemicals and plastics (nearly 6 percent annual growth), stone and clay products, and canned and bottled goods.

Potential Clusters

Based on aggregate statistics, one cluster may be emerging as a key Northeast specialization: securities and insurance. However, on close inspection, nearly 98 percent of employment in the cluster is concentrated in the real estate agents and managers sector (part of the cluster because it utilizes similar worker skills as several securities and insurance industries). The large real estate industry in the Northeast is driven by tourism and recreation. Average wages in the cluster are only $16,490, reflecting the large number of part-time, temporary, and clerical staff in the real estate industry. There is virtually no activity in the region in other key cluster segments such as securities and commodity exchanges, investment houses, and insurance.

Other potential clusters posting solid job gains include motor vehicle manufacturing and transportation, shipping and logistics. Employment in the former is expanding by nearly 13 percent per year, though the cluster remains small in relative terms. Jobs in the transportation services, shipping and logistics cluster are growing by 4.2 percent annually, compared to 2.9 percent nationwide.

High-Technology Clusters

High-technology activity in the Northeast is extremely limited. The only technology cluster with a significant presence is chemicals and plastics. Its roughly 2,900 workers are employed in 67 establishments. The chemicals and plastics benchmark high-tech cluster comprises producers of chemicals and plastics products as well as major consumers of those goods (e.g., health services). The cluster includes some biotechnology activity as well, since some biotech firms are classified in the agricultural chemicals, chemical preparations, and industrial chemicals industries. However, in the Northeast, just two sectors make up the bulk of the high-tech chemicals and plastics cluster's employment: phosphatic fertilizers and specialty outpatient clinics, n.e.c.[11]

Motor vehicle manufacturing is the only other high-tech cluster with more than 500 workers.

Enabling Infrastructure and Programs

Aside from tailored training programs run by area community colleges, there are few specialized initia-

Table 5

Northeast Industry Clusters

Clusters	Employment 1998	Employment Annual % Change '89-'98	Employment Location Quotient 1998	Average Wage
Existing industry clusters				
Chemicals and plastics	5,157	5.9	1.54	38,162
Apparel	5,134	-5.8	3.30	20,529
Packaged food products	4,581	0.5	2.31	17,605
Wood products and furniture	3,906	-2.5	3.23	40,086
Fabricated textiles	3,142	-6.1	1.97	19,872
Stone and clay products	s	s	s	s
Canned and bottled goods	s	s	s	s
Potential general industry clusters				
Transportation, shipping and logistics	2,782	4.2	0.74	23,185
Securities and insurance	2,274	5.2	1.12	16,490
Motor vehicle manufacturing	1,977	12.9	0.57	24,632
U.S. technology clusters, presence in the region				
Chemicals and plastics	2,910	33.6	1.81	36,007
Motor vehicle manufacturing	823	7.0	0.46	25,795
Communications services and software	450	8.8	0.14	28,068
Industrial machinery	284	s	0.42	26,422
Information technology and instruments	205	83.8	0.05	33,523
Household appliances	0	0.0	0.00	n/a
Aerospace	s	s	s	s
Pharmaceuticals and medical technologies	s	s	s	s

Source: NC Employment Security Commission (ES-202 files). *s* indicates data suppressed to satisfy confidentiality restrictions. Clusters are not mutually exclusive.

tives and programs in the Northeast designed to leverage specific industrial strengths. The region's primary resource for academic R&D is Elizabeth City State University. The University's principal research strengths (based on recent funding trends) are physical sciences, geosciences, and computer science.

Piedmont Triad Region

Summary

- The Piedmont Triad remains highly specialized in low-tech manufacturing sectors;
- Four of the region's clusters are declining (apparel, fabricated textiles, wood products, and tobacco);
- Based on trends over the last decade, the region's most promising clusters are transportation, shipping and logistics and construction materials. The hospitals, labs and specialized services cluster may be emerging, especially in industries that overlap with research strengths at Wake Forest University, but it remains under-represented relative to the nation;
- The region's strongest technology cluster is chemicals and plastics, which posted strong annual job gains between 1989 and 1998;
- Two technology clusters that are growing at a strong clip nationwide are barely expanding in the Triad: information technology/instruments and communications services/software.

Existing Clusters

The most promising existing industry cluster in the Triad may be the transportation, shipping and logistics cluster. The Triad region is a natural candidate for an inland transportation cluster, being roughly midway between the sizable population centers of the northeast and Great Lakes regions and the fast-growing metro areas of the south. The region also stands at the crossroads of several major interstate highways. The decision by Federal Express Corporation to locate a hub in the region should give a considerable boost to what is already a sizable cluster (nearly 30,000 workers in 1998).

Table 6

Piedmont Triad Industry Clusters

Clusters	Employment 1998	Employment Annual % Change '89-'98	Location Quotient 1998	Average Wage
Existing industry clusters				
Apparel	64,535	-2.0	7.06	27,501
Fabricated textiles	35,300	-2.9	3.77	26,067
Transportation, shipping and logistics	29,781	2.7	1.35	31,717
Construction materials	28,286	2.6	1.22	30,876
Wood products	19,220	-1.0	2.71	22,938
Tobacco products	9,374	-5.2	32.02	57,013
Canned and bottled beverages	2,045	1.3	1.43	59,695
Emerging industry clusters				
Hospitals, labs, specialized medical services	37,614	4.7	0.80	29,110
Metalworking and industrial machinery	33,481	2.5	0.91	32,211
Chemicals and plastics	20,910	4.0	1.06	32,557
Banking and advertising	19,855	4.9	0.84	38,181
Motor vehicle manufacturing	18,464	2.8	0.90	31,257
U.S. technology clusters, presence in the region				
Information technology and instruments	14,266	0.2	0.60	42,100
Chemicals and plastics	13,306	4.3	1.41	36,546
Motor vehicle manufacturing	8,162	5.9	0.77	36,452
Communications services and software	6,628	0.6	0.35	41,698
Pharmaceuticals and medical technologies	4,881	2.2	0.72	27,732
Industrial machinery	3,428	0.5	0.86	36,924
Aerospace	788	10.6	0.14	34,955
Household appliances	0	s	0.00	n/a

Source: NC Employment Security Commission (ES-202 files). *s* indicates data suppressed to satisfy confidentiality restrictions. Clusters are not mutually exclusive.

Snapshot: Piedmont Triad

Private sector employment, 1998	725,461
Annual employment growth, '89–'98	2.1%
Share of state private employment growth, '89–'98	15.3%
Average annual private sector wage, 1998	$27,090
Annual real wage growth, '89–'98	0.20%
Net new establishments,	4,325
Unemployment rate, 1998	3.1%
Poverty rate, 1990	10.0%
Adults w/college education, 1990	17.2%
Manufacturing employment intensity, 1998	27.4%
Agricultural employment intensity, 1998	0.6%

Employment is declining in four of seven of the region's key clusters: apparel, fabricated textiles, wood products, tobacco products, and wood products and furniture. The region's apparel, fabricated textiles, and wood products clusters are among the most extensive in the U.S. and will remain regional strengths. However, they will likely continue to shed jobs as firms automate. In addition to transportation and logistics, existing clusters that are expanding in the region are construction materials and canned and bottled beverages.

Emerging Clusters

The chemicals and plastics cluster is gradually emerging as a strength in the Triad. Emerging clusters that remain modest in relative size are hospitals/labs/specialized medical services (fast growth with potential to build on research strengths of Wake Forest University), metalworking and industrial machinery (growing considerably faster than the national average), banking and advertising (job gains of nearly 5 percent annually between 1989 and 1998), and motor vehicle manufacturing (primarily parts and accessories and assorted supplier industries).

Technology Clusters

During the 1990s, technology-related employment growth in the Triad has occurred primarily in advanced manufacturing (chemicals and plastics and motor vehicle manufacturing). High-tech chemicals and plastics is the only technology cluster in the region with any absolute and relative size. Employment in pharmaceuticals and medical technologies is increasing at 2.2 percent each year, but most activity in the cluster is in electric housewares and fans industry (a sector that is a member of the supply chains of several instruments industries; see Figure 6). The Triad's pharmaceuticals and medical technologies cluster has no significant activity in medicinals/botanicals and diagnostic substances, though the surgical appliances and medical instruments industries are well-represented.

Perhaps most striking about high-tech cluster activity in the region is the very poor performance of the information technology/instruments and communications services/software clusters. Job gains in both clusters are an anemic one-half of one percent each year. Jobs in both high-tech clusters are growing at a fast clip nationwide (by1.8 and 5.5 percent per annum, respectively).

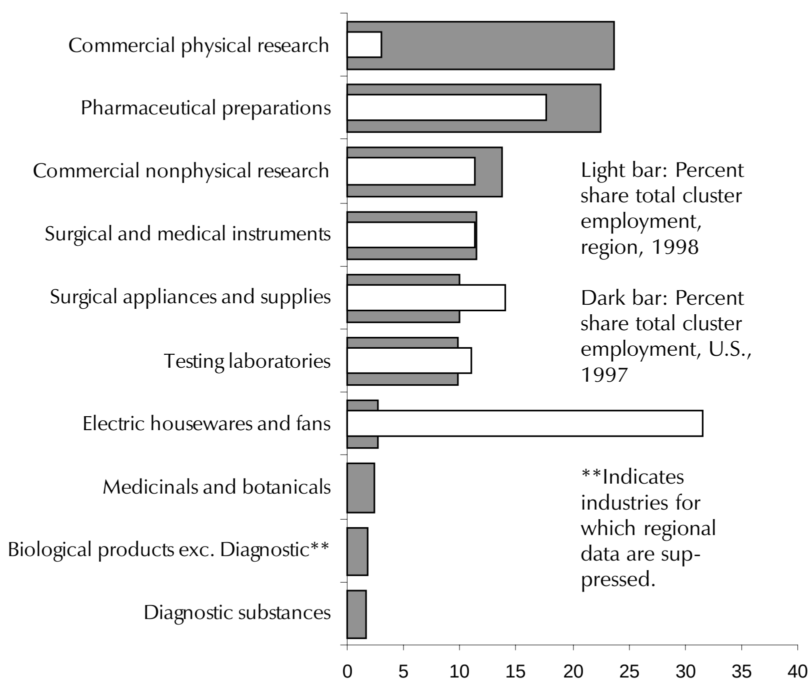

FIGURE 6
High tech pharmaceuticals & medical technologies cluster
Industry mix, Piedmont Triad region vs. nation

Enabling Infrastructure and Programs

The Piedmont Triad Center for Advanced Manufacturing offers technology and training assistance for many key manufacturing industries in the region. Principal research strengths at area universities include mechanical engineering and agricultural sciences at NC A&T, physics and life sciences at UNC Greensboro, and chemistry, physics, and medical sciences at Wake Forest University.

Research Triangle

Summary

- Top clusters in the Research Triangle are hospitals, labs and specialized medical services, information technology and instruments, and pharmaceuticals;
- Biotechnology activity, a growing strength in the region, falls into the hospitals/medical services and pharmaceuticals clusters;
- The apparel cluster is declining at a faster rate in the Triangle than it is statewide;
- Emerging clusters include printing and publishing, transportation and logistics, and securities and insurance;
- The Triangle's dominance in North Carolina as a location for high-tech activity is growing. The region increased its share of the state's technology-intensive employment between 1989 and 1998, particularly in very high-tech industrial categories;
- Restricting the focus to high-tech industries, the U.S. technology clusters with the strongest presence in the region include information technology and instruments, communications services and software, and pharmaceuticals and medical technologies;
- The Research Triangle has the best-developed network of supporting institutions and programs in the state and boasts three universities with nationally ranked research programs;
- The Triangle's leading knowledge-based economic strength is a broad and deep combined health sciences cluster that includes internationally renowned academic programs in biological and medical sciences and industrial specializations in pharmaceuticals, biotechnology, and specialized medical services.

Existing Clusters

Based on criteria of absolute size, relative size, and diversity, the Triangle's existing industry clusters include: hospitals, labs, and specialized medical ser-

Table 7

Research Triangle Industry Clusters

	Employment			
Clusters	1998	Annual % Change '89-'98	Location Quotient 1998	Average Wage
Existing general industry clusters				
Hospitals, labs, specialized medical services	65,719	10.3	1.31	39,723
Information technology and instruments	56,205	6.6	1.90	50,981
Apparel	16,262	-3.7	1.68	24,591
Pharmaceuticals	8,892	5.2	4.38	61,404
Tobacco products	1,223	-4.6	3.94	26,658
Emerging general industry clusters				
Printing and publishing	75,886	8.8	1.13	40,648
Transportation, shipping and logistics	18,149	7.2	0.77	30,109
Securities and insurance	10,650	2.8	0.84	37,592
Wood products (incl. furniture)	7,687	4.3	1.02	26,390
Potential general industry clusters				
Chemicals and plastics	12,017	7.2	0.58	34,886
Legal services	4,864	6.4	0.68	37,006
U.S. technology clusters, presence in the region				
Information technology and instruments	55,244	6.7	2.18	51,025
Communications services and software	27,775	11.1	1.39	49,995
Pharmaceuticals and medical technologies	14,441	1.5	2.02	54,890
Chemicals and plastics	10,223	7.5	1.02	34,274
Motor vehicle manufacturing	4,142	9.5	0.37	34,079
Industrial machinery	3,042	0.8	0.72	41,779
Aerospace	357	-2.7	0.06	46,979
Household appliances	0	-	0.00	n/a

Source: NC Employment Security Commission (ES-202 files). Clusters are not mutually exclusive.

Snapshot: Research Triangle

Private sector employment, 1998	769,605
Annual employment growth, '89–'98	4.4%
Share of state private employment growth, '89–'98	28.9%
Average annual private sector wage, 1998	$29,882
Annual real wage growth, '89–'98	0.84%
Net new establishments, '89–'98	9,639
Unemployment rate, 1998	2.3%
Poverty rate, 1990	11.4%
Adults w/college education, 1990	26.6%
Manufacturing employment intensity, 1998	16.8%
Agricultural employment intensity, 1998	1.3%

vices; information technology and instruments; apparel; and pharmaceuticals. The tobacco products cluster, though now totaling only 1,200 workers, remains a regional specialization. Employment in the cluster is declining by an annual rate of 4.6 percent. Biotechnology activity, a recent growth sector that is difficult to detect with available employment and wage statistics, falls into several clusters (mainly hospitals/labs/medical services and pharmaceuticals, but also information technology). Employment in the hospitals, labs and specialized medical services cluster has expanded by roughly 10 percent each year during the 1990s, while the information technology and instruments cluster is growing by 6.6 percent per annum.

A traditional cluster in the region—apparel—is declining fast. Some 3.7 percent of jobs in the apparel cluster are eliminated in the region each year, compared to 3.3 percent statewide and 3.0 percent nationwide.

Emerging Clusters

Several clusters may emerge as regional specializations if current trends continue. They include: printing and publishing; transportation, shipping, and logistics; securities and insurance, and wood products. The growth of printing and publishing has been driven mainly by growth in software and health services, both component industries in the cluster. But the presence of publishing in the Triangle has also expanded. More in-depth analysis is needed to determine the regional linkages among sectors in the cluster.

The region's rapid population and general economic expansion provides most of the explanation for the considerable growth of the transportation, shipping and logistics cluster. The fastest growing sectors in the cluster are scheduled air transportation, air courier services, and local trucking, all industries that cater mainly to local personal and business transportation needs. It is uncertain whether the cluster will develop into a regional specialization that effectively exports services.

Surprisingly, wood products may be the most significant emerging cluster. Employment in wood products is growing by 4.3 percent annually in the Triangle, compared to almost no change statewide and less than 1 percent annual growth nationwide.

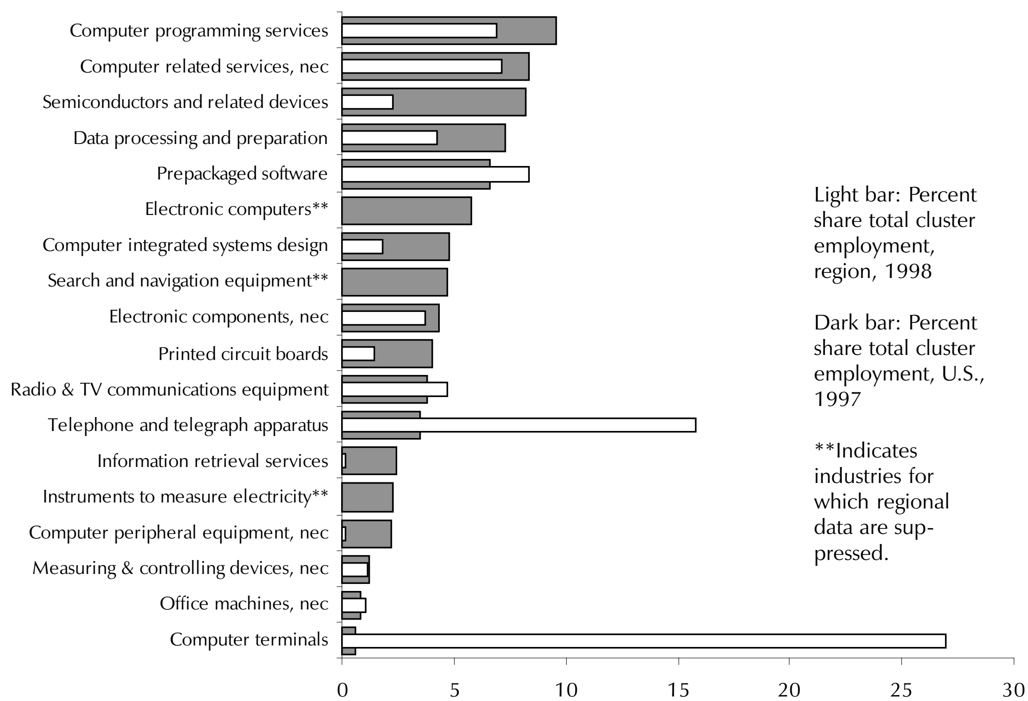

FIGURE 7
High tech information technology & instruments cluster
Industry mix, Triangle region vs. nation

Technology Clusters

The Research Triangle is a national leader in the emerging knowledge economy and is, by far, the most technology-intensive region in the state. Private sector employment is expanding faster in the Triangle than in any other region in North Carolina. The Triangle is also increasing its share of the North Carolina's total technology-intensive employment, especially in very high-tech industries.[12] Between 1989 and 1998, the Triangle added more jobs in very high-tech sectors than all other Development Partnership regions combined.

The following U.S. high-tech clusters have a significant presence in the Triangle: information technology and instruments, communications services and software, pharmaceuticals and medical technologies, and chemicals and plastics. The Triangle's growth in information technology/instruments and communications services/software is outpacing national trends by a significant margin. Note that there is considerable overlap in the definition of the two clusters; communications services and software is an important component of information technology and instruments. Indeed, most of the growth of information technology and instruments in the Triangle is in software and services rather than hardware. Both clusters are becoming more diverse, as the region's traditional and fairly narrow strength in computer manufacturing and electronics is expanding to include a broader range of infotech industries.

The pharmaceuticals and medical technologies cluster is also a major regional technology specialization, although it has seen only modest employment growth over the last decade. The general pharmaceuticals cluster (comprised entirely by the medicinals and botanicals, pharmaceutical preparations, diagnostic substances, and biological products industries) is actually a subset of the high-tech pharmaceuticals and medical technologies cluster pictured in Figure 8. The strong growth in the general pharmaceuticals cluster is almost completely offset by employment losses in commercial physical research, surgical appliances and supplies, and electric housewares and fans, hence the smaller aggregate growth rate of the larger industry grouping.

Specialized Enabling Infrastructure and Programs

The Triangle benefits from a broad array of programs and infrastructure designed specifically to leverage regional industrial strengths. Many programs serve businesses statewide. However, their presence in the Triangle is a considerable asset to local companies. Such programs and organizations include MCNC, the North Carolina Biotechnology Center, and the wide range industrial extension and applied research programs at North Carolina State University (particularly in textiles and wood products). The Research Triangle Park itself, and now Centennial Campus, offer the infrastructure and amenities many technology companies demand. Outside the Raleigh-Durham metro area, specialized programs are few. The Triangle South Enterprise Center in Harnett county, the Piedmont Community College Business Development

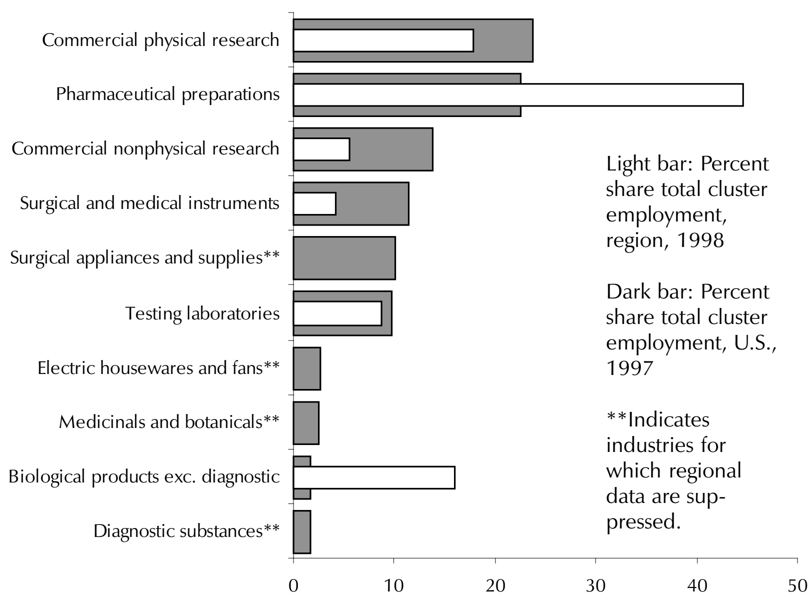

FIGURE 8
High tech pharmaceuticals & medical technologies cluster
Industry mix, Triangle region vs. nation

Center in Person county, and the Gateway Community Development Center in Vance county all provide general assistance to small businesses and entrepreneurs.

The region's strongest asset in the emerging knowledge economy is undoubtedly its three major research universities. A 1998 study identified nineteen nationally competitive academic programs in the state.[13] Eight of those are at Duke University, eight at the University of North Carolina at Chapel Hill, and three at North Carolina State University. Five programs at North Carolina State University are rapidly achieving national prominence: physics, mathematics, chemistry, civil engineering, and statistics.

NCSU's electrical, materials science, and chemicals engineering programs are all nationally ranked and are key assets for the electronics, information technology, and chemicals and plastics industries in the Triangle. However, considering overlapping strengths at the three institutions, the leading disciplines from a regional perspective are all in the health/biological sciences: cell and development biology, pharmacology, biochemistry and molecular biology, physiology, molecular and genetic sciences, neurosciences, and biomedical engineering. Only five states award more biological and health science bachelors degrees than do colleges and universities in North Carolina.

Overall, the Triangle's leading knowledge-based economic strength is a combined health sciences cluster that includes internationally renowned academic programs in biological sciences and industrial specializations in pharmaceuticals, biotechnology, medical instruments, and specialized medical services. Although impossible to verify with published data, the region's growing information technology and communications services/software clusters may also overlap with health sciences (though the growing field of bioinformatics).

Southeast Region

Summary

- Two clusters with significant job gains between 1989 and 1998 are packaged food products and chemicals and plastics. Employment in the packaged food products cluster is growing by nearly 10 percent each year, compared to less than 1 percent nationwide;

- A transportation, shipping, and logistics cluster may be emerging in the region. Employment in the cluster, which is now over 10,000, is growing by an average 4 percent each year;

- Two high-technology clusters with a significant presence in the Southeast are high-tech industrial machinery and chemicals and plastics. The latter pays among the highest wages in the region;

- Although there is relatively little communications services and software activity in the region (just 4,000 workers), employment is growing by 17.5 percent annually, compared to 5.5 percent nationwide.

Snapshot: Southeast Economy

Private sector employment, 1998	352,386
Annual employment growth, '89–'98	3.5%
Share of state private employment growth, '89–'98	11.2%
Average annual private sector wage, 1998	$23,345
Annual real wage growth, '89–'98	0.18%
Net new establishments, '89–'98	3,258
Unemployment rate, 1998	5.3%
Poverty rate, 1990	16.8%
Adults w/college education, 1990	13.8%
Manufacturing employment intensity, 1998	20.1%
Agricultural employment intensity, 1998	2.0%

Existing Clusters

Five clusters constitute regional strengths in the Southeast: the declining apparel and fabricated textiles clusters and the growing packaged food products, chemicals and plastics, and wood products clusters. While packaged food products—driven by growth of the poultry and meat processing industries—nearly doubled its employment over the last decade, the cluster has few linkages to higher value-added sectors and clusters and its wage is relatively low (at $22,699, its average annual wage is 97 percent of the regional private sector average). In contrast, wages are high by regional standards in the chemicals and plastics cluster, which is made up of—and has linkages to—a number of technologically advanced industries. Two high growth component industries in the cluster are tires and inner tubes and industrial organic chemicals.

The fabricated textiles and apparel clusters are declining more rapidly in the Southeast than in much of the rest of the state, while the region's wood products cluster is expanding despite little growth at the state and national levels.

Emerging Clusters

Shipping has long been an important industry in the Southeast. Employment in the broader transportation, shipping and logistics cluster has grown by roughly 4 percent each year since 1989; transportation, shipping and logistics may represent one of the Southeast's most important emerging clusters. While the marine cargo handling industry represents a sizable share of the cluster's total employment, the sector is currently in decline. Land-based transportation and trucking industries, both local and non-local, have been the principal sources of transportation and logistics growth over the last decade. Growth in the air courier and freight transportation arrangement industries has also been strong.

Another emerging cluster is hospitals, labs and specialized medical services. Its 8.0 percent annual employment growth is over twice the national rate. Increasing population, driven by the popularity of the Southeast for retirees, may explain the rapid growth. Over 70 percent of the cluster's employment is in one industry, namely general medical and surgical hospitals; many key cluster industries are under-represented in the region.

Table 8

Southeast Industry Clusters

Clusters	Employment 1998	Annual % Change '89-'98	Location Quotient 1998	Average Wage
Existing general industry clusters				
Apparel	20,649	-3.6	4.65	22,595
Chemicals and plastics	13,555	4.4	1.42	43,850
Fabricated textiles	12,209	-4.3	2.68	20,522
Packaged food products	10,316	9.5	1.82	22,699
Wood products (incl. furniture)	5,139	1.0	1.49	32,858
Emerging general industry clusters				
Hospitals, labs, specialized medical services	19,934	8.0	0.87	32,311
Transportation, shipping and logistics	10,416	3.9	0.97	26,115
U.S. technology clusters, presence in the region				
Chemicals and plastics	6,097	4.6	1.33	44,187
Communications services and software	4,032	17.2	0.44	39,563
Pharmaceuticals and medical technologies	3,065	5.3	0.94	37,931
Motor vehicle manufacturing	2,966	1.3	0.58	30,101
Industrial machinery	2,957	6.5	1.52	25,123
Information technology and instruments	1,801	8.2	0.15	31,572
Household appliances	0	0.0	0.00	n/a
Aerospace	*s*	*s*	*s*	*s*

Source: NC Employment Security Commission (ES-202 files). *s* indicates data suppressed to satisfy confidentiality restrictions. Clusters are not mutually exclusive.

Technology Clusters

The Southeast compares favorably against the U.S. benchmark technology clusters in several core areas. The industrial machinery and chemicals and plastics technology clusters appear to be emerging as regional specializations; both have posted above average employment growth between 1989 and 1998. The industrial machinery technology cluster is not very well diversified however, with activity confined to a handful of industries. Over 50 percent of the employment in this cluster is in the power-driven hand tools industry, with lesser concentrations in the transformers and blower and fans industries. Among other sectors, there is very little activity in the region in special industrial machinery, motors and generators, and machine tools.

The technology-intensive chemicals and plastics cluster is more diversified, although several component sectors are dominated by a small number of large employers. Most employment is concentrated in several firms in the industrial organic chemicals and the organic fibers industries. Segments of the cluster with little presence in the region include medical laboratories, special industrial machinery, soaps and detergents, and chemical preparations (see Figure 9).

Both information technology/instruments and communications services/software are small but growing fast. The latter's 17.2 percent annual employment growth is over three times the national rate. Part of the rapid growth is a function of the small size of the industry in 1989. Both clusters lack diversity and have only a small *relative* presence in the region. While information technology/instruments accounts for 3.3 percent of private sector employment nationwide, it makes up only a half percent in the Southeast. Similarly, as of 1997, 2.6 percent of the U.S. private sector workforce is in the communications services/software cluster; the share was 1.1 percent in the Southeast in 1998.

Specialized Enabling Infrastructure and Programs

The Southeast region has many programs that offer training and technical assistance for small businesses and entrepreneurs, but few programs specially targeted at existing and emerging regional clusters. Programs that provide training or assistance for small businesses/entrepreneurs (either through universities or community colleges) are in place in five counties. The principal research strengths at Fayetteville State University are chemistry, physics, and biological sciences while UNC Wilmington is nationally ranked in marine biology. Through its new Information Technology Systems Division, UNC Wilmington is using challenge grants to encourage innovation in education and training-related information technology, applications, and programs. With a history of utilizing advanced information technology to deliver education and training, the University is a critical resource for expanding the Southeast's small information technology and communications services clusters.

Transpark Region

Summary

- Key clusters in the Transpark include apparel, packaged food products, fabricated textiles, pharmaceuticals manufacturing, boat building and tobacco products;

- Of the existing clusters, only packaged food products is adding significant employment;

- The most promising emerging clusters in the region are construction materials and chemicals and plastics; metalworking and industrial machinery is also expanding, but at a slower pace;

- U.S. high-technology clusters with a sizable relative presence in the region include household appliances and pharmaceuticals/medical technologies; the former is dominated by a few large producers;

- In general, very little of the Transpark's employment growth over the last decade has occurred in technology-intensive industries. However, the Global Transpark facility is poised to attract higher tech activity now that some key infrastructure is in place.

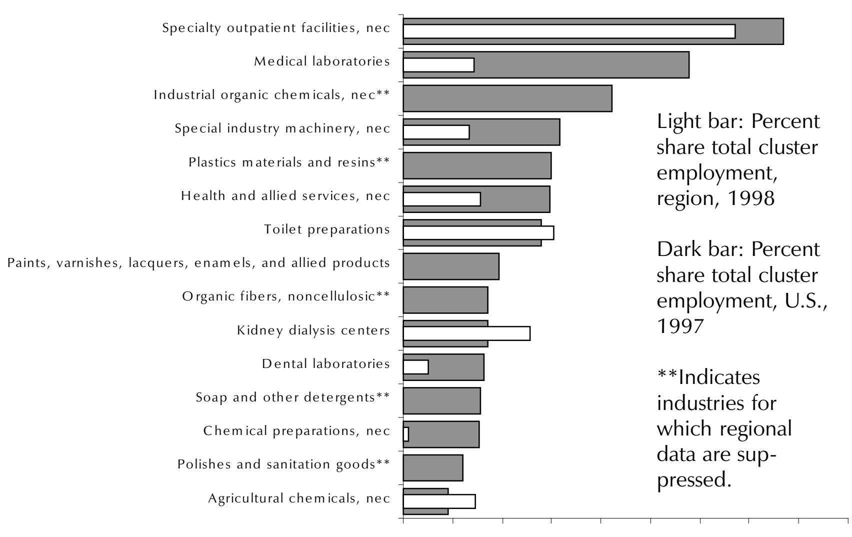

FIGURE 9
High tech chemicals & plastics cluster
Industry mix, Southeast region vs. nation

Existing Clusters

The Transpark region's economic base is well diversified across eight clusters. However, three of those eight—boat building, apparel, and fabricated textiles—are declining both regionally and nationally. Only packaged food products is adding jobs at a significant rate (3.9 percent annually compared to less than 1 percent nationwide). The cluster is led by poultry slaughtering and processing and—reflecting the region's booming hog industry—meat packing plants, sausages, and prepared meats. Overall, the Transpark's packaged foods products cluster pays a wage slightly above the regional average.

Employment has remained fairly steady during the 1990s in the tobacco products and pharmaceuticals clusters. The latter is the most technology-intensive of the region's eight clusters, and the one that pays the highest average wage. However, the pharmaceuticals cluster is dominated by a handful of branch plant manufacturers; regional inter-industry connections in cluster are probably very weak.

Emerging Clusters

Emerging clusters include metalworking and industrial machinery, chemicals and plastics, and construction materials. While growth in latter has been particularly strong (3.4 percent per annum compared to less than 1 percent nationwide), total employment remains relatively small. If current trends continue, the chemicals and plastics cluster will emerge as a clear regional specialization. It pays considerably higher wages that the regional average and its continued development may help support the pharmaceuticals and packaged foods clusters. The future prospects of the metalworking and industrial machinery cluster are uncertain. Though the region's growth in the cluster outpaced the national average, the technology-intensive components of metalworking/industrial machinery declined between 1989 and 1998.

Technology Clusters

The Transpark's two leading technology-intensive clusters—pharmaceuticals and medical technologies and household appliances—lack sectoral diversity (each primarily contains a single industry) and are dominated by a few firms. It may be possible to develop supplier industries to the appliance manufacturers in the industry, all of which are new to the region since 1989. Information technology/instruments and communications services/software are both experiencing solid growth, though at rates well below national averages.

Specialized Enabling Infrastructure and Programs

While there are a number of traditional business assistance programs in the region, none are focused on specific industrial strengths. Based on funding trends, East Carolina University's principal research strengths are in oceanography, medical sciences, and

Snapshot: Transpark Economy

Private sector employment, 1998	369,879
Annual employment growth, '89–'98	2.3%
Share of state private employment growth, '89–'98	8.4%
Average annual private sector wage, 1998	$23,334
Annual real wage growth, '89–'98	0.52%
Net new establishments, '89–'98	1,987
Unemployment rate, 1998	5.3%
Poverty rate, 1990	15.4%
Adults w/college education, 1990	13.8%
Manufacturing employment intensity, 1998	18.8%
Agricultural employment intensity, 1998	3.2%

Table 9

Transpark Industry Clusters

	Employment			
Clusters	1998	Annual % Change '89-'98	Location Quotient 1998	Average Wage
Existing general industry clusters				
Apparel	12,822	-5.0	2.75	23,678
Packaged food products	11,092	3.9	1.87	24,939
Fabricated textiles	7,233	-6.1	1.51	19,603
Pharmaceuticals	4,100	0.5	4.20	42,415
Boat Building	3,131	-1.3	4.36	32,208
Tobacco products	2,957	0.1	19.81	19,576
Emerging general industry clusters				
Metalworking and industrial machinery	16,367	1.2	0.88	28,932
Construction materials	9,369	3.4	0.79	26,741
Chemicals and plastics	9,874	2.2	0.98	35,825
U.S. technology clusters, presence in the region				
Motor vehicle manufacturing	5,444	-0.9	1.01	32,855
Pharmaceuticals and medical technologies	4,922	0.6	1.43	39,883
Chemicals and plastics	3,984	0.8	0.83	33,065
Information technology and instruments	2,926	5.7	0.24	31,503
Industrial machinery	1,893	-2.4	0.93	31,757
Communications services and software	1,792	4.6	0.19	29,481
Household appliances	1,135	n/a	3.62	23,501
Aerospace	239	30.8	0.08	33,906

Source: NC Employment Security Commission (ES-202 files). *s* indicates data suppressed to satisfy confidentiality restrictions. Clusters are not mutually exclusive.

life sciences. It is a national leader in health services delivery through telemedicine and is a potentially important conduit for growth of information technology and communications services in the region. ECU is also the site of the eastern offices of the North Carolina Manufacturing Extension Partnership.

The region's future technology-related development hinges greatly on the Global Transpark transportation and industrial complex. The completion in 1999 of the 32,000 square-foot Global Transpark Education and Training Center makes a state of the art training facilities available to new and existing firms in the region. Overall, now that some facilities are in place, the complex is shifting from a focus on concept and infrastructure development to one of active business development.

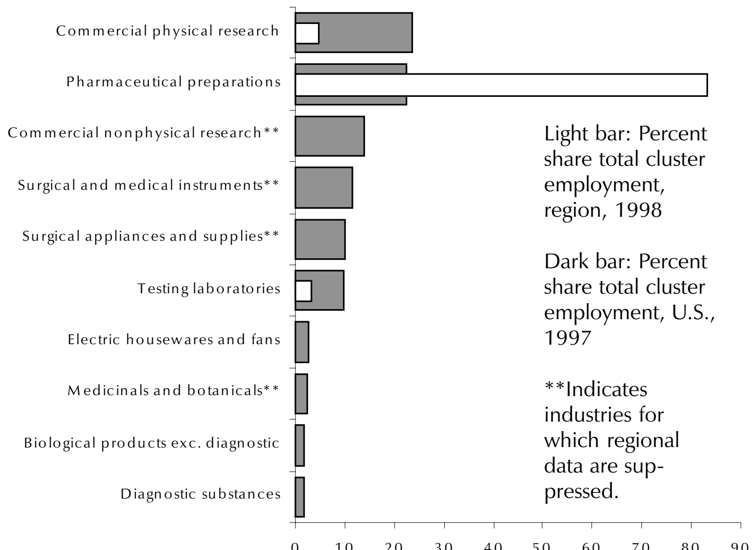

FIGURE 10
High tech pharmaceuticals & medical technologies cluster
Industry mix, Transpark region vs. nation

Western Region

Summary

- Employment decline has been heavy in two of the region's principal clusters–apparel and fabricated textiles–during the 1990s; wood products and furniture has also declined over the period, though at a slower pace;

- Key growth clusters include chemicals and plastics and construction materials; employment in motor vehicles manufacturing is also expanding at a rate of 1.0 percent annually;

- The most promising high-tech clusters are high-tech motor vehicle manufacturing, pharmaceuticals and medical technologies, and chemicals and plastics;

- The high-tech information technology and instruments cluster, a growth cluster nationwide, is not expanding in the West.

Existing Clusters

The three largest clusters in the Western region are apparel, wood products, and fabricated textiles. Both the apparel cluster and the fabricated textiles cluster are mature regional clusters, with employment well distributed over the many component industries. Unfortunately, both are also shedding jobs rapidly at the national, state, and regional levels. The wood products cluster has also registered net job losses over the past decade, although the rate of decline has been more modest. Employment in the wood products cluster is also fairly well distributed across its component industries, al-

Snapshot: Western Region

Private sector employment, 1998	407,722
Annual employment growth, '89–'98	2.1%
Share of state private employment growth, '89–'98	8.4%
Average annual private sector wage, 1998	$23,448
Annual real wage growth, '89–'98	1.7%
Net new establishments, '89–'98	2,483
Unemployment rate, 1998	4.2%
Poverty rate, 1990	13.1%
Adults w/college education, 1990	14.0%
Manufacturing employment intensity, 1998	28.5%
Agricultural employment intensity, 1998	1.0%

though the cluster itself has few linkages to more technologically advanced sectors.

Three smaller clusters in the region are construction materials, chemicals and plastics, and motor vehicle manufacturing. Chemicals and plastics continue to add jobs at both the regional and national levels and pays relatively high wages by regional standards. The industrial composition of the cluster is fairly diverse, with raw materials, processing, and end-market sectors represented in the region. The vehicle manufacturing cluster is also diverse and stands to benefit from the Western region's proximity to major vehicle assemblers in Tennessee, Kentucky, Ohio, and South Carolina.

Emerging Clusters

Two fast-growing clusters that may become significant regional specializations if current trends continue are hospitals/labs/specialized medical services and metalworking and industrial machinery.

Technology Clusters

Of the eight benchmark technology clusters identified at the national level, high-tech motor vehicles manufacturing is the only clear specialization in the region. Though the cluster comprises relatively few firms, its employment is expanding at a rate above the national average. Three high-tech clusters that may emerge if current trends continue are pharmaceuticals/medical technologies, industrial machinery, and chemicals and plastics. The chemicals and plastics high-tech sector is under-represented in industrial inorganic chemicals, chemical preparations, and several other key industries (see Figure 11).

Two key U.S. technology clusters—information technology/instruments and communications services/software—have a modest presence in the West, though 1989-1998 employment growth in communications services/software in the region outpaced the national average (in part due to the small size of the cluster in the West in the base period). In 1998 communications services and software still accounted for just 0.4 percent of private sector employment in the West, compared to 2.6 percent for the U.S. as a whole. High-tech information technology/instruments are actually declining the West even as it expands at the state and national levels.

Table 10

Western Region Industry Clusters

Clusters	Employment 1998	Employment Annual % Change '89-'98	Employment Location Quotient 1998	Average Wage
Existing general industry clusters				
Apparel	30,408	-3.2	5.92	23,312
Wood products (incl. furniture)	23,717	-0.9	5.94	26,398
Fabricated textiles	18,902	-3.6	3.59	22,822
Construction materials	16,541	2.1	1.27	26,227
Chemicals and plastics	15,438	2.5	1.40	32,476
Motor vehicle manufacturing	15,173	1.0	1.32	28,171
Emerging general industry clusters				
Hospitals, labs, specialized medical services	24,854	4.3	0.94	29,495
Metalworking and industrial machinery	19,420	2.4	0.94	30,038
U.S. technology clusters, presence in the region				
Motor vehicle manufacturing	7,821	3.4	1.31	34,102
Information technology and instruments	6,670	-0.3	0.50	27,791
Chemicals and plastics	5,306	2.5	1.00	30,912
Pharmaceuticals and medical technologies	4,277	1.6	1.13	26,482
Industrial machinery	2,016	1.1	0.90	28,771
Communications services and software	1,818	6.1	0.17	30,960
Aerospace	1,151	0.8	0.36	33,739
Household appliances	0	-	0.00	n/a

Source: NC Employment Security Commission (ES-202 files). Clusters are not mutually exclusive.

Specialized Enabling Infrastructure and Programs

General programs supportive of industry in the region include worker training and small business/entrepreneurial development assistance out of the community colleges and area universities. Like most other North Carolina regions, few programs are targeted to specific industrial strengths. An exception is the Flexible Automated Manufacturing Training Center at Asheville-Buncombe Technical Community College (training in plastics technologies). Key university R&D strengths include atmospheric sciences, aerospace engineering, and materials engineering at Appalachian State University and chemistry and biological sciences at Western Carolina University.

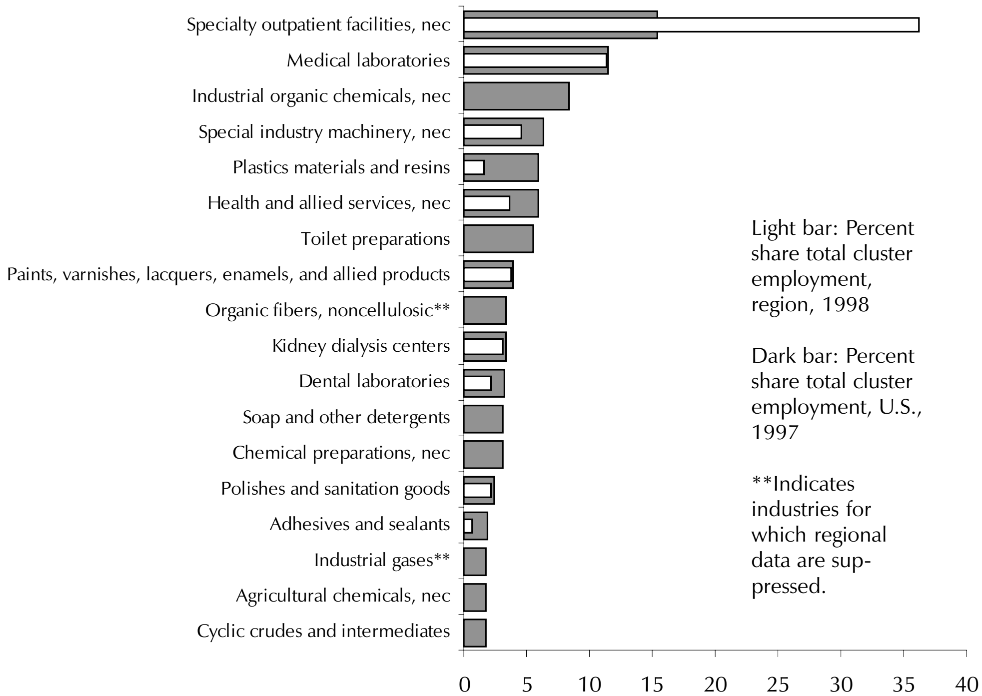

FIGURE 11
High tech chemicals & plastics cluster
Industry mix, Western region vs. nation

Endnotes

[1] See *Boosting Innovation—The Cluster Approach*, edited by T. J. A. Roelandt and P. den Hertog (Paris, Organisation for Economic Co-operation and Development, 1999); Porter, M. E., "Clusters and the new economics of competition," Harvard Business Review, November/December 1998; Feser, E. J., "Old and new theories of industry clusters," in *Clusters and Regional Specialisation*, edited by M. Steiner (London, Pion, 1998).

[2] See "The economy pays a high price for low-wage jobs," *Business North Carolina*, April 1997, p. 10.

[3] That information may be quantitative or qualitative in nature (e.g. in the case of the latter, obtained via interviews).

[4] The benchmarking approach to industry cluster analysis is described in more detail in "National industry cluster templates: A framework for applied regional cluster analysis," by E. J. Feser and E. M. Bergman, *Regional Studies* 34 (1), 2000, pp. 1-20.

[5] Note that by "exporting," we mean any sector that does not serve a primarily local market. "Exports" may be from the state or region in question to other states, regions, or overseas. Note also that our concern is with sectors that could, in principle, export, not necessarily those that are exporting at the present time.

[6] Contact Professor Edward Feser, Department of City and Regional Planning, CB 3140, University of North Carolina, Chapel Hill, NC 27599-3140, feser@email.unc.edu.

[7] The sectors comprising each technology cluster are reported in Appendix Table 2.

[8] The findings of the cluster analysis are also summarized in *Tracking Innovation: North Carolina Innovation Index 2000* (Raleigh, NC, Board of Science and Technology, 2000). After *Tracking Innovation* went to press, a revision of the data indicated that a hospitals, labs and specialized medical services cluster may be emerging in the state. Thus we include it in the discussion here. In addition, data for the emerging construction materials cluster were not reported in *Tracking Innovation*. The data are included here in Table 3.

[9] See Appendix Table 1.

[10] See *At the Crossroads: North Carolina's Place in the Knowledge Economy of the Twenty-First Century* (Raleigh, NC, North Carolina Board of Science and Technology, April 1998).

[11] Not otherwise classified.

[12] See *Tracking Innovation 2000* (Raleigh, NC, North Carolina Board of Science and Technology, 2000). Very high tech sectors include pharmaceuticals, computers, aircraft, instruments, software, and engineering services and research.

[13] See *At the Crossroads: North Carolina's Place in the Knowledge Economy of the Twenty-First Century* (Raleigh, NC, NC Board of Science and Technology, April 1998).

APPENDIX 1

Component Industries, U.S. Benchmark Clusters

(Note: Clusters are not mutually exclusive.)

Metalworking and industrial machinery

SIC	Description
2514	Metal household furniture
2522	Office furniture, except wood
2542	Partitions and fixtures, except wood
2591	Drapery hardware & blinds & shades
2599	Furniture and fixtures, nec
3053	Gaskets, packing and sealing devices
3255	Clay refractories
3272	Concrete products, nec
3274	Lime
3312	Blast furnaces and steel mills
3313	Electrometallurgical products
3315	Steel wire and related products
3316	Cold finishing of steel shapes
3317	Steel pipe and tubes
3321	Gray and ductile iron foundries
3322	Malleable iron foundries
3324	Steel investment foundries
3325	Steel foundries, nec
3398	Metal heat treating
3411	Metal cans
3412	Metal barrels, drums, and pails
3421	Cutlery
3423	Hand and edge tools, nec
3425	Saw blades and handsaws
3429	Hardware, nec
3431	Metal sanitary ware
3433	Heating equipment, except electric
3441	Fabricated structural metal
3442	Metal doors, sash, and trim
3443	Fabricated plate work (boiler shops)
3444	Sheet metalwork
3446	Architectural metal work
3448	Prefabricated metal buildings
3449	Miscellaneous metal work
3451	Screw machine products
3452	Bolts, nuts, rivets, and washers
3462	Iron and steel forgings
3465	Automotive stampings
3466	Crowns and closures
3469	Metal stampings, nec
3471	Plating and polishing
3479	Metal coating and allied services
3483	Ammunition, exc. for small arms, nec
3484	Small arms
3489	Ordnance and accessories, nec
3491	Industrial valves
3492	Fluid power valves & hose fittings
3493	Steel springs, except wire
3494	Valves and pipe fittings, nec
3495	Wire springs
3496	Misc. fabricated wire products
3498	Fabricated pipe and fittings
3499	Fabricated metal products, nec
3511	Turbines and turbine generator sets
3519	Internal combustion engines, nec
3523	Farm machinery and equipment
3524	Lawn and garden equipment
3531	Construction machinery
3532	Mining machinery
3533	Oil and gas field machinery
3534	Elevators and moving stairways
3535	Conveyors and conveying equipment
3536	Hoists, cranes, and monorails
3537	Industrial trucks and tractors
3541	Machine tools, metal cutting types
3542	Machine tools, metal forming types
3543	Industrial patterns
3544	Special dies, tools, jigs & fixtures
3545	Machine tool accessories
3546	Power-driven handtools
3547	Rolling mill machinery
3548	Welding apparatus
3549	Metalworking machinery, nec
3552	Textile machinery
3553	Woodworking machinery
3554	Paper industries machinery
3555	Printing trades machinery
3556	Food products machinery
3559	Special industry machinery, nec
3561	Pumps and pumping equipment
3562	Ball and roller bearings
3563	Air and gas compressors
3564	Blowers and fans
3565	Packaging machinery
3566	Speed changers, drives, and gears
3567	Industrial furnaces and ovens
3568	Power transmission equipment, nec
3569	General industrial machinery, nec
3581	Automatic vending machines
3582	Commercial laundry equipment
3585	Refrigeration and heating equipment
3586	Measuring and dispensing pumps
3589	Service industry machinery, nec
3592	Carburetors, pistons, rings, valves
3593	Fluid power cylinders & actuators
3594	Fluid power pumps and motors
3599	Industrial machinery, nec
3612	Transformers, except electronic
3613	Switchgear and switchboard apparatus
3621	Motors and generators
3624	Carbon and graphite products
3631	Household cooking equipment
3632	Household refrigerators and freezers
3633	Household laundry equipment

3634	Electric housewares and fans
3639	Household appliances, nec
3643	Current-carrying wiring devices
3644	Noncurrent-carrying wiring devices
3692	Primary batteries, dry and wet
3713	Truck and bus bodies
3714	Motor vehicle parts and accessories
3715	Truck trailers
3731	Ship building and repairing
3732	Boat building and repairing
3743	Railroad equipment
3751	Motorcycles, bicycles, and parts
3795	Tanks and tank components
3821	Laboratory apparatus and furniture
3949	Sporting and athletic goods, nec
3995	Burial caskets

Packaged Food Products

SIC	Description
2011	Meat packing plants
2013	Sausages and other prepared meats
2015	Poultry slaughtering and processing
2021	Creamery butter
2022	Cheese, natural and processed
2023	Dry, condensed, evaporated products
2024	Ice cream and frozen desserts
2026	Fluid milk
2032	Canned specialties
2033	Canned fruits and vegetables
2034	Dehydrated fruits, vegetables, soups
2035	Pickles, sauces, and salad dressings
2037	Frozen fruits and vegetables
2038	Frozen specialties, nec
2043	Cereal breakfast foods
2044	Rice milling
2045	Prepared flour mixes and doughs
2051	Bread, cake, and related products
2052	Cookies and crackers
2053	Frozen bakery products, except bread
2061	Raw cane sugar
2062	Cane sugar refining
2063	Beet sugar
2064	Candy & other confectionaries
2066	Chocolate and cocoa products
2067	Chewing gum
2068	Salted and roasted nuts and seeds
2079	Edible fats and oils, nec
2082	Malt beverages
2084	Wines, brandy, and brandy spirits
2085	Distilled and blended liquors
2086	Bottled and canned soft drinks
2091	Canned and cured fish and seafoods
2092	Fresh or frozen prepared fish
2095	Roasted coffee
2096	Potato chips and similar snacks
2098	Macaroni and spaghetti
2099	Food preparations, nec
2676	Sanitary paper products
2861	Gum and wood chemicals
3262	Vitreous china table & kitchenware
3263	Semivitreous table & kitchenware
3556	Food products machinery
3565	Packaging machinery
3914	Silverware and plated ware

Construction Materials

SIC	Description
2273	Carpets and rugs
2394	Canvas and related products
2421	Sawmills and planing mills, general
2426	Hardwood dimension & flooring mills
2429	Special product sawmills, nec
2431	Millwork
2434	Wood kitchen cabinets
2435	Hardwood veneer and plywood
2436	Softwood veneer and plywood
2439	Structural wood members, nec
2452	Prefabricated wood buildings
2491	Wood preserving
2493	Reconstituted wood products
2499	Wood products, nec
2541	Wood partitions and fixtures
2679	Converted paper products, nec
2851	Paints, varnishes, lacquers, enamels, etc.
2951	Asphalt paving mixtures and blocks
2952	Asphalt felts and coatings
3251	Brick and structural clay tile
3253	Ceramic wall and floor tile
3259	Structural clay products, nec
3261	Vitreous plumbing fixtures
3264	Porcelain electrical supplies
3271	Concrete block and brick
3273	Ready-mixed concrete
3275	Gypsum products
3281	Cut stone and stone products
3291	Abrasive products
3296	Mineral wool
3315	Steel wire and related products
3357	Nonferrous wiredrawing & insulating
3425	Saw blades and handsaws
3431	Metal sanitary ware
3432	Plumbing fixture fittings and trim
3433	Heating equipment, except electric
3442	Metal doors, sash, and trim
3444	Sheet metalwork
3449	Miscellaneous metal work
3491	Industrial valves
3492	Fluid power valves & hose fittings
3494	Valves and pipe fittings, nec
3495	Wire springs
3496	Misc. fabricated wire products
3498	Fabricated pipe and fittings
3561	Pumps and pumping equipment
3563	Air and gas compressors
3585	Refrigeration and heating equipment
3586	Measuring and dispensing pumps
3613	Switchgear and switchboard apparatus
3634	Electric housewares and fans
3639	Household appliances, nec
3643	Current-carrying wiring devices
3644	Noncurrent-carrying wiring devices
3645	Residential lighting fixtures

3646	Commercial lighting fixtures
3647	Vehicular lighting equipment
3648	Lighting equipment, nec
3663	Radio & TV communications equipment
3669	Communications equipment, nec
3699	Electrical equipment & supplies, nec
3799	Transportation equipment, nec
3822	Environmental controls
3851	Ophthalmic goods
3991	Brooms and brushes
3996	Hard surface floor coverings, nec
8711	Engineering services
8712	Architectural services
8713	Surveying services

Printing and Publishing

SIC	Description
2611	Pulp mills
2652	Setup paperboard boxes
2653	Corrugated and solid fiber boxes
2655	Fiber cans, drums & similar products
2656	Sanitary food containers
2657	Folding paperboard boxes
2671	Paper coated & laminated, packaging
2672	Paper coated and laminated, nec
2673	Bags: plastics, laminated, & coated
2674	Bags: uncoated paper & multiwall
2675	Die-cut paper and board
2676	Sanitary paper products
2677	Envelopes
2678	Stationery products
2679	Converted paper products, nec
2711	Newspapers: publishing, or pub. & printing
2721	Periodicals: publishing and printing
2731	Book publishing
2732	Book printing
2741	Miscellaneous publishing
2752	Commercial printing, lithographic
2754	Commercial printing, gravure
2759	Commercial printing, nec
2761	Manifold business forms
2771	Greeting cards
2782	Blankbooks and looseleaf binders
2789	Bookbinding and related work
2791	Typesetting
2796	Platemaking services
3275	Gypsum products
3861	Photographic equipment and supplies
3953	Marking devices
3955	Carbon paper and inked ribbons
3993	Signs and advertising specialities
3999	Manufacturing industries, nec
4812	Radiotelephone communications
4813	Telephone communications, exc. radio
4822	Telegraph & other message communications
4899	Communications services, nec
7371	Computer programming services
7372	Prepackaged software
7373	Computer integrated systems design
7374	Data processing and preparation
7375	Information retrieval services
7376	Computer facilities management
7377	Computer rental & leasing
7378	Computer maintenance & repair
7379	Computer related services, nec
8062	General medical and surgical hospitals
8063	Psychiatric hospitals
8069	Specialty hospitals, except psychiatric
8731	Commercial physical research
8732	Commercial nonphysical research
8734	Testing laboratories

Information Technology and Instruments

SIC	Description
3471	Plating and polishing
3571	Electronic computers
3572	Computer storage devices
3575	Computer terminals
3577	Computer peripheral equipment, nec
3578	Calculating and accounting equipment
3579	Office machines, nec
3596	Scales and balances, exc. laboratory
3625	Relays and industrial controls
3629	Electrical industrial apparatus, nec
3651	Household audio and video equipment
3661	Telephone and telegraph apparatus
3663	Radio & TV communications equipment
3669	Communications equipment, nec
3672	Printed circuit boards
3674	Semiconductors and related devices
3675	Electronic capacitors
3676	Electronic resistors
3677	Electronic coils and transformers
3678	Electronic connectors
3679	Electronic components, nec
3694	Engine electrical equipment
3699	Electrical equipment & supplies, nec
3728	Aircraft parts and equipment, nec
3761	Guided missiles and space vehicles
3769	Space vehicle equipment, nec
3812	Search and navigation equipment
3821	Laboratory apparatus and furniture
3822	Environmental controls
3823	Process control instruments
3824	Fluid meters and counting devices
3825	Instruments to measure electricity
3826	Analytical instruments
3827	Optical instruments and lenses
3829	Measuring & controlling devices, nec
3841	Surgical and medical instruments
3844	X-ray apparatus and tubes
3845	Electromedical equipment
3861	Photographic equipment and supplies
3873	Watches, clocks, watchcases and parts
3931	Musical instruments
7371	Computer programming services
7372	Prepackaged software
7373	Computer integrated systems design
7374	Data processing and preparation
7375	Information retrieval services
7376	Computer facilities management
7377	Computer rental & leasing

7378 Computer maintenance & repair
7379 Computer related services, nec

Chemicals and Plastics

SIC	Description
2087	Flavoring extracts and syrups, nec
2611	Pulp mills
2621	Paper mills
2631	Paperboard mills
2812	Alkalies and chlorine
2813	Industrial gases
2816	Inorganic pigments
2821	Plastics materials and resins
2822	Synthetic rubber
2823	Cellulosic manmade fibers
2824	Organic fibers, noncellulosic
2841	Soap and other detergents
2842	Polishes and sanitation goods
2843	Surface active agents
2851	Paints, varnishes, lacquers, enamels, etc.
2865	Cyclic crudes and intermediates
2869	Industrial organic chemicals, nec
2875	Fertilizers, mixing only
2879	Agricultural chemicals, nec
2891	Adhesives and sealants
2893	Printing ink
2899	Chemical preparations, nec
3011	Tires and inner tubes
3061	Mechanical rubber goods
3069	Fabricated rubber products, nec
3081	Unsupported plastics film & sheet
3082	Unsupported plastics profile shapes
3083	Laminated plastics plate & sheet
3084	Plastics pipe
3085	Plastics bottles
3086	Plastics foam products
3087	Custom compound purchased resins
3088	Plastics plumbing fixtures
3089	Plastics products, nec
3111	Leather tanning and finishing
3291	Abrasive products
3399	Primary metal products, nec
3559	Special industry machinery, nec
3692	Primary batteries, dry and wet
3996	Hard surface floor coverings, nec
8042	Offices and clinics of optometrists
8043	Offices and clinics of podiatrists
8049	Offices of health practitioners, nec
8071	Medical laboratories
8072	Dental laboratories
8092	Kidney dialysis centers
8093	Specialty outpatient facilities, nec
8099	Health and allied services, nec

Apparel

SIC	Description
2211	Broadwoven fabric mills, cotton
2221	Broadwoven fabric mills, manmade
2231	Broadwoven fabric mills, wool
2241	Narrow fabric and other smallwares mills
2251	Women's hosiery, except socks
2252	Hosiery, nec
2253	Knit outerwear mills
2254	Knit underwear mills
2257	Weft knit fabric mills
2258	Lace & warp knit fabric mills
2259	Knitting mills, nec
2261	Finishing plants, cotton
2262	Finishing plants, manmade
2269	Finishing plants, nec
2273	Carpets and rugs
2281	Yarn spinning mills
2282	Throwing and winding mills
2284	Thread mills
2296	Tire cord and fabrics
2297	Nonwoven fabrics
2298	Cordage and twine
2299	Textile goods, nec
2311	Men's and boys' suits, coats and overcoats
2321	Men's and boys' shirts
2322	Men's & boys' underwear and nightwear
2323	Men's and boys' neckwear
2325	Men's and boys' trousers and slacks
2326	Men's and boys' work clothing
2329	Men's and boys' clothing, nec
2331	Women's & misses' blouses & shirts
2335	Women's, junior's, & misses' dresses
2337	Women's and misses' suits and coats
2339	Women's and misses' outerwear, nec
2341	Women's and children's underwear
2342	Bras, girdles, and allied garments
2353	Hats, caps, and millinery
2361	Girls' & children's dresses, blouses
2369	Girls' and children's outerwear, nec
2371	Fur goods
2381	Fabric dress and work gloves
2384	Robes and dressing gowns
2385	Waterproof outerwear
2386	Leather and sheep-lined clothing
2387	Apparel belts
2389	Apparel and accessories, nec
2395	Pleating and stitching
2397	Schiffli machine embroideries
2824	Organic fibers, noncellulosic
3965	Fasteners, buttons, needles, & pins

Motor Vehicle Manufacturing

SIC	Description
2273	Carpets and rugs
2299	Textile goods, nec
2396	Automotive and apparel trimmings
2399	Fabricated textile products, nec
2531	Public building and related furniture
2599	Furniture and fixtures, nec
2851	Paints, varnishes, lacquers, enamels, etc.
2891	Adhesives and sealants
3011	Tires and inner tubes
3052	Rubber & plastics hose & belting
3061	Mechanical rubber goods
3069	Fabricated rubber products, nec
3081	Unsupported plastics film & sheet
3082	Unsupported plastics profile shapes

3083	Laminated plastics plate & sheet
3084	Plastics pipe
3085	Plastics bottles
3086	Plastics foam products
3087	Custom compound purchased resins
3088	Plastics plumbing fixtures
3089	Plastics products, nec
3142	House slippers
3211	Flat glass
3229	Pressed and blown glass, nec
3231	Glass products, made of purchased glass
3465	Automotive stampings
3493	Steel springs, except wire
3519	Internal combustion engines, nec
3524	Lawn and garden equipment
3585	Refrigeration and heating equipment
3592	Carburetors, pistons, rings, valves
3641	Electric lamps
3651	Household audio and video equipment
3694	Engine electrical equipment
3711	Motor vehicles and car bodies
3713	Truck and bus bodies
3714	Motor vehicle parts and accessories
3715	Truck trailers
3716	Motor homes

Fabricated Textiles

SIC	Description
2211	Broadwoven fabric mills, cotton
2221	Broadwoven fabric mills, manmade
2231	Broadwoven fabric mills, wool
2261	Finishing plants, cotton
2262	Finishing plants, manmade
2295	Coated fabrics, not rubberized
2311	Men's and boys' suits, coats and overcoats
2321	Men's and boys' shirts
2322	Men's & boys' underwear + nightwear
2323	Men's and boys' neckwear
2325	Men's and boys' trousers and slacks
2326	Men's and boys' work clothing
2329	Men's and boys' clothing, nec
2331	Women's & misses' blouses & shirts
2335	Women's, junior's, & misses' dresses
2337	Women's and misses' suits and coats
2339	Women's and misses' outerwear, nec
2341	Women's and children's underwear
2342	Bras, girdles, and allied garments
2353	Hats, caps, and millinery
2361	Girls' & children's dresses, blouses
2369	Girls' and children's outerwear, nec
2371	Fur goods
2381	Fabric dress and work gloves
2384	Robes and dressing gowns
2385	Waterproof outerwear
2386	Leather and sheep-lined clothing
2387	Apparel belts
2389	Apparel and accessories, nec
2391	Curtains and draperies
2392	Housefurnishings, nec
2393	Textile bags
2394	Canvas and related products
2396	Automotive and apparel trimmings
2399	Fabricated textile products, nec
2512	Upholstered household furniture
2515	Mattresses and bedsprings
2823	Cellulosic manmade fibers
3021	Rubber and plastics footwear
3052	Rubber & plastics hose & belting
3161	Luggage
3172	Personal leather goods, nec
3842	Surgical appliances and supplies
3942	Dolls and stuffed toys
3965	Fasteners, buttons, needles, & pins
3995	Burial caskets

Stone, Clay and Glass Products

SIC	Description
2873	Nitrogenous fertilizers
2874	Phosphatic fertilizers
2911	Petroleum refining
3011	Tires and inner tubes
3241	Cement, hydraulic
3255	Clay refractories
3261	Vitreous plumbing fixtures
3262	Vitreous china table & kitchenware
3263	Semivitreous table & kitchenware
3264	Porcelain electrical supplies
3269	Pottery products, nec
3274	Lime
3295	Minerals, ground or treated
3297	Nonclay refractories
3299	Nonmetallic mineral products, nec
3629	Electrical industrial apparatus, nec

Wood Products and Furniture

SIC	Description
2411	Logging
2426	Hardwood dimension & flooring mills
2431	Millwork
2434	Wood kitchen cabinets
2439	Structural wood members, nec
2441	Nailed wood boxes and shook
2448	Wood pallets and skids
2449	Wood containers, nec
2451	Mobile homes
2452	Prefabricated wood buildings
2493	Reconstituted wood products
2499	Wood products, nec
2511	Wood household furniture
2517	Wood TV and radio cabinets
2521	Wood office furniture
2611	Pulp mills
2621	Paper mills
2631	Paperboard mills
2861	Gum and wood chemicals
3792	Travel trailers and campers
3931	Musical instruments

Primary Nonferrous Metals

SIC	Description
3321	Gray and ductile iron foundries
3322	Malleable iron foundries

3324	Steel investment foundries
3325	Steel foundries, nec
3331	Primary copper
3339	Primary nonferrous metals, nec
3351	Copper rolling and drawing
3356	Nonferrous rolling and drawing, nec
3363	Aluminum die-castings
3364	Nonferrous die-casting exc. aluminum
3365	Aluminum foundries
3366	Copper foundries
3369	Nonferrous foundries, nec
3399	Primary metal products, nec
3599	Industrial machinery, nec

Leather Goods

SIC	Description
3111	Leather tanning and finishing
3131	Boot and shoe cut stock and findings
3142	House slippers
3143	Men's footwear, except athletic
3144	Women's footwear, except athletic
3149	Footwear, except rubber, nec
3151	Leather gloves and mittens
3171	Women's handbags and purses
3172	Personal leather goods, nec
3199	Leather goods, not elsewhere classified

Tobacco Products

SIC	Description
2111	Cigarettes
2121	Cigars
2131	Chewing and smoking tobacco
2141	Tobacco stemming and redrying

Canned and Bottled Beverages

SIC	Description
2046	Wet corn milling
2047	Dog and cat food
2048	Prepared feeds, nec
2083	Malt
2087	Flavoring extracts and syrups, nec
2873	Nitrogenous fertilizers
2874	Phosphatic fertilizers
2875	Fertilizers, mixing only
2879	Agricultural chemicals, nec
3221	Glass containers
3411	Metal cans

Food Oil Mills

SIC	Description
2074	Cottonseed oil mills
2075	Soybean oil mills
2076	Vegetable oil mills, nec
2077	Animal and marine fats and oils
2079	Edible fats and oils, nec

Aerospace

SIC	Description
3463	Nonferrous forgings
3482	Small arms ammunition
3483	Ammunition, exc. for small arms, nec
3721	Aircraft
3724	Aircraft engines and engine parts
3728	Aircraft parts and equipment, nec
3761	Guided missiles and space vehicles
3764	Space propulsion units and parts
3769	Space vehicle equipment, nec
3812	Search and navigation equipment

Petroleum Products

SIC	Description
2895	Carbon black
2911	Petroleum refining
2951	Asphalt paving mixtures and blocks
2952	Asphalt felts and coatings
2992	Lubricating oils and greases
2999	Petroleum and coal products, nec

Jewelry

SIC	Description
3339	Primary nonferrous metals, nec
3911	Jewelry, precious metal
3915	Jewelers' materials & lapidary work
3961	Costume jewelry

Boat Building

SIC	Description
3732	Boat building and repairing
3543	Industrial patterns
3541	Machine tools, metal cutting types
3519	Internal combustion engines, nec
3511	Turbines and turbine generator sets
2892	Explosives

Aluminum

SIC	Description
2819	Industrial inorganic chemicals, nec
3334	Primary aluminum
3353	Aluminum sheet, plate, and foil
3354	Aluminum extruded products
3355	Aluminum rolling and drawing, nec
3411	Metal cans
3463	Nonferrous forgings
3497	Metal foil and leaf

Hospitals, Labs, Specialized Medical Services

SIC	Description
2731	Book publishing
7371	Computer programming services
7372	Prepackaged software
7373	Computer integrated systems design
7374	Data processing and preparation
7375	Information retrieval services
7376	Computer facilities management
7377	Computer rental & leasing
7378	Computer maintenance & repair
7379	Computer related services, nec
8042	Offices and clinics of optometrists
8043	Offices and clinics of podiatrists
8049	Offices of health practitioners, nec
8062	General medical and surgical hospitals
8063	Psychiatric hospitals

8069	Specialty hospitals, except psychiatric
8071	Medical laboratories
8072	Dental laboratories
8092	Kidney dialysis centers
8093	Specialty outpatient facilities, nec
8099	Health and allied services, nec
8731	Commercial physical research
8732	Commercial nonphysical research
8734	Testing laboratories

Platemaking and Typesetting

SIC	Description
2791	Typesetting
2796	Platemaking services
2893	Printing ink
3555	Printing trades machinery

Securities and Insurance

SIC	Description
6231	Security and commodity exchanges
6282	Investment advice
6289	Security and commodity exchange nec
6311	life insurance
6321	Accident and health insurance
6324	Hospital and medical service plans
6351	Surety insurance
6361	Title insurance
6371	Pension, health, and welfare funds
6399	Insurance carriers, nec
6531	Real estate agents and managers

Banking and Advertising

SIC	Description
6011	Federal reserve banks
6019	Central reserve depository institutions, nec
6021	National commercial banks
6022	State commercial banks
6029	Comerica banks, nec
6035	Savings institutions, Federally chartered
6036	Savings institutions, not Federally chartered
6061	Credit unions, Federally chartered
6062	Credit unions, not Federally chartered
6081	Branched and agencies of foreign banks
6082	Foreign trade & intl. banking institutions
6091	Nondeposit trust facilities
6099	Functions related to depository banking, nec
6111	Federal and Fed.-sponsored credit
6141	Personal credit institutions
6153	Short-term bus. credit institutions, exc. ag
6159	Misc. business credit institutions
6162	Mortgage bankers and loan correspondents
6163	Loan Brokers
6211	Security brokers, dealers, & flotation co
6221	Commodity contracts brokers and dealers
7311	Advertising agencies
7312	Outdoor advertising services
7313	Radio, TV, publisher representatives
7319	Advertising, nec

Legal Services

SIC	Description
8111	Legal services

Transportation, Shipping, & Logistics

SIC	Description
4212	Local Trucking without Storage
4213	Trucking, except local
4214	Local Trucking with Storage
4215	Courier Services, except Air
4221	Farm product warehousing and storage
4222	Refrigerated warehousing and storage
4225	General warehousing and storage
4226	Special warehousing and storage, nec
4231	Trucking terminal facilities
4311	U.S. Postal Service
4412	Deep sea foreign transportation of freight
4424	Deep sea domestic transportation of freight
4432	Freight trans. on Great Lakes-St. Lawrence
4449	Water transport of freight, nec
4481	Deep sea passenger trans., ex. ferry
4482	Ferries
4489	Water passenger transportation, nec
4491	Marine cargo handling
4492	Towing and tugboat service
4493	Marinas
4499	Water transportation services, nec
4512	Air transportation, scheduled
4513	Air courier services
4522	Air transportation, nonscheduled
4612	Crude petroleum pipelines
4613	Refined petroleum pipelines
4619	Pipelines, nec
4731	Freight transportation arrangement
4741	Rental of railroad cars
4783	Packing and crating
4785	Vehicle inspection and weighing services
4789	Transportation services, nec

Pharmaceuticals

SIC	Description
2833	Medicinals and botanicals
2834	Pharmaceutical preparations
2835	Diagnostic substances
2836	Biological products exc. diagnostic

APPENDIX 2

Component Industries, U.S. Benchmark Technology- Intensive Clusters

(Note: Clustering based on analysis of technology-intensive industries only. Clusters are not mutually exclusive.)

Chemicals and Plastics

SIC	Description
2812	Alkalies and chlorine
2813	Industrial gases
2816	Inorganic pigments
2821	Plastics materials and resins
2822	Synthetic rubber
2823	Cellulosic manmade fibers
2824	Organic fibers, noncellulosic
2841	Soap and other detergents
2842	Polishes and sanitation goods
2843	Surface active agents
2844	Toilet preparations
2851	Paints, varnishes, lacquers, enamels, etc.
2865	Cyclic crudes and intermediates
2869	Industrial organic chemicals, nec
2873	Nitrogenous fertilizers
2874	Phosphatic fertilizers
2875	Fertilizers, mixing only
2879	Agricultural chemicals, nec
2891	Adhesives and sealants
2893	Printing ink
2899	Chemical preparations, nec
3559	Special industry machinery, nec
3624	Carbon and graphite products
3692	Primary batteries, dry and wet
3843	Dental equipment and supplies
8071	Medical laboratories
8072	Dental laboratories
8092	Kidney dialysis centers
8093	Specialty outpatient facilities, nec
8099	Health and allied services, nec

Information Technology and Instruments

SIC	Description
3571	Electronic computers
3572	Computer storage devices
3575	Computer terminals
3577	Computer peripheral equipment, nec
3578	Calculating and accounting equipment
3579	Office machines, nec
3625	Relays and industrial controls
3629	Electrical industrial apparatus, nec
3631	Household cooking equipment
3643	Current-carrying wiring devices
3644	Noncurrent-carrying wiring devices
3661	Telephone and telegraph apparatus
3663	Radio & TV communications equipment
3669	Communications equipment, nec
3672	Printed circuit boards
3674	Semiconductors and related devices
3675	Electronic capacitors
3676	Electronic resistors
3677	Electronic coils and transformers
3678	Electronic connectors
3679	Electronic components, nec
3694	Engine electrical equipment
3699	Electrical equipment & supplies, nec
3812	Search and navigation equipment
3821	Laboratory apparatus and furniture
3822	Environmental controls
3823	Process control instruments
3824	Fluid meters and counting devices
3825	Instruments to measure electricity
3826	Analytical instruments
3827	Optical instruments and lenses
3829	Measuring & controlling devices, nec
3844	X-ray apparatus and tubes
3845	Electromedical equipment
7371	Computer programming services
7372	Prepackaged software
7373	Computer integrated systems design
7374	Data processing and preparation
7375	Information retrieval services
7379	Computer related services, nec

Industrial Machinery

SIC	Description
3511	Turbines and turbine generator sets
3532	Mining machinery
3535	Conveyors and conveying equipment
3536	Hoists, cranes, and monorails
3541	Machine tools, metal cutting types
3542	Machine tools, metal forming types
3546	Power-driven handtools
3547	Rolling mill machinery
3549	Metalworking machinery, nec
3553	Woodworking machinery
3555	Printing trades machinery
3556	Food products machinery
3559	Special industry machinery, nec
3561	Pumps and pumping equipment
3563	Air and gas compressors
3564	Blowers and fans
3565	Packaging machinery
3612	Transformers, except electronic
3621	Motors and generators

Motor Vehicle Manufacturing

SIC	Description
2851	Paints, varnishes, lacquers, enamels, etc.
2893	Printing ink
3519	Internal combustion engines, nec
3531	Construction machinery
3534	Elevators and moving stairways
3537	Industrial trucks and tractors
3548	Welding apparatus
3641	Electric lamps
3645	Residential lighting fixtures
3646	Commercial lighting fixtures
3647	Vehicular lighting equipment
3648	Lighting equipment, nec
3651	Household audio and video equipment
3691	Storage batteries
3694	Engine electrical equipment
3711	Motor vehicles and car bodies
3713	Truck and bus bodies
3714	Motor vehicle parts and accessories
3715	Truck trailers

Aerospace

SIC	Description
3544	Special dies, tools, jigs & fixtures
3545	Machine tool accessories
3721	Aircraft
3724	Aircraft engines and engine parts
3728	Aircraft parts and equipment, nec
3761	Guided missiles and space vehicles
3764	Space propulsion units and parts
3769	Space vehicle equipment, nec

Household Appliances

SIC	Description
3632	Household refrigerators and freezers
3633	Household laundry equipment
3635	Household vacuum cleaners
3639	Household appliances, nec
3716	Motor homes

Communications Services and Software

SIC	Description
4899	Communications services, nec
7371	Computer programming services
7372	Prepackaged software
7373	Computer integrated systems design
7374	Data processing and preparation
7375	Information retrieval services
7379	Computer related services, nec
8711	Engineering services
8712	Architectural services
8713	Surveying services
8731	Commercial physical research
8732	Commercial nonphysical research
8734	Testing laboratories

Pharmaceuticals and Medical Technologies

SIC	Description
2833	Medicinals and botanicals
2834	Pharmaceutical preparations
2835	Diagnostic substances
2836	Biological products exc. diagnostic
3634	Electric housewares and fans
3841	Surgical and medical instruments
3842	Surgical appliances and supplies
8731	Commercial physical research
8732	Commercial nonphysical research
8734	Testing laboratories