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Targeting North Carolina Manufacturing:

Understanding A State Economy Through National Industrial Cluster Analysis

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Acknowledgments and Contributions

This project was conceived originally and the report prepared mainly in Chapel Hill, N.C. for the North Carolina Alliance for Competitive Technologies (NCACTS) in Research Triangle Park, N.C. Edward Bergman first conceived the research design while at the University of North Carolina (UNC-CH) and reviewed all subsequent analytic results, including various text edits, at the Vienna University of Economics and Business Administration in Austria (WUW). Edward Feser took principal responsibility for all phases of project management, core analyses, and preparation of the report at UNC-CH; Stuart Sweeney provided key programming assistance, particularly in preparing data on longitudinal changes among N.C. firms and regions. Very capable assistance with many detailed tables and figures was provided by Joel Bauman, Somik Lall, and Danielle Rinsler, all of whom were graduate students in the UNC Department of City and Regional Planning, working under the direction of Edward Feser. Somik Lall also patiently located key data, assisted with map preparation, and managed certain data conversations necessary to complete the study.

This report was first distributed by NCACTS for North American readers and is reproduced by IIR-WUW for European readers.

Executive Summary

Businesses do not operate or prosper in isolation. They rely on other firms in numerous industries for timely supplies of quality intermediate inputs, innovations and improvements in production machinery and equipment, and exchanges of technical knowledge, information and skilled personnel. Groups of producers share collective fortunes. Economic development agencies in the state should consider organizing some of their major activities in recognition of such mutualities.

Targeting North Carolina Manufacturing has been prepared to assist the North Carolina Alliance for Competitive Technologies (NC ACTS) and other industrial development groups in their efforts to design economic development policies and programs for those segments of the economy that face the greatest peril or that promise to generate the most significant impact. It is based on the economic logic that holds that industries must not be viewed in isolation. Rather, each individual industry in the state is seen as a member of a larger group of related sectors that maintains its ties through formal and informal channels.

These groups of interdependent sectors, or industry clusters, become a valuable analytic tool whenever economic development strategies to exploit interfirm linkages are being considered. These include buyer-supplier, import replacement, and entrepreneurship-based strategies, as well as technology deployment and cross-firm networking initiatives.

Recasting the state's manufacturing economy in terms of clusters of related industries provides a unique view of its relative specializations, strengths, and weaknesses. The present document provides a comprehensive overview of this picture. It also lays the groundwork for subsequent in-depth studies of specific clusters and industries so necessary for the proper consideration and evaluation of targeted economic policies. Volume II of *Targeting North Carolina Manufacturing* provides many of the tools and much of the data necessary to conduct these investigations.

Principal Findings

Analysis of the U.S. manufacturing economy revealed 23 *benchmark industrial clusters* or extended input-output chains. They consist of heavy manufacturing (e.g. metalworking, vehicle manufacturing, chemicals and rubber, nonferrous metals), light manufacturing (e.g. electronics and computers, knitted goods, fabricated textiles, wood products, leather goods, printing and publishing), five separate food-related clusters, and several clusters closely related

to other major industry groups (e.g. brake products and platemaking and typesetting).

When examined for North Carolina and its subregions, the clusters reveal the existence of *potential* buyer-supplier chains in the state. As benchmarks, the distribution of U.S. manufacturing activity across and within each cluster provides a *map* to detect whether certain sectors (i.e. pieces of an extended supplier chain) are under- or over-represented in North Carolina. The under-representation of some sectors may block or otherwise inhibit important technology transfers within a cluster, thereby implying opportunities for more activist roles by NCACTs or other economic development groups. Conversely, the over-representation of some sectors, particularly those producing high-technology goods or utilizing high-technology production regimes, indicates the presence of potentially important technology leaders and disseminators that might serve as NCACTs technology partners.

The U.S. benchmark clusters can also help identify important missing links in a North Carolina input-output chain that might serve as targets of opportunity for policy measures designed to stimulate the growth, introduction, or recruitment of one or more key sectors.

Nine of the twenty-three benchmark clusters represent a significant manufacturing presence in the state:

- Metalworking
- Vehicle Manufacturing
- Chemicals & Rubber (including plastics)
- Electronics & Computers
- Packaged Foods
- Printing & Publishing
- Wood Products (including furniture)
- Knitted Goods (including hosiery & apparel)
- Fabricated Textile Products

Together, these clusters accounted for nearly 90 percent of all North Carolina manufacturing establishments in 1994, 84 percent of employment, and 72 percent of estimated output. Of particular interest is the fact that North Carolina's well-hidden vehicle manufacturing industries share first position with the far more visible knitted goods industries in terms of total manufacturing output (about 14% each).

The degree to which each major cluster is specialized in some but not other industries varies

dramatically. Several NC clusters are quite specialized, i.e. contain relatively few component industries, while others are remarkably similar to U.S. benchmark clusters in representation and proportion of all key industries:

- North Carolina metalworking production is concentrated heavily in the industrial machinery and electrical equipment sectors that help drive demand in basic metals, rather than being strongly representative of basic and fabricated metals industries themselves.

- Although there are few major vehicle assemblers in the state, North Carolina possesses a very wide range of industries that provide key inputs in the production of automobiles, trucks, and busses. With the recent location of major automobile manufacturers in nearby states, this already large but still incomplete cluster is surely one of the most promising clusters for further development and expansion.

- Most key linkages in the chemicals and rubber cluster are present in North Carolina, however it is somewhat specialized in plastics and synthetic materials rather than industrial chemicals. In contrast, the electronics and computers cluster is heavily concentrated in just a few sectors, including computer peripherals, telephone equipment, nonferrous wiredrawing, and relays and industrial controls.

- North Carolina production of packaged foods is highly specialized in a few industries, as might be expected given the need for proximity to low-value, high-weight inputs and perishability-of-product considerations. Plastic and paperboard packaging materials, among the most important inputs in food manufacturing, are significant industries in the state.

- The distribution of sector output within both the printing and publishing and wood products clusters closely matches the U.S. benchmarks, with some specialization in wood furniture manufacturing in the wood products cluster. Knitted goods and fabricated textile production in North Carolina is dominated by major intermediate supplier sectors (yarn and fabric mills), rather than higher value-added, final market goods industries such as fashion apparel, toys, luggage, and surgical appliances and supplies.

An examination of recent growth trends found the following:

- The state clusters showing the highest rates of estimated output growth between 1989 and 1994 were chemicals and rubber, printing and publishing, metalworking, vehicle manufacturing, and wood products. These clusters generally posted more moderate gains in employment, reflecting the steady influence of productivity gains. Estimated real output was essentially unchanged in the knitted goods cluster, though employment in the cluster fell by between 21,000 and 26,000 depending on the cluster definition. Jobs in the fabricated textiles cluster also declined significantly, as did estimated real output.

- A viable meat products cluster may be emerging in the state, driven by substantial growth in meat processing from the booming hog and poultry industries. Sectors processing meat by-products (e.g. leather tanning and finishing), though still very small, also grew between 1989 and 1994. Though in the aggregate, industries in the small leather goods cluster (48 total establishments) suffered a net decline, several individual leather processing sectors grew moderately (e.g. the leather goods, n.e.c., and luggage sectors).

- The five-year performance of NC manufacturing firms operating in 1989 shows their employment losses due to declines or closures exceed their gains due to expansions in nearly every cluster. At the same time, employment growth due to new plants was significant in many clusters, leading to sizable job gains in the chemicals and rubber, printing and publishing, and metalworking clusters.

- Although industries in the knitted goods and fabricated textiles clusters suffered large declines in net employment between 1989 and 1994, a substantial number of new jobs were nevertheless created in the same sectors over this period. These results are suggestive of a significant amount of restructuring occurring in the textile and apparel clusters, rather than uniform, steady decline. This may indicate the loss of least productive facilities and replacement by more advanced, productive producers.

The study also examined the degree to which North Carolina producers in the same cluster co-locate geographically. Information about geographic co-location is useful to identify potential industrial complexes, or regional industrial clusters where targeted competitiveness strategies might be efficiently and cost-effectively applied. The following summary shows strong evidence for some but not all clusters.

1. Introduction

In recent years, North Carolina has attempted to improve the level of coordination and reduce the degree of overlap in the delivery of economic development programs. In an era of shrinking government budgets, the pressure to minimize expenditures while also maximizing the impact and reach of development programs has increased. Reports by the Government Performance Audit Committee, and subsequent analysis by the NC Economic Development Board in 1993-4, found a "fragmented set of economic development programs and organizations with no clear direction or single source of accountability."[1]

One result of this finding was the preparation by the Board of a comprehensive strategic plan. Among other issues, the plan emphasized the need to focus resources on improving the competitiveness of key North Carolina industries, particularly through the increased development and deployment of advanced production technologies. The strategic planning process developed by the North Carolina Alliance for Competitive Technologies (NC ACTS), an agency created by Governor Hunt in 1994 to coordinate the state's technology policy, is designed to identify or *target* particular industries for policy attention. For each target industry, NC ACTs seeks to assist private sector representatives in the development and implementation of industry-wide competitiveness strategies. The approach is intended to serve as a model for the strategic planning efforts of economic development organizations statewide.

Targeting North Carolina Manufacturing (Volumes I and II) has been prepared to assist NC ACTS and other development agencies in North Carolina in the process of industrial targeting. It is based on an industrial clustering logic that argues that industries must not be viewed in isolation; rather, each individual industry in the state is a member of a larger group of sectors related through formal and informal channels. When the state's manufacturing economy is recast in these terms, a unique picture of its relative specializations, strengths, and weaknesses emerges.

This document provides both an overview of this picture as well as some of the raw materials necessary for similar analyses at the substate level (e.g. in each of the seven Economic Development Partnership regions). The report is primarily designed to assist development organizations with one of the first phases in a general strategic planning process, i.e. the identification of key groups of sectors that may warrant further attention. It also supplies some data useful for subsequent steps, such as the careful analysis of the potential need for alternative policies that must precede the design and implementation of specific plans (and subsequent expenditure of scarce development resources).

2. The Logic of Strategic Cluster Targeting

Nationwide, attention among state and local officials to the advantages of strategically targeting modernization and competitiveness programs to key industries has grown markedly in the last five years.[2] Policy makers are faced with designing strategies for strengthening regional economies that possess hundreds of industries and thousands of firms. Strategic targeting involves the allocation of scarce economic development resources to those segments of the economy that face the greatest peril or that promise to generate the largest and most long-lasting positive impact. Identifying those segments is no easy task, however.

Many communities have attempted to identify potential target sectors based on a series of economic performance indicators. Sectors may be targeted for policy attention, for example, based on their size relative to other industries, their past and/or predicted growth trajectories, their wage levels, their use or production of high technology goods and equipment, their status as international exporters, and/or their proportion of small- and medium-sized enterprises. Although each criterion is based on some underlying economic rationale, identifying targets is only an initial step in a broader economic development strategic planning process.

While there are legitimate reasons for using size, growth rates, wages, technology, market location, and firm size distribution as criteria for initially targeting industries, when applied to individual and unrelated sectors, such scattered indicators fail to paint a clear overall picture of a given economy. The economic strength of enterprises in any particular sector is closely tied to the performance of firms in numerous other sectors. One implication of this interdependence may be conceptualized under a somewhat broader notion of the well-known concept of the multiplier effect. The transmission of growth pulses from a given industry backward to its suppliers and forward to its customers is well-known. Information on formal buyer-supplier linkages is most often used for short-run demand impact analysis where projected growth in a particular sector is traced through the economy to determine secondary growth in other sectors and markets.

But if the policy interest is one of assessing the present and future competitiveness of particular businesses and industries, the significance of the relationships between producers must be viewed in a far broader context than that suggested in the typical impact analysis. The activities of firms in a given sector can affect the performance of producers in other sectors, not just in the short run through the demand for inputs and services, but also in the long run through the development of new manufacturing

technologies, through the exertion of influence on producers' use of production technologies and general business strategies, through informal exchanges of information, and through exchanges in skill and knowledge that occur via shared labor markets.

Businesses do not exist in isolation. Competitive firms rely on their suppliers to make timely deliveries of high quality intermediate inputs and services. They also depend on the continued discovery of technological innovations and product improvements by their providers of production machinery and other forms of capital equipment. For those firms that manufacture producer durables and nondurables, the sustained competitiveness of their customers, and thus the continued stability and growth of their market, is critical. Finally, even if particular businesses are not trading directly with one another, the informal exchange of information, knowledge, and skilled labor that typically occurs among firms in related industries is increasingly acknowledged by analysts as an important source of both individual and collective competitiveness.[4] *Groups* of producers in multiple sectors thus share *collective fortunes*. The analysis of industries in isolation of one another ignores these interdependencies.[5]

Changing Buyer-Supplier Relations

Since each producer's own success depends critically on the quality and ready availability of its key inputs, firms naturally demand high levels of technological sophistication, quality, and flexibility from their suppliers. A growing body of research also shows that in some industries, firms are increasingly accompanying these demands with the direct provision of assistance with technology upgrading and the implementation of improved workforce and quality management techniques.[3] Some advanced manufacturing techniques such as just-in-time (JIT) inventory and sourcing systems also require such close coordination between contracting parties that buyers must often take an active role in determining the production strategies of their suppliers.

Scope and Purpose of the Report

This document, *Targeting North Carolina Manufacturing, Volume I*, reports the results of an analysis of industrial interdependence in manufacturing sector. Extended buyer-supplier chains (23 total), or ***benchmark industrial clusters***, are identified in the U.S. manufacturing economy. These clusters represent re-aggregations of the Standard Industrial Classification (SIC) system (i.e. industries and firms similar in product) around the major final market producing sectors in combination with their key first-, second- and third- tier supplier sectors. When used in subsequent analyses, the clusters provide a view of the manufacturing economy that is wholly distinct from that revealed through studies and typical data summaries that rely on SIC categories. By grouping those firms that are most likely to interact with each other, both directly and indirectly, the clusters reveal relative specializations in the

economy in terms of extended product chains. The clusters are thus a valuable analytic tool whenever economic development strategies that seek to exploit direct and indirect interfirm linkages are being considered. These include buyer-supplier, import replacement and entrepreneurship-based strategies, as well as technology deployment and cross-firm networking initiatives.

When applied to North Carolina and its subregions, the clusters reveal the existence of ***potential*** buyer-supplier chains in the state, as well as their spatial distribution and degree of geographic concentration. The document evaluates the relative statewide presence of these chains in order to identify specializations, potential opportunities, and significant gaps. It calculates basic indicators typically used in targeting studies (and adopted by NC ACTS) and evaluates growth and turbulence in each cluster over the 1989 to 1994 period. It also demonstrates how sectoral interdependencies can be analyzed in detail.

Figure 1 summarizes the document's scope. The U.S.

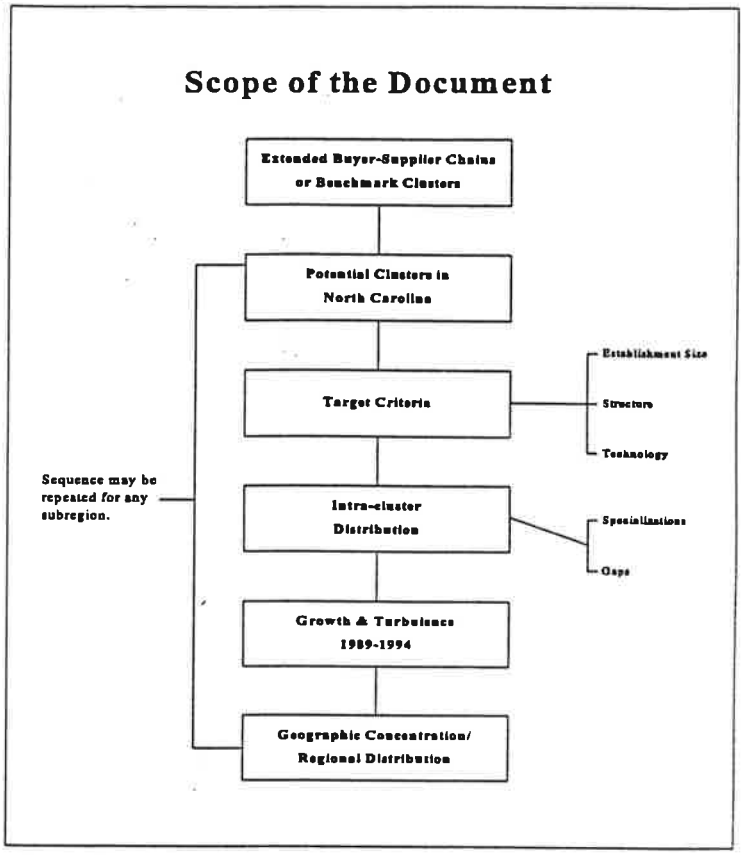


Figure 1

manufacturing economy is first analyzed to identify benchmark clusters or extended input-output chains. Next, the relative distribution of North Carolina manufacturing activity across each of the clusters is examined to identify key potential clusters. After describing the basic characteristics of the potential clusters according to targeting criteria adopted by NC ACTS, the sectoral distribution of NC manufacturing activity *within* each cluster is briefly examined to identify specializations and gaps. Recent growth patterns as well as the geographic distribution of the clusters are then presented. All steps in the analysis beyond the definition of benchmark cluster definitions may be duplicated for any relevant subregion in the state.

Volume II of the document contains detailed

data appendices, measures of interindustry linkages, and additional maps. This cannot be made available for public release due to provisions protecting the confidentiality of proprietary information collected by the North Carolina Employment Security Commission. Volume II is mainly designed to assist NC ACTS staff in preparing focused in-house industry studies and analyses of intersectoral linkages.

3. The Manufacturing Economy: 23 Benchmark Clusters

Analysis of the U.S. manufacturing economy revealed 23 industrial ***clusters*** or extended input-output chains. These clusters represent aggregations of closely related individual ***sectors*** (industries). The 1987 U.S. input-output tables were the basic source of information on industrial interdependencies. The tables 1) identify all significant sales of one industry's output to all other industries; 2) show how much of all other industries' outputs are purchased by each industry as production inputs, much like a "production recipe;" and 3) with some manipulation, reveal implied sales and purchases between sectors that occur through intermediate industries. Thus both direct and indirect relationships between buyers and suppliers were evaluated when grouping sectors. A cluster, for example, may include seemingly unrelated industries (e.g. vacuums and vehicles) that purchase (sell) similar input (output) mixes, though they may not trade significantly with each other (see Figure 2).

An important distinction in the report is that between ***actual benchmark*** and ***potential clusters***. Clusters defined based on national input-output patterns represent groups of producers (in different sectors) that do, in

Section 3. Summary of Findings

- The clustering methodology identified 23 extended input-output chains or benchmark industrial clusters in the U.S. manufacturing economy. These clusters identify those clusters that are most closely related through direct and indirect input-output linkages.
- Because the clusters contain industries in multiple 2-digit level SIC categories, they offer a view of the manufacturing sector that is distinct from those using traditional industry classification systems.
- The largest cluster in the U.S. is the vehicle manufacturing cluster, followed by metalworking, electronics and computers, printing and publishing, petroleum, and chemicals and rubber. The remaining 17 clusters each produced less than 5 percent of total national estimated manufacturing output in 1993; 7 of the 17 each produced less than 1 percent.
- Not all individual sectors tightly linked to a given cluster. The largest of these sectors are drugs and paper/paperboard mills.
- Individual industries may be members of multiple clusters. As a result, two cluster definitions are used in the report. The first includes only the most tightly linked sectors in a cluster (primary industries); the second includes both tightly and moderately linked (secondary industries) sectors. When only primary industries are included in the cluster definitions, a mutually exclusive set of clusters results.

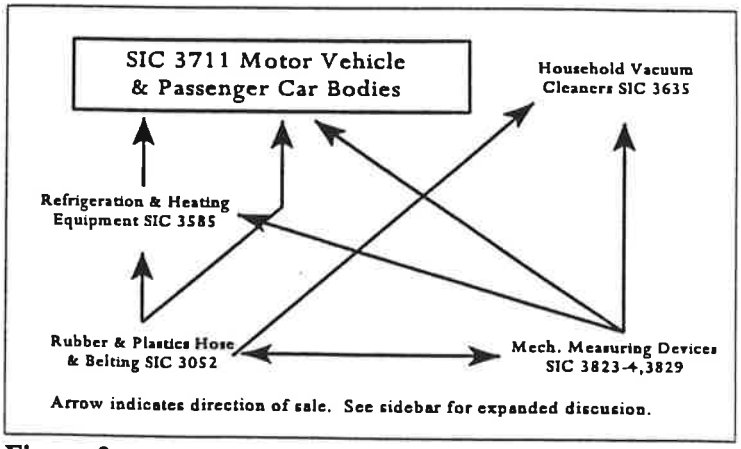


Figure 2

Analyzing Industrial Clusters

The term "cluster" means different things to different researchers and policy makers. Various definitions of industrial clusters as groups of related firms encompass one or more of the following dimensions: formal input-output or buyer-supplier linkages, geographic co-location, shared business-related local institutions, and evidence of informal cooperative competition. In the influential *Competitive Advantage of Nations*, Michael Porter wrote of clusters as groups of related industries, regardless of geographic location.[6] Yet he stressed the fact that such clusters *tend* to be localized in space. In *Understanding State Economies Through Industry Studies*, John Redman denotes a cluster as "a pronounced geographic concentration of production chains for one product or a range of similar products, as well as linked institutions that influence the competitiveness of these concentrations (e.g. education, infrastructure, and research programs)."[7] This is similar to, though perhaps somewhat broader, than the definition adopted by Stuart Rosenfeld in *Industrial-Strength Strategies: Regional Business Clusters and Public Policy*: "A cluster is a loose, geographically bounded agglomeration of similar, related firms that together are able to achieve synergy. Firms 'self-select' into clusters based on their mutual interdependencies in order to increase economic activity and facilitate business transactions."[8] In the early scientific literature on this subject, clusters were defined as collections of sectors related through formal production linkages, regardless of geographic proximity. When such clusters did exhibit a high degree of geographic concentration, they were referred to as *industrial complexes*.[9]

The appropriateness of any given definition, as well as any subsequent method of cluster identification, depends on the specific policy objectives involved. Recognizing that interactions between firms occur both locally and over great distances, this study sought to first identify clusters as *groups of technologically linked industries, irrespective of geographic location*. Since interindustry trade occurs across local, state, and national boundaries, such a non-location based approach is the most effective means of revealing the groups of industries that are most closely related with each other, based on similarities in input-output structure. The resulting extended buyer-supplier chains represent *benchmark clusters* that may be used to identify specializations and gaps in the sectoral distribution of economic activity in North Carolina. For example, there may be substantial North Carolina manufacturing activity in nearly all of the links of some buyer-supplier chains and only some of the links of others. In the case of the former, a key *potential* specialization in the state is identified. In the case of the latter, the gaps may represent pieces of the chain that might be filled through economic development strategies.

In order to identify related sectors irrespective of location, 362 three- and four-digit manufacturing industries--the full range of manufacturing industries in United States--are grouped into clusters based on *national* input-output patterns. The types of input-output linkages between firms in different industries are complex and multidimensional. The link between a given buying sector and a given selling sector, where the former buys as inputs the output of the latter, is a *direct* one. In Figure 2, the refrigeration and heating equipment, hoses and belting, and measuring devices industries are *first-tier* suppliers to the motor vehicles and car bodies industry. *Indirect* linkages between two given sectors are those that occur through intermediary industries. For example, the automobile assembly industry (SIC 3711) purchases inputs from the refrigeration and heating equipment industry (SIC 3585), which in turn is supplied by the rubber and plastics hose and belting sector (SIC 3052). In this case, the link between belts and hoses and automobiles is indirect; many firms in SIC 3052 are *second-tier* suppliers to producers in SIC 3711 (they are *first-tier* suppliers to firms in SIC 3585). Other indirect relationships may be revealed through the sharing of intermediate inputs. The household vacuum cleaners sector (SIC 3635) purchases a significant share of its total inputs from the hoses and belting (3052) and mechanical measuring devices (SIC 3823-4, 3829) industries, both important first- and second-tier suppliers to motor vehicles. If the similarities in input mix are strong enough, indirect linkages can suggest that the fortunes of seemingly unrelated industries (autos and vacuums) are actually joined to some degree. The cluster methodology adopted here is designed to evaluate, without imposing arbitrary *a priori* restrictions, the relative strengths of these complex direct and indirect linkages.

An alternative to the present methodology would be to identify clusters in North Carolina using data on real local input-output patterns. Conceptually, this would reveal actual buyer-supplier chains within the state. While useful for some purposes, the approach would have limited policy implications. Such an analysis would yield buyer-supplier chains that exclude any industries that do not trade locally at a significant level. Thus key sectors that may informally interact or share pools of labor with local cluster firms (by virtue of being engaged in related production) would be ignored. Likewise, the method would not reveal gaps in supplier-chains that might be filled through economic development initiatives. This would sacrifice a major advantage of the benchmark clusters, i.e. their ability to reveal latent opportunities or strengths in the North Carolina economy that are not apparent using standard SIC aggregations.[10]

fact, currently engage directly or indirectly in trade (within the U.S. as a whole). When the cluster definitions are applied to North Carolina manufacturing data, they identify groups of local producers that may or may not be presently engaged in trade. Rather, there is the clear potential that local manufacturers within a cluster could engage in such trade. There is also the likelihood that North Carolina firms in a given cluster are more likely to interact through informal channels with other local firms in that cluster, rather than with firms in different clusters. Additional detail on the basic approach and methodology used here is provided in the supplementary boxes that appear in the text, as well as in Appendix 4.

Definitions

Sector (or Industry): A sector or industry is a group of enterprises that manufacture similar products, as typically defined under the Standard Industrial Classification (SIC) system.

Cluster: A (benchmark) cluster is a group of businesses that make up an extended input-output or buyer-supplier chain. It includes final market producers, and first, second and third tier suppliers that directly and indirectly engage in trade. It is comprised of multiple sectors or industries.

Potential Cluster: A potential cluster is a group of businesses that *may* constitute an extended input-output chain based on data available a higher geographic level. Firms in a potential cluster may or may not presently trade with each other, although such trade could possibly occur in the future.

23 Manufacturing Clusters

The 23 benchmark clusters identified in the U.S. manufacturing economy are listed in Table 1. The clusters consist of heavy manufacturing (e.g. metalworking, vehicle manufacturing, chemicals and rubber, nonferrous metals), light manufacturing (e.g. electronics and computers, knitted goods, fabricated textiles, wood products, leather goods, printing and publishing), five separate food-related clusters, and several clusters closely related to other major clusters (e.g. brake products and platemaking and typesetting). With the exception of the growth in importance of key high tech clusters (electronics and computers and aerospace), the set of

Table 1
23 U.S. Benchmark Manufacturing Clusters

		Primary Only		All Sectors	
#	Cluster	# of Sectors	2-Digit SIC Sectors	# of Sectors	2-Digit SIC Sectors
1	Metalworking	93	9	116	10
2	Vehicle Manufacturing	35	13	58	16
3	Chemicals & Rubber	20	6	48	14
4	Electronics & Computers	25	6	38	8
5	Packaged Foods	21	1	44	5
6	Printing & Publishing	21	5	32	8
7	Wood Products	16	2	23	6
8	Knitted Goods	13	3	23	5
9	Fabricated Textile Products	12	7	22	9
10	Nonferrous Metals	8	3	14	4
11	Canned & Bottled Goods	6	2	12	2
12	Leather Goods	6	1	9	1
13	Aerospace	5	2	10	6
14	Feed Products	5	1	10	2
15	Platemaking & Typesetting	4	3	14	7
16	Aluminum	4	3	9	4
17	Brake Products	4	3	9	4
18	Concrete, Cement, & Brick	3	1	8	2
19	Earthenware Products	5	1	8	1
20	Tobacco Products	4	1	4	1
21	Dairy Products	3	1	6	1
22	Petroleum	3	2	5	2
23	Meat Products	2	1	5	2

Technical Methodology

The basic methodology for clustering manufacturing industries consisted of factor analysis on a data matrix constructed from the 1987 U.S. input-output (I-O) accounts. Factor analysis treats each given industry as a variable, with a measure of the linkages between the industry and all other industries treated as observations. The analysis then seeks to reduce the number of variables by exploiting the common variation among them, i.e. it groups industries together based on similarities in their input-output structures. The result is a set of input-output based industrial clusters. A detailed discussion of several slightly different factor analytic approaches tested and compared in this study, as well as the criteria developed for identifying clusters from the statistical output, is provided in Appendix 4. For the most part, alternative statistical specifications generated similar results, though the final set of clusters reported below proved to best reveal both direct and indirect input-output links.

Input-Output Based Industrial Clusters. The 23 clusters generated by the analysis and their component sectors are reported in Table A.1 in Appendix 1.[11] Because interindustry linkages are extremely complex, aggregating industries into single, mutually exclusive clusters risks masking key input-output relationships. In reality, many industries belong to more than one cluster, and their linkages across clusters may vary in degree or strength; i.e. an industry may be tightly linked to one group of sectors and weakly or moderately linked to one or more additional groups. Such interrelationships can make the comparison of clusters very difficult, since, by definition, there may be a significant amount of double counting in any set of aggregations. The factor analysis methodology provides a partial way around this problem by generating a set of "loadings," which roughly measure the degree or significance of linkage between a given industry and the cluster of which it is a part. Loadings closer to 1.0 indicate tighter linkages.[12] They are reported in the last column of Table A.1 (labeled *Load*) and are summarized in the three columns labeled *Cluster ID*.

Primary vs. Secondary Cluster Industries. The loadings have been used to designate each cluster sector as "primary" or "secondary." In general, *primary* industries are those that are most tightly linked to a given cluster while *secondary* industries are those that are only moderately or weakly linked to the cluster. Specifically, primary industries for a given cluster are defined as those sectors 1) that achieved a loading of at least .60 on that cluster; *and* 2) that did not achieve a higher loading on any other cluster. Secondary industries are defined as those sectors that achieved a loading on the cluster of between .35 and .60. The columns in Table 1 labeled *Cluster ID* help identify inter-cluster linkages. Column *L1* reports the cluster on which a given sector achieved its highest loading; column *L2* indicates the cluster (if any) on which the sector achieved an additional loading exceeding .60; column *L3* indicates the clusters (if any) on which the sector achieved loadings of between .35 and .60. Restricting the analysis to primary industries results in a set of 23 mutually exclusive clusters that may be used for cross-comparison purposes. However, both primary and secondary industries provide the most complete picture of any given cluster. As a rule, indirect buyer-supplier linkages between industries in a cluster tend to be revealed through an examination of the cluster's secondary industries.

Non-Loading Industries. Not all industries demonstrated clustering tendencies. Of 362 input-output sectors, 44 failed to achieve a factor loading of .60 or higher. These sectors, reported in Table A.2 in Appendix 1, are classified only as secondary industries in their respective clusters. Although half of these sectors did achieve loadings exceeding .50 on at least one cluster, most of the 318 industries classified as primary industries achieved loadings of .80 or higher on one or more clusters. Three sectors (SICs 328--cut stone and stone products, 387--plumbing fixture, fittings and trim, and 3432--watches, clocks, watchcases, and parts) achieved maximum loadings below .35 and thus should not be classified even as secondary industries according to the criteria above. Nevertheless, in order that all manufacturing sectors be included in the analysis, they are listed as secondary industries in the cluster in which they achieved their maximum loading. The nonloading sectors are not overlooked in the analysis in the text since some of them are important industries in the North Carolina economy (e.g. SIC 283, drugs; SIC 2015, poultry slaughtering and processing; and SICs 262-3, paper and paperboard mills).

clusters is roughly similar to results found in earlier cluster studies conducted using input-output data from the 1960s and 1970s.

Each cluster is composed of multiple sectors, which are, in turn, defined as either ***primary*** or ***secondary***. A detailed list of component sectors in each cluster is provided in Table A.1 in Appendix 1. Primary sectors in a given cluster are those sectors

that are the most tightly linked to the other industries in the cluster; secondary sectors are industries that are only weakly linked. Generally secondary sectors in one cluster are classified as primary in other clusters. When only primary industries are included, the 23 clusters are mutually exclusive, facilitating cross-cluster comparisons. However, since the most complete picture of a given cluster includes its primary and secondary sectors, data are presented on each cluster both exclusive and inclusive of secondary industries.

Table 1 highlights two key features of the clusters. First, the number of component sectors in each cluster varies dramatically from 116 in the metalworking cluster to just 4 in the tobacco products cluster (when both primary and secondary industries are included in the cluster definitions). Clusters with the largest number of component sectors include multiple final market product chains, whereas smaller clusters (tobacco, dairy products, meat products, etc.) generally describe only a single major product chain. Second, most clusters are composed of sectors from a variety of 2-digit

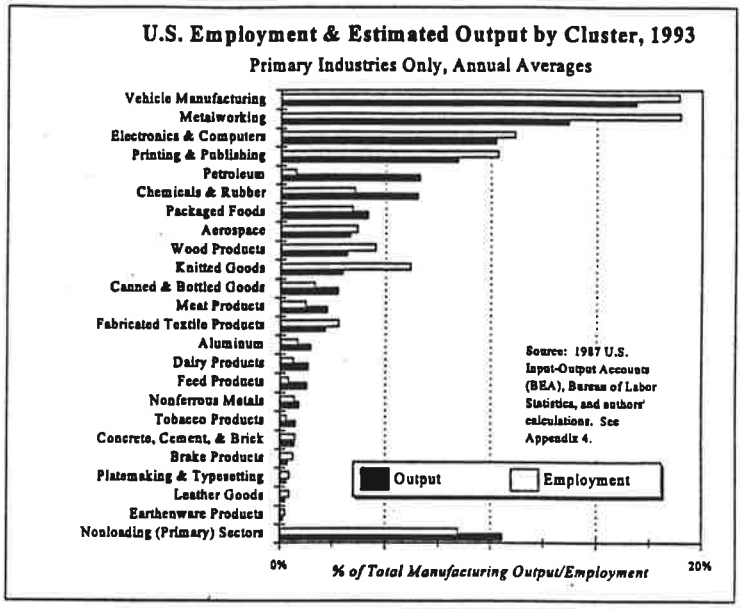


Figure 3

level SIC industries (see the third and fifth columns of Table 1). Sectors from *10* different 2-digit SIC industries are represented in the metalworking cluster, for example; sectors from *16* different 2-digit SIC categories make up the vehicle manufacturing cluster. Clusters defined on the basis of interindustry linkages will thus generate a very different picture of the manufacturing economy when used in subsequent economic analyses than studies that employ the SIC system.

Figure 3 illustrates the relative size of each benchmark cluster in the U.S., in estimated output and employment terms, when only primary cluster industries are included (see also Table 2). The following subsections briefly describe the basic makeup and characteristics of the largest of the nation's 23 benchmark input-output chains. Description of a few of the chains that are particularly significant for the North Carolina manufacturing economy (e.g. packaged foods, wood products, knitted goods, and fabricated textiles) is deferred to later sections of the report.

Vehicle Manufacturing. The vehicle manufacturing cluster is the largest cluster in the U.S., accounting for nearly 17 percent of total estimated manufacturing output in 1993.[13] The cluster consists of 35 primary industries and 23 secondary industries (see Table A.1). That it is comprised of 3- and 4-digit SIC sectors in 16 of 20 2-digit level categories illustrates the difference between input-output clusters and the SIC classification system. SIC 37, transportation equipment, is made up of industries producing similar products; the vehicle manufacturing benchmark cluster includes many first- and second-tier transportation equipment supplier industries that manufacture significantly different products, from rubber hoses and belts (SIC 3052), storage batteries (SIC 3691), and paints (SIC 285), to carburetors (SIC 3592), carpets (SIC 227), and steel springs (SIC 349).

The columns labeled *Cluster ID* in Table A.1 provide a rough indication of some of the linkages between the vehicle manufacturing cluster and the remaining 22 clusters, though a complete analysis is possible only with primary input-output data and

Table 2

1993 U.S. Manufacturing Output & Employment Per Cluster

Primary Industries Only

#	Cluster	Est. Output (Millions)	% Total Output	Employ-ment	% Total Emp.
2	Vehicle Manufacturing	434,924	16.8%	3,550,536	18.9%
1	Metalworking	351,652	13.6%	3,561,025	18.9%
4	Electronics & Computers	263,758	10.2%	2,087,595	11.1%
6	Printing & Publishing	215,148	8.3%	1,936,904	10.3%
22	Petroleum	169,503	6.6%	128,875	0.7%
3	Chemicals & Rubber	166,846	6.5%	664,384	3.5%
5	Packaged Foods	107,076	4.1%	642,019	3.4%
13	Aerospace	85,636	3.3%	676,119	3.6%
7	Wood Products	80,421	3.1%	839,442	4.5%
8	Knitted Goods	76,097	2.9%	1,153,520	6.1%
11	Canned & Bottled Goods	69,494	2.7%	299,335	1.6%
23	Meat Products	56,672	2.2%	226,143	1.2%
9	Fabricated Textile Products	54,195	2.1%	514,540	2.7%
16	Aluminum	36,467	1.4%	149,082	0.8%
21	Dairy Products	33,841	1.3%	111,057	0.6%
14	Feed Products	31,362	1.2%	73,229	0.4%
10	Nonferrous Metals	21,396	0.8%	123,235	0.7%
20	Tobacco Products	18,035	0.7%	45,369	0.2%
18	Concrete, Cement, & Brick	16,613	0.6%	126,975	0.7%
17	Brake Products	8,595	0.3%	109,416	0.6%
15	Platemaking & Typesetting	6,628	0.3%	78,788	0.4%
12	Leather Goods	5,017	0.2%	81,209	0.4%
19	Earthenware Products	2,455	0.1%	42,546	0.2%
	Nonloading (Primary) Sectors	272,115	10.5%	1,575,712	8.4%
	Totals:	2,583,948		18,797,055	

Source: BEA, U.S. Bureau of Labor Statistics, and authors' calculations; see Appendix 4.

detailed intersectoral comparisons. The cluster in which a given sector is most tightly linked is given in column *L1*. *L2* and *L3* report additional clusters, if any, in which the sector is also moderately linked. (Clusters are numbered consistently throughout the report as given in the first column of Table 1; see the supplementary box "Technical Methodology" and Appendix 4 for detailed discussion of sector to cluster linkages.) As might be expected given the high metal content of most transportation equipment, 20 of 58 total primary and secondary industries in the vehicle manufacturing cluster are also members of the metalworking cluster. Other sectors are members of an additional 10 clusters, with the chemicals and rubber, printing and publishing, fabricated textile products, and communications, electronics, computers clusters the most significant (in terms of number of cross-cluster linkages). The vehicle manufacturing

cluster is also, as expected, closely linked to the brake products cluster, which itself shares most of its component industries with the former as well as the metalworking cluster.

Metalworking. The second-largest cluster in the U.S. economy in 1993 (in terms share of output when only primary industries are considered--13.6 percent) is the largest cluster in terms of sheer numbers of component sectors. The metalworking cluster is comprised of 116 sectors (93 primary) that span 11 different 2-digit SIC categories. The cluster consists of most primary metal, fabricated metal, and industrial machinery industries, as well as many sectors in the electronic and electrical equipment industries (SIC 36). As reflective of its key role in the manufacturing sector as a whole, the metalworking cluster shares component industries with 14 other clusters. Its primary sectors also accounted for nearly one-fifth of total U.S. manufacturing wage payments in 1993, the highest share of any cluster.

Electronics & Computers. The electronics and computers, printing and publishing, petroleum, and chemicals and rubber clusters round out the top six U.S. clusters in share of 1993 output terms (10, 10.2, 6.6, and 6.5, percent respectively). The electronics and computers cluster includes most major high-technology goods producers in SIC sectors 35, 36, and 38, including computers, telephones and other communication equipment, x-rays, surgical and medical instruments, and laboratory instruments. Both final market and intermediate goods sectors are represented (e.g. electronic computers (SIC 3571) and key supplier sectors such as semiconductors (SIC 3674), electronic components (SICs 3672, 3675-9), and electrical machinery and equipment (SIC 3699)). Intercluster linkages, through component industries that also make up other clusters, extend to the high technology aerospace cluster, as well as the metalworking, printing and publishing, and vehicle manufacturing clusters.

Printing & Publishing. A total of 32 3- and 4-digit SIC sectors (21 primary) make up the printing and publishing cluster. They range from most of the sectors classified as printing/publishing under the SIC system (SIC 27), to paper and pulp mills (SIC 261, 262), paper industries machinery (SIC 3554), and photographic equipment and supplies (SIC 386). Key intercluster linkages extend to the wood products, chemicals and rubber, vehicle manufacturing, and platemaking and typesetting clusters. The platemaking and typesetting cluster, like the brake products cluster, is nearly a sub-cluster of the printing and publishing cluster, though the statistical analysis indicated that it possessed strong enough clustering tendencies on its own to be analyzed separately.

Chemicals & Rubber. The chemicals/rubber and petroleum clusters are, as might be expected,

closely related. The chemicals and rubber cluster includes industrial chemicals, tile, pesticides, synthetic rubber, soaps, brick, plastics, fertilizers, and ink producers. It is one of only two clusters in which the number of component secondary sectors (28) significantly exceeds the number of primary sectors (20), suggesting that the cluster plays a limited though critical part in the manufacture of an extremely wide variety of products; in the case of chemicals and rubber, the *intra*-cluster linkages are not nearly as significant as the *inter*-cluster linkages. Various chemical and rubber products components sectors are members of a total of 13 other clusters.

Petroleum. The petroleum cluster, though accounting for nearly 7 percent of estimated 1993 manufacturing output, is made up of only three primary and two secondary industries. Its only significant intercluster linkages as revealed through the statistical analysis are with the chemicals and rubber and metalworking clusters. *All* of the component sectors in the petroleum cluster are also members of the chemicals and rubber cluster.

Smaller Clusters. The remaining seventeen clusters each produced less than 5 percent of the total estimated national manufacturing output in 1993.[14] Five of the seventeen are food products clusters of one type or another (packaged, canned and bottled, feed products, dairy, and meats). As in the case of the chemicals and rubber cluster, the number of secondary industries in the packaged foods cluster (cluster 5) well exceeds the number of primary sectors. This is largely because of the considerable sub-clustering that occurred among food products industries in the factor analysis, rather than the ubiquitous nature of food products in the manufacturing sector as a whole. Together, the sectors making up all five food products clusters span only six separate SIC 2-digit categories; the vast majority fall into SIC 20. As noted above, fabricated textiles, knitted goods, wood products and other clusters whose primary component industries contributed less than 5 percent of 1993 U.S. manufacturing output, yet that are important industries in North Carolina, are discussed in subsequent sections of the report.

Nonloading (Primary) Sectors. In order to calculate shares of total manufacturing activity, only the primary industries in each cluster are included in Figure 3 and Table 2. But not all of the 362 manufacturing sectors included in this analysis demonstrated strong enough sectoral interdependencies to be classified as a primary industry in a cluster. 44 sectors are classified only as secondary sectors. Therefore, there remains a residual category of industries that requires attention. The last row of Table 2 reports the total U.S. 1993 estimated manufacturing output and employment accounted for by such industries. At nearly 11 percent of total output in 1993, nonloading industries constitute a

significant share of national manufacturing production. Table A.2 in Appendix 1 reports the industries that failed to load as a primary industry on any cluster. The most significant of these are drugs (accounted for 2.2 percent of total 1993 U.S. manufacturing output) and paper and paperboard mills (1.9 percent). Other nonloading industries accounting for at least 5 percent of total nonloading sectors output are photographic equipment and supplies, poultry slaughtering and processing, toilet preparations, and flavoring extracts and syrups. The proportion of total estimated North Carolina 1994 output accounted for by nonloading sectors is also reported in Table A.2. Drugs, poultry slaughtering and processing, and paper and paperboard mills together constituted nearly 8 percent of manufacturing production in the state in 1994. The total share of estimated output in the state in sectors that are only moderately linked to specific clusters is nearly 12 percent.

Table 3

1993 U.S. Manufacturing Output & Employment Per Cluster

Includes Primary & Secondary Industries

#	Cluster	Est. Output (Millions)	Employment	Output Size Rank
3	Chemicals & Rubber	611,832	2,642,913	6
2	Vehicle Manufacturing	587,549	5,130,644	1
1	Metalworking	481,231	4,629,706	2
4	Electronics & Computers	418,642	3,381,171	3
6	Printing & Publishing	322,252	2,585,278	4
5	Packaged Foods	317,917	1,701,024	7
22	Petroleum	172,394	141,395	5
8	Knitted Goods	135,887	1,604,970	10
15	Platemaking & Typesetting	135,887	696,734	21
13	Aerospace	128,023	1,062,188	8
9	Fabricated Textile Products	127,873	1,617,165	13
14	Feed Products	118,623	415,155	16
11	Canned & Bottled Goods	110,406	381,694	11
7	Wood Products	91,222	948,069	9
23	Meat Products	84,623	507,264	12
16	Aluminum	67,518	328,167	14
21	Dairy Products	48,891	175,614	15
10	Nonferrous Metals	43,898	265,931	17
17	Brake Products	33,530	472,051	20
18	Concrete, Cement, & Brick	27,525	236,049	19
20	Tobacco Products	18,035	45,369	18
12	Leather Goods	8,729	117,303	22
19	Earthenware Products	4,820	62,194	23

Source: BEA, U.S. Bureau of Labor Statistics, and authors' calculations; see Appendix 4.

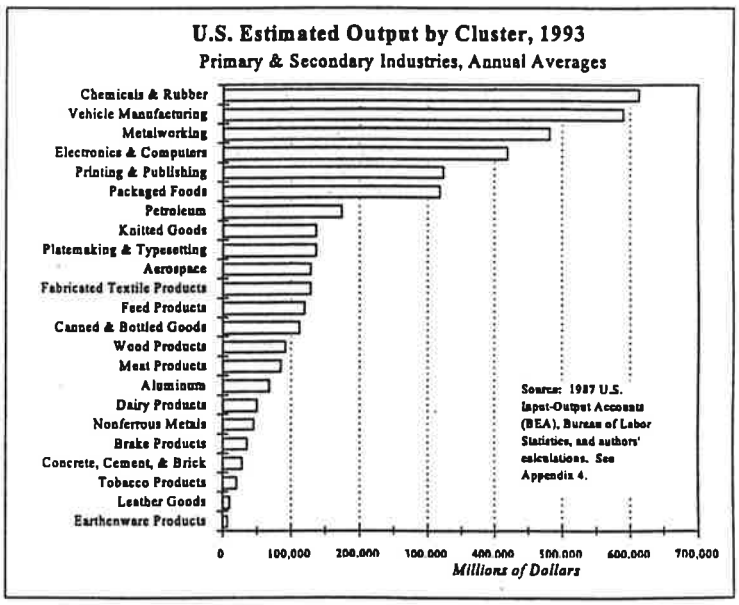


Figure 4

Clusters with Secondary Industries Included. Because of the large size of some of the nonloading (primary) sectors, the comparison of clusters based on primary industries alone could potentially be misleading. Table 3 reports U.S. output and employment data by cluster, inclusive of both primary and secondary industries. Figure 4 and the rightmost column in Table 3 illustrate how the relative size

rankings of each cluster can change when all component industries are included.

Most significantly, the chemicals and rubber cluster replaces vehicle manufacturing as the largest manufacturing cluster in the U.S. economy, generating an estimated $611.8 billion in output in 1993. The shift in size rank is consistent with the point noted above, i.e. that industries that make up the chemicals cluster have moderate linkages with a large number of other manufacturing industries (thus the large number of secondary as opposed to primary sectors). Other major clusters with significant shifts in rank include the petroleum, fabricated textile products, and platemaking and typesetting clusters. A careful examination of estimated output and employment shares by component sectors in each cluster (reported in *Volume II: Detailed Appendices*), shows that the platemaking and typesetting cluster made the most dramatic jump of any cluster, from 21st to 11th largest, on the strength of three large secondary industries: paper and paperboard mills; photographic equipment and supplies, and periodicals. The large shift, driven by just a few key sectors, underscores the importance of analyzing the component industries within a cluster. This is an especially important element in the examination of the distribution of the benchmark clusters in the North Carolina economy, since, in some cases, the state possesses a very different relative distribution of industries within each cluster.

4. North Carolina's Manufacturing Clusters

The twenty-three industrial clusters listed in Table A.1 identify which U.S. industries are linked through direct and indirect input-output flows. These clusters suggest industries among which the transfer and exchange of intermediate goods, advanced production technologies, formal and informal information about new methods and innovations, and skilled production workers and technical personnel is likely to occur. The clusters help characterize the manufacturing economy in terms of concentrations in major product chains, thereby revealing relative specializations in the economy by groups of interdependent, rather than independent, sectors.

Most analyses of the North Carolina manufacturing economy emphasize the overwhelming dominance of textiles, followed by smaller but significant concentrations of manufacturing activity in furniture, apparel, heavy industrial machinery, and tobacco (see Figure 5). But a somewhat different picture of the state's manufacturing economy is revealed through the cluster analysis (see Tables 4 and 5).

Section 4. Summary of Findings

- An examination of the distribution of North Carolina manufacturing activity across the 23 benchmark clusters reveals the presence of nine major potential clusters that together account for 90 percent of all manufacturing establishments.
- North Carolina producers in the vehicle manufacturing cluster accounted for nearly 14 percent of estimated statewide manufacturing output in 1994, a share equaled only by the knitted goods cluster.
- Though the high tech chemicals and electronics and computers clusters are sizeable, compared to the U.S., North Carolina manufacturing is concentrated in lower technology, lower wage clusters such as fabricated textiles, knitted goods, wood products, and tobacco.

Most significant is the emergence of a large vehicle manufacturing cluster in a state generally not viewed to have a significant volume of production in the transportation sector. When only primary industries are considered, sectors linked within the benchmark vehicle manufacturing input-output chain accounted for nearly 14 percent of total estimated North Carolina manufacturing output in 1994. Though it is not

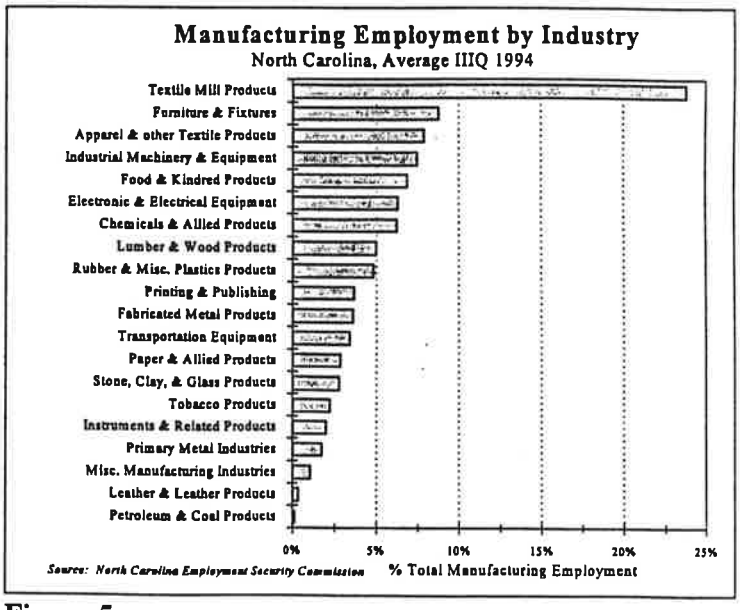


Figure 5

known to what degree local firms in this cluster manufacture goods related directly to vehicle manufacturing, there is clearly significant potential in the state for the further development of a substantially expanded real vehicle manufacturing cluster. Vehicle manufacturing is only slightly smaller than knitted goods, the potential cluster with the largest presence in the state. Together, manufacturers associated with these two clusters accounted for 37 percent of statewide third quarter 1994 manufacturing employment.

Other clusters with a significant presence are the following (Table 4, clusters defined as mutually exclusive): tobacco products (9.4 percent of manufacturing output, but just 2.2 percent of employment), electronics and computers (9 percent output, 7.7 percent employment), fabricated textile products (8.7 percent output, 9.5 percent employment), metalworking (7.9 percent, 10.6 percent), chemicals and rubber (6.2 percent, 3.8 percent), and wood products (6.1 percent, 9 percent). The printing and publishing cluster also accounted for nearly 5 percent of estimated manufacturing output (5.5 percent of employment) in 1994.

Table 4

1994 State Output & Employment by Cluster

Primary Industries Only (Sorted by Estimated Output)

Cluster	Estimated 1994 Annual Output (Millions)	% Total	IIIQ '94 Employment Total	% Total
Knitted Goods	13,821.8	13.9%	187,341	21.6%
Vehicle Manufacturing	13,774.2	13.9%	129,607	15.0%
Tobacco Products	9,374.6	9.4%	19,015	2.2%
Electronics & Computers	8,930.6	9.0%	66,972	7.7%
Fabricated Textile Products	8,641.1	8.7%	82,288	9.5%
Metalworking	7,869.9	7.9%	91,451	10.6%
Chemicals & Rubber	6,205.8	6.2%	32,658	3.8%
Wood Products	6,068.2	6.1%	77,607	9.0%
Printing & Publishing	4,788.6	4.8%	47,730	5.5%
Canned & Bottled Goods	1,948.3	2.0%	8,043	0.9%
Meat Products	1,625.2	1.6%	7,788	0.9%
Packaged Foods	1,551.4	1.6%	12,381	1.4%
Feed Products	780.5	0.8%	2,232	0.3%
Aluminum	640.8	0.6%	2,901	0.3%
Concrete, Cement, & Brick	416.9	0.4%	3,735	0.4%
Aerospace	323.8	0.3%	2,551	0.3%
Dairy Products	226.6	0.2%	1,238	0.1%
Nonferrous Metals	224.3	0.2%	1,327	0.2%
Brake Products	142.2	0.1%	1,932	0.2%
Platemaking & Typesetting	103.2	0.1%	1,576	0.2%
Leather Goods	95.6	0.1%	1,555	0.2%
Earthenware Products	41.1	0.0%	974	0.1%
Petroleum	8.8	0.0%	53	0.0%
Nonloading (Primary) Sectors	11,813.4	11.9%	82,498	9.5%
Total:	99,416.8	100.0%	865,454	100.0%

Source: NCESC and authors' calculations. See Appendix 4.

Like many other Southeastern states, lower skill, lower wage industries predominate in the North Carolina manufacturing sector. Compared to the U.S. as a whole, the state's manufacturing sector is significantly over-represented in the tobacco, fabricated textile, knitted goods, and wood products clusters, while it is slightly under-represented in somewhat higher valued-added, generally higher technology clusters such as vehicle manufacturing, metalworking, and electronics and computers (see Figures 6 and 7). While the state has a comparable proportion of total manufacturing production in the high technology chemicals cluster, it has virtually no activity in the very high-tech aerospace and petroleum clusters. (Technology definitions are described in the

following section.) The distribution of manufacturing activity toward lower technology clusters is slightly more pronounced in employment terms: 42 percent of manufacturing jobs (versus 38 percent of manufacturing output) in the state are in the comparatively lower-tech, lower wage fabricated textile, knitted goods, tobacco, and wood products clusters.

The last row of Table 4 and Figures 6-7 indicate sizable NC manufacturing employment--nearly 12 percent--in sectors that are only moderately linked to their respective clusters (nonloading primary sectors). Drugs (SIC 283), poultry slaughtering and processing (SIC 2015), and paper and paperboard mills (SIC 262-3), are the largest of these. The drugs sector, a secondary member of both the chemicals and feed product clusters, accounted for nearly 4 percent of statewide manufacturing output in 1994; the poultry and paper mills industries each accounted for nearly 2 percent. These as well as other nonloading primary sectors can lead to shifts in the rankings of the potential clusters when both primary and secondary industries are included in the cluster

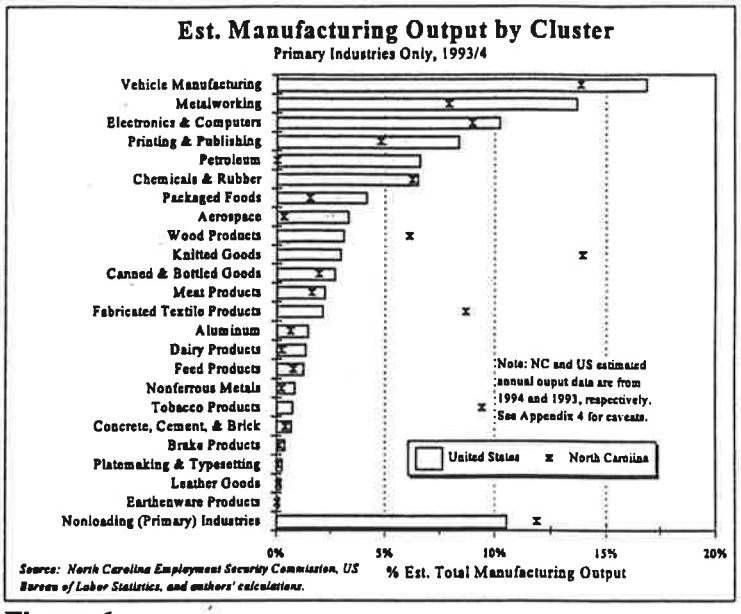


Figure 6

Table 5

1994 State Output & Employment by Cluster

Includes Primary & Secondary Industries (Sorted by Est. Output)

#	Cluster	Estimated 1994 Annual Output (Millions)	IIIQ '94 Employment	Output Size Rank	
8	Knitted Goods	24,965.4	279,728	1	
9	Fabricated Textile Products	18,113.2	211,858	5	
3	Chemicals & Rubber	17,202.0	106,831	7	
2	Vehicle Manufacturing	16,776.6	168,744	2	
1	Metalworking	12,090.3	132,755	6	
4	Electronics & Computers	12,072.0	97,287	4	
20	Tobacco Products	9,374.6	19,015	3	
6	Printing & Publishing	8,674.2	72,591	9	
5	Packaged Foods	8,344.0	61,372	12	
7	Wood Products	6,795.3	85,520	8	
14	Feed Products	5,586.9	22,378	13	
23	Meat Products	3,666.2	29,309	11	
15	Platemaking & Typesetting	2,762.9	15,512	20	
11	Canned & Bottled Goods	2,112.7	8,463	10	
10	Nonferrous Metals	1,858.1	11,825	18	
16	Aluminum	1,291.1	7,788	14	
13	Aerospace	980.7	8,929	16	
18	Concrete, Cement, & Brick	760.3	7,489	15	
17	Brake Products	616.3	9,353	19	
21	Dairy Products	496.9	2,920	17	
12	Leather Goods	202.2	2,680	21	
19	Earthenware Products	114.5	1,955	22	
22	Petroleum	46.8	409	23	

Source: NCESC and authors' calculations. See Appendix 4.

definitions (see Table 5). Nevertheless, the most significant shifts occur among the smallest clusters (e.g. feed products), where the inclusion or exclusion

of a single sector can lead to dramatic changes in relative size. Under either cluster definition, the largest and most significant potential clusters in the state remain largely the same.

Based on an analysis of estimated output and employment shares, and after comparing size rankings under both the comprehensive and limited cluster definitions, nine ***major North Carolina potential clusters*** were selected for detailed presentation and description. In the sections that follow, these are examined in detail, while the remaining 14 clusters are discussed where results are particularly significant or noteworthy. The nine clusters are the following:

- **Metalworking**
- **Vehicle Manufacturing**
- **Chemicals & Rubber (inc. plastics)**
- **Electronics & Computers**
- **Packaged Foods**
- **Printing & Publishing**
- **Wood Products (inc. furniture)**
- **Knitted Goods (inc. hosiery and apparel)**
- **Fabricated Textile Products**

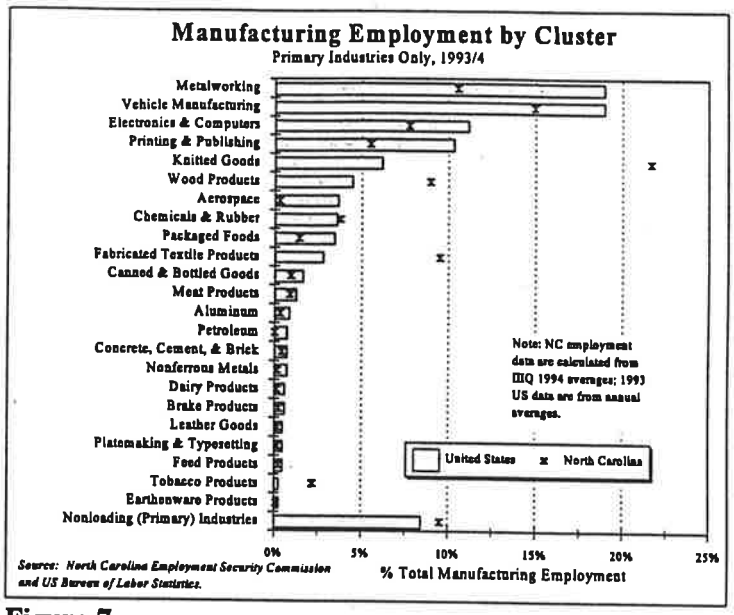


Figure 7

Table 6

1994 North Carolina Wages by Cluster

Total Payments, Third Quarter 1994

Cluster	Primary Industries (Millions)	% Total	Primary & Secondary (Millions)
Metalworking	654,316	11.4%	950,483
Vehicle Manufacturing	882,563	15.4%	1,126,292
Chemicals & Rubber	291,060	5.1%	939,650
Electronics & Computers	631,793	11.0%	831,291
Packaged Foods	77,434	1.4%	391,000
Printing & Publishing	325,577	5.7%	529,540
Wood Products	398,150	6.9%	450,103
Knitted Goods	907,813	15.8%	1,472,496
Fabricated Textile Products	454,473	7.9%	1,066,043
Nonferrous Metals	11,692	0.2%	92,038
Canned & Bottled Goods	68,065	1.2%	71,207
Leather Goods	7,415	0.1%	13,467
Aerospace	24,655	0.4%	84,661
Feed Products	15,692	0.3%	262,296
Platemaking & Typesetting	12,684	0.2%	149,350
Aluminum	29,068	0.5%	61,145
Brake Products	12,851	0.2%	65,134
Concrete, Cement, & Brick	25,601	0.4%	50,020
Earthenware Products	4,464	0.1%	11,220
Tobacco Products	216,032	3.8%	216,032
Dairy Products	6,706	0.1%	16,056
Petroleum	434	0.0%	1,944
Meat Products	41,299	0.7%	140,080
Nonloading (Primary) Sectors	635,927	11.1%	—
Total:	5,735,762	100.0%	—

Source: NCESC and authors' calculations. See Appendix 4.

Together, these clusters accounted for nearly 90 percent of all manufacturing establishments in the state in 1994, 84 percent of employment, and 72 percent of

estimated output. They include nearly all major industries that have been the subject of, or are currently are being considered for, targeted technology-based competitiveness strategies, including furniture (wood products, metalworking), general textiles, hosiery, and apparel (knitted goods, fabricated textiles), computing (electronics and computers), transportation equipment (vehicle manufacturing), industrial machinery (metalworking), plastics (chemicals and rubber), and prefabricated or manufactured buildings (metalworking, wood products).[15]

5. Targeting North Carolina Clusters

Targeting studies often use a range of criteria or basic indicators to filter through the large number of possible target industries and identify key sectors for policy attention. Three of the most common criteria are technology classification, establishment size distribution, and industry structure. Technology initiatives may be focused on firms producing high technology goods or using high technology production equipment. Where this is the case, clusters predominantly made up of high tech producers (e.g. aerospace) may represent the most important policy targets. Alternatively, rather than limit attention to purely high technology producers, technology assistance programs might seek to leverage interfirm synergies that encourage technology upgrading among firms (both high- and low-tech) in the same buyer-supplier chain. Since the high technology sectors in a given buyer-supplier chain are often the key developers, demanders, and/or disseminators of advanced technologies and methods, it is then useful to identify potential clusters in the state where such sectors are over- or under-represented (relative to the U.S. benchmark).

Section 5. Summary of Findings

- The share of high tech production in the North Carolina chemicals and rubber, electronics and computers, and aluminum clusters closely match the U.S. benchmarks, providing an initial indication that key high tech links in these extended buyer-supplier clusters are present in the state. The share of high tech production in the state's potential metalworking clusters well exceeds the U.S. average.
- The share of high tech production in the potential North Carolina vehicle manufacturing cluster is well below the U.S. benchmark however; lower tech sectors currently predominate NC's links in this product chain.
- Across the nine major potential NC clusters, the highest shares of very small (less than 50 employees) enterprises are found in the metalworking, wood products, and printing and publishing clusters. The lowest shares are found in the knitted goods, packaged foods, chemicals, and fabricated textile products clusters.
- The knitted goods, packaged foods, chemicals, and fabricated textile products clusters also have the highest shares of branch plants (about one-third of all cluster enterprises) among the nine largest potential clusters in the state.

Economic development programs, including technology policies, are also frequently targeted to smaller plants, based on evidence that such enterprises face greater obstacles to modernization (e.g. resource constraints, expertise, etc.). For the same reasons, a further distinction may be made between branch plants and single establishment firms, where the latter are assumed to have fewer resources at their disposal. These three criteria are used in this section to further describe and characterize the set of potential North Carolina clusters for the purposes of selecting policy targets.

High Technology Sectors

Table 7 reports the distribution of output and employment classified as high tech by cluster for both the U.S. and North Carolina.[16] Output in several U.S. benchmark clusters is predominantly in sectors that are characterized as high tech at some level. When only primary industries are included in the cluster definitions (third column, Table 7), the share of output in sectors classified as high tech meets or exceeds 80 percent in the ***U.S. benchmark*** petroleum, aerospace, chemicals and rubber, electronics and computers, and aluminum clusters. Several other benchmark clusters generate low to moderate shares of high tech output: vehicle manufacturing (63 percent), platemaking and typesetting (35 percent), metalworking (36 percent), and fabricated textile products (23 percent). 14 of 23 clusters, including the five food products clusters, knitted goods, nonferrous metals, wood products, printing and publishing, tobacco, cement and brick, brake products, and earthenware products produce very little or no high tech output.

Table 7

Percent High Technology Output & Employment by Cluster

Primary/Primary & Secondary Industries, 1993/4

#	Cluster	Primary Industries Only				Primary & Secondary			
		Output		Employment		Output		Employment	
		US	NC	US	NC	US	NC	US	NC
1	Metalworking	36%	56%	36%	54%	43%	62%	42%	59%
2	Vehicle Manufacturing	63%	36%	36%	27%	52%	32%	32%	25%
3	Chemicals & Rubber	94%	94%	84%	83%	69%	63%	45%	50%
4	Electronics & Computers	90%	85%	90%	85%	77%	72%	73%	68%
5	Packaged Foods	0%	0%	0%	0%	8%	10%	6%	8%
6	Printing & Publishing	1%	1%	1%	1%	9%	11%	5%	7%
7	Wood Products	0%	0%	0%	0%	1%	1%	1%	1%
8	Knitted Goods	0%	0%	0%	0%	8%	8%	3%	4%
9	Fabricated Textile Products	23%	3%	21%	3%	10%	1%	7%	1%
10	Nonferrous Metals	6%	21%	11%	33%	3%	3%	5%	4%
11	Canned & Bottled Goods	0%	0%	0%	0%	0%	0%	0%	0%
12	Leather Goods	0%	0%	0%	0%	0%	0%	0%	0%
13	Aerospace	97%	56%	98%	62%	97%	85%	97%	89%
14	Feed Products	0%	0%	0%	0%	47%	68%	64%	77%
15	Platemaking & Typesetting	35%	19%	27%	16%	20%	15%	18%	15%
16	Aluminum	80%	87%	75%	75%	43%	43%	34%	28%
17	Brake Products	0%	0%	0%	0%	19%	27%	15%	20%
18	Concrete, Cement, & Brick	0%	0%	0%	0%	2%	0%	3%	0%
19	Earthenware Products	0%	0%	0%	0%	0%	0%	0%	0%
20	Tobacco Products	0%	0%	0%	0%	0%	0%	0%	0%
21	Dairy Products	0%	0%	0%	0%	0%	0%	0%	0%
22	Petroleum	99%	18%	89%	16%	97%	3%	81%	2%
23	Meat Products	0%	0%	0%	0%	0%	0%	0%	0%
	Nonloading (Primary) Sectors	38%	42%	31%	30%	–	–	–	–
	Total	46%	29%	35%	23%	–	–	–	–

Figures give percent cluster activity classified as high, moderately high, or somewhat high technology (definitions from NC ACTS and the North Carolina Employment Security Commission). NC and US data are from 1994 and 1993, respectively (NCESC and USBLS).

A comparison of the relative distribution high-tech output in North Carolina versus the U.S. suggests some under- and over-representation of high tech activity in the state's ***potential*** clusters (see Figure 8). The ratio of high tech to standard technology production in the North Carolina chemicals, electronics and computers, and aluminum clusters is nearly even with, or exceeds (in the case of aluminum), the ratio for the U.S. as a whole. Although confirmation is not possible without a detailed look at the component sectors in each potential cluster, the aggregate numbers provide an initial indication that at least some of the critical high tech links in these extended buyer-supplier chains are present in the state. These results also suggest that although North Carolina manufacturing may be concentrated in low technology activity in the

aggregate, this is not necessarily the case for individual clusters or product chains. The percentage of high tech production in the potential metalworking cluster in North Carolina, for example, well exceeds the U.S. benchmark. As is shown below, the majority of statewide activity in this cluster is in the higher tech, higher wage industrial machinery sectors, rather than basic metals production and fabrication.

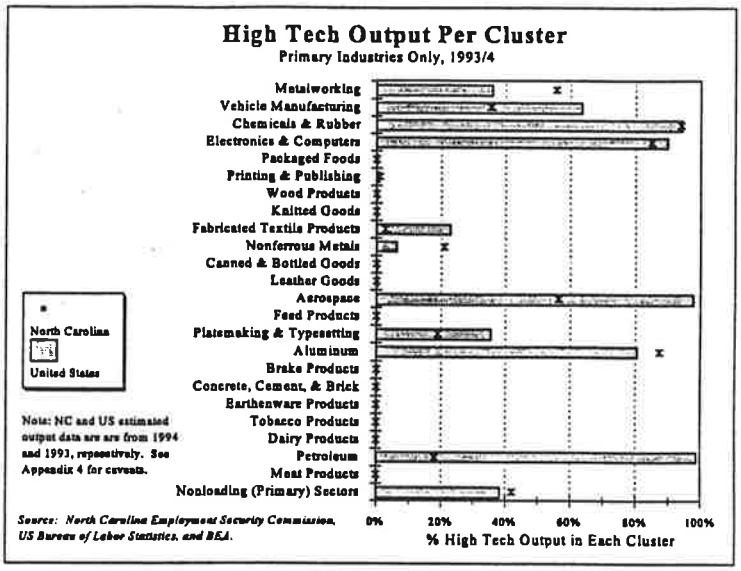


Figure 8

Conversely, the share of high tech production in the comparatively very small NC aerospace and petroleum clusters is well below U.S. averages; the few establishments in the state in these clusters are producing largely standard technology, rather than high tech, components in these buyer-supplier chains. More importantly, among some larger potential clusters with moderate shares of high tech activity at the national level, the NC vehicle manufacturing, fabricated textiles, and platemaking and typesetting clusters produce significantly lower shares of high tech output relative to the U.S. To the degree that buyer-supplier relations do influence technology adoption behavior, the fact that some high technology links in these chains

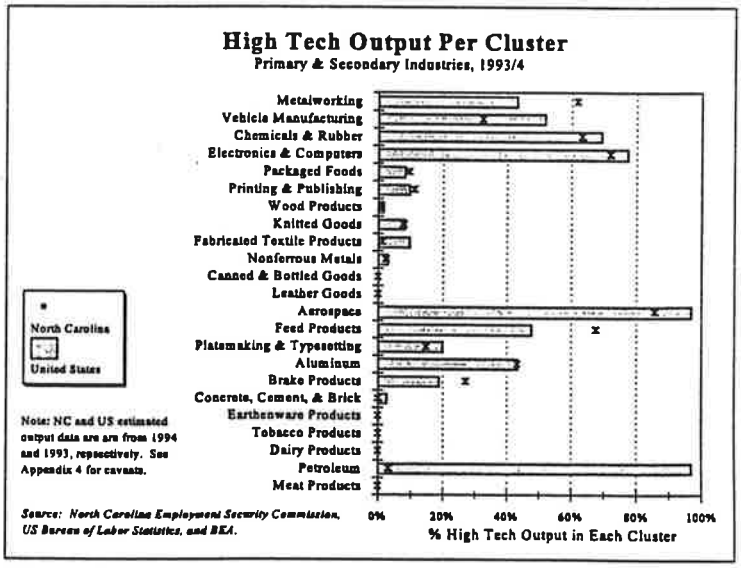


Figure 9

are underrepresented in the state could limit any local interfirm influences encouraging technology upgrading among cluster members.

Except in the case of the feed products cluster, these differences generally hold when both primary and secondary sectors are included in the cluster definitions (see Figure 9 and columns 7-10 in Table 7). Under the more comprehensive definition, the ratio of high tech to standard production in the feed

products cluster rises from 0 to nearly 50 percent. The drastic change in the share of high tech output is a result of the inclusion of the high-tech drugs sector (SIC 283) as a secondary industry in the feed products cluster. SIC 283 produced nearly $4 billion in estimated output and employed over 17,000 people in North Carolina in 1994. Yet, it should be noted that SIC 283 it is only weakly linked to the feed products cluster. The drugs industry is a strong independent sector based heavily on R & D rather than typical intermediate inputs. Most of its traditional intermediate inputs are purchased from other firms in the same sector.[17]

The example of SIC 283 and the feeds products cluster underscores the importance of a careful examination of cluster output and employment by cluster members. The differences between the U.S. benchmark and North Carolina potential clusters in aggregate high tech production can stem from two related factors. First, important high technology sectors may simply be absent in North Carolina; in some clusters, there may be no enterprises in the state classified in high tech sectors. This could lead to shares

Table 8

Plant Size and Status by Cluster, North Carolina

Primary/Primary & Secondary Industries, Third Quarter 1994

Cluster	Primary Industries Only			Primary & Secondary		
	Total	Single	<50 Emp.	Total	Single	<50 Emp.
Metalworking	2,183	88.0%	76.1%	2,613	87.8%	74.6%
Vehicle Manufacturing	1,356	78.1%	57.8%	2,283	80.1%	62.6%
Chemicals & Rubber	332	71.1%	54.8%	1,017	75.7%	53.9%
Electronics & Computers	509	81.3%	62.3%	905	82.8%	60.1%
Packaged Foods	120	71.7%	51.7%	433	73.0%	54.0%
Printing & Publishing	1,668	87.8%	79.3%	2,229	87.6%	78.5%
Wood Products	2,025	87.6%	80.2%	2,144	87.4%	79.5%
Knitted Goods	1,485	62.4%	40.9%	1,998	63.2%	42.4%
Fabricated Textile Products	606	73.4%	54.5%	1,751	66.2%	46.9%
Nonferrous Metals	42	88.1%	83.3%	94	76.6%	59.6%
Canned & Bottled Goods	70	67.1%	42.9%	85	71.8%	49.4%
Leather Goods	22	63.6%	45.5%	50	84.0%	64.0%
Aerospace	27	74.1%	55.6%	71	70.4%	50.7%
Feed Products	84	72.6%	69.0%	159	75.5%	62.3%
Platemaking & Typesetting	94	93.6%	85.1%	342	88.6%	80.4%
Aluminum	46	84.8%	63.0%	87	75.9%	48.3%
Brake Products	46	93.5%	80.4%	605	97.7%	92.2%
Concrete, Cement, & Brick	173	33.5%	32.4%	322	57.1%	54.3%
Earthenware Products	53	90.6%	81.1%	68	86.8%	77.9%
Tobacco Products	26	46.2%	3.8%	26	46.2%	3.8%
Dairy Products	14	21.4%	14.3%	33	45.5%	36.4%
Petroleum	10	70.0%	70.0%	19	73.7%	73.7%
Meat Products	101	89.1%	75.2%	149	74.5%	59.1%
Nonloading (Primary) Sectors	533	69.8%	88.7%	-----	-----	-----
Totals/Cluster Average:	11,625	79.7%	67.5%	-----	79.5%	64.7%

Source: NCESC and authors' calculations.

of high tech production in some North Carolina clusters that fall below the U.S. benchmark levels. Alternatively, some of the state's potential clusters may simply be over-represented (under-represented) in standard technology sectors. This can lead to shares of high tech output in NC clusters that also appear very low (high) versus the U.S. In sum, only by examining the distribution of cluster output *among the cluster's component industries*, is it possible to fully understand the nature of the differences between NC and U.S. aggregate clusters.

Establishment Size and Structure

Size and branch plant status have consistently proven key indicators of the level and rate of advanced process technology adoption among manufacturing

plants in scientific studies. Numerous survey-based studies have found that large branch plants in nearly every major manufacturing industry adopt new technologies faster and to a greater degree than their smaller counterparts. Smaller producers may have fewer of the necessary resources, both financial and human, to effectively integrate complicated new technologies into their production regimes. Alternatively, the owners of some smaller businesses may be reluctant to invest in technology upgrading if such investment requires some dilution of their equity in and control of the firm.[18] Identifying those sectors with a predominance of smaller manufacturers, particularly those at the smallest end of the size scale, is thus one preliminary means of narrowing down areas of potential demand and need for competitiveness initiatives. When sectors are analyzed as input-output based clusters, high relative shares of smaller enterprises may signal less potential for interfirm exchange of information about new technologies as well as a lower predominance of the kind of buyer-supplier relationships and agreements that result in the upgrading of suppliers' production

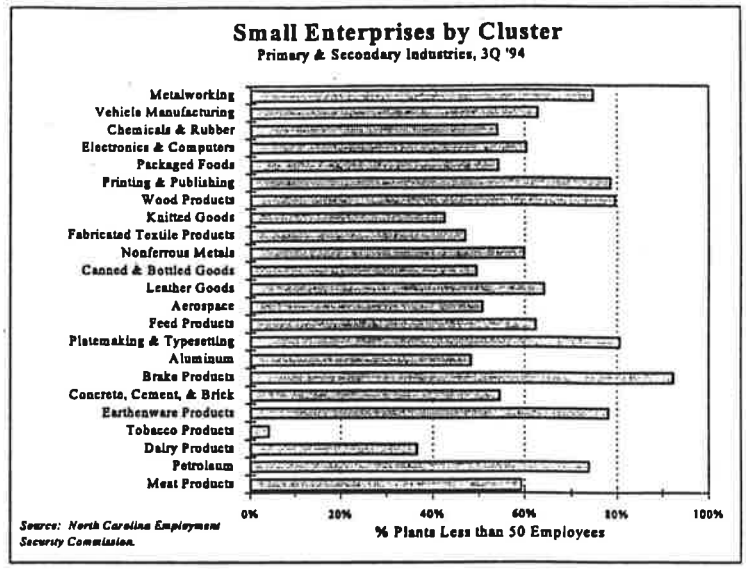


Figure 10

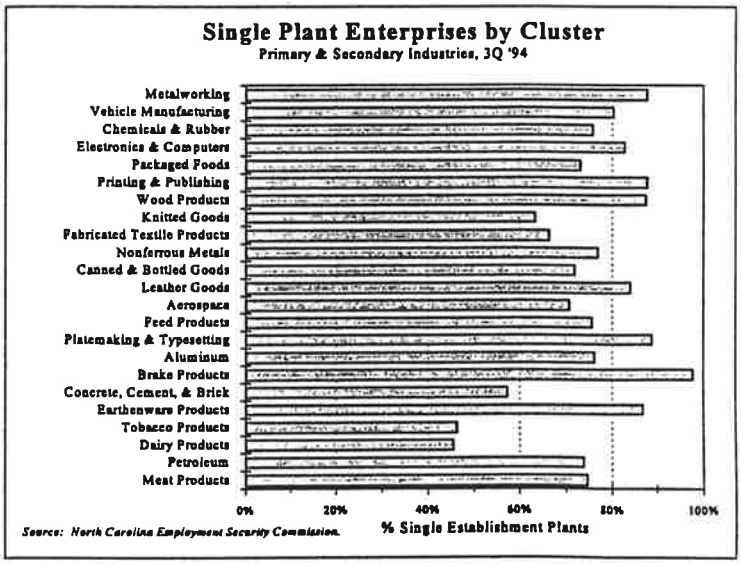


Figure 11

systems to meet buyers' specifications. All other things equal, any interindustry dynamics encouraging upgrading are probably weaker the lower the share of producers that have already adopted advanced manufacturing systems and practices. Size, in effect, serves as a very rough proxy for level of modernization, and indirectly, of a need for some form of technology assistance.

Table 8 lists the shares of both small and single

(versus branch plant) establishments in each cluster. Among the largest North Carolina clusters, the wood products, printing and publishing, and metalworking clusters are each made up predominantly of very small firms and establishments (see Figure 10). In each case, close to 80 percent of businesses employ fewer than 50 workers. With the average share of branch plants at just 12 percent, these clusters are also largely composed of single-establishment enterprises (see Figure 11). The clusters with the lowest shares of small plants are knitted goods (41 percent), packaged foods (52 percent), fabricated textile products (55 percent), chemicals and rubber (55 percent), and vehicle manufacturing (58 percent). With the exception of vehicle manufacturing, close to one-third of the establishments in each of these clusters are branch locations of multilocation firms.

6. Specializations, Gaps, & Opportunities

Although differences in total output and employment can help uncover the relative aggregate presence of potential extended buyer-supplier chains or clusters in the state, an examination of the distribution of production within clusters reveals more about the real presence of each cluster. In other words, the relative presence of the aggregate 23 benchmark clusters varies dramatically in North Carolina versus the United States as a whole, and more importantly, the distribution of production across industries *within each cluster* differs significantly as well. Differences between North Carolina and the U.S. clusters can often be explained by variations in sectoral mix. As benchmarks, the distribution of U.S. sector output across and within each cluster provides a *map* to detect whether certain sectors (i.e. pieces of an extended supplier chain) are under- or over-represented in North Carolina. The under representation of some sectors may block or otherwise inhibit important technology transfers within a cluster. Conversely, the over representation of sectors producing high-technology goods or utilizing high-technology production regimes can help identify potentially important technology leaders and disseminators, thereby permitting NC ACTs to fine-tune its activities. The U.S. benchmark comparisons also help identify

Section 6. Summary of Findings

- Among the nine key potential North Carolina clusters, several are specialized in a relatively few component industries while the sectoral mix in others parallels the U.S. benchmarks reasonably closely.
- The North Carolina metalworking cluster is under-represented relative to the U.S. in basic metal and fabricated metal production. Instead, it is specialized in industrial machinery and electrical equipment sectors that help drive demand in basic metals. In contrast, although there are few final market vehicle assemblers in the state, a wide range of key intermediate input sectors are well-represented.
- Most key linkages in the chemicals cluster are present in North Carolina, although it is somewhat specialized in plastics and synthetic materials rather than industrial chemicals. The electronics and computers cluster is heavily concentrated in just a few sectors, including computer peripherals, telephone equipment, nonferrous wiredrawing, and relays and industrial controls. The under-representation of electronic computers production indicated by the data may be a function of SIC misclassification; results for this cluster should be interpreted cautiously.
- The NC packaged food products cluster is dominated by production of cakes and cookies as well as the major supplier sector to these two industries: flour and grain mills. Plastics and paperboard packaging materials, additional major inputs to the food products industries, are also well-represented in the state. As a heavily location-dependent industry (due to perishability of product and low value to weight ratios on key inputs), it is not surprising that only a few sectors are present in the state with any significant size.
- The NC distribution of output within both the printing and publishing and wood products clusters closely matches the U.S. benchmarks, with some specialization in the wood furniture manufacturing in the wood products cluster.
- Knitted goods and fabricated textile production in North Carolina is dominated by major intermediate supplier sectors (yarn and fabric mills), rather than higher value-added, final market goods industries such as apparel, toys, luggage, and surgical appliances and supplies.

important missing links in North Carolina's input-output chain that might serve as targets of opportunity for other policy measures designed to stimulate the growth, introduction, or recruitment of one or more key sectors.[19]

There are many reasons why a particular industry may be unrepresented or relatively under-developed in the state. Locational factors (including transportation infrastructure, labor availability and quality, government regulations and taxes, amenities, etc.), regional sources of demand, and proximity to key natural resource and intermediate inputs may all play a role. The relative absence of one industry in a cluster of sectors in North Carolina may not necessarily signal a deficiency, but instead reflect the current specialization of the state's manufacturing economy in those sectors in which it has proven to be most competitive. The use of U.S. benchmark clusters to identify potential gaps in particular buyer-supplier chains in North Carolina must therefore proceed with more in-depth investigations of reasons behind the existing industry mix. It is these subsequent analyses that will reveal most about the competitive strengths and weaknesses in the state's manufacturing economy. In this context, the participation of local business representatives in the preparation of industry competitiveness strategies is critical. The identification of factors driving the local sectoral mix in each cluster will require much first-hand information from industry itself, perhaps through a series of well-organized focus group discussions.

Buyer-supplier dynamics are fully capable of encouraging technology adoption and upgrading across geographical boundaries, since they are a function of relations between business enterprises wherever they are located. Thus even clusters that are incompletely developed (in the sense that few component sectors are represented) benefit from the interindustry influences that drive all North Carolina enterprises in that cluster to upgrade their production systems. For example, enterprises in North Carolina that supply producers in other U.S. regions readily adopt more competitive production regimes and practices in order to continue to serve their out-of-state customers. At the same time, research suggests that buyer-supplier dynamics are even stronger when cluster enterprises are co-located. Therefore, well-developed potential clusters may indicate competitive advantages for the state on which a technology strategy that encourages interfirm collaboration and networking could be built.

Figures A.1 through A.18 in Appendix 2 chart the detailed intersectoral distributions of production for the largest clusters in North Carolina, both *ex*clusive (Figures A.1-A.9) and *in*clusive (Figures A.10-A.18) of secondary industries. The charts provide a means of easily identifying the particular elements of a given extended buyer-supplier chain that

have a significant local representation. They also indicate clearly which pieces of the chain are missing.[20]

Metalworking. The benchmark U.S. metalworking cluster constitutes an extended buyer-supplier chain that touches nearly every manufacturing industry. Most firms in this cluster produce basic metals, fabricated metal goods, and electronic components for the eventual manufacture of major producer and consumer durables, including most types of industrial machinery and transportation equipment. The largest sectors are basic metal production and metal fabrication, including blast furnaces and steel mills (SIC 3312), iron and steel foundries (332), automotive stampings (3465), sheet metal work (3444), and fabricated plate work (3443). Although several industrial machinery sectors also account for significant shares of total U.S. cluster output (e.g. general industrial machines--SIC 3599, special dies, tools, and accessories--SIC 3544-5, and construction machinery and equipment--SIC 3531), 10 of the top 15 producing sectors are in the primary metals and fabricated metals industries. The activity in these sectors is driven by demand originating from a wide variety of industrial machinery and transportation equipment producers, although these sectors individually account for relatively small shares of total cluster output.

The distribution of production in the NC metalworking cluster differs significantly from the national benchmark (see Figure A.1 in Appendix 2). Metalworking output in North Carolina is dominated by the electrical equipment (e.g. wiring devices--SIC 3643-4, motors and generators--SIC 3621, and transformers--SIC 3612) and industrial machinery (e.g. construction machinery--3531, general commercial machinery--3599, and textile machinery) industries, while shares of steel and many types of fabricated metal production in total cluster output are relatively small. These differences account for the higher overall share of high-tech output in NC metalworking production reported in Section 5. The five largest metalworking sectors in North Carolina are classified as high-tech, whereas the benchmark U.S. metalworking cluster is primarily composed of activity in standard technology (metals and metal fabrication) sectors. Thus although North Carolina is under-represented in the basic metals intermediate good industries, it is over-represented in some of the major producer durables sectors that drive demand for basic metals.

Vehicle Manufacturing. In contrast to the metalworking cluster, where a relatively few large basic intermediate good industries supply firms in a wide variety of final market, producer and consumer durable goods industries, the U.S. vehicle manufacturing cluster is composed primarily of automobile assemblers and their many first- and

second-tier suppliers (see Figure A.2, Appendix 2). SIC 3711 (motor vehicles and passenger car bodies) accounts for over one-third of U.S. vehicle cluster output. SICs 308 (miscellaneous plastics) and 3714 (motor vehicle parts and accessories) account for nearly another third.

Except for a significantly lower relative share of activity in SIC 3711, the NC vehicle manufacturing cluster closely parallels the U.S. benchmark. Without any major automobile assemblers, the cluster is concentrated in motor vehicle parts/accessories and a range of important supplier sectors, including upholstered furniture (2512), tires (301), glass products (321, 3229, 323), and carpets and rugs (227). The upholstered furniture industry, a producer of consumer durables as well as intermediate goods to vehicle manufacturing firms, accounts for nearly 15 percent of state output in the cluster. Miscellaneous plastics products account for another 14 percent.

The vehicle manufacturing cluster emphasizes the potential of linkage analysis to reveal latent potential in the state's manufacturing economy. While North Carolina is well-known as a major furniture manufacturing state, many producers in the upholstered furniture industry may now, or could in the future, supply the automotive and truck building sectors. This is also the case for the carpets, rugs, glass, plastics, and many types of electronic equipment industries, all key inputs in the production of cars, trucks, and busses. As is shown in the next section, growth in this cluster has occurred in the western part of the state. This may be due, in some part, to the relatively recent location of major vehicle assembly plants in Alabama, South Carolina, and Tennessee. More important may the role of the I-75 corridor in providing good JIT access to western North Carolina. In general, the recent trend toward the location of major automotive assembly plants in the Southeast represents a potential opportunity for North Carolina to capitalize on its diverse and sizable share of intermediate industries in the vehicle manufacturing cluster.

Chemicals & Rubber. As noted in Section 3, the chemicals and rubber cluster is composed of many more secondary industries than primary industries. This may be a function of the wide variety of manufacturing sectors that require inputs from the chemicals, rubber, and plastics industries. The distribution of output in the cluster is charted in Figure A.3 (see also Figure A.12 for the distribution including secondary industries). As a whole, the NC chemicals and rubber cluster, like vehicle manufacturing, parallels the national benchmark reasonably closely, i.e. the state possesses a mix of sectors that cover most key linkages in the cluster. At the same time, the cluster is concentrated in certain specific types of plastics and synthetic materials industries while industrial chemicals are under-

represented. Whereas the organic and inorganic chemicals sector (SICs 281, 2865, 2861--a major basic supplier to many other chemicals industries) constitutes a nearly 35 percent share in U.S. chemicals cluster production, it accounts for only 20 percent in North Carolina.[21] The NC chemicals cluster is instead concentrated in manmade organic fibers (SIC 2824) and agricultural chemicals (2873, 4, 9).

When primary and secondary industries are included in the cluster definition, importance of the petroleum industry in the chemicals and rubber cluster is evident (see Figure A.12 in Appendix 2). Although there is no petroleum refining activity in North Carolina, two other important cluster secondary industries are well represented in the state: drugs (SIC 283) and paper and paperboard mills (SIC 262-3). Both of these industries are major purchasers of inorganic and organic chemicals, the former directly, and the latter indirectly through the secondary industry SIC 261 (pulp mills industry), which is itself a major buyer of organic and inorganic chemicals.

Electronics & Computers. Output in the electronics and computers benchmark U.S. cluster is heavily dominated by the electronic computers sector (SIC 3571) when only primary cluster industries are considered. Other sectors accounting for large shares of cluster output are the semiconductors (3674), electronic components (3672, 3675-9), search and navigation equipment (381), telephones and telegraph apparatus (3661), and computer peripherals (3572, 75, 77) industries.

The data indicate that there are few North Carolina firms in the computer and semiconductors industries, a potentially important missing link since both of these sectors are important supplier industries to a range of sectors in this cluster (as well as vehicle manufacturing).[22] The computer industry is also a major high tech final market producer that, like the major automotive and truck assemblers, can exert a significant influence on the technology adoption behavior of its own suppliers. Electronics and computers in North Carolina is heavily over-represented relative to the U.S. benchmark in computer peripherals and telephones and telegraph apparatus. The telephone and telegraph apparatus sector is itself a major supplier to the computer peripherals industry, as are the electronic components (SIC 3672, 3675-9) and miscellaneous plastic products sectors (SIC 308), both relatively large industries in the state. The latter (SIC 308) accounts for the highest share of cluster output when both secondary and primary industries are included in the cluster definition (see figure A.13 in Appendix 2). SICs 308 and 3672, 3675-9 are also important suppliers to the telephone and telegraph apparatus sector. That the NC cluster's four largest sectors account for three-quarters of total output is indicative of its level of

specialization (the four largest industries in the U.S. electronics and computers cluster account for only about one-half of its output).

Packaged Food Products. The packaged food products cluster is composed primarily of consumer food products producers and their input suppliers (grains, dough, packaging--including boxes and paper products). Not included are industrial machinery industries that supply the equipment for the large scale production of packaged foods. Because purchases from these capital goods industries constitute such a small proportion of each food producer's expenditure per unit of product, linkages among industrial machinery sectors and food products were apparently too weak to show up in the statistical cluster analysis. Like the computers cluster, the NC packaged foods product cluster is heavily specialized in a few key sectors, while other sectors are relatively small or nonexistent. Figure A.5 in Appendix 2 shows that NC cluster output is dominated by breads and cakes (SIC 2051), flour and grain mill products (2041), and cookies and crackers (2052).

Printing & Publishing. The printing and publishing cluster is comprised of all of the major printing and publishing sectors (commercial printing, newspapers, periodicals, book printing and publishing, miscellaneous publishing, and greeting cards) as well as paper and ink suppliers. North Carolina's distribution of output in the cluster parallels the U.S. benchmark closely (see Figures A.6 and A.15 in Appendix 2), with some specialization in the paper and paper milling industries (paperboard containers and boxes--SIC 265, pulp mills--261, paper and paperboard mills--262-3). The state is somewhat under-represented in the final market goods in the cluster, e.g. book publishing and periodicals. Nevertheless, printing and publishing is one of the most developed clusters, vis a vis the U.S. benchmark, in the state.

Wood Products. Basic wood materials industries account for the largest shares of output in the wood products cluster (sawmills and planing mills--SIC 2421, logging--241, and millwork--2431). While the NC wood products cluster is under-represented in these basic sectors, it is over-represented in the key consumer durables sectors that drive much of the demand for wood materials: wood household furniture (2511), mobile homes (2451), and wood office furniture (2521). Overall, all important linkages in the cluster are represented, although to greater or lesser degrees; North Carolina firms produce in nearly all major supplier sectors to the wood furniture and mobile homes industries. The mobile homes (or manufactured homes) sector also purchases a significant volume of inputs from the motor vehicle parts and accessories industry (3714), one of the dominant sectors in the NC vehicle manufacturing cluster. North Carolina production of woodworking machinery, a sector linked most closely to the

metalworking cluster, also parallels the benchmark U.S. wood products cluster in relative terms (see Figure A.16 in Appendix 2).

Knitted Goods. Apparel made from purchased materials (e.g. suits and coats, furnishings, outerwear, undergarments, hats, fur goods, belts and accessories--SICs 231-8, 3999) accounts for nearly 63 percent of U.S. knitted goods cluster production when only primary cluster industries are considered. Yarn mills and textile finishing, n.e.c. (SIC 2269, 2281-2) accounts for another 13 percent. In contrast, the share of apparel in North Carolina knitted goods cluster production is one-third that of the U.S. Instead, production is specialized in yarn mills and textile finishing, n.e.c., hosiery (SIC 2251-2), and knit fabric mills (SICs 2257-8). Along with fabricated textile products, the knitted goods cluster is one of the most specialized in the state.

Fabricated Textile Products. The fabricated textile products cluster is closely linked to the knitted goods cluster. Three significant industries are members of both clusters when both primary and secondary industries are included in the cluster definitions: apparel, broadwoven fabric mills (221-3, 2261-2), and yarn mills n.e.c. (2269, 2281-2). Production in the NC fabricated textile products cluster is heavily concentrated in broadwoven fabric mills, a sector that accounts for 77 percent of primary industry cluster output. The housefurnishings n.e.c. (2392) industry produces another 13 percent. Missing are a number of smaller consumer nondurable goods sectors: dolls and stuffed toys, canvas and related products, luggage, textile bags, coated nonrubberized fabrics, and textile goods n.e.c.

There is also very little production in surgical appliances and supplies (3842) and cellulosic manmade fibers (2823), the two high tech fabricated products industries. This, despite the fact that major suppliers to these industries are well established in the state and that the state's sizable health care sector represents a major local source of demand. The surgical appliances/supplies industry purchases relatively large shares of inputs from broadwoven fabric mills, industrial inorganic and organic chemicals (2812-6, 2865, 2869), and metal stampings n.e.c. (3469), while the pulp mills (261), organic/inorganic chemicals, paper and paperboard mills (262-3), yarn mills n.e.c., and plastics materials and resins (2821) industries all provide key inputs to the cellulosic manmade fibers industry.

7. Components of Cluster Change: 1989-1994

Previous sections describe the existing mix of North Carolina manufacturing activity in terms of groups of interdependent sectors. The present section examines the economic performance of the state's most significant potential clusters over the 1989 to 1994 period. Though the time period is limited and does not necessarily reflect consistent, long run trends, the analysis does provide a useful picture of how individual clusters performed over an important period of general restructuring and downsizing of the national economy. It also permits an initial assessment of which clusters may be in decline.

A unique data set created specifically for this study permits a close examination of cluster performance in terms of specific components of employment change, including enterprise birth, expansion, decline, and closure. The results are indicative of a state manufacturing sector in considerable flux, as new and more competitive businesses in even traditional sectors such as textiles and apparel replace employment lost from declining plants and plant closures.

Section 7. Summary of Findings

- The potential state clusters showing the highest rates of estimated output growth between 1989 and 1994 were chemicals and rubber, printing and publishing, metalworking, vehicle manufacturing, and wood products. These clusters generally posted more moderate gains in employment. Estimated real output was essentially unchanged in the knitted goods cluster, though employment in the cluster fell by between 21,000 and 26,000 depending on the cluster definition. Jobs in the fabricated textiles cluster also declined significantly, as did estimated real output.

- A viable meat products cluster may be emerging in the state, driven by substantial growth in meat processing. Sectors processing meat byproducts (e.g. leather tanning and finishing), though still very small, grew between 1989 and 1994. Though in the aggregate, industries in the small leather goods cluster (48 total establishments) suffered a net decline, several individual leather processing sectors grew moderately (e.g. the leather goods, n.e.c., and luggage sectors).

- Observing the performance of manufacturing facilities present in the state in 1989 shows their employment declines and closures exceed gains due to expansions in nearly every potential cluster. At the same time, employment growth due to new plants was significant in many clusters, leading to sizable net job gains in the chemicals and rubber, printing and publishing, and metalworking clusters.

- Although industries in the knitted goods and fabricated textiles clusters suffered large declines in net employment between 1989 and 1994, a substantial number of new jobs were nevertheless created in the same sectors over this period. These results are suggestive of a significant amount of restructuring occurring in the textile and apparel clusters, rather than uniform, steady decline.

Net Growth and Decline

Tables 9 and 10 (and Figures 12-14) report changes in estimated real output, employment, and average wages between 1989 and 1994 for the 23 clusters. Defining the clusters as inclusive of primary industries only, chemicals and rubber (estimated real output growth of 29 percent), printing and publishing

(18 percent), metalworking (18 percent), vehicle manufacturing (17 percent), wood products (16 percent), and packaged food products (13 percent) clusters posted the highest rates of real output growth between 1989 and 1994 among the nine key potential North Carolina clusters. The electronics and computers cluster also registered a slight gain in estimated real output (3 percent), while the knitted goods cluster was unchanged.[23] Most of these clusters also registered lesser increases in employment and real average wages. Exceptions are the electronics and computers cluster where real wages were virtually unchanged, and knitted goods, a cluster which lost over 21,000 jobs over the five year period. At the same time, real wages were 11.5 percent higher in the knitted goods cluster in 1994 than in 1989, perhaps due to the relative decline (gain) in the lowest (highest) wage industries in the cluster. The differences in magnitude between output and job growth for most potential North Carolina clusters are consistent with the general trend toward leaner manufacturing and downsizing.[24] The fabricated textile products cluster is the only one of the nine largest NC clusters to suffer a decline in real estimated output (10 percent). Employment in the cluster also fell by over 10,000 over the five year period.

Table 9

Percent Growth Rates by Cluster, North Carolina

Primary Industries Only, IIIQ 1989 to IIIQ 1994

Cluster	Real Output	Std. Deviation	Employ-ment	Real Wage
Metalworking	17.9	74%	9.9	6.5
Vehicle Manufacturing	17.0	47%	4.5	10.3
Chemicals & Rubber	29.0	788%	20.5	1.3
Electronics & Computers	3.4	1015%	4.6	-0.9
Packaged Foods	12.7	1066%	4.6	2.1
Printing & Publishing	18.2	53%	11.4	4.7
Wood Products	15.5	32%	2.9	9.6
Knitted Goods	0.3	29%	-10.1	11.5
Fabricated Textile Products	-10.1	102%	-10.9	-1.4
Nonferrous Metals	-49.4	84%	-46.8	10.5
Canned & Bottled Goods	-15.5	29%	-18.7	5.4
Leather Goods	-30.3	50%	-42.3	22.0
Aerospace	360.4	2175%	191.7	27.5
Feed Products	11.2	56%	8.7	7.6
Platemaking & Typesetting	-27.1	41%	-29.8	0.7
Aluminum	-41.2	106%	-32.4	-9.2
Brake Products	6.8	49%	-1.5	12.6
Concrete, Cement, & Brick	21.2	52%	10.6	8.4
Earthenware Products	-3.3	54%	-4.5	0.0
Tobacco Products	-18.7	14%	-22.4	6.3
Dairy Products	-49.1	47%	-40.5	-11.7
Petroleum	33.8	64%	25.0	11.9
Meat Products	30.7	32%	46.0	-5.7
Nonloading (Primary) Sectors	26.0	------	12.2	12.9
Total	5.8		0.0	7.4

Source: Real output is an annual estimate; see Appendix 4. Real wage is percent change in real weekly wage between IIIQ 1989 and IIIQ 1994. Employment and wage data from NCESC.

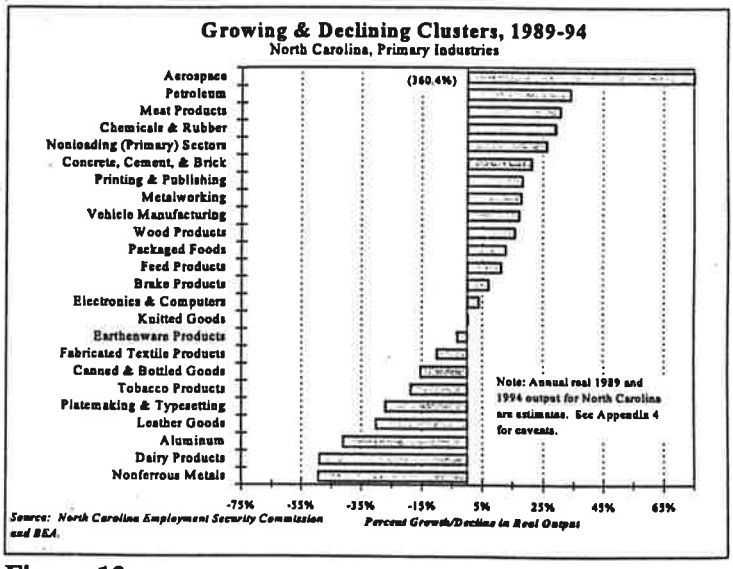


Figure 12

Three of the fastest growing clusters over the period are among the smallest in the state: aerospace (real output growth of 360 percent), petroleum (34 percent), and meat products (31 percent). Generally, the high growth rates are a function of the small base size of these clusters in 1989. They may suggest emerging clusters, however, depending on the distribution of output growth across member industries.[25] Only an examination of real estimated output, employment, and real wage growth by component industry for each cluster can reveal whether aggregate growth rates in these small clusters are dominated by above average growth in only one or a few isolated member industries. While the petroleum cluster is so small (18 establishments in 1994) that any changes are difficult to interpret, the aerospace and meat products clusters are large enough so that trends might be detected.[26] A close look at the sectoral distribution of each cluster shows that, in the case of the aerospace cluster, some state sectors grew significantly (SIC 3721--aircraft, SIC 3356--nonferrous rolling and drawing, n.e.c.), while others suffered major declines (SIC 3724,

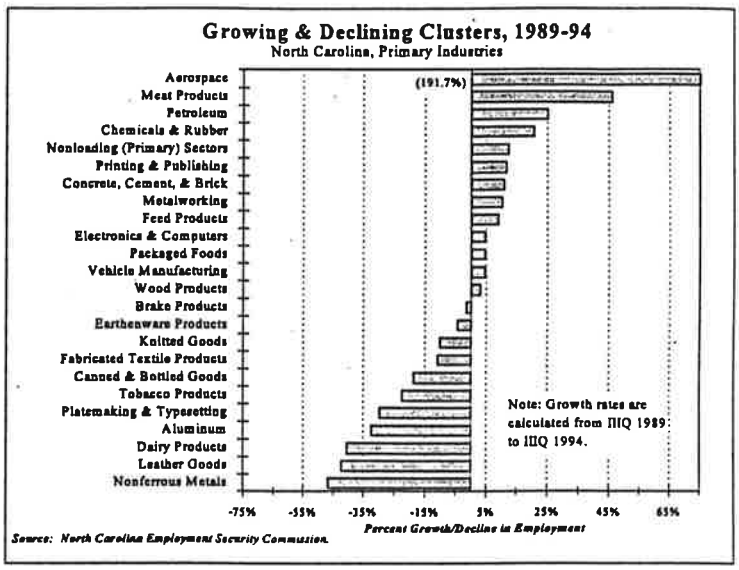


Figure 13

Table 10

Percent Growth Rates by Cluster, North Carolina

Primary & Secondary Industries, IIIQ 1989 to IIIQ 1994

Cluster	Real Output	Std. Deviation	Employ-ment	Real Wage
Metalworking	13.4	199%	8.7	7.0
Vehicle Manufacturing	14.9	64%	6.1	9.1
Chemicals & Rubber	23.9	511%	18.0	10.4
Electronics & Computers	9.0	829%	7.8	0.8
Packaged Foods	3.9	747%	5.5	-0.4
Printing & Publishing	13.4	77%	9.0	4.4
Wood Products	12.4	90%	1.3	9.6
Knitted Goods	-2.5	26%	-8.6	6.5
Fabricated Textile Products	-7.9	77%	-12.7	5.3
Nonferrous Metals	20.6	281%	26.1	4.7
Canned & Bottled Goods	-16.3	238%	-17.6	5.1
Leather Goods	0.9	90%	-19.9	20.0
Aerospace	24.9	1562%	14.8	6.8
Feed Products	25.9	260%	17.1	25.4
Platemaking & Typesetting	5.8	258%	7.6	-2.9
Aluminum	-16.6	80%	1.3	-11.0
Brake Products	6.4	88%	1.0	5.5
Concrete, Cement, & Brick	8.1	30%	7.7	1.3
Earthenware Products	11.8	77%	13.5	3.9
Tobacco Products	-23.1	14%	-22.4	6.3
Dairy Products	-70.3	39%	-23.8	-21.7
Petroleum	20.5	50%	66.1	-23.5
Meat Products	17.4	26%	18.2	1.7
Total	6.1		0.1	7.7

Source: Real output is an annual estimate; see Appendix 4. Real wage is percent change in real weekly wage between IIIQ 1989 and IIIQ 1994. Employment and wage data from NCESC.

3764--aircraft and missile engines and parts, SIC 381--search and navigation equipment, SIC 3364, 9--nonferrous castings, n.e.c.). Although, in the

aggregate, the North Carolina industries that make up the cluster are growing, it is unlikely that a significant aerospace cluster, in terms of the systematic development of sectors representing all key linkages, is emerging in the state. In contrast, the meat products cluster shows clear signs of development. The distribution of output in the cluster closely matches the U.S. benchmark, though it is specialized more heavily in poultry slaughtering and processing (SIC 2015), and all five component sectors registered estimated real output gains over the five year period, with the largest coming in SICs 2013 (sausages and other prepared meat products) and 2015 (poultry slaughtering and processing). The very small leather tanning and finishing sector (SIC 311) also grew significantly in relative terms over the period.

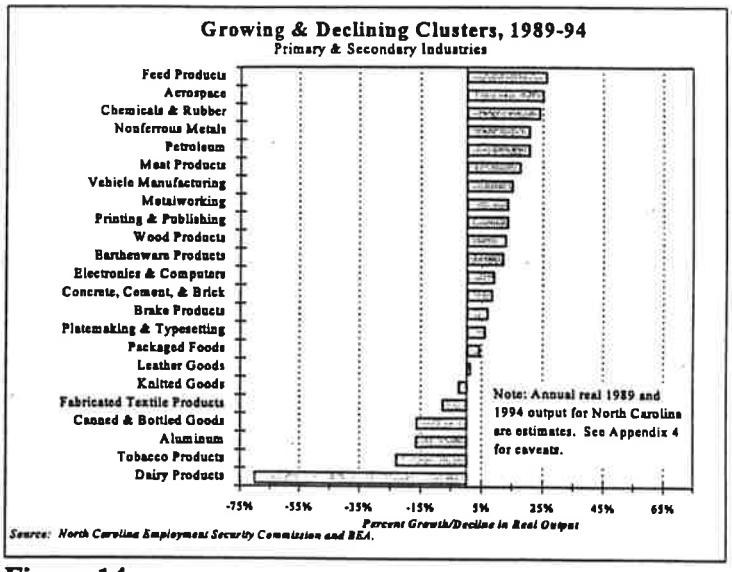


Figure 14

Decomposing Employment Change

Average aggregate growth rates mask important fundamental dynamics of firm growth and change. Over a given time period, some enterprises grow, others decline, and still others cease operating entirely. New firms and plants are added to the state's stock of manufacturing activity through spin-offs, start-ups, and plant relocations. Average growth figures are, in effect, single net measures of the four basic components of firm change: growth, decline, closure and start-up (interpreted broadly in this context as plants new to the state due to either start-up or relocation). As such, they provide no information about the amount of flux or turbulence occurring in a given industry or cluster over time. If these components are known, it is possible to examine how the stock of economic activity at a given point in time performed over a subsequent period, separate from the entry (birth or relocation) of entirely new enterprises over the same time period. Since different factors (firm-, industry- and regional-level) arguably influence the birth or relocation of new establishments versus the continued health of existing enterprises, decomposing employment growth in this way can better identify sectors (and regions) of potential concern.

The case of an industry or cluster that suffered a decline in average employment over some period

and that established no new plants over the same period, for example, is potentially worse than one that also suffered a net decline but still generated start-ups. In the first case, enterprises existing in the initial period fared poorly while no new plants were established. This situation could be the result of general macroeconomic trends or it may be the case that the state or local environment is neither supportive of existing economic activity nor conducive to the birth or relocation of firms or branch plants. In the second case, new, presumably more dynamic and competitive enterprises partially took the place of declining and closing firms and establishments. The first case is one of steady decline, while the second is suggestive of a process of (possibly healthy) turnover or flux in the industry or cluster.

Tables 11 and 12 report 1989-1994 estimated job gains and losses for each potential North Carolina cluster for plants existing in 1989. They also list the number of jobs created through start-ups/relocations over the five year period. The net of the two figures is the standard change in employment (or average employment growth, in percentage terms).[27] Most significant is the near universal decline in employment over the period for base year enterprises; only the nonferrous metals and feed products clusters (when both primary and secondary cluster industries are considered--see Table 12) posted positive average job change from among base year enterprises. Nevertheless, job gains from new plants and relocations exceed job loss from the contraction or closure of base year enterprises in 13 of 23 potential clusters when only primary industries are included in the cluster definitions. The significant flux suggested by these figures is consistent with trends in the manufacturing sector nationwide over the last decade. Manufacturing posted a very slight decline in North Carolina between 1989 and 1994 while other broad sectors, particularly services, grew. Yet beneath the surface, the manufacturing sector is in a significant

Table 11

Employment Growth, Plants Existing in 1989 and New Plants

North Carolina, Primary Industries Only (IIIQ 1989 to IIIQ 1994)

	Employment Change in:		Employment Growth		
Cluster	Plants Existing in '89	New Plants	Plants Existing in '89	New Plants	Net
Metalworking	-10,991	19,217	-13.2%	23.1%	9.9%
Vehicle Manufacturing	-18,734	24,345	-15.1%	19.6%	4.5%
Chemicals & Rubber	-1,801	7,348	-6.6%	27.1%	20.5%
Electronics & Computers	-6,438	9,373	-10.1%	14.6%	4.6%
Packaged Foods	-2,220	2,762	-18.8%	23.3%	4.6%
Printing & Publishing	-3,052	7,951	-7.1%	18.6%	11.4%
Wood Products	-11,837	14,031	-15.7%	18.6%	2.9%
Knitted Goods	-66,893	45,789	-32.1%	22.0%	-10.1%
Fabricated Textile Products	-25,121	15,020	-27.2%	16.3%	-10.9%
Nonferrous Metals	-1,653	485	-66.3%	19.4%	-46.8%
Canned & Bottled Goods	-2,921	1,070	-29.5%	10.8%	-18.7%
Leather Goods	-1,368	226	-50.7%	8.4%	-42.3%
Aerospace	-326	2,002	-37.3%	228.9%	191.7%
Feed Products	-297	476	-14.5%	23.2%	8.7%
Platemaking & Typesetting	-834	165	-37.2%	7.4%	-29.8%
Aluminum	-2,257	868	-52.6%	20.2%	-32.4%
Brake Products	-871	842	-44.4%	42.9%	-1.5%
Concrete, Cement, & Brick	-320	678	-9.5%	20.1%	10.6%
Earthenware Products	-436	390	-42.7%	38.3%	-4.5%
Tobacco Products	-6,134	659	-25.0%	2.7%	-22.4%
Dairy Products	-957	114	-46.0%	5.5%	-40.5%
Petroleum	-17	28	-40.6%	65.6%	25.0%
Meat Products	-93	2,546	-1.7%	47.7%	46.0%
Nonloading (Primary) Sectors	-10,522	19,471	-14.3%	26.5%	12.2%
Totals:	-176,094	175,856	-20.3%	20.3%	-0.03%

Estimates of employment change due to existing and new plants are derived from matching NCESC ES-202 files; see Appendix 4. Column 7 ("Net") is aggregate employment growth (see Tables 9-10).

process of transition and restructuring, presumably as outmoded industries and firms give way to leaner, more competitive enterprises. In many businesses, jobs may have been reduced as part of efforts to become more cost efficient and competitive.

The knitted goods (45,789), vehicle manufacturing (24,345), fabricated textile products (15,020), and wood products (14,031) clusters generated the most new jobs from new firms, plants, and plant relocations to the state. A significant number of jobs from plants established between 1989 and 1994 were also created in the electronics and computers (9,373), printing and publishing (7,951), chemicals and rubber (7,348), packaged foods (2,762), meat products (2,546), and aerospace clusters (2,002). The highest relative gain came in the chemicals and rubber cluster (27 percent).[28] While the knitted goods and fabricated textile products clusters show signs of overall relative decline in the state based on aggregate figures, the number of jobs created from new plants and firms between 1989 and 1994 suggest that a more dynamic process of industry restructuring may be at work. New plants in these industries may represent relatively footloose plants that have relocated temporarily to North Carolina to take advantage of lower wages and a workforce trained in the textile industries. Alternatively, they may be new, more competitive enterprises that are prepared to compete with firms in overseas locations on dimensions other than low labor costs.

Table 12

Employment Growth, Plants Existing in 1989 and New Plants

North Carolina, Primary & Secondary Industries (IIIQ 1989 to IIIQ 1994)

Cluster	Employment Change in: Plants Existing in '89	Employment Change in: New Plants	Employment Growth Plants Existing in '89	Employment Growth New Plants	Net
Metalworking	-16,710	27,350	-13.7%	22.4%	8.7%
Vehicle Manufacturing	-22,294	32,007	-14.0%	20.1%	6.1%
Chemicals & Rubber	-8,211	24,508	-9.1%	27.1%	18.0%
Electronics & Computers	-10,675	17,751	-11.8%	19.7%	7.8%
Packaged Foods	-12,244	15,427	-21.0%	26.5%	5.5%
Printing & Publishing	-7,231	13,241	-10.9%	19.9%	9.0%
Wood Products	-14,008	15,135	-16.6%	17.9%	1.3%
Knitted Goods	-88,512	62,175	-28.9%	20.3%	-8.6%
Fabricated Textile Products	-80,994	50,123	-33.4%	20.6%	-12.7%
Nonferrous Metals	123	2,323	1.3%	24.8%	26.1%
Canned & Bottled Goods	-2,893	1,087	-28.2%	10.6%	-17.6%
Leather Goods	-1,123	456	-33.6%	13.6%	-19.9%
Aerospace	-3,246	4,399	-41.7%	56.6%	14.8%
Feed Products	96	3,165	0.5%	16.6%	17.1%
Platemaking & Typesetting	-1,376	2,471	-9.5%	17.1%	7.6%
Aluminum	-2,139	2,240	-27.8%	29.1%	1.3%
Brake Products	-2,001	2,098	-21.6%	22.7%	1.0%
Concrete, Cement, & Brick	-661	1,196	-9.5%	17.2%	7.7%
Earthenware Products	-255	488	-14.8%	28.3%	13.5%
Tobacco Products	-6,134	659	-25.0%	2.7%	-22.4%
Dairy Products	-1,826	914	-47.7%	23.8%	-23.8%
Petroleum	121	42	49.0%	17.0%	66.1%
Meat Products	-3,047	7,558	-12.3%	30.5%	18.2%
Totals:	-285,240	286,811	-20.9%	21.0%	0.1%

Estimates of employment change due to existing and new plants are derived from matching NCESC ES-202 files; see Appendix 4. Column 7 ("Net") is aggregate employment growth (see Tables 9-10).

8. Clusters Across North Carolina

Previous sections describe the largest potential clusters in the state, some basic characteristics used for standard targeting purposes, their relative diversity or specialization vis a vis the U.S. benchmark, and their recent statewide growth patterns. This section examines the degree to which North Carolina producers in the same extended input-output chain are geographically co-located. This helps identify potential industrial complexes, or regional industrial clusters where targeted sector competitiveness strategies might be efficiently and cost-effectively applied. An examination of differences in regional growth rates supplements the static analysis by indicating where particular complexes are emerging or declining. Although the brief descriptive analysis here focuses on general trends, the detailed exhibits in Appendix 3 permit a more focused examination by interested readers. Note also that while it is not possible with existing data to determine whether plants in given regional cluster are actually engaging in trade (a true regional industrial complex), the analysis here can suggest where in North Carolina more in-depth local cluster studies and analyses of interindustry linkages might be performed.

Section 8. Summary of Findings

- Producers in the fabricated textiles, knitted goods, vehicle manufacturing, and metalworking clusters are predominantly located in the western Economic Development Partnership regions (Carolinas, Piedmont and Western), for the most part in the heavily urbanized areas. At the same time, there are also smaller geographic concentrations of nearly every cluster in areas in the eastern half of the state (Southeast, Transpark and Northeast regions).
- Electronics and computers is one of the most geographically concentrated of the major clusters, with the majority of plants located in one of four areas of the state: the Research Triangle, Charlotte-Gastonia, Statesville-Hickory, and Asheville. Very few manufacturers in this cluster are located in relative isolation in rural areas.
- The degree of geographic concentration in the packaged food products, printing and publishing, and wood products clusters is comparatively low; chemicals and rubber is one of the most evenly distributed clusters across Partnership regions when regional shares of statewide cluster output and employment are examined.
- In the metalworking, vehicle manufacturing, and printing and publishing clusters, growth trends over the 1989-1994 period tended to reinforce the clusters' existing western spatial orientation. In several other clusters, most notably food products and electronics and computers, trends favored a slight redistribution of manufacturing activity toward the eastern half of the state.
- On the whole, new plants tended to locate near existing plants in their cluster over the 1989-1994 period. The regions with the highest statewide shares of most clusters (Piedmont, Carolinas, Western, Triangle) also tended to garner the largest employment increases from start-ups and/or relocations to the state. Relatively few new plants located in the smaller manufacturing regions of the east over the study period.

Regional Distributions

Table 13 reports the share of statewide estimated output by cluster across the seven Economic Development Partnership regions, the primary

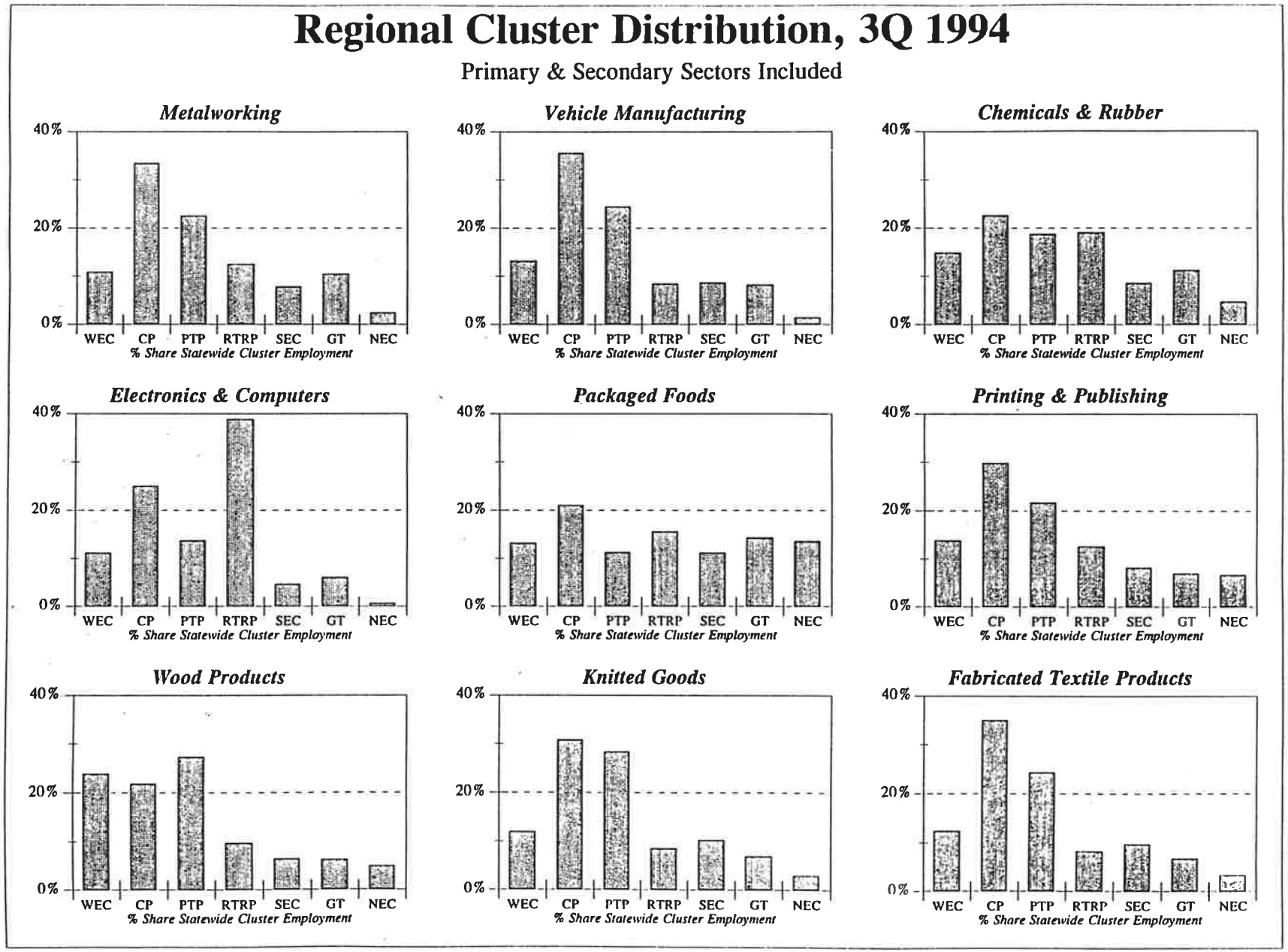

Regional Cluster Distribution, 3Q 1994
Primary & Secondary Sectors Included
Metalworking
Vehicle Manufacturing
Chemicals & Rubber
Electronics & Computers
Packaged Foods
Printing & Publishing
Wood Products
Knitted Goods
Fabricated Textile Products
40%
20%
0%
WEC CP PTP RTRP SEC GT NEC
% Share Statewide Cluster Employment

Figure 15

economic development planning jurisdictions being utilized by NC ACTS. The data emphasize the significant difference between the eastern and western halves of the state in terms of the level of development of the manufacturing sector. Several major potential clusters are heavily concentrated in the most urbanized North Carolina regions, primarily the Carolinas and Piedmont. (The seven regions and their member counties are displayed graphically in the Exhibits in Appendix 3.) Over 60 percent of estimated output manufactured by North Carolina enterprises in the fabricated textiles, knitted goods, and vehicle manufacturing clusters is produced in these two regions, for example, as is 58 percent of statewide metalworking output. In each of these clusters save metalworking, the next largest share of production originates in the Western Economic Commission Region.

Electronics and computers is also heavily geographically concentrated, but in this case in the central part of the state. Nearly one-half of statewide output in the electronics and computers cluster is produced in the Research Triangle. Another

Table 13

Regional Share of Statewide Estimated Cluster Output, 1994

Includes Primary & Secondary Sectors

#	Cluster	Western (WEC)	Carolinas (CP)	Piedmont (PTP)	Triangle (RTRP)	South-eastern (SEC)	Transpark (GT)	North-eastern (NEC)
1	Metalworking	10.6%	34.9%	23.3%	12.5%	7.1%	9.7%	1.9%
2	Vehicle Manufacturing	11.6%	37.2%	22.9%	8.3%	9.9%	8.9%	1.2%
3	Chemicals & Rubber	12.3%	18.9%	16.5%	24.4%	10.7%	10.5%	6.7%
4	Electronics & Computers	8.9%	23.7%	13.2%	46.0%	3.5%	4.0%	0.6%
5	Packaged Foods	16.7%	20.4%	11.1%	13.9%	11.9%	11.4%	14.5%
6	Printing & Publishing	17.9%	28.5%	17.4%	9.8%	8.5%	8.2%	9.7%
7	Wood Products	19.6%	20.3%	24.4%	11.3%	8.5%	9.8%	6.0%
8	Knitted Goods	11.5%	32.0%	29.4%	8.7%	8.9%	6.7%	2.7%
9	Fabricated Textile Products	11.9%	34.9%	27.5%	8.8%	8.1%	5.7%	3.1%
10	Nonferrous Metals	2.4%	56.1%	13.6%	15.1%	1.9%	10.8%	0.0%
11	Canned & Bottled Goods	7.4%	23.2%	40.1%	10.9%	11.2%	2.7%	4.5%
12	Leather Goods	11.5%	47.7%	26.9%	9.6%	0.8%	3.3%	0.1%
13	Aerospace	1.8%	34.4%	21.6%	26.0%	13.7%	1.9%	0.5%
14	Feed Products	6.5%	6.1%	15.6%	52.0%	4.2%	15.7%	0.0%
15	Platemaking & Typesetting	39.6%	14.8%	6.7%	3.9%	10.3%	1.0%	23.8%
16	Aluminum	3.6%	39.8%	19.7%	19.5%	10.6%	0.2%	6.5%
17	Brake Products	15.4%	48.9%	15.6%	5.1%	3.5%	9.9%	1.7%
18	Concrete, Cement, & Brick	8.4%	35.9%	18.5%	16.0%	16.7%	3.0%	1.5%
19	Earthenware Products	17.2%	34.3%	2.4%	29.5%	4.2%	12.3%	0.1%
20	Tobacco Products	0.0%	13.0%	80.0%	4.5%	0.1%	2.3%	0.0%
21	Dairy Products	7.5%	10.5%	21.9%	5.5%	0.5%	54.1%	0.1%
22	Petroleum	1.4%	69.8%	8.4%	5.0%	12.8%	2.6%	0.0%
23	Meat Products	9.8%	14.3%	5.7%	14.0%	27.2%	20.2%	8.8%

Source: North Carolina Employment Security Commission and authors' estimates. See Appendix 4.

25 percent is produced in the Carolinas region. There is very little manufacturing activity in this high tech cluster in eastern North Carolina (the Southeastern, Transpark, and Northeastern regions). Although the remaining largest potential clusters, particularly chemicals and packaged food products, are more evenly distributed across the seven regions, the majority of production even in these clusters is still located in the west. The results are similar when employment is used as the measure of manufacturing activity (see Table 14 and Figure 15).

Geographic Concentration

The calculation of employment or output shares across administrative spatial units provides only a limited picture of geographic clustering. Any

concentrations of activity spanning regional border areas can obscure the analysis. Moreover, the use of measures of economic size (output or employment) ignores the spatial clustering of smaller enterprises in particular areas. Exhibits 1-9 in Appendix, which plot the distribution of establishments in the nine largest potential North Carolina clusters, provide a more detailed picture of the geographic distribution of North Carolina manufacturing activity. They show that while most enterprises in each cluster tend to be located in the state's major population centers and along major interstates, there is a limited degree of geographic clustering in a few more rural areas of the state.

Table 14

Regional Share of Statewide Cluster Employment, 3Q 1994

Includes Primary & Secondary Sectors

#	Cluster	Western (WEC)	Carolinas (CP)	Piedmont (PTP)	Triangle (RTRP)	South-eastern (SEC)	Transpark (GT)	North-eastern (NEC)
1	Metalworking	10.8%	33.5%	22.5%	12.5%	7.8%	10.4%	2.5%
2	Vehicle Manufacturing	13.2%	35.6%	24.5%	8.4%	8.7%	8.2%	1.5%
3	Chemicals & Rubber	14.8%	22.6%	18.8%	19.0%	8.6%	11.2%	4.8%
4	Electronics & Computers	11.2%	25.0%	13.7%	38.8%	4.7%	6.0%	0.7%
5	Packaged Foods	13.2%	21.0%	11.2%	15.5%	11.1%	14.3%	13.5%
6	Printing & Publishing	13.8%	29.8%	21.7%	12.6%	8.2%	7.0%	6.7%
7	Wood Products	23.8%	21.8%	27.3%	9.7%	6.3%	6.2%	4.9%
8	Knitted Goods	11.9%	30.8%	28.3%	8.6%	10.3%	6.9%	3.1%
9	Fabricated Textile Products	12.4%	35.0%	24.4%	8.2%	9.7%	6.8%	3.4%
10	Nonferrous Metals	3.9%	53.4%	11.3%	18.1%	1.6%	11.8%	0.0%
11	Canned & Bottled Goods	8.6%	21.0%	26.3%	16.1%	12.7%	5.9%	9.4%
12	Leather Goods	14.5%	40.9%	29.2%	10.0%	1.0%	4.2%	0.2%
13	Aerospace	3.2%	31.0%	21.6%	30.1%	10.6%	2.6%	0.8%
14	Feed Products	14.5%	6.8%	9.8%	45.4%	2.5%	20.9%	0.0%
15	Platemaking & Typesetting	32.5%	22.2%	9.8%	7.6%	8.2%	1.2%	18.6%
16	Aluminum	4.2%	32.4%	25.0%	14.8%	15.7%	0.4%	7.6%
17	Brake Products	16.0%	43.3%	17.5%	6.5%	4.7%	10.2%	1.7%
18	Concrete, Cement, & Brick	8.8%	28.3%	21.4%	15.7%	20.0%	4.4%	1.3%
19	Earthenware Products	16.2%	29.4%	3.5%	31.3%	5.3%	14.2%	0.1%
20	Tobacco Products	0.0%	9.2%	66.6%	8.3%	0.7%	15.3%	0.0%
21	Dairy Products	7.0%	8.4%	20.4%	6.5%	0.4%	57.0%	0.2%
22	Petroleum	1.2%	77.5%	6.9%	3.9%	7.0%	3.5%	0.0%
23	Meat Products	12.1%	17.0%	5.1%	15.1%	21.7%	17.0%	12.0%

Source: North Carolina Employment Security Commission and authors' estimates. See Appendix 4.

The maps show, for example, that smaller geographic concentrations of activity in even those clusters predominantly located in the west are also found in certain areas in the east. In addition to the heavy concentrations of metalworking production in the metro areas of Greensboro, Winston-Salem, Charlotte, and Asheville, smaller geographic clusters of metalworking activity are also found in Wake County and Sanford, in Washington, Greenville, and Kinston, and in the Fayetteville and Wilmington metro areas. Although producers in the vehicle manufacturing cluster are also located primarily in the western half of the state (see Exhibit 2), including the Greensboro-High Point-Winston Salem area, Charlotte-Gastonia, Hickory, and Asheville, there are a few minor concentrations in the east as well.

In contrast, the chemicals and rubber cluster has a fairly strong presence in both eastern and western North Carolina (see Exhibit 3). The largest concentrations of establishments in this cluster remain in the major urbanized centers of the west (Winston Salem-High Point, Charlotte, Asheville). But groups of chemicals and rubber producers are also present in the Research Triangle and generally southeast toward

Smithfield, Rocky Mount, Wilson and Greenville. As Tables 13 and 14 illustrate, this cluster is one of the most evenly distributed *across* economic development regions when regional shares of statewide cluster output and employment are examined. This is because the somewhat fewer chemicals producers in the east tend to be larger than the more numerous producers in the major urbanized centers in the west. Comparisons of Exhibit 3 with 1 and 2 also suggests that a greater *relative* number of chemicals and rubber establishments are located in rural areas than is the case for the metalworking and vehicle manufacturing clusters.

As noted above, establishments in the North Carolina electronics and computers cluster are perhaps the most geographically concentrated of any manufacturing cluster (Exhibit 4). An overwhelming majority of the activity in electronics and computers is located in one of four regions: the Research Triangle area, Charlotte-Gastonia, Statesville-Hickory, and Asheville. Unlike metalworking, vehicle manufacturing, and chemicals, very few manufacturers in this cluster are located in geographic isolation in rural areas. This may be a function of the greater relative importance of local producer services, technical expertise and research and development, informal and formal interfirm linkages, and pools of skilled labor that are required to maintain competitiveness in this high tech cluster.

The degree of geographic concentration in the packaged food products, printing and publishing, and wood products clusters is comparatively low (Exhibits 5, 6 and 7). Aside from some slight concentration in the major population centers, manufacturers in these clusters are distributed fairly evenly across the state. An exception is part of the wood products cluster. Furniture manufacturing is concentrated in the well-known furniture districts of Statesville-Lenoir-Hickory and Greensboro-High Point; the wood processing

Table 15

Regional Share of Statewide Estimated Real Output Growth, 1989-94

Cluster Definition Includes Primary & Secondary Sectors

#	Cluster	Western (WEC)	Carolinas (CP)	Piedmont (PTP)	Triangle (RTRP)	South-eastern (SEC)	Transpark (GT)	North-eastern (NEC)	Statewide Absolute Change
1	Metalworking	18.2%	34.4%	27.6%	13.2%	3.4%	4.2%	-0.9%	1,353.1
2	Vehicle Manufacturing	10.5%	51.3%	24.4%	-1.0%	7.0%	5.6%	2.2%	2,095.9
3	Chemicals & Rubber	-1.4%	13.8%	15.1%	45.1%	9.6%	5.4%	12.4%	3,703.5
4	Electronics & Computers	25.3%	15.0%	-18.5%	62.0%	5.5%	7.5%	3.1%	915.2
5	Packaged Foods	-0.6%	-3.3%	11.3%	35.9%	3.2%	8.3%	45.1%	541.5
6	Printing & Publishing	21.5%	33.3%	17.3%	5.6%	-0.8%	14.9%	8.2%	1,250.4
7	Wood Products	2.6%	20.2%	19.8%	28.2%	15.6%	18.5%	-4.8%	711.1
8	Knitted Goods	38.8%	51.2%	-51.2%	-10.4%	22.5%	32.6%	16.5%	-522.5
9	Fabricated Textile Products	-2.8%	39.9%	28.3%	8.5%	5.2%	13.1%	7.8%	-1,207.4
10	Nonferrous Metals	2.4%	57.1%	-8.5%	38.4%	-1.2%	11.9%	0.0%	319.4
11	Canned & Bottled Goods	-1.3%	-2.5%	85.7%	-7.8%	1.7%	14.1%	10.2%	-288.5
12	Leather Goods	-1916.9%	2137.4%	1876.9%	1012.7%	143.2%	-2889%	-264.6%	0.9
13	Aerospace	-19.4%	50.0%	-10.1%	21.5%	54.9%	1.1%	2.0%	204.5
14	Feed Products	2.9%	-0.5%	-22.5%	107.6%	0.6%	11.8%	0.0%	1,229.0
15	Platemaking & Typesetting	56.3%	21.8%	0.1%	4.5%	-10.9%	1.5%	26.5%	378.6
16	Aluminum	-6.5%	-14.9%	-73.5%	-50.4%	236.3%	-1.0%	10.1%	-186.9
17	Brake Products	33.8%	45.6%	14.7%	14.6%	18.8%	-37.7%	10.2%	39.2
18	Concrete, Cement, & Brick	10.9%	-20.7%	-7.7%	45.1%	72.1%	-0.5%	0.7%	52.1
19	Earthenware Products	-50.4%	14.9%	-7.6%	20.3%	18.2%	103.8%	0.8%	11.3
20	Tobacco Products	0.0%	-12.5%	105.6%	8.9%	-0.6%	-1.3%	0.0%	-1,782.8
21	Dairy Products	3.4%	31.4%	22.9%	8.3%	2.4%	31.7%	0.0%	-279.4
22	Petroleum	-2.8%	73.9%	13.3%	17.4%	-10.8%	9.0%	0.0%	10.9
23	Meat Products	-6.0%	15.6%	5.0%	4.2%	50.5%	29.2%	1.5%	531.7

Source: North Carolina Employment Security Commission and authors' calculations. See Appendix 4.

plants located near the many sources of timber as well as small mills serving local markets account for the generally even distribution of this cluster overall. Likewise, the printing and publishing cluster includes many producers serving local markets (e.g. newspapers and periodicals). Thus it tends to be more evenly distributed. In the packaged food products cluster, the predominance of larger producers (see size distributions by cluster reported earlier) located in relative isolation suggests that localized formal and informal interfirm linkages in this cluster may be relatively unimportant.

Finally, manufacturing activity in the knitted goods and fabricated textile products clusters is generally concentrated in the central Piedmont and Charlotte-Gastonia areas of the state (Exhibits 8 and 9). Yet many plants are also located in very rural areas, far from other producers in these clusters. Many of these rural producers may be branch plants that rely more on external linkages with headquarters facilities in other states than on links to their host regions. Since they are made up of the largest manufacturing industries in the state, the knitted goods and fabricated textile products clusters represent a significant presence in all seven economic development regions.

Regional Specializations

Although the present document focuses on the pattern of cluster activity across the state as a whole, the relative mix of cluster activity in each of the seven Economic Development Partnership regions is charted in Figures A.19 to A.25 in Appendix 2 for the purposes of providing a brief summary picture of intraregional specializations. The figures emphasize the significance of the knitted goods cluster in nearly every region, the relative importance of vehicle manufacturing to the Western, Carolinas, Piedmont, Transpark, and Southeast regions, and the

Table 16

Regional Share of Statewide Employment Growth, 1989-94

Cluster Definition Includes Primary & Secondary Sectors

#	Cluster	Western (WEC)	Carolinas (CP)	Piedmont (PTP)	Triangle (RTRP)	South-eastern (SEC)	Transpark (GT)	North-eastern (NEC)	Statewide Absolute Change
1	Metalworking	18.4%	37.6%	31.6%	8.1%	3.7%	4.8%	-4.2%	10,598
2	Vehicle Manufacturing	24.3%	54.3%	27.0%	-15.6%	-0.4%	6.8%	3.7%	9,873
3	Chemicals & Rubber	-0.8%	27.6%	18.4%	31.9%	7.9%	2.9%	12.1%	17,893
4	Electronics & Computers	10.4%	26.0%	-16.3%	57.7%	6.5%	11.4%	4.2%	7,179
5	Packaged Foods	-14.7%	1.9%	18.1%	25.4%	-5.4%	37.2%	37.6%	4,711
6	Printing & Publishing	15.6%	38.2%	18.7%	8.9%	0.8%	13.7%	4.2%	7,572
7	Wood Products	-20.3%	64.5%	-68.6%	161.4%	38.1%	15.7%	-90.8%	1,103
8	Knitted Goods	12.5%	40.0%	3.2%	9.1%	7.0%	19.9%	8.4%	-26,298
9	Fabricated Textile Products	3.2%	35.4%	13.0%	15.2%	9.4%	16.5%	7.4%	-30,986
10	Nonferrous Metals	4.0%	66.8%	-15.3%	40.3%	-1.6%	5.9%	0.0%	2,446
11	Canned & Bottled Goods	7.4%	13.8%	40.8%	3.7%	9.2%	15.7%	9.4%	-1,783
12	Leather Goods	86.6%	-35.3%	-39.2%	-20.8%	-3.8%	104.6%	7.9%	-672
13	Aerospace	-59.3%	53.6%	-24.8%	42.5%	82.0%	-0.2%	6.1%	1,156
14	Feed Products	4.9%	2.3%	-28.8%	112.0%	-0.3%	9.8%	0.0%	3,425
15	Platemaking & Typesetting	42.5%	29.0%	-2.4%	11.3%	-7.0%	-0.1%	26.7%	2,478
16	Aluminum	89.9%	460.3%	1620.1%	487.2%	-2485%	41.3%	-113.4%	60
17	Brake Products	80.4%	-92.6%	2.9%	61.3%	85.0%	-57.9%	21.0%	216
18	Concrete, Cement, & Brick	12.4%	-19.5%	-24.3%	13.7%	127.2%	-2.9%	-6.5%	541
19	Earthenware Products	-64.4%	42.4%	-2.6%	-11.6%	16.8%	118.8%	0.6%	233
20	Tobacco Products	0.0%	-0.5%	92.5%	9.6%	-2.3%	0.7%	0.0%	-5,366
21	Dairy Products	6.7%	67.4%	33.7%	8.3%	5.6%	-21.7%	0.0%	-882
22	Petroleum	-2.5%	82.2%	7.4%	8.9%	-4.0%	8.0%	0.0%	176
23	Meat Products	-4.2%	18.6%	6.3%	1.6%	54.9%	20.9%	1.8%	4,512

Source: North Carolina Employment Security Commission.

overwhelming dominance of electronics and computers in the Research Triangle. Sectors that are only moderately linked to specific clusters (nonloading primary industries) are also important employers in several regions. Paper mills in the Western region, drugs in the Triangle and Transpark, and poultry processing in the Southeast all account for significant shares of manufacturing activity in their respective regions. In the Northeast, poultry processing, prepared fish products, salted nut products, and paper mills together account for nearly 30 percent of manufacturing employment.[29] As might be expected in a smaller regional manufacturing economy, a high share manufacturing activity in the Northeast region is in sectors that are only moderately linked to broader industrial clusters.

The following summarizes the major specializations in each Economic Development Partnership region. Note that distributions of activity within each cluster vary dramatically by region. The specializations do not necessarily represent viable potential clusters in the sense that many or all key linkages are present in the given region.

Western Economic Commission Region:

- Knitted goods
- Wood products
- Vehicle manufacturing
- Fabricated textile products
- Metalworking
- Nonloading primary sectors: paper and paperboard mills, drugs.

Carolinas and Piedmont Triad Partnership Regions:

- Knitted goods
- Vehicle manufacturing
- Fabricated textile products
- Metalworking.

Research Triangle Regional Partnership:

- Electronics and computers
- Metalworking
- Knitted goods
- Nonloading primary sectors: drugs.

Southeastern Economic Commission Region:

- Knitted goods
- Vehicle manufacturing
- Nonloading primary sectors: poultry slaughtering and processing.

Global Transpark Region:

- Knitted goods
- Vehicle manufacturing
- Metalworking
- Nonloading primary sectors: poultry slaughtering and processing, drugs, paper and paper board mills.

Northeast Economic Commission Region:

- Nonloading primary sectors: see above.
- Knitted goods
- Wood products.

Regional Patterns of Growth & Decline

Tables 15 and 16 report the regional shares of statewide estimated output and employment growth for each cluster over the 1989-1994 period. Figures 16-24 plot the distribution of regional employment *growth shares* along with the regional *total shares* of statewide cluster employment in 1989. The charts make it possible to compare the spatial pattern of growth or decline in a particular cluster between 1989 and 1994 to its locational pattern at the beginning of the period.

The shaded area in Figure 16, for example, illustrates the generally western orientation (in employment terms) of the state's metalworking cluster (largest regional shares in the Piedmont and Carolina regions). The highest shares of statewide growth in the industries that make up this cluster were also observed in the western North Carolina over the 1989 to 1994 period. Employment in metalworking declined in the Northeast region and enjoyed only moderate to low increases in the Triangle, Transpark and Southeast regions. Figure 16 shows that not only is the metalworking cluster

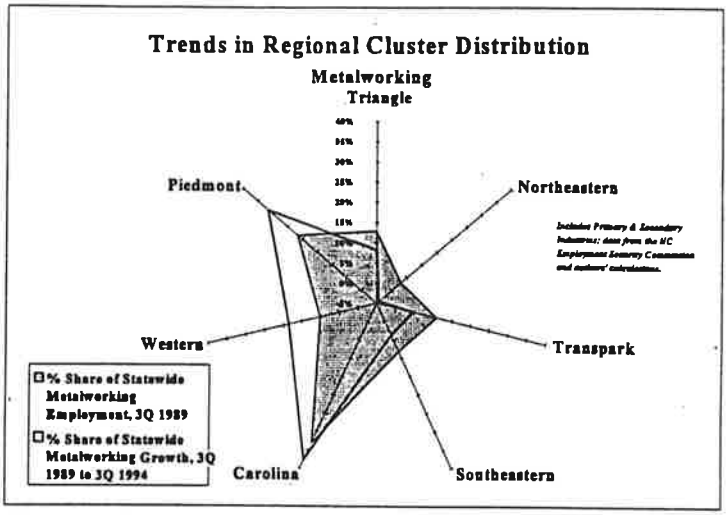


Figure 16

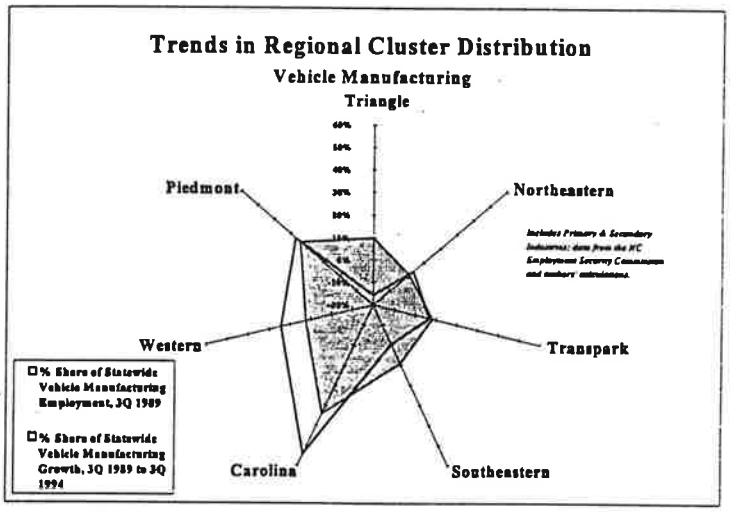


Figure 17

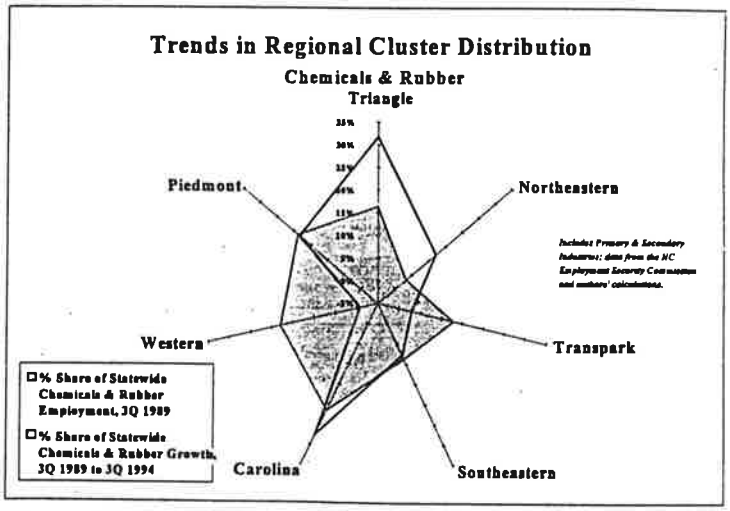


Figure 18

located predominantly in the western half of the state, but growth rates over the 1989-1994 period reinforced the geographic pattern. Likewise, most statewide growth in vehicle manufacturing and printing and publishing occurred in the west (see Figures 17 and 21), regions with already predominant shares of activity in these manufacturing clusters.

At the same time, a general relative shift in manufacturing activity toward eastern North Carolina may be occurring in several clusters. While the largest employment increases over the five year period in the chemicals and rubber cluster occurred in the Triangle, Carolinas and Piedmont regions, the Northeast region's share of growth significantly exceeded its share of cluster employment in 1989 (see Figure 18), thus increasing its overall proportion of statewide activity in the cluster in 1994. Employment in chemicals and rubber also increased in the Transpark, Southeast, and Piedmont, but fell in the Western region. Figures 19 and 20 illustrate similar geographical shifts in the electronics and computers and packaged food products clusters, while the wood products cluster

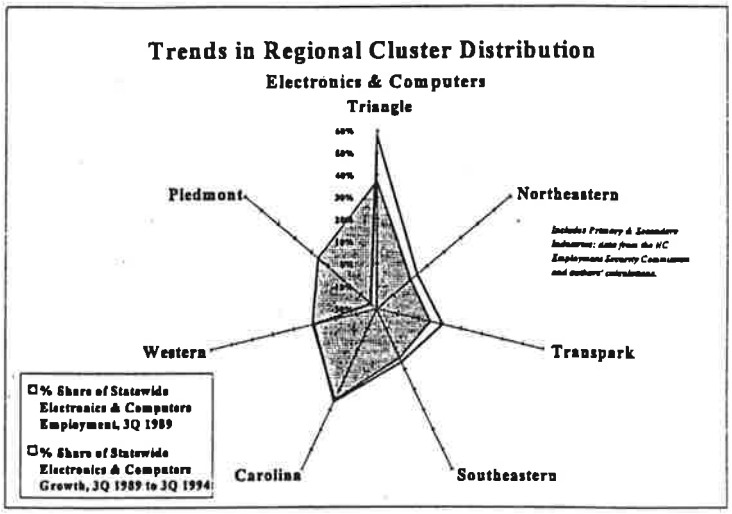


Figure 19

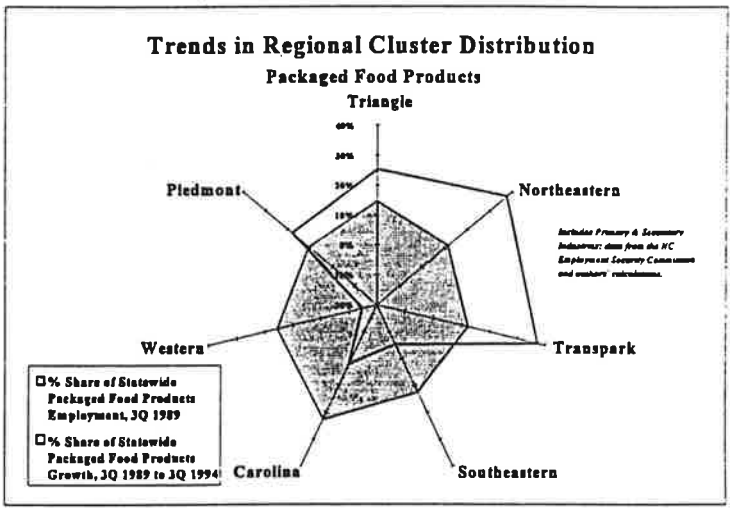


Figure 20

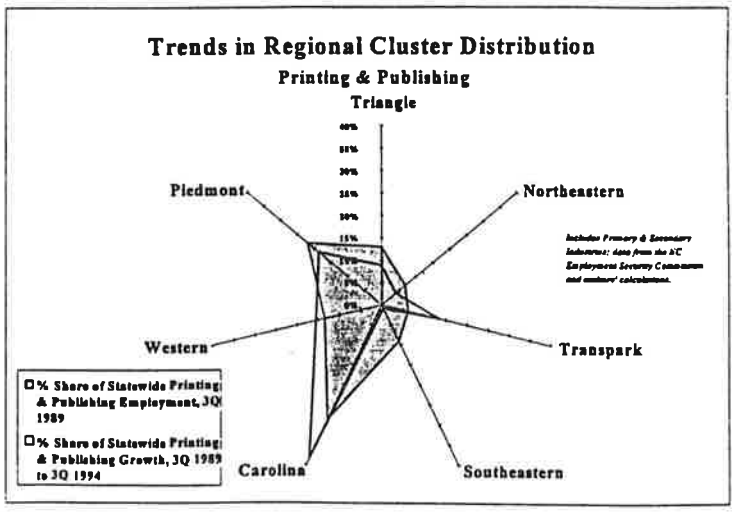


Figure 21

experienced growth primarily in the central and southeast-central parts of the state (Triangle, Carolinas, Southeast, and Transpark--see Figure 22). And while employment in knitted goods and fabricated textiles fell everywhere, the shares of the statewide decline were generally highest in the western regions (Figures 23 and 24). Although this is partly a function of the larger size of the clusters in the west, it nevertheless indicates a slight overall shift in the relative size of the eastern knitted goods and fabricated textiles clusters.

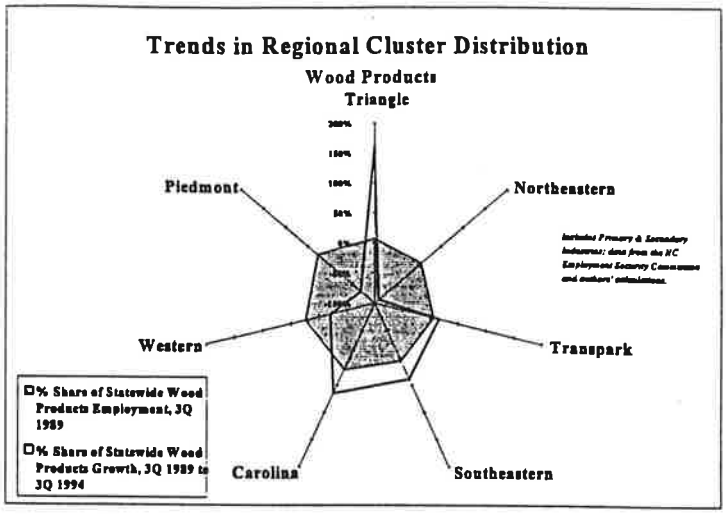


Figure 22

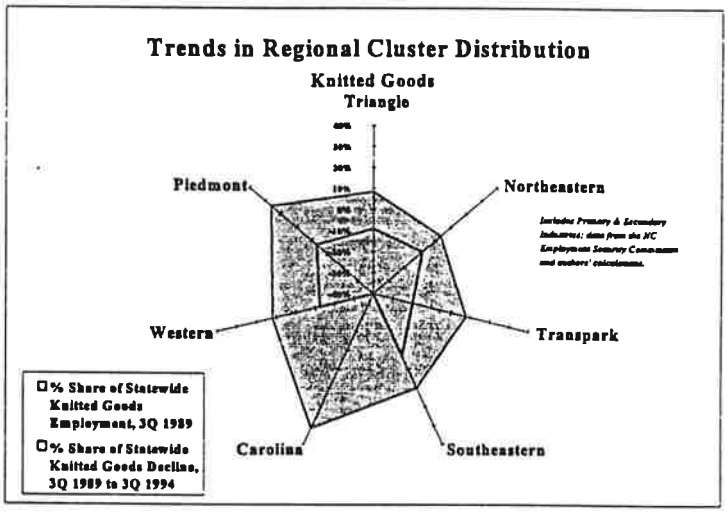


Figure 23

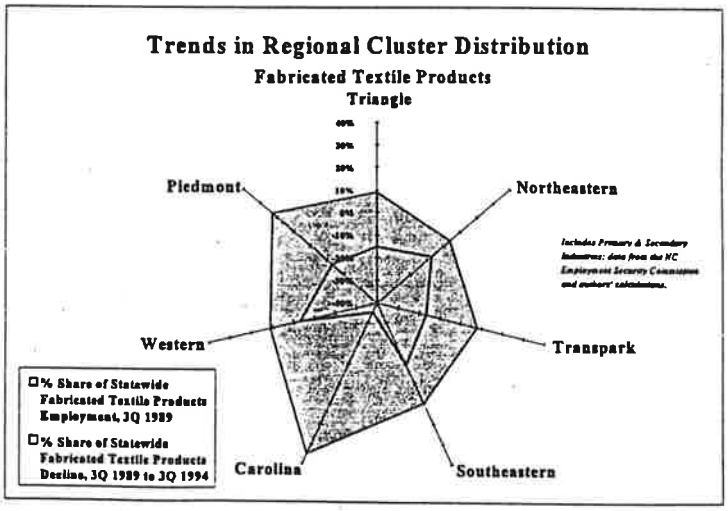


Figure 24

New Plant Employment

Data on new business activity between 1989 and 1994 provide another means of assessing geographical differences in the recent economic performance of the state's largest clusters. Table 17 reports the regional shares of estimated employment created by new firms and plants that began operations in North Carolina at some point between 1989 and 1994. The data suggest that, to some degree, manufacturing enterprises new to the state over this period tended to locate nearby other plants in their respective cluster (see also

Exhibits 10-18 in Appendix 3). Regions with the largest shares of cluster activity often garnered the largest increases in employment due to start-ups and relocations. In the case of metalworking, vehicle manufacturing, and printing and publishing, for example, the Carolinas region enjoyed the greatest share of new jobs from plants established in the state between 1989 and 1994. It also held the largest share of activity in these clusters in 1989. The three regions with the largest shares of statewide employment in the vehicle manufacturing, electronics and computers, printing and publishing, and fabricated textiles clusters, also enjoyed the greatest increases in new plant employment. And, except in the case of the packaged food products cluster, the three less urbanized areas of the east (Southeast, Transpark, and Northeast) tended to generate the least start-up and/or relocation activity.

Although new plants tended to locate where their respective cluster was already well-developed, there were significant differences among the most urbanized regions in terms of their relative shares of new plant

Table 17

Regional Share of Statewide Estimated Start-up Employment, 1989-94

Cluster Definition Includes Primary & Secondary Sectors

#	Cluster	Western (WEC)	Carolinas (CP)	Piedmont (PTP)	Triangle (RTRP)	South-eastern (SEC)	Transpark (GT)	North-eastern (NEC)
1	Metalworking	13.9%	33.9%	20.1%	14.7%	5.4%	10.4%	1.6%
2	Vehicle Manufacturing	11.5%	40.7%	25.6%	7.7%	5.2%	6.4%	2.9%
3	Chemicals & Rubber	10.1%	17.4%	21.1%	25.1%	10.7%	8.4%	7.2%
4	Electronics & Computers	24.2%	24.7%	13.5%	20.9%	8.0%	6.0%	2.7%
5	Packaged Foods	15.7%	14.9%	9.8%	30.1%	5.0%	16.9%	7.5%
6	Printing & Publishing	15.2%	32.8%	19.0%	10.8%	9.3%	11.9%	1.1%
7	Wood Products	12.9%	28.6%	20.9%	15.5%	8.8%	10.1%	3.2%
8	Knitted Goods	12.9%	25.5%	32.1%	5.5%	13.7%	6.0%	4.2%
9	Fabricated Textile Products	14.6%	27.5%	31.0%	6.3%	11.0%	6.7%	3.1%
10	Nonferrous Metals	12.5%	60.1%	2.0%	16.0%	6.9%	2.5%	0.0%
11	Canned & Bottled Goods	3.0%	41.2%	19.5%	7.4%	13.6%	5.4%	9.8%
12	Leather Goods	6.8%	33.4%	38.0%	16.2%	5.7%	0.0%	0.0%
13	Aerospace	3.4%	23.0%	23.1%	27.6%	21.5%	0.0%	1.4%
14	Feed Products	3.0%	5.0%	13.3%	74.1%	1.0%	3.2%	0.3%
15	Platemaking & Typesetting	50.2%	20.0%	9.4%	13.1%	3.5%	1.1%	2.7%
16	Aluminum	0.5%	48.8%	38.6%	3.2%	6.0%	0.4%	2.5%
17	Brake Products	10.2%	49.3%	12.7%	12.6%	6.8%	7.5%	0.9%
18	Concrete, Cement, & Brick	6.6%	30.8%	35.5%	7.1%	17.1%	2.5%	0.4%
19	Earthenware Products	34.9%	43.3%	8.1%	12.8%	0.6%	0.0%	0.3%
20	Tobacco Products	0.0%	0.0%	0.0%	5.7%	19.4%	74.9%	0.0%
21	Dairy Products	0.0%	0.8%	23.4%	1.1%	0.0%	74.7%	0.0%
22	Petroleum	0.0%	24.6%	4.8%	37.3%	0.0%	33.3%	0.0%
23	Meat Products	29.4%	21.4%	0.8%	7.4%	34.6%	6.2%	0.2%

Source: North Carolina Employment Security Commission and authors' calculations. See Appendix 4.

employment. Figures A.26 to A.34 in Appendix 2 chart the data in Table 17 along with the beginning-of-period (1989) shares of cluster employment. Despite the Piedmont's edge in metalworking, vehicle manufacturing, printing and publishing, wood products, knitted goods, and fabricated textiles, fewer jobs from new activity in these clusters were generated in the region than in the smaller Western and Triangle regions. On the other hand, the Piedmont registered the highest share of new plant job growth in the electronics and computers cluster, despite the heavy geographical concentration of electronics and computers in the Triangle and Carolinas regions. Among the smallest regions of the east, employment growth from new manufacturing activity was greatest in the packaged food products, chemicals and rubber, wood products, and knitted goods clusters.

Notes

1. *North Carolina: A High Performance State*, comprehensive strategic economic development plan completed by the North Carolina Economic Development Board (Raleigh, NC Department of Commerce, 1994), p. ii.

2. See *Understanding State Economies Through Industry Studies*, by J. M. Redman (Washington, DC: Council of Governors' Policy Advisors, 1994), pp. 3-11.

3. *Beyond Partnership: Strategies for Innovation and Lean Supply*, by R. Lamming (Hemel Hempstead: Prentice Hall International, 1993); "The Impact of Lean Manufacturing on Sourcing Relationships," by T. H. Klier (*Economic Perspectives, Federal Reserve Bank of Chicago* July/August: 8-18, 1994); *Modern Production Practices and Needs: North Carolina's Transportation Equipment Manufacturers*, by E.M. Bergman, E. J. Feser, and J. Scharer (Chapel Hill, NC: Institute for Economic Development, 1995); "The influence of internal and external factors on the technology adoption behavior of transportation equipment industries," by E. M. Bergman and E. J. Feser (paper presented at the 42nd North American Meetings of the Regional Science Association International, Cincinnati, Ohio, November, 1995).

4. See *The Competitive Advantage of Nations*, by M. E. Porter (New York: Free Press, 1990); *The New Competition*, by M. Best (Cambridge, MA: Harvard University Press, 1993); "Industrial clusters and the competitiveness of the Netherlands," by D. Jacobs and M. W. De Jong (*De Economist* 140: 233-52, 1992); "Porter's Model for Geographic Competitive Advantage: The Case of New Hampshire,"by A. Kaufman et al. (*Economic Development Quarterly* 8: 43-66, 1994); and "Business Strategy and Cross-Industry Clusters," by P. B. Doeringer and D. G. Terkla (*Economic Development Quarterly* 9: 225-37, 1995).

5. This notion may appear to contradict the idea that U.S. firms must be engaged in a fierce competitive struggle in order for incentives for efficiency and innovation to be maintained. There is growing recognition, however, that elements of cooperation are not uncommon even among heavily competing firms. See, for example, *The New Competition*, *op cit.*

6. *Op cit.*

7. *Op cit.*, p. 37.

8. *Industrial-Strength Strategies: Regional Business Clusters and Public Policy*, by S. A. Rosenfeld (Washington, DC: The Aspen Institute, 1995), p. 12.

9. "Some empirical evidence of the strengths of linkages between groups of industries in urban regional complexes, by S. Czamanski (*Papers, Regional Science Association* 27: 137-50, 1971); *Study of Clustering of Industries*, by S. Czamanski (Halifax, Nova Scotia: Institute of Public Affairs, 1976); "Identification of industrial clusters and complexes: a comparison of methods and findings," by S. Czamanski and L. A. de Ablas (*Urban Studies* 16: 61-80, 1979); "A new approach to the identification of industrial complexes using input-output data," by H. Roepke, D. Adams, and R. Wiseman (*Journal of Regional Science* 14: 15-29, 1974).

10. Although this study ruled out an examination of local input-output patterns based on the study objectives, there is an additional problem of data availability. A table of actual input-output linkages for North Carolina is not available. Regionalized national tables make assumptions about the level of local intersectoral trade and thus would also generate, to the degree that these assumptions are incorrect,

potential buyer-supplier chains.

11. Since the I-O classification system aggregates the over one-thousand 4-digit SIC sectors into 362 I-O industries (thus representing the maximum industrial disaggregation possible using an input-output based clustering methodology), many of the industries reported in the third and fourth columns of Table A.1 represent aggregations of 4-digit SIC sectors.

12. There were no significantly large negative loadings; see Appendix 4.

13. Rough estimates of 1993 U.S. output were derived by multiplying 1993 wages and the ratio of output to wages in 1987 (the latest year for which output data are available). The method tends to underestimate output. Data and caveats are discussed in Appendix 4 (section 2).

14. Seven of the seventeen clusters (nonferrous metals, tobacco products, concrete, cement and brick, brake products, platemaking and typesetting, leather goods, and earthenware products) produced less than 1.0 percent of estimated 1993 manufacturing output.

15. The biotechnology and environmental industries have also received substantial recent policy attention. To date, a definition of biotechnology in terms of SIC codes has not been achieved. This industry thus falls outside the scope of this analysis. SIC sectors classified as environmental industries by various sources range over 11 two-digit manufacturing codes. They did not load as a distinct cluster in this analysis, probably because many of these sectors produce or otherwise process by-products of traditional manufacturing industries (e.g. SIC 2299--processing of textile mill waste and recovering fibers, SIC 3399--recovery of iron ore from open hearth slag, and SIC 2499--reground sawdust, pressed logs of sawdust). As a result, firms in the environmental technologies sector interact little in a traditional input-output sense; they can not be analyzed as a cluster using the approach developed here.

16. Sectors within a cluster are identified as high technology based on a classification system provided to NC ACTS by the North Carolina Employment Security Commission. Estimated output and employment in sectors classified by NCESC as either "Very High Tech," "Moderately High Tech," or "Somewhat High Tech" are treated as high tech in Table 6 and Figures 8 and 9. The classification of each sector in each cluster is reported in Table 1.1 in Volume II of the study. For the distribution of high tech North Carolina establishments and employment in non-manufacturing 3-digit SIC sectors, see *Making Manufacturing & Technology Work for North Carolina* (Research Triangle Park: North Carolina Alliance for Competitive Technologies, December 1995).

17. As noted above, SIC 283 (drugs) achieved a loading of only .35 on the feed products cluster (see Table A.1). Since this was its highest loading, it is classified as a nonloading primary industry. Although it is a secondary industry for feed products, its low loading indicates a very weak link to the sectors in this cluster. The primary link between 283 and this cluster is the role of 283 as a important supplier to prepared feed goods producers (SIC 2048).

18. This factor was shown to be important in a recent study of North Carolina transportation equipment manufacturers. See *Modern Production Practices and Needs, op cit.*

19. Data on a number of key indicators, including estimated output, employment, wage payments, size distribution, branch plant status, market orientation, technology code, and 1989-1994 output and employment growth rates are reported in Tables 1.1 through 5.1 in Volume II of *Targeting North Carolina Manufacturing*. These tables *profile* the North Carolina clusters in detail, and comparison U.S. estimated output and employment data are included throughout.

20. The data in the figures are reproduced in Tables 2.1 and 3.1 in Volume II; these tables also report

relative distributions for the 14 remaining clusters.

21. The top five supplier and purchasing sectors (in terms of share of total intermediate inputs purchased or output sold) for each industry are reported in Tables 9.1 and 10.1 in Volume II.

22. This may be due to misclassification in the North Carolina Employment Security Commission files. Major computer manufacturers in the state produce both computers as well as computer peripheral equipment. Since plants are classified under only one SIC code, the production of multiple products by individual manufacturers is not accounted for in the wage and employment data. In reality, some North Carolina production assigned to the computer peripherals industry should be assigned to the electronic computers sector.

23. Note again that the estimates of output assume a constant wage/output ratio between 1987 and 1994. This method may clearly underestimate output levels and changes, particularly for high technology sectors where significant productivity gains are common. See endnote 13 and Appendix 4.

24. Aggregate cluster growth rates reveal nothing about differences in performance across cluster members. Table 9 also reports the standard deviation in real output growth rates for the 23 primary industry clusters. Several clusters' growth rates among component sectors were highly variable relative to other clusters: chemicals and rubber, communications, electronics, and computers, packaged foods, and aerospace. Some sectors in these clusters grew rapidly while others may have suffered major decline. Table 4.1 in Volume II reports real output, real wage, and employment growth rates by component sector for each cluster, thus permitting the detailed examination of intracluster growth patterns.

25. Similarly, some of the fastest declining clusters are among the smallest: platemaking and typesetting, leather goods, dairy products, and nonferrous metals. The sectors in these clusters may be declining as a group, or heavy losses in one industry may be dominating the net output growth figures.

26. This, however, is much more the case for the meat products cluster (149 establishments) than the aerospace cluster (70 establishments).

27. The data reported in Tables 11 and 12 are derived from matching the IIIQ 1989 and IIIQ 1994 establishment level ES-202 files provided by the North Carolina Employment Security Commission. Start-ups represent plants appearing in the IIIQ 1994 file that were not listed on the IIIQ 1989 file; they thus do not include establishments that started up and closed between the two periods. See the discussion of the file merging process and associated limitations in Appendix 4.

28. It is also notable that the chemicals and rubber cluster posted the smallest relative decline in employment from the existing stock of enterprises in 1989 (6.6 percent). Also with a small relative decline was the printing and publishing cluster (7.1 percent). Both of these clusters generated significant growth in the sense that base year employment fared better than other large NC clusters *and* they generated a large number of new jobs from new enterprises created over the five year period. On the other extreme, the tobacco cluster suffered major job losses from base year plants and posted few job gains from startups.

29. These industries account for nearly 40 percent of estimated manufacturing output.

APPENDIX 1

Additional Tables

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
1. Metal-working	I400600	3443	Fabricated plate work (boiler shops)	1			0.98
	I230500	2542	Partitions & fixtures, except wood	1			0.98
	I400901	3448	Prefabricated metal buildings & components	1			0.98
	I370102	3313	Electrometallurgical products, except steel	1			0.98
	I400400	3441	Fabricated structural metal	1			0.98
	I360400	3255	Clay refractories	1			0.97
	I370104	3316	Cold-rolled steel sheet, strip, & bars	1			0.97
	I460100	3534	Elevators & moving stairways	1			0.97
	I362100	3297	Nonclay refractories	1			0.97
	I370105	3317	Steel pipe & tubes	1			0.97
	I610100	3731	Ship building & repairing	1			0.97
	I440001	3523	Farm machinery & equip.	1			0.96
	I400800	3446	Architectural & ornamental metal work	1			0.96
	I540300	3633	Household laundry equip.	1			0.96
	I370101	3312	Blast furnaces & steel mills	1			0.96
	I410203	3469	Metal stampings, n.e.c.	1			0.96
	I460200	3535	Conveyors & conveying equip.	1			0.96
	I400300	3433	Heating equip., except electric & warm	1			0.95
	I400902	3449	Miscellaneous structural metal work	1			0.95
	I450300	3533	Oil & gas field machinery & equip.	1			0.95
	I421100	3499	Fabricated metal products, n.e.c.	1			0.95
	I400100	3431	Enameled iron & metal sanitary ware	1			0.95
	I420500	3495-6	Miscellaneous fabricated wire products	1			0.94
	I370103	3315	Steel wiredrawing & steel nails & spikes	1			0.94
	I420100	3421	Cutlery	1			0.93
	I460400	3537	Industrial trucks & tractors	1			0.93
	I490300	3564	Blowers & fans	1			0.93
	I420201	3423	hand & edge tools, except machine tools	1			0.93
	I370300	3462	Iron & steel forgings	1			0.93
	I530200	3612	Power, distribution, & specialty transformers	1			0.92
	I460300	3536	Hoists, cranes, & monorails	1			0.92
	I530400	3621	Motors & generators	1			0.92
	I130500	3484	Small arms	1			0.92
	I520200	3582	Commercial laundry equip.	1			0.91
	I480100	3556	Food products machinery	1			0.91
	I420202	3425	Saw blades & handsaws	1			0.91
	I540700	3639	Household appliances, n.e.c.	1			0.91
	I470402	3547	Rolling mill machinery & equip.	1			0.90
	I520500	3589	Service industry machinery, n.e.c.	1			0.90
	I370401	3398	Metal heat treating	1			0.89
	I230700	2599	Furniture & fixtures, n.e.c.	1			0.88
	I450100	3531	Construction machinery & equip.	1			0.88
	I400700	3444	Sheet metal work	1			0.88
	I550300	3643-4	Wiring devices	1			0.88
	I410202	3466	Crowns & closures	1			0.88

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
1. Metal-working *cont.*	I390200	3412	Metal shipping barrels, drums, kegs, & pails	1		3	0.88
	I470500	3549	Metalworking machinery, n.e.c.	1			0.87
	I420402	3479	Coating,engraving, & allied services, n.e.c.	1			0.87
	I540100	3631	Household cooking equip.	1			0.87
	I490500	3566, 3568	Mechanical power transmission equip.	1		17	0.84
	I410100	3451-2	Screw machine products, bolts, etc.	1		2	0.84
	I420800	3491-2, 3494, 3498	Pipe, valves, & pipe fittings	1		3	0.84
	I470404	3548	Electric & gas welding & soldering equip.	1		2	0.84
	I640503	3953	Marking devices	1			0.83
	I500200	3593-4	Fluid power equip.	1		17	0.83
	I420300	3429	Hardware, n.e.c.	1		2	0.83
	I370200	332	Iron & steel foundries	1			0.83
	I530700	3624	Carbon & graphite products	1			0.82
	I520100	3581	Automatic vending machines	1			0.82
	I470200	3542	Machine tools, metal forming types	1			0.81
	I610300	374	Railroad equip.	1			0.81
	I450200	3532	Mining machinery, except oil field	1			0.80
	I361300	3274	Lime	1		6	0.80
	I470300	3544-5	Special dies, tools & machine tool accessories	1		2	0.80
	I500400	3599	Industrial & commercial machinery	1		17	0.79
	I480300	3553	Woodworking machinery	1		7	0.77
	I490700	3569	General industrial machinery & equip., n.e.c.	1			0.77
	I420700	3493	Steel springs, except wire	1		2	0.77
	I410201	3465	Automotive stampings	1		3	0.77
	I641000	3995	Burial caskets	1		9	0.76
	I490600	3567	Industrial process furnaces & ovens	1			0.76
	I540400	3634	Electric housewares & fans	1			0.76
	I480200	3552	Textile machinery	1			0.76
	I310102	2992	Lubricating oils & greases	1		22	0.75
	I540200	3632	Household refrigerators & freezers	1			0.75
	I360701	3262	Vitreous china table & kitchenware	1		19	0.75
	I390100	3411	Metal cans	1		16	0.74
	I530300	3613	Switchgear & switchboard apparatus	1		4	0.74
	I220300	2514	Metal household furniture	1		2	0.73
	I490100	3561, 3563	Pumps & compressors	1			0.73
	I490800	3565	Packaging machinery	1			0.72
	I490200	3562	Ball & roller bearings	1		17	0.71
	I610500	375	Motorcycles, bicycles, & parts	1			0.70
	I230200	2522	Office furniture, except wood	1	2		0.70
	I240400	2677	Envelopes	1	6		0.69
	I361100	3272	Concrete products, except block & brick	1	18		0.68
	I130600	3482	Small arms ammunition	1		18	0.67
	I130300	3795	Tanks & tank components	1		16, 2	0.67
	I480600	3559	Special industry machinery, n.e.c.	1	3		0.66
	I130200	3483	Ammunition, except for small arms, n.e.c.	1		4	0.66
	I130700	3489	Ordnance & accessories, n.e.c.	1			0.62

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
1. Metal-working *cont.*	I470100	3541	Machine tools, metal cutting types	1		2	0.62
	I430100	3511	Turbines & turbine generator sets	1		13	0.60
	I620102	3821	Laboratory apparatus & furniture	4	1		0.62
	I400500	3442	Metal doors, sash, frames, molding, & trim	1		16	0.58
	I610700	3799	Transportation equip., n.e.c.	17		1, 2	0.58
	I590100	3713	Truck & bus bodies	2		1	0.56
	I520400	3586	Measuring & dispensing pumps	2		1	0.56
	I361900	3295	Minerals, ground or treated	1		18, 19	0.56
	I230600	2591	Drapery hardware & window blinds & shades	16		1	0.55
	I440002	3524	Lawn & garden equip.	2		1	0.53
	I480400	3554	Paper industries machinery	6		1	0.51
	I480500	3555	Printing trades machinery & equip.	15		1	0.51
	I380501	3339	Primary nonferrous metals, n.e.c.	10		1	0.50
	I500300	3596	Scales & balances, except laboratory	4		1	0.49
	I470401	3546	Power-driven handtools	1			0.48
	I590200	3715	Truck trailers	2		1	0.46
	I470405	3543	Industrial patterns	1			0.45
	I520300	3585	Refrigeration & heating equip.	2		1	0.45
	I230300	253	Public building & related furniture	2		1	0.44
	I590302	3714	Motor vehicle parts & accessories	2		1	0.44
	I610200	3732	Boat building & repairing	1			0.43
	I500100	3592	Carburetors, pistons, rings, & valves	2		1	0.41
	I381400	3463	Nonferrous forgings	13		16, 1	0.38
	I550200	3645-8	Lighting fixtures & equip.	2		1	0.38
	I380600	334	Secondary nonferrous metals	16		1	0.35
2. Vehicle Manufac-turing	I610603	3716	Motor homes	2			0.96
	I580400	3694	Electrical equip. for internal combustion eng.	2			0.93
	I320100	301	Tires & inner tubes	2			0.93
	I560100	3651	Household audio & video equip.	2		4	0.91
	I320300	306	Fabricated rubber products, n.e.c.	2		3	0.89
	I310300	2952	Asphalt felts & coatings	2			0.89
	I320200	302	Rubber & plastics footwear	2		9	0.88
	I550200	3645-8	Lighting fixtures & equip.	2		1	0.88
	I590301	3711	Motor vehicles & passenger car bodies	2			0.87
	I430200	3519	Internal combustion engines, n.e.c.	2			0.86
	I350100	321, 3229, 323	Glass & glass products, except containers	2			0.86
	I540500	3635	Household vacuum cleaners	2			0.86
	I190306	2399	Fabricated textile products, n.e.c.	2		9	0.86
	I550100	3641	Electric lamp bulbs & tubes	2			0.86
	I230100	2521	Wood office furniture	2		7	0.86
	I640502	3952	Lead pencils & art goods	2			0.83
	I590302	3714	Motor vehicle parts & accessories	2		1	0.83
	I520300	3585	Refrigeration & heating equip.	2		1	0.83
	I320500	3052	Rubber & plastics hose & belting	2			0.82
	I580100	3691	Storage batteries	2		3	0.82

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
2. Vehicle Manufac-turing *cont.*	I190304	2396	Automotive & apparel trimmings	2		9	0.81
	I300000	285	Paints & allied products	2		3	0.80
	I590200	3715	Truck trailers	2		1	0.79
	I230300	253	Public building & related furniture	2		1	0.79
	I590100	3713	Truck & bus bodies	2		1	0.78
	I500100	3592	Carburetors, pistons, rings, & valves	2		1	0.78
	I170100	227	Carpets & rugs	2		8	0.74
	I340305	319	Leather goods, n.e.c.	2		12	0.73
	I641100	3993	Signs & advertising specialties	2			0.70
	I270402	2891	Adhesives & sealants	2	3		0.68
	I220200	2512	Upholstered household furniture	2	9		0.68
	I630200	385	Ophthalmic goods	2			0.66
	I320400	308	Miscellaneous plastics products, n.e.c.	2		3, 4	0.65
	I440002	3524	Lawn & garden equip.	2		1	0.62
	I520400	3586	Measuring & dispensing pumps	2		1	0.60
	I230200	2522	Office furniture, except wood	1	2		0.66
	I620200	3823-4, 3829	Mechanical measuring devices	4	2		0.62
	I361600	3291	Abrasive products	3		2	0.59
	I410201	3465	Automotive stampings	1		2	0.59
	I420700	3493	Steel springs, except wire	1		2	0.58
	I620600	3843	Dental equip. & supplies	10		2	0.57
	I230400	2541	Wood partitions & fixtures	2		7	0.56
	I320600	3053	Gaskets, packing, & sealing devices	17		2	0.51
	I240500	2676	Sanitary paper products	6		2	0.50
	I220400	2515	Mattresses & bedsprings	9		2	0.50
	I470300	3544-5	Special dies, tools & machine tool accessories	1		2	0.49
	I420300	3429	Hardware, n.e.c.	1		2	0.48
	I470404	3548	Electric & gas welding & soldering equip.	1		2	0.48
	I260400	274	Miscellaneous publishing	6		2, 15	0.48
	I260100	271	Newspapers	6		2	0.48
	I160200	224	Narrow fabric mills	8		2	0.47
	I260200	272	Periodicals	6		15, 2	0.46
	I220300	2514	Metal household furniture	1		2	0.45
	I410100	3451-2	Screw machine products, bolts, etc.	1		2	0.44
	I610601	3792	Travel trailers & campers	17		2	0.42
	I470100	3541	Machine tools, metal cutting types	1		2	0.38
	I610700	3799	Transportation equip., n.e.c.	17		1, 2	0.36
	I130300	3795	Tanks & tank components	1		16, 2	0.36
3. Chemi-cals & Rubber	I360300	3253	Ceramic wall & floor tile	3			0.97
	I270100	2812-6, 2865, 2869	Industrial inorganic & organic chemicals	3			0.96
	I270406	2899	Chemicals & chemical preparations n.e.c.	3			0.93
	I270300	2879	Pesticides & agricultural chemicals	3			0.93
	I280200	2822	Synthetic rubber	3			0.91
	I290201	2841	Soap & other detergents	3			0.90
	I290203	2843	Surface active agents	3		6	0.87

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
3. Chemicals & Rubber *cont.*	I360200	3251	Brick & structural clay tile	3			0.87
	I310103	2999	Products of petroleum & coal, n.e.c.	3		22	0.84
	I280100	2821	Plastics materials & resins	3			0.82
	I280400	2824	Manmade organic fibers, except cellulosic	3		8	0.81
	I290202	2842	Polishes & sanitation goods	3		5	0.81
	I270202	2875	Fertilizers, mixing only	3			0.80
	I362000	3296	Mineral wool	3			0.79
	I270404	2893	Printing ink	3		15	0.78
	I360500	3259	Structural clay products, n.e.c.	3		19	0.70
	I641200	3999	Manufacturing industries, n.e.c.	3		5	0.68
	I580200	3692	Primary batteries, dry & wet	3			0.65
	I270401	2861	Gum & wood chemicals	3	7		0.64
	I270201	2873-4	Nitrogenous & phosphatic fertilizers	3			0.61
	I270402	2891	Adhesives & sealants	2	3		0.67
	I240702	2673-4	Bags, except textile	6	3		0.63
	I480600	3559	Special industry machinery, n.e.c.	1	3		0.61
	I310101	291	Petroleum refining	22	3		0.60
	I361600	3291	Abrasive products	3	2		0.59
	I350200	3221	Glass containers	5	3		0.57
	I300000	285	Paints & allied products	2	3		0.54
	I270403	2892	Explosives	3			0.49
	I142003	2067	Chewing gum	5		3	0.49
	I640900	3996	Hard surface floor coverings, n.e.c.	3			0.49
	I171001	2297	Nonwoven fabrics	3		8	0.48
	I220102	2519	Household furniture, n.e.c.	3			0.47
	I290100	283	Drugs	3		14	0.47
	I290300	2844	Toilet preparations	5		3	0.45
	I640102	3915	Jewelers' materials & lapidary work	10		3	0.44
	I320400	308	Miscellaneous plastics products, n.e.c.	2		3, 4	0.42
	I310200	2951	Asphalt paving mixtures & blocks	22		3	0.41
	I420800	3491-2, 3494, 3498	Pipe, valves, & pipe fittings	1		3	0.41
	I142300	2087	Flavoring extracts & flavoring syrups, n.e.c.	11		5, 3, 15	0.40
	I390200	3412	Metal shipping barrels, drums, kegs, & pails	1		3	0.39
	I270405	2895	Carbon black	22		3	0.39
	I240800	262-3	Paper & paperboard mills	5		6, 3, 15	0.38
	I640301	3944	Games, toys, & children's vehicles	5		3, 6	0.37
	I370402	3399	Primary metal products, n.e.c.	10		4, 3	0.37
	I240100	261	Pulp mills	6		3, 7	0.37
	I320300	306	Fabricated rubber products, n.e.c.	2		3	0.36
	I200904	2493	Reconstituted wood products	7		3	0.36
	I580100	3691	Storage batteries	2		3	0.35

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
4. Electronics & Computers	I560300	3661.00	Telephone & telegraph apparatus	4			0.97
	I620900	3845	Electromedical & electrotherapeutic apparatus	4			0.96
	I580700	3699	Electrical machinery, equip., & supplies, n.e.c.	4			0.96
	I621100	3825	Instruments to measure electricity	4			0.95
	I530500	3625	Relays & industrial controls	4			0.95
	I620800	3844	X-ray apparatus & tubes	4			0.90
	I510102	3578	Calculating & accounting machines	4			0.90
	I560500	3663, 3669	Communication equip.	4		13	0.88
	I570200	3674	Semiconductors & related devices	4			0.86
	I570300	3672, 3675-9	Other electronic components	4			0.86
	I510103	3571	Electronic computers	4			0.85
	I620101	381	Search & navigation equip.	4		13	0.84
	I530800	3629	Electrical industrial apparatus, n.e.c.	4			0.83
	I620300	3822	Environmental controls	4			0.83
	I510104	3572, 3575, 3577	Computer peripheral equip.	4			0.82
	I420401	3471	Plating & polishing	4			0.80
	I500300	3596	Scales & balances, except laboratory	4		1	0.78
	I621000	3826-7	Laboratory & optical instruments	4			0.75
	I640400	3949	Sporting & athletic goods, n.e.c.	4			0.73
	I620102	3821	Laboratory apparatus & furniture	4	1		0.69
	I620400	3841	Surgical & medical instruments & apparatus	4			0.67
	I620200	3823-4, 3829	Mechanical measuring devices	4	2		0.67
	I381000	3357	Nonferrous wiredrawing & insulating	4		10	0.60
	I580600	3695	Magnetic & optical recording media	4			0.60
	I510400	3579	Office machines, n.e.c.	4			0.60
	I640200	393	Musical instruments	4		7	0.59
	I600400	3728, 3769	Aircraft & missile equip., n.e.c.	13	4		0.57
	I530300	3613	Switchgear & switchboard apparatus	1	4		0.52
	I130200	3483	Ammunition, except for small arms, n.e.c.	1		4	0.49
	I570100	3671	Electron tubes	4			0.49
	I630300	386	Photographic equip. & supplies	15		4, 6	0.48
	I130100	3761	Guided missiles & space vehicles	13		4	0.47
	I620500	3842	Surgical appliances & supplies	9		4	0.46
	I560200	3652	Prerecorded records & tapes	6		4	0.43
	I370402	3399	Primary metal products, n.e.c.	10		4, 3	0.41
	I320400	308	Miscellaneous plastics products, n.e.c.	2		3, 4	0.39
	I560100	3651	Household audio & video equip.	2		4	0.36
	I620700	387	Watches, clocks, watchcases, & parts	4			0.17
5. Packaged Foods	I141802	2052	Cookies & crackers	5			0.93
	I141402	2043	Cereal breakfast foods	5			0.90
	I142001	2064	C&y & other confectionery products	5			0.86
	I141403	2045	Prepared flour mixes & doughs	5			0.84
	I143100	2098	Macaroni, spaghetti, vermicelli, & noodles	5			0.82
	I141803	2053	Frozen bakery products, except bread	5			0.81
	I141801	2051	Bread, cake, & related products	5			0.80

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
5. Packaged Foods *cont.*	I141000	2034	Dehydrated fruits, vegetables, & soups	5		15	0.74
	I143201	2096	Potato chips & similar snacks	5			0.73
	I142002	2066	Chocolate & cocoa products	5			0.73
	I141600	2044	Rice milling	5			0.73
	I140500	2024	Ice cream & frozen desserts	5	21		0.72
	I141302	2038	Frozen specialties, n.e.c.	5		23	0.72
	I143202	2099	Food preparations, n.e.c.	5			0.71
	I142003	2067	Chewing gum	5		3	0.70
	I141900	2061-3	Sugar	5			0.70
	I141301	2037	Frozen fruits, fruit juices, & vegetables	5			0.69
	I141401	2041	Flour & other grain mill products	5		14	0.68
	I142600	2076	Vegetable oil mills, n.e.c.	5		14	0.68
	I142800	2095	Roasted coffee	5	11		0.66
	I140400	2023	Dry, condensed, & evaporated dairy products	5	21		0.64
	I140600	2026	Fluid milk	21	5		0.63
	I350200	3221	Glass containers	5	3		0.59
	I141100	2035	Pickles, sauces, & salad dressings	5		21	0.57
	I640501	3951	Pens, mechanical pencils, & parts	5		15	0.57
	I290300	2844	Toilet preparations	5		3	0.55
	I140200	2021	Creamery butter	21	5		0.55
	I141700	2046	Wet corn milling	5		11	0.50
	I142004	2068	Salted & roasted nuts & seeds	5			0.48
	I142900	2079	Edible fats & oils, n.e.c.	14		5	0.47
	I240800	262-3	Paper & paperboard mills	5		6, 3, 15	0.44
	I140700	2091	Canned & cured fish & seafoods	11		5	0.44
	I141501	2047	Dog & cat food	14		11, 5	0.43
	I141200	2092	Prepared fresh or frozen fish & seafoods	5			0.43
	I142300	2087	Flavoring extracts & flavoring syrups, n.e.c.	11		5, 3, 15	0.42
	I640301	3944	Games, toys, & children's vehicles	5		3, 6	0.42
	I140300	2022	Natural, processed, & imitation cheese	21		5	0.41
	I140105	2015	Poultry slaughtering & processing	23		5	0.41
	I142102	2083	Malt	15		5	0.39
	I142200	2086	Bottled & canned soft drinks	11		5	0.38
	I140800	2032	Canned specialties	11		5	0.37
	I290202	2842	Polishes & sanitation goods	3		5	0.37
	I641200	3999	Manufacturing industries, n.e.c.	3		5	0.35
	I143000	2097	Manufactured ice	5			0.35
6. Printing & Publishing	I260302	2732	Book printing	6			0.98
	I260602	2782	Blankbooks, looseleaf binders & devices	6			0.97
	I260501	275	Commercial printing	6			0.96
	I260802	2789	Bookbinding & related work	6			0.93
	I240701	2671-2	Paper coating & glazing	6			0.91
	I240705	2678	Stationery, tablets, & related products	6			0.90
	I260700	277	Greeting cards	6			0.90
	I250000	265	Paperboard containers & boxes	6			0.90

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
6. Printing & Publishing *cont.*	I260601	276	Manifold business forms	6			0.87
	I260301	2731	Book publishing	6			0.87
	I240706	2679	Converted paper products, n.e.c.	6			0.87
	I240703	2675	Die-cut paper & paperboard & cardboard	6			0.85
	I640504	3955	Carbon paper & inked ribbons	6			0.83
	I260100	271	Newspapers	6		2	0.79
	I240500	2676	Sanitary paper products	6	2		0.77
	I240100	261	Pulp mills	6		3, 7	0.76
	I480400	3554	Paper industries machinery	6	1		0.74
	I240702	2673-4	Bags, except textile	6	3		0.69
	I260200	272	Periodicals	6		15, 2	0.67
	I361400	3275	Gypsum products	6		18	0.63
	I260400	274	Miscellaneous publishing	6		2	0.63
	I240400	2677	Envelopes	1	6		0.68
	I260803	2791	Typesetting	15	6		0.64
	I560200	3652	Prerecorded records & tapes	6		4	0.54
	I361300	3274	Lime	1	6		0.53
	I200200	2421	Sawmills & planing mills, general	7	6		0.50
	I200901	2448	Wood pallets & skids	7		6	0.47
	I260806	2796	Platemaking & related services	15		6	0.43
	I240800	262-3	Paper & paperboard mills	5		6, 3, 15	0.42
	I290203	2843	Surface active agents	3		6	0.41
	I630300	386	Photographic equip. & supplies	15		4, 6	0.39
	I640301	3944	Games, toys, & children's vehicles	5		3, 6	0.35
7. Wood Products	I200702	2452	Prefabricated wood buildings & components	7			0.94
	I200501	2431	Millwork	7			0.94
	I200300	2426	Hardwood dimension & flooring mills	7			0.93
	I200701	2439	Structural wood members, n.e.c.	7			0.90
	I200903	2499	Wood products, n.e.c.	7			0.88
	I210000	2441, 2449	Wood containers, n.e.c.	7			0.87
	I200800	2491	Wood preserving	7			0.86
	I220101	2511	Wood household furniture, exc. upholstered	7			0.86
	I200502	2434	Wood kitchen cabinets	7			0.85
	I200100	241	Logging	7			0.82
	I200904	2493	Reconstituted wood products	7		3	0.78
	I200901	2448	Wood pallets & skids	7		6	0.73
	I200600	2435-6	Veneer & plywood	7			0.68
	I200200	2421	Sawmills & planing mills, general	7	6		0.64
	I200703	2451	Mobile homes	7			0.63
	I220103	2517	Wood television & radio cabinets	7			0.62
	I200400	2429	Special product sawmills, n.e.c.	7			0.51
	I270401	2861	Gum & wood chemicals	3	7		0.51
	I480300	3553	Woodworking machinery	1		7	0.48
	I230400	2541	Wood partitions & fixtures	2		7	0.46
	I640200	393	Musical instruments	4		7	0.44

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
7. Wood Products *cont.*	I230100	2521	Wood office furniture	2		7	0.43
	I240100	261	Pulp mills	6		3, 7	0.37
8. Knitted Goods	I180201	2253	Knit outerwear mills	8			0.93
	I180300	2257-8	Knit fabric mills	8			0.93
	I180202	2254	Knit underwear & nightwear mills	8			0.93
	I160400	2284	Thread mills	8			0.92
	I180203	2259	Knitting mills, n.e.c.	8			0.91
	I190303	2395	Pleating & stitching	8			0.88
	I190305	2397	Schiffli machine embroideries	8		9	0.85
	I180102	2252	Hosiery, n.e.c.	8			0.85
	I160200	224	Narrow fabric mills	8		2	0.78
	I640700	3965	Fasteners, buttons, needles, & pins	8			0.77
	I180101	2251	Women's hosiery, except socks	8			0.71
	I180400	231-8, 3999	Apparel made from purchased materials	8	9		0.70
	I160300	2269, 2281-2	Yarn mills & finishing of textiles, n.e.c.	8		9	0.65
	I340301	315	Leather gloves & mittens	12	8		0.58
	I160100	221-3, 2261-2	Broadwoven fabric mills & finishing plants	9	8		0.57
	I170100	227	Carpets & rugs	2	8		0.52
	I170900	2298	Cordage & twine	8			0.52
	I170700	2296	Tire cord & fabrics	8			0.51
	I171100	2299	Textile goods, n.e.c.	9		8	0.49
	I171001	2297	Nonwoven fabrics	3		8	0.47
	I280400	2824	Manmade organic fibers, except cellulosic	3		8	0.44
	I170600	2295	Coated fabrics, not rubberized	9		8	0.36
	I190200	2392	Housefurnishings, n.e.c.	9		8	0.36
9. Fabricated Textile Products	I190100	2391	Curtains & draperies	9			0.90
	I640302	3942	Dolls & stuffed toys	9			0.89
	I190302	2394	Canvas & related products	9			0.88
	I190200	2392	Housefurnishings, n.e.c.	9		8	0.86
	I340302	316	Luggage	9		12	0.84
	I190301	2393	Textile bags	9			0.81
	I170600	2295	Coated fabrics, not rubberized	9		8	0.79
	I220400	2515	Mattresses & bedsprings	9	2		0.78
	I280300	2823	Cellulosic manmade fibers	9			0.74
	I160100	221-3, 2261-2	Broadwoven fabric mills & finishing plants	9	8		0.74
	I171100	2299	Textile goods, n.e.c.	9		8	0.68
	I620500	3842	Surgical appliances & supplies	9		4	0.62
	I220200	2512	Upholstered household furniture	2	9		0.62
	I180400	231-8, 3999	Apparel made from purchased materials	8	9		0.57
	I640800	3991	Brooms & brushes	9			0.57
	I641000	3995	Burial caskets	1		9	0.49
	I160300	2269, 2281-2	Yarn mills & finishing of textiles, n.e.c.	8		9	0.44

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
9. Fabricated Textile Products *cont.*	I190304	2396	Automotive & apparel trimmings	2		9	0.42
	I340304	3172	Personal leather goods, n.e.c.	12		9	0.42
	I190306	2399	Fabricated textile products, n.e.c.	2		9	0.39
	I190305	2397	Schiffli machine embroideries	8		9	0.38
	I320200	302	Rubber & plastics footwear	2		9	0.37
10. Non-ferrous Metals	I640101	3911	Jewelry, precious metal	10			0.84
	I380100	3331	Primary smelting & refining of copper	10			0.76
	I381200	3366	Copper foundries	10			0.73
	I380700	3351	Rolling, drawing, & extruding of copper	10			0.71
	I380501	3339	Primary nonferrous metals, n.e.c.	10	1		0.70
	I640104	3914	Silverware & plated ware	10			0.63
	I620600	3843	Dental equip. & supplies	10	2		0.62
	I381300	3364, 3369	Nonferrous castings, n.e.c.	10	13		0.61
	I380900	3356	Nonferrous rolling & drawing, n.e.c.	13	10		0.60
	I640105	3961	Costume jewelry	10		15	0.53
	I370402	3399	Primary metal products, n.e.c.	10		4, 3	0.48
	I640102	3915	Jewelers' materials & lapidary work	10		3	0.45
	I381000	3357	Nonferrous wiredrawing & insulating	4		10	0.36
	I400200	3432	Plumbing fixture fittings & trim	10			0.27
11. Canned & Bottled Goods	I140900	2033	Canned fruits, vegetables, preserves, etc.	11			0.88
	I140800	2032	Canned specialties	11		5	0.80
	I142200	2086	Bottled & canned soft drinks	11		5	0.78
	I140700	2091	Canned & cured fish & seafoods	11		5	0.74
	I142101	2082	Malt beverages	11	14		0.66
	I380800	3353-5	Aluminum rolling & drawing	11		16	0.62
	I142800	2095	Roasted coffee	5	11		0.61
	I142300	2087	Flavoring extracts & flavoring syrups, n.e.c.	11		5, 3, 16	0.49
	I141501	2047	Dog & cat food	15		11, 5	0.47
	I141700	2046	Wet corn milling	5		11	0.45
	I142103	2084	Wines, brandy, & brandy spirits	15		11	0.43
	I142104	2085	Distilled & blended liquors	11		11	0.35
12. Leather Goods	I340201	3143-4, 3149	Shoes, except rubber	12			0.94
	I340100	313	Boot & shoe cut stock & findings	12			0.91
	I340303	3171	Women's handbags & purses	12			0.87
	I340202	3142	House slippers	12			0.87
	I340304	3172	Personal leather goods, n.e.c.	12		9	0.76
	I340301	315	Leather gloves & mittens	12	8		0.71
	I330001	311	Leather tanning & finishing	23	12		0.56
	I340305	319	Leather goods, n.e.c.	2	12		0.51
	I340302	316	Luggage	9		12	0.35

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
13. Aero-space	I600200	3724, 3764	Aircraft & missile engines & engine parts	13			0.92
	I600100	3721	Aircraft	13			0.90
	I130100	3761	Guided missiles & space vehicles	13		4	0.82
	I600400	3728, 3769	Aircraft & missile equip., n.e.c.	13	4		0.70
	I380900	3356	Nonferrous rolling & drawing, n.e.c.	13	10		0.69
	I381400	3463	Nonferrous forgings	13		16, 1	0.59
	I430100	3511	Turbines & turbine generator sets	1	13		0.58
	I381300	3364, 3369	Nonferrous castings, n.e.c.	10	13		0.56
	I620101	381	Search & navigation equip.	4		13	0.41
	I560500	3663, 3669	Communication equip.	4		13	0.36
14. Feed Products	I142400	2074	Cottonseed oil mills	14			0.91
	I142500	2075	Soybean oil mills	14			0.90
	I141502	2048	Prepared feeds, n.e.c.	14			0.89
	I142900	2079	Edible fats & oils, n.e.c.	14		5	0.71
	I142700	2077	Animal & marine fats & oils	14	10		0.65
	I141501	2047	Dog & cat food	14		11, 5	0.56
	I142101	2082	Malt beverages	11	14		0.56
	I141401	2041	Flour & other grain mill products	5		14	0.44
	I142600	2076	Vegetable oil mills, n.e.c.	5		14	0.42
	I290100	283	Drugs	3		14	0.35
15. Plate-making & Type-setting	I260806	2796	Platemaking & related services	15		6	0.81
	I260803	2791	Typesetting	15	6		0.68
	I142102	2083	Malt	15		5	0.63
	I480500	3555	Printing trades machinery & equip.	15	1		0.62
	I630300	386	Photographic equip. & supplies	15		4, 6	0.58
	I142103	2084	Wines, brandy, & brandy spirits	15		11	0.55
	I270404	2893	Printing ink	3		15	0.47
	I260400	274	Miscellaneous publishing	6		2, 15	0.47
	I260200	272	Periodicals	6		15, 2	0.43
	I142300	2087	Flavoring extracts & flavoring syrups, n.e.c.	11		5, 3, 15	0.40
	I640501	3951	Pens, mechanical pencils, & parts	5		10, 15	0.40
	I640105	3961	Costume jewelry	10		15	0.40
	I141000	2034	Dehydrated fruits, vegetables, & soups	5		15	0.38
	I240800	262-3	Paper & paperboard mills	5		6, 3, 15	0.35
16. Aluminum	I380400	3334, 2819	Primary aluminum	16			0.84
	I421000	3497	Metal foil & leaf	16			0.82
	I380600	334	Secondary nonferrous metals	16		1	0.80
	I230600	2591	Drapery hardware & window blinds & shades	16	1		0.72
	I400500	3442	Metal doors, sash, frames, molding, & trim	1	16		0.58
	I390100	3411	Metal cans	1		16	0.47
	I381400	3463	Nonferrous forgings	13		16, 1	0.47
	I380800	3353-5	Aluminum rolling & drawing	11		16	0.41
	I130300	3795	Tanks & tank components	1		16, 2	0.38

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
17. Brake Products	I361700	3292	Asbestos products	17			0.81
	I381100	3363, 3365	Aluminum castings	17			0.79
	I320600	3053	Gaskets, packing, & sealing devices	17	2		0.68
	I610700	3799	Transportation equip., n.e.c.	17	1	2	0.63
	I490200	3562	Ball & roller bearings	1	17		0.55
	I610601	3792	Travel trailers & campers	17		2	0.48
	I500400	3599	Industrial & commercial machinery &	1		17	0.43
	I500200	3593-4	Fluid power equip.	1		17	0.35
	I490500	3566, 3568	Mechanical power transmission equip.	1		17	0.35
18. Concrete, Cement, & Brick	I361000	3271	Concrete block & brick	18			0.94
	I361200	3273	Ready-mixed concrete	18			0.93
	I360100	324	Cement, hydraulic	18			0.90
	I361100	3272	Concrete products, except block & brick	1	18		0.66
	I130600	3482	Small arms ammunition	1	18		0.54
	I361900	3295	Minerals, ground or treated	1		18, 19	0.45
	I361400	3275	Gypsum products	6		18	0.41
	I361500	328	Cut stone & stone products	18			0.34
19. Earthern-ware Products	I360702	3263	Fine earthenware table & kitchenware	19			0.86
	I360900	3269	Pottery products, n.e.c.	19			0.83
	I360600	3261	Vitreous china plumbing fixtures	19			0.67
	I360800	3264	Porcelain electrical supplies	19			0.65
	I362200	3299	Nonmetallic mineral products, n.e.c.	19			0.61
	I360701	3262	Vitreous china table & kitchenware	1	19		0.58
	I360500	3259	Structural clay products, n.e.c.	3		19	0.46
	I361900	3295	Minerals, ground or treated	1		18, 19	0.38
20. Tobacco Products	I150101	212	Cigars	20			0.95
	I150102	214	Tobacco stemming & redrying	20			0.94
	I150103	213	Chewing & smoking tobacco & snuff	20			0.93
	I150200	211	Cigarettes	20			0.90
21. Dairy Products	I140300	2022	Natural, processed, & imitation cheese	21		5	0.79
	I140200	2021	Creamery butter	21	5		0.75
	I140600	2026	Fluid milk	21	5		0.67
	I140400	2023	Dry, condensed, & evaporated dairy products	5	21		0.61
	I140500	2024	Ice cream & frozen desserts	5	21		0.60
	I141100	2035	Pickles, sauces, & salad dressings	5		10, 21	0.36
22. Petroleum	I270405	2895	Carbon black	22		3	0.83
	I310200	2951	Asphalt paving mixtures & blocks	22		3	0.83
	I310101	291	Petroleum refining	22	3		0.74
	I310103	2999	Products of petroleum & coal, n.e.c.	3		22	0.43
	I310102	2992	Lubricating oils & greases	1		22	0.40

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.1: Benchmark Manufacturing Clusters (Secondary Industries Shaded)

Cluster	I-O Code	SIC Sector	Description	Cluster ID L1	L2	L3	Load
23. Meat Products	I140102	2013	Sausages & other prepared meat products	23			0.90
	I140101	2011	Meat packing plants	23			0.87
	I330001	311	Leather tanning & finishing	23	12		0.57
	I140105	2015	Poultry slaughtering & processing	23		5	0.51
	I141302	2038	Frozen specialties, n.e.c.	5		23	0.49

Note: L1 gives the cluster for which the row sector obtained the highest loading. L2 gives the next highest cluster on which the sector loaded, for values over .50. L3 gives clusters for loadings between .35 and .50.

Table A.2
Non-Primary Loading Industry Sectors, 1993 Estimated U.S. Output
(Maximum Loadings < .60)

SIC	Description	Maximum Load	Cluster ID L1	Cluster ID L3	Est. U.S. Output (Millions)	Percent Total Non-Loading	Percent Total All US Manf.	Percent Total All NC Manf.
2015	Poultry slaughtering & processing	0.51	23	5	19,223	7.1%	0.7%	2.0%
2035	Pickles, sauces, & salad dressings	0.57	5	21	5,114	1.9%	0.2%	0.2%
2092	Prepared fresh or frozen fish & seafoods	0.43	5		7,163	2.6%	0.3%	0.1%
2047	Dog & cat food	0.56	14	11, 5	6,410	2.4%	0.2%	0.0%
2046	Wet corn milling	0.50	5	11	4,824	1.8%	0.2%	0.0%
2068	Salted & roasted nuts & seeds	0.48	5		2,091	0.8%	0.1%	0.2%
2084	Wines, brandy, & brandy spirits	0.55	15	11	3,858	1.4%	0.1%	0.0%
2085	Distilled & blended liquors	0.35	11	11	7,545	2.8%	0.3%	0.0%
2087	Flavoring extracts & flavoring syrups, n.e.c.	0.49	11	5, 3, 15	12,796	4.7%	0.5%	0.0%
2097	Manufactured ice	0.35	5		334	0.1%	0.0%	0.0%
2296	Tire cord & fabrics	0.51	8		1,271	0.5%	0.0%	0.1%
2298	Cordage & twine	0.52	8		532	0.2%	0.0%	0.1%
2297	Nonwoven fabrics	0.48	3	8	1,475	0.5%	0.1%	0.3%
2429	Special product sawmills, n.e.c.	0.51	7		149	0.1%	0.0%	0.0%
2519	Household furniture, n.e.c.	0.47	3		467	0.2%	0.0%	0.1%
2541	Wood partitions & fixtures	0.56	2	7	2,891	1.1%	0.1%	0.1%
262-3	Paper & paperboard mills	0.44	5	6, 3, 15	48,496	17.8%	1.9%	1.8%
2892	Explosives	0.49	3		635	0.2%	0.0%	0.0%
283	Drugs	0.47	3	14	56,229	20.7%	2.2%	3.8%
2844	Toilet preparations	0.55	5	3	17,251	6.3%	0.7%	0.7%
311	Leather tanning & finishing	0.57	23		2,358	0.9%	0.1%	0.1%
3221	Glass containers	0.59	5		4,229	1.6%	0.2%	0.2%
328	Cut stone & stone products	0.34	18		789	0.3%	0.0%	0.0%
3291	Abrasive products	0.59	3		2,482	0.9%	0.1%	0.1%
3295	Minerals, ground or treated	0.56	1	18, 19	1,991	0.7%	0.1%	0.0%
3399	Primary metal products, n.e.c.	0.48	10	4, 3	1,351	0.5%	0.1%	0.1%
3463	Nonferrous forgings	0.59	13	16, 1	815	0.3%	0.0%	0.0%
3432	Plumbing fixture fittings & trim	0.27	10		3,545	1.3%	0.1%	0.3%
3442	Metal doors, sash, frames, molding, & trim	0.58	1		6,041	2.2%	0.2%	0.2%
3546	Power-driven handtools	0.48	1		2,667	1.0%	0.1%	0.4%
3543	Industrial patterns	0.45	1		486	0.2%	0.0%	0.0%
3652	Prerecorded records & tapes	0.54	6	4	5,091	1.9%	0.2%	0.2%
3671	Electron tubes	0.49	4		2,292	0.8%	0.1%	0.0%
3732	Boat building & repairing	0.43	1		3,773	1.4%	0.1%	0.2%
3792	Travel trailers & campers	0.48	17	2	1,872	0.7%	0.1%	0.0%
387	Watches, clocks, watchcases, & parts	0.17	4		812	0.3%	0.0%	0.0%
386	Photographic equip. & supplies	0.58	15	4, 6	21,471	7.9%	0.8%	0.3%
3915	Jewelers' materials & lapidary work	0.45	10	3	1,215	0.4%	0.0%	0.0%
3961	Costume jewelry	0.53	10	15	1,155	0.4%	0.0%	0.0%
393	Musical instruments	0.59	4	7	937	0.3%	0.0%	0.0%
3944	Games, toys, & children's vehicles	0.42	5	3, 6	4,539	1.7%	0.2%	0.1%
3951	Pens, mechanical pencils, & parts	0.57	5	15	915	0.3%	0.0%	0.0%
3991	Brooms & brushes	0.57	9		1,023	0.4%	0.0%	0.1%
3996	Hard surface floor coverings, n.e.c.	0.49	3		1,509	0.6%	0.1%	0.0%
Totals:					272,115	100.0%	10.5%	11.9%

Source: BEA, NCESC, and authors' calculations (see Appendix 4). Last column gives the sector's estimated NC output in 1994 as a percent of total NC estimated output.

APPENDIX 2

Additional Figures

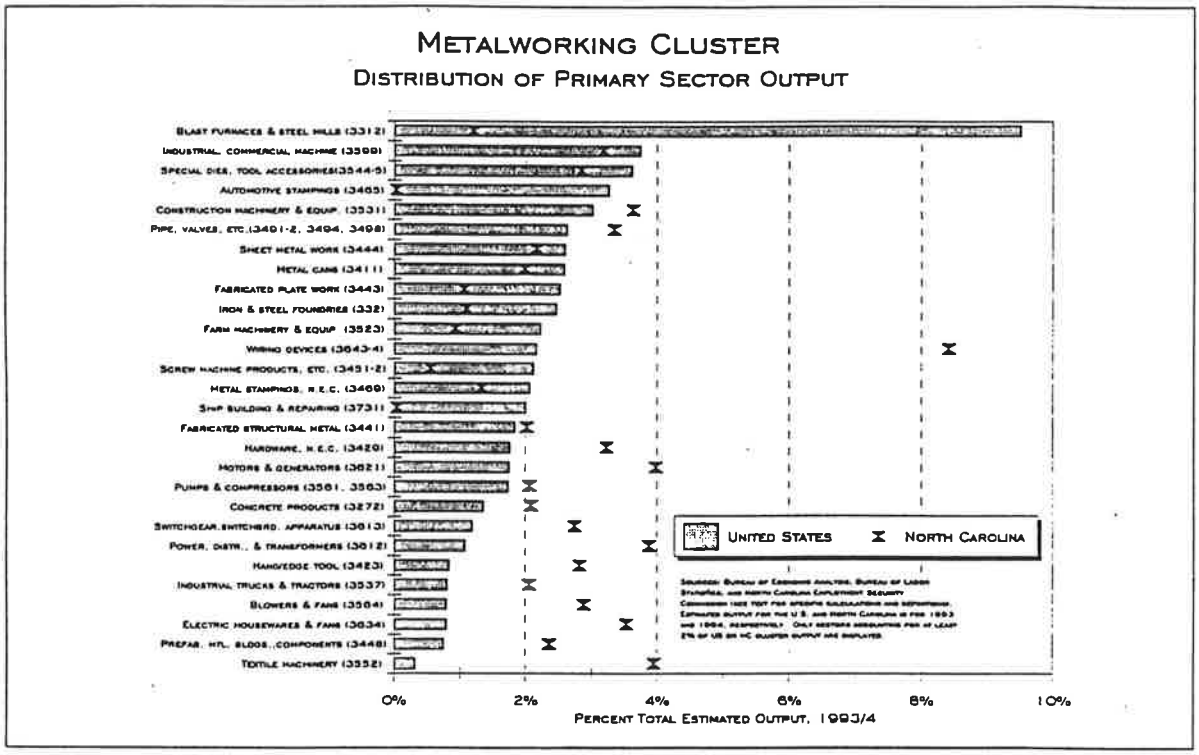


Figure A.1

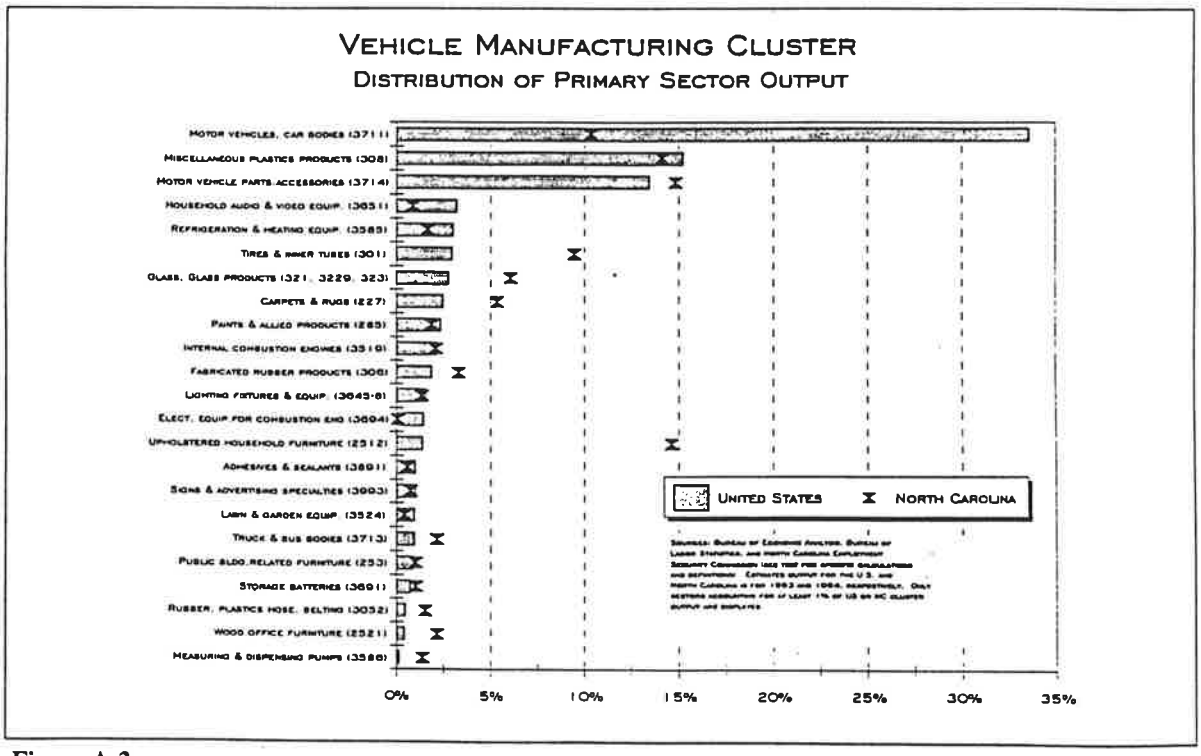
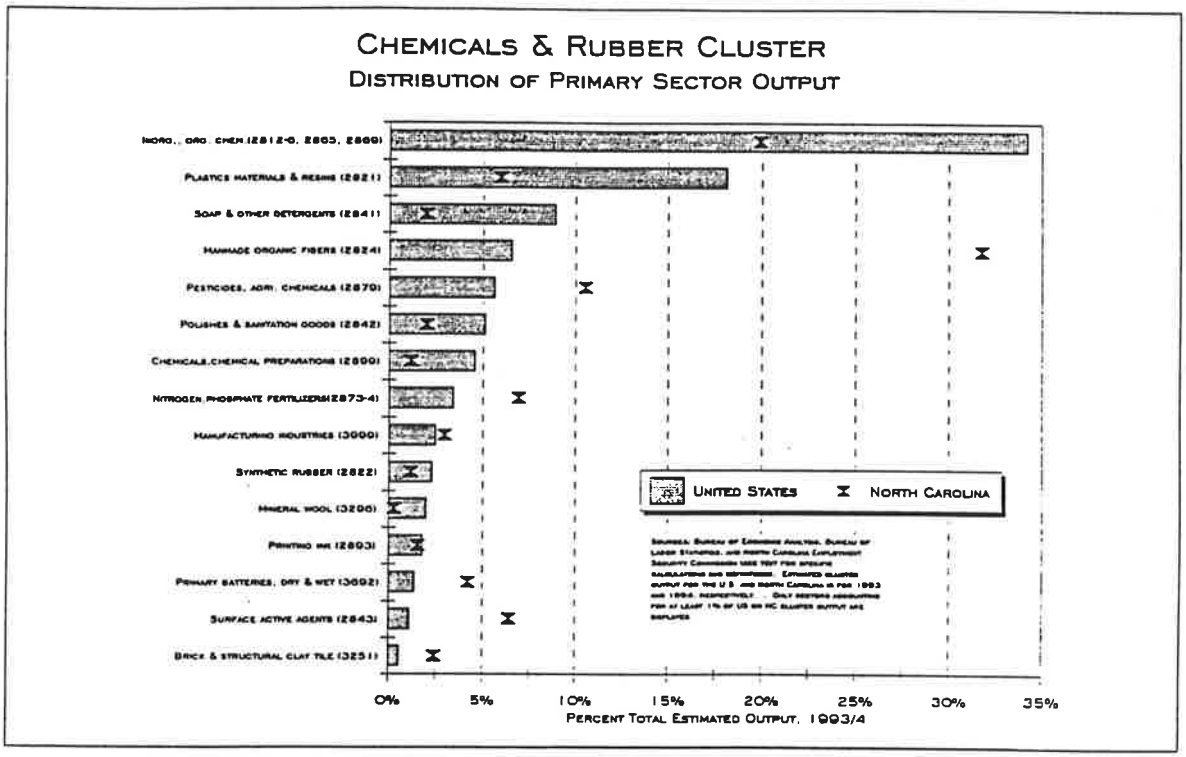


Figure A.2



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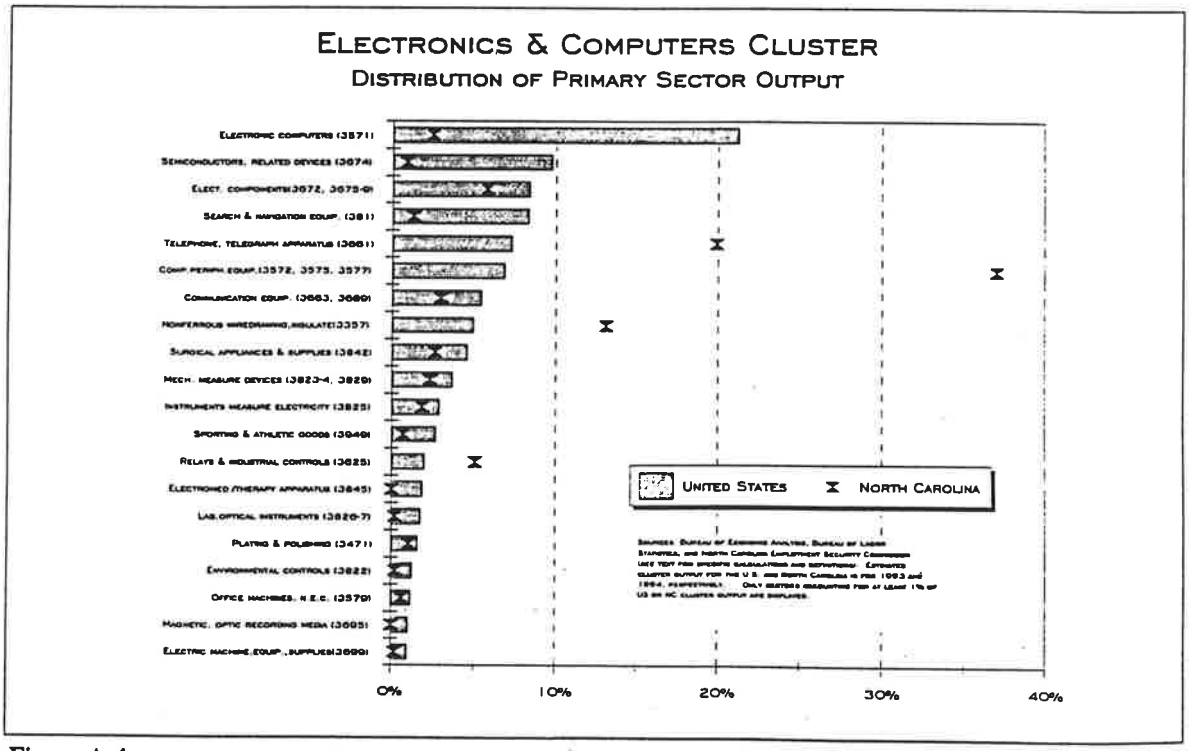

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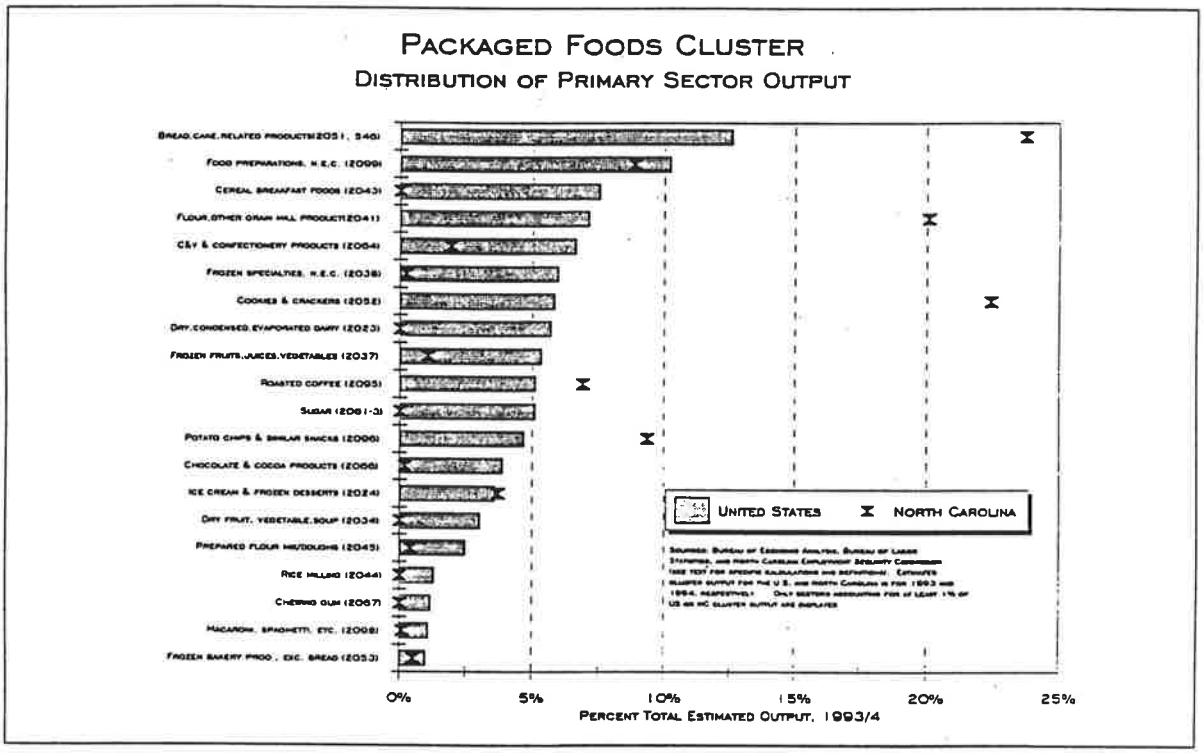

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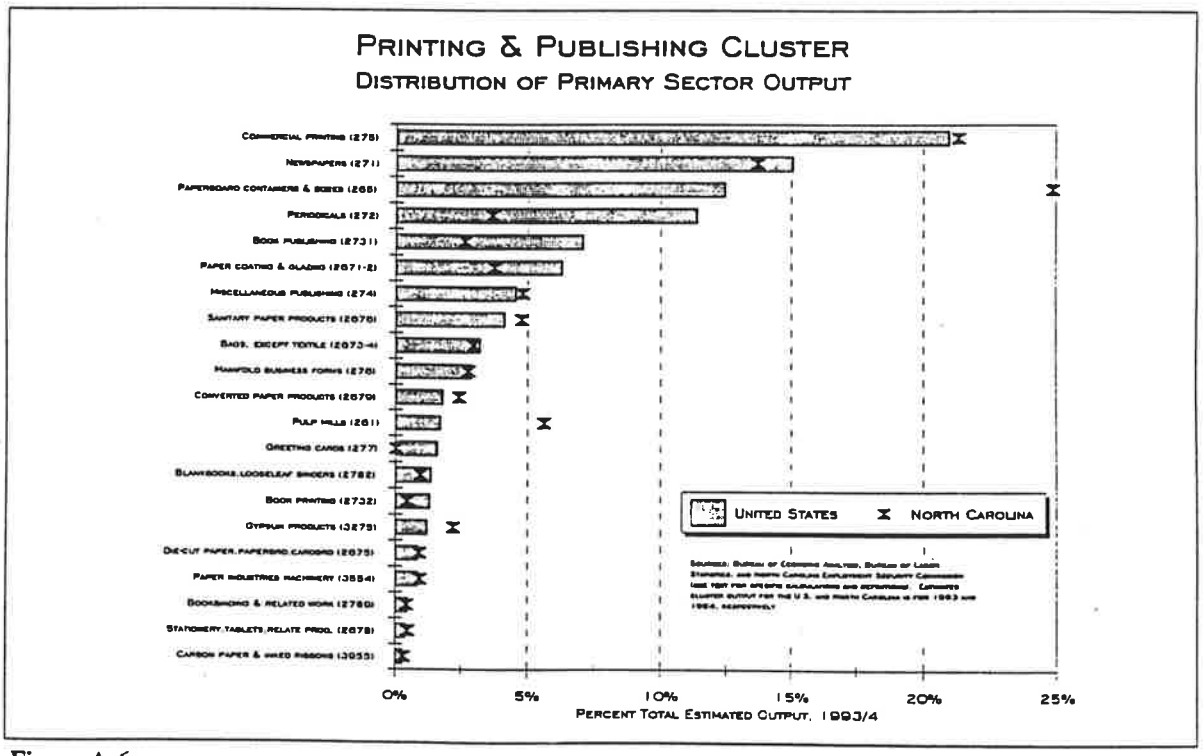

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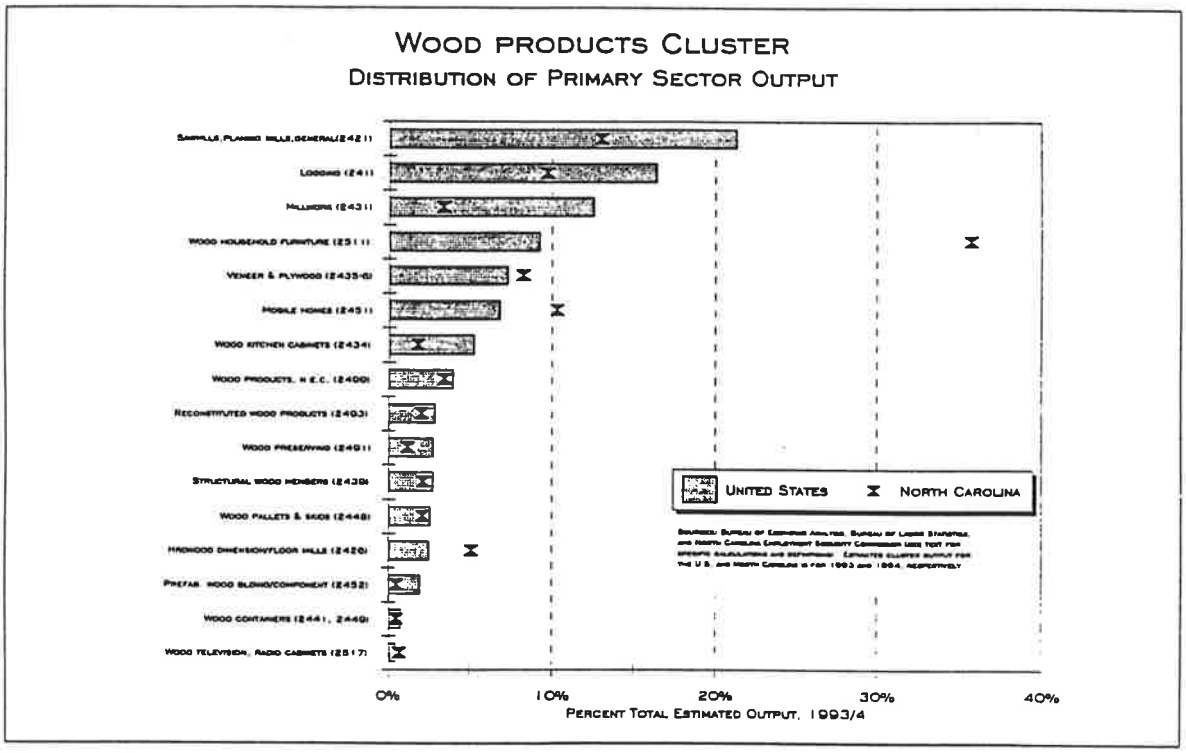

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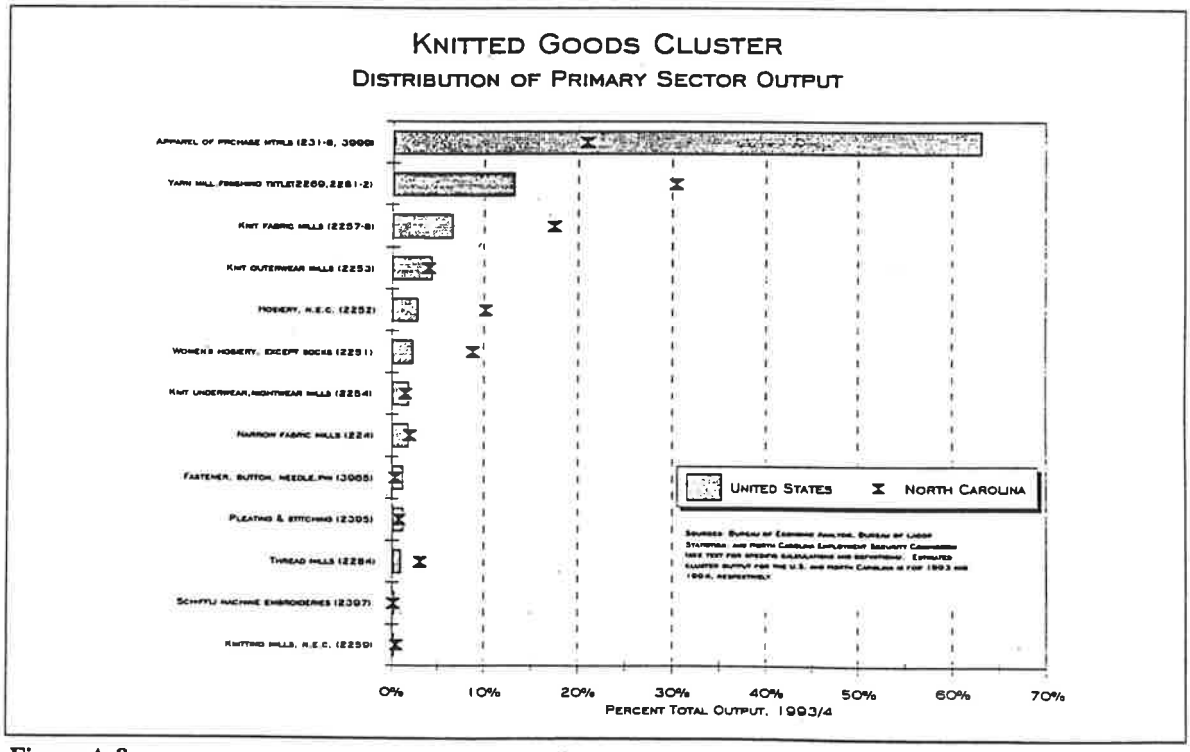

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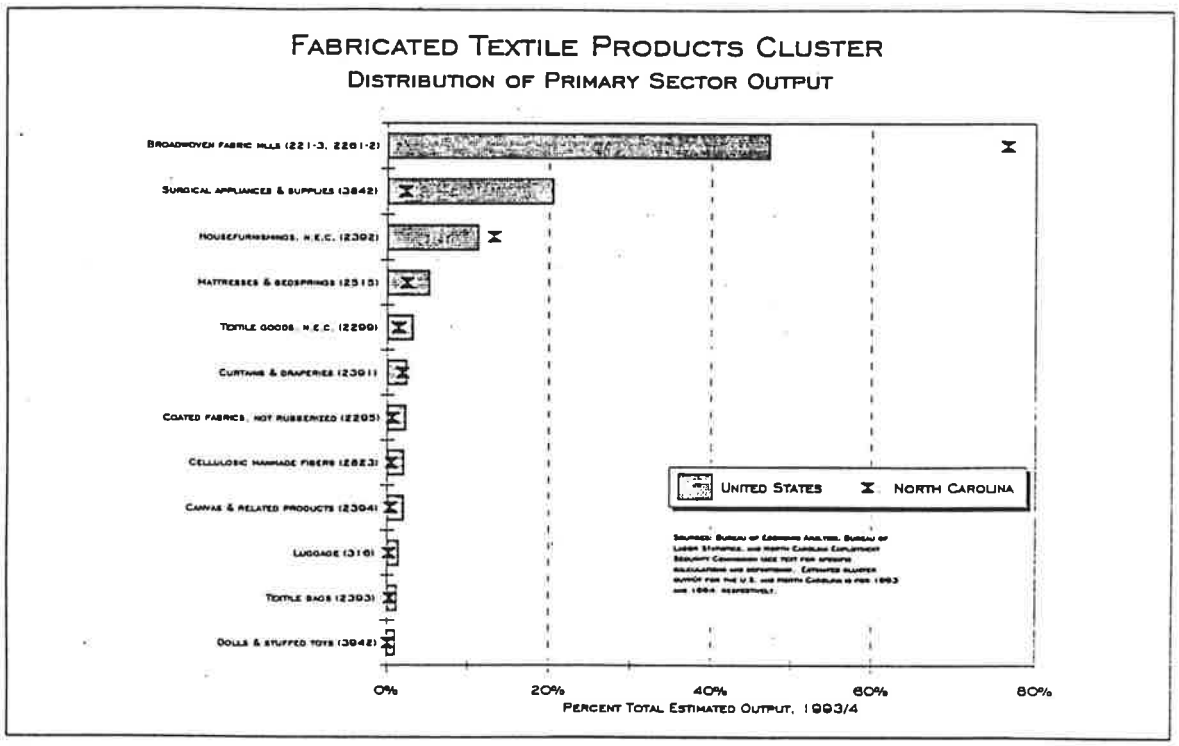

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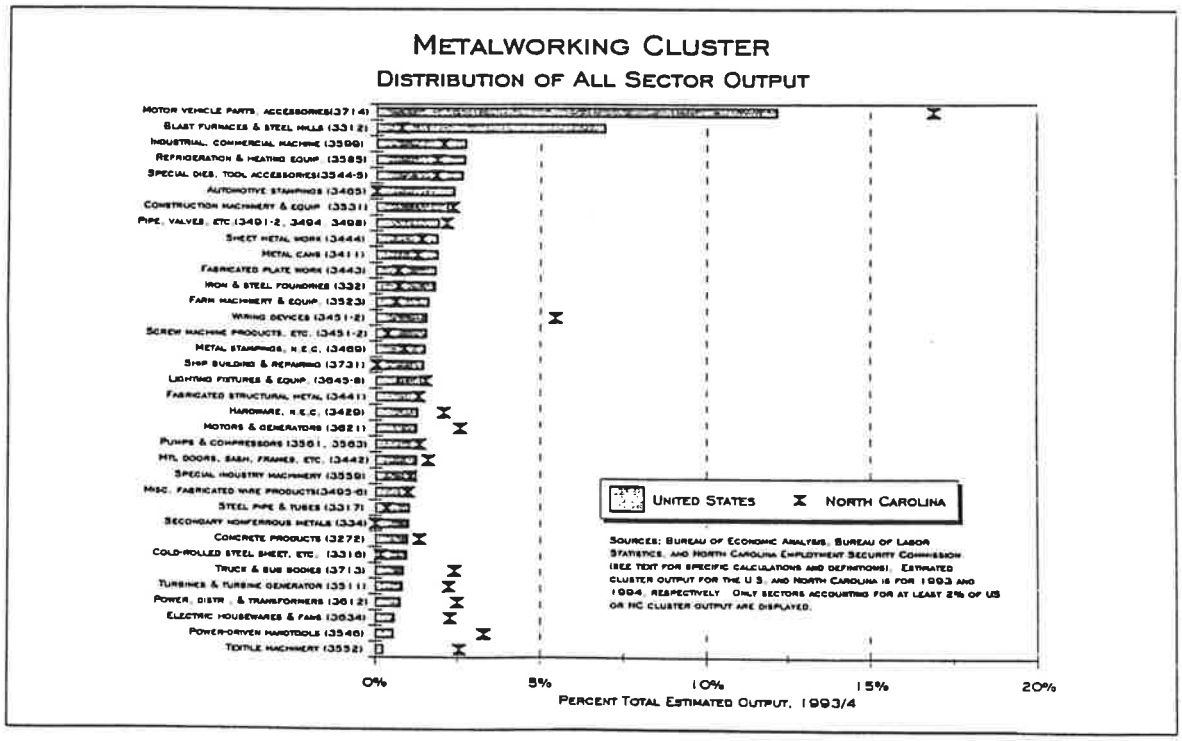

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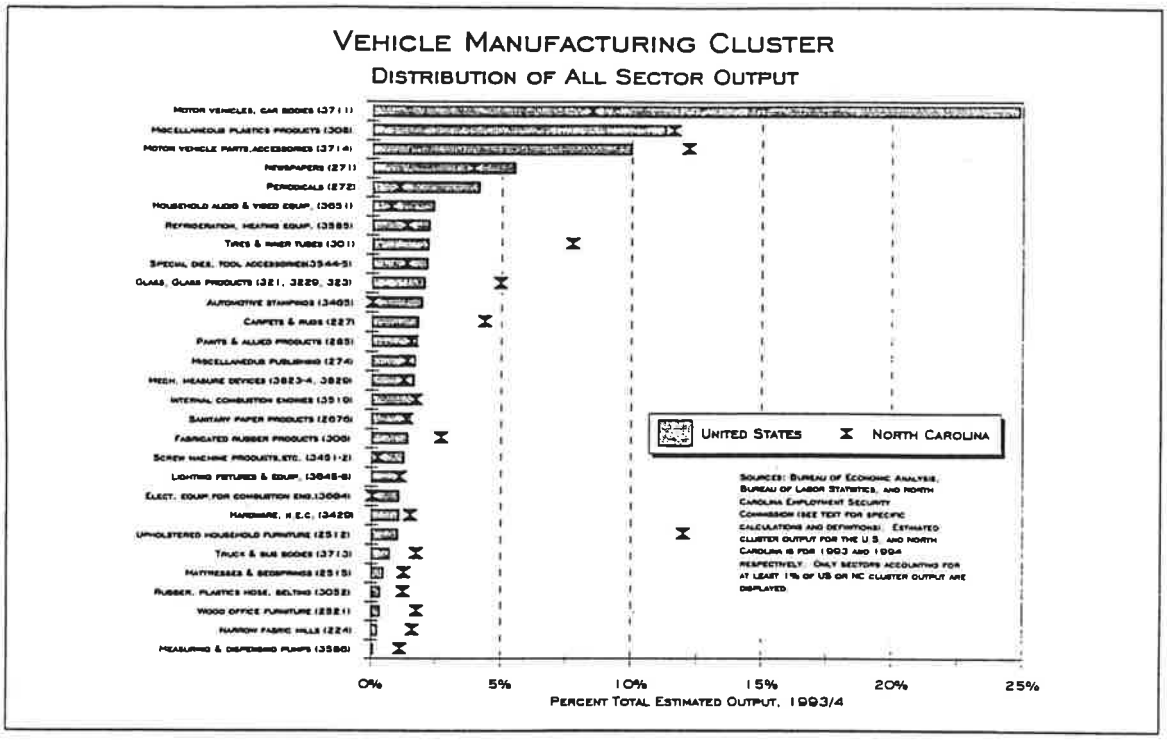

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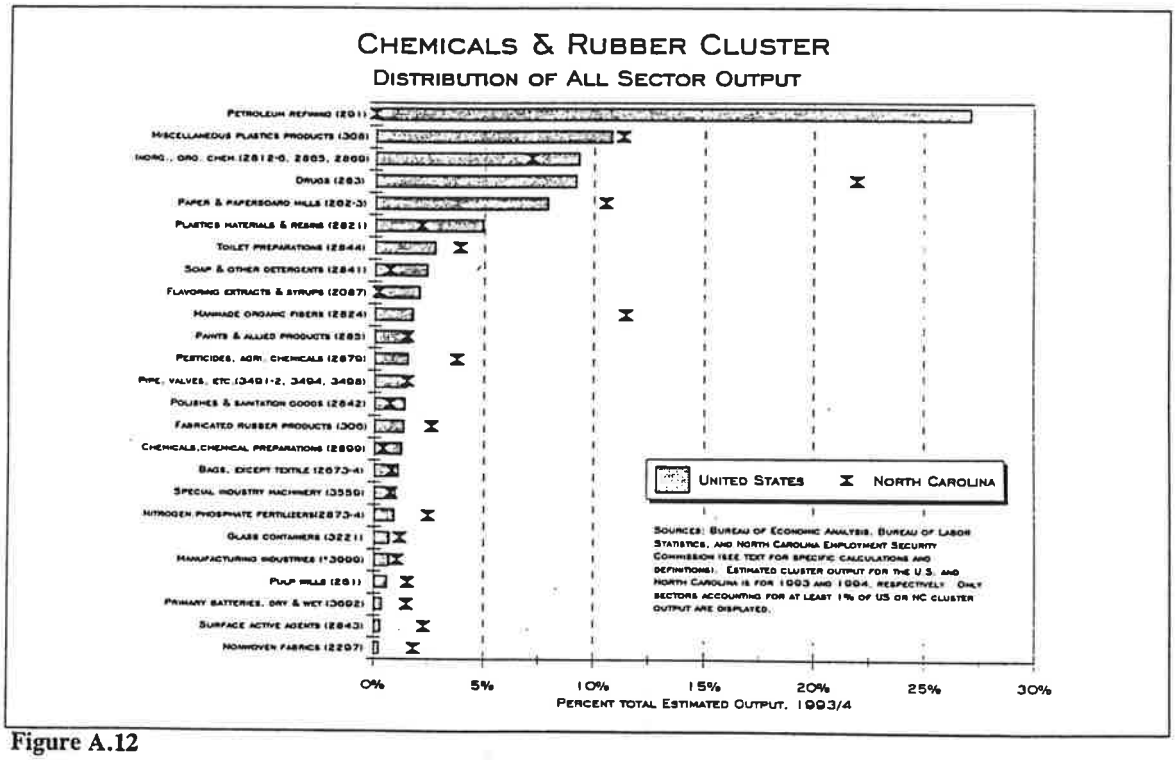

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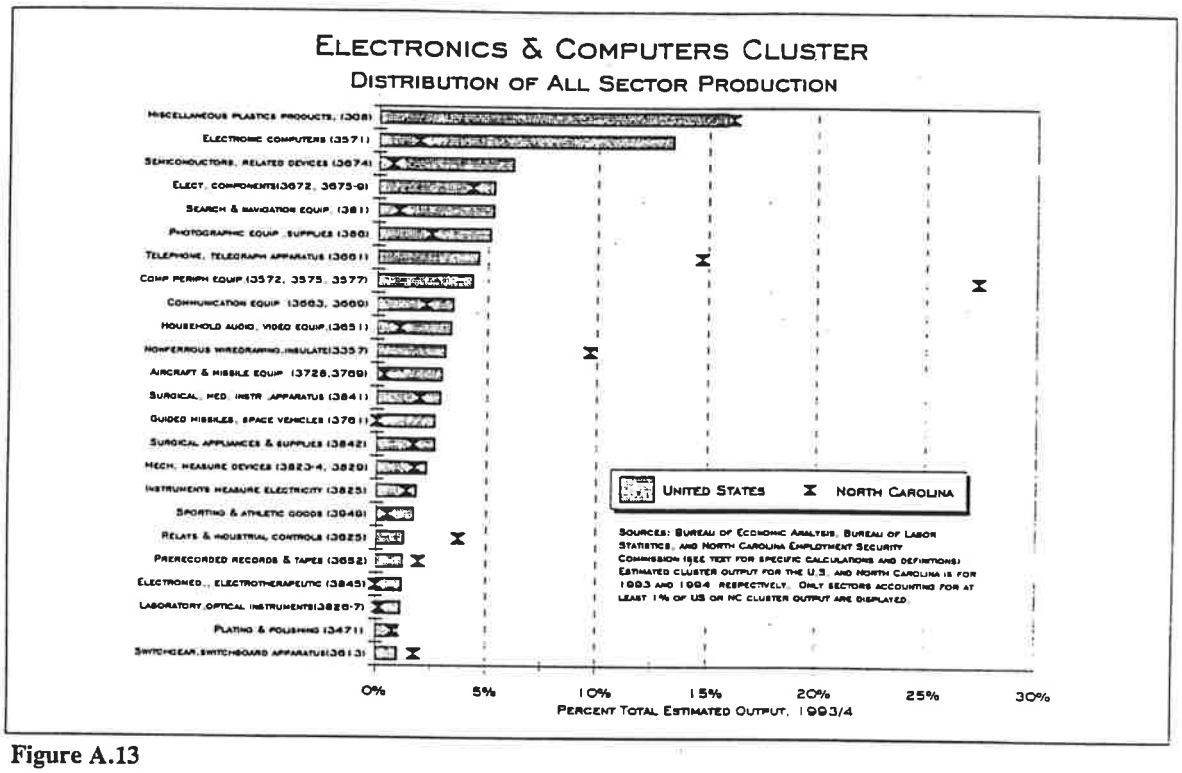

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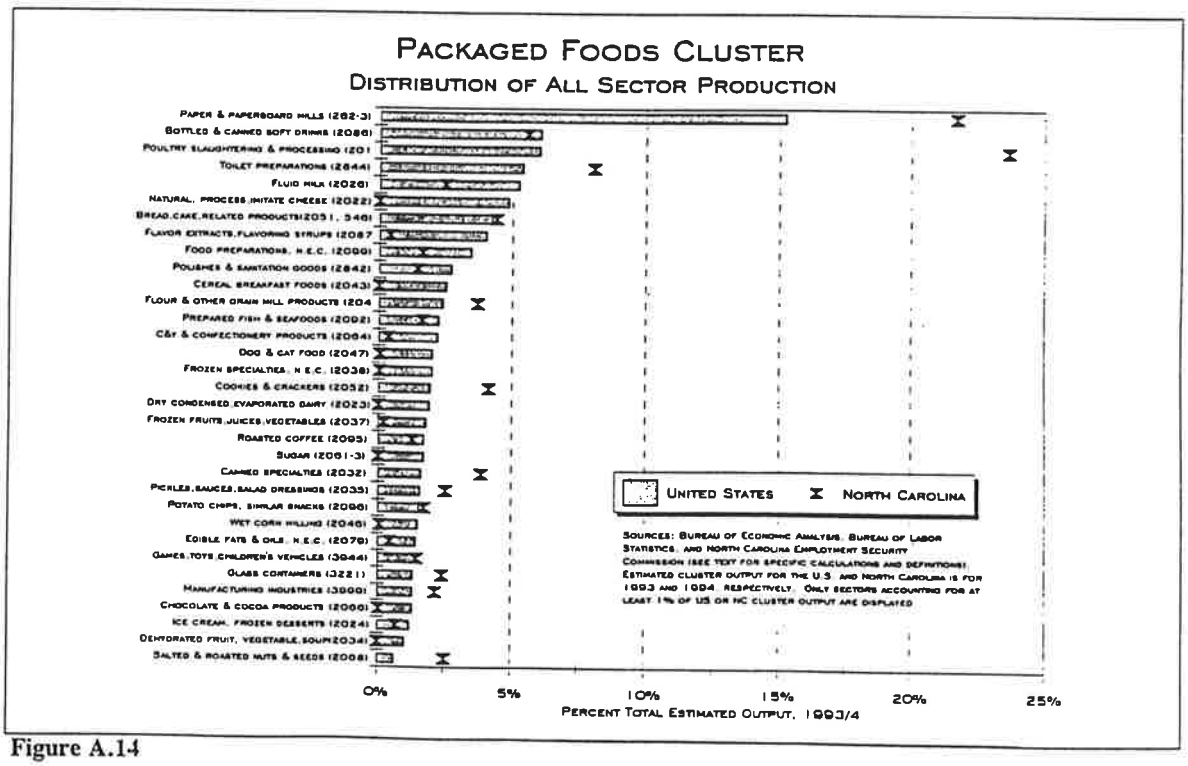

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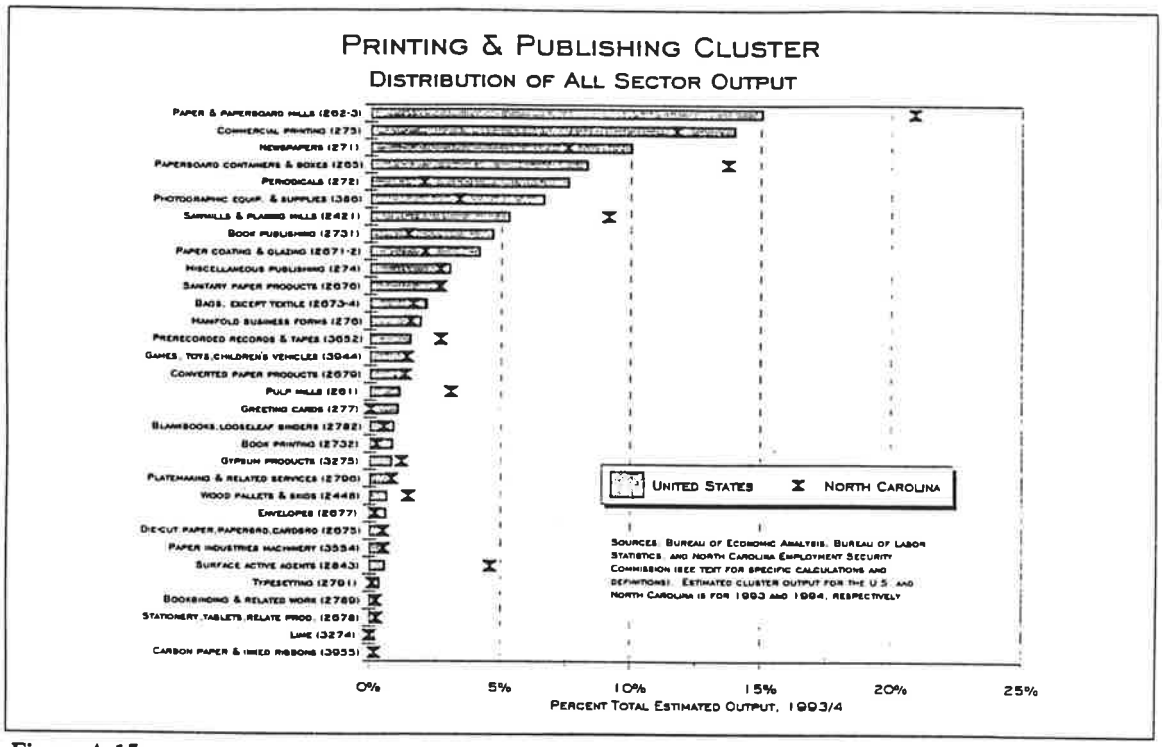

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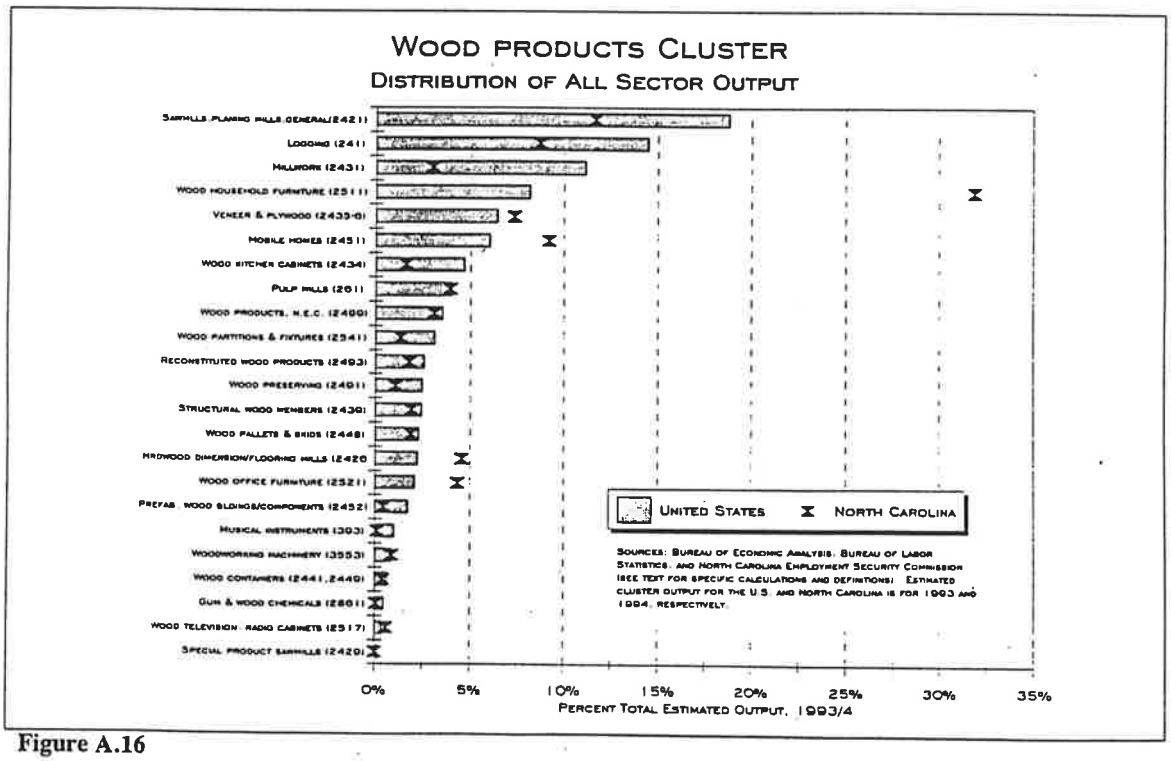

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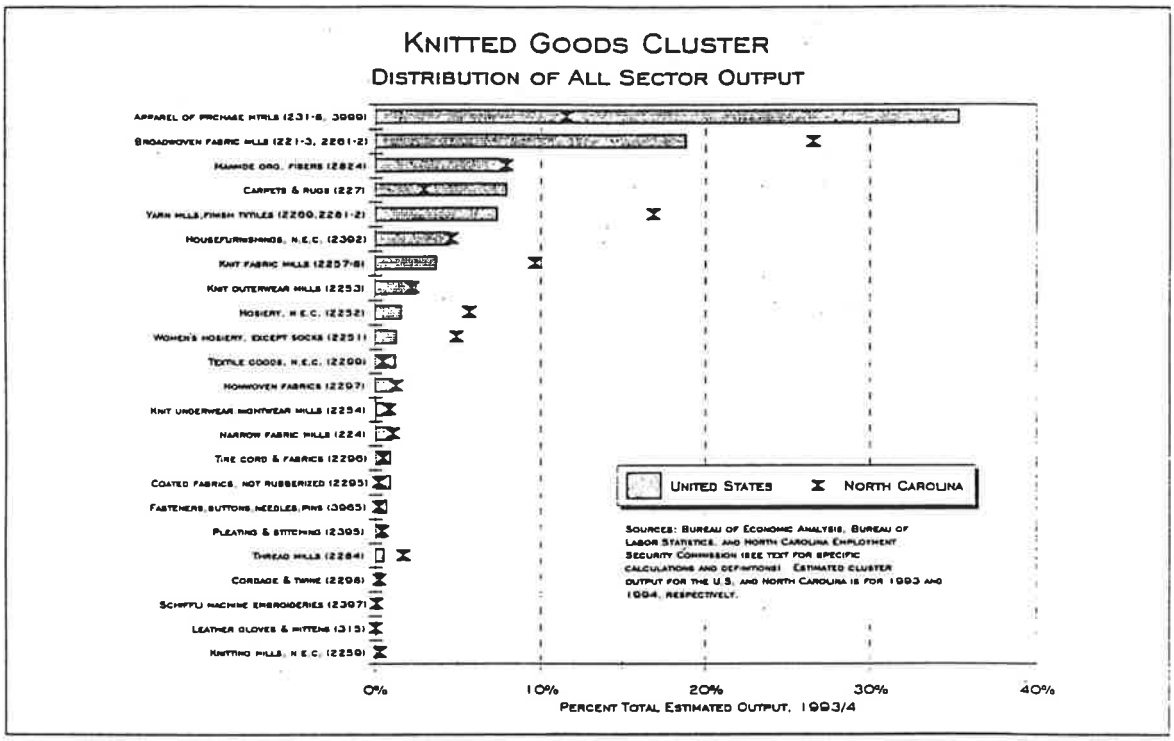

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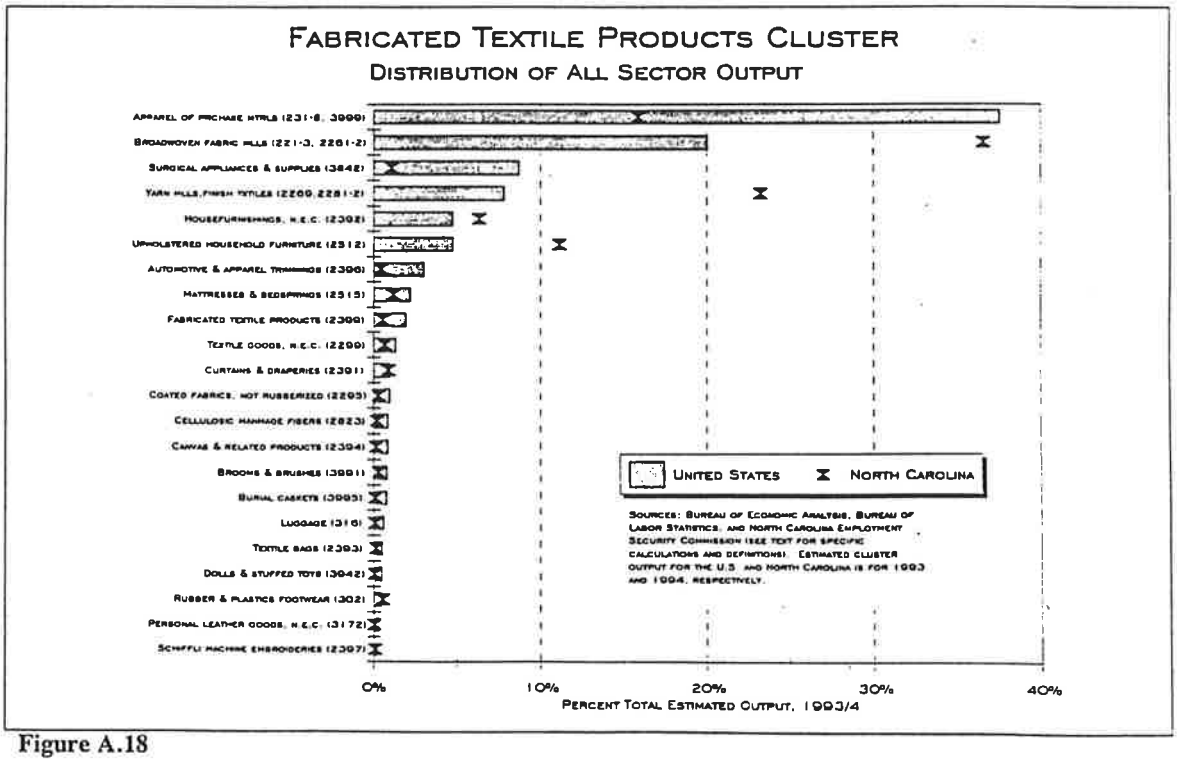

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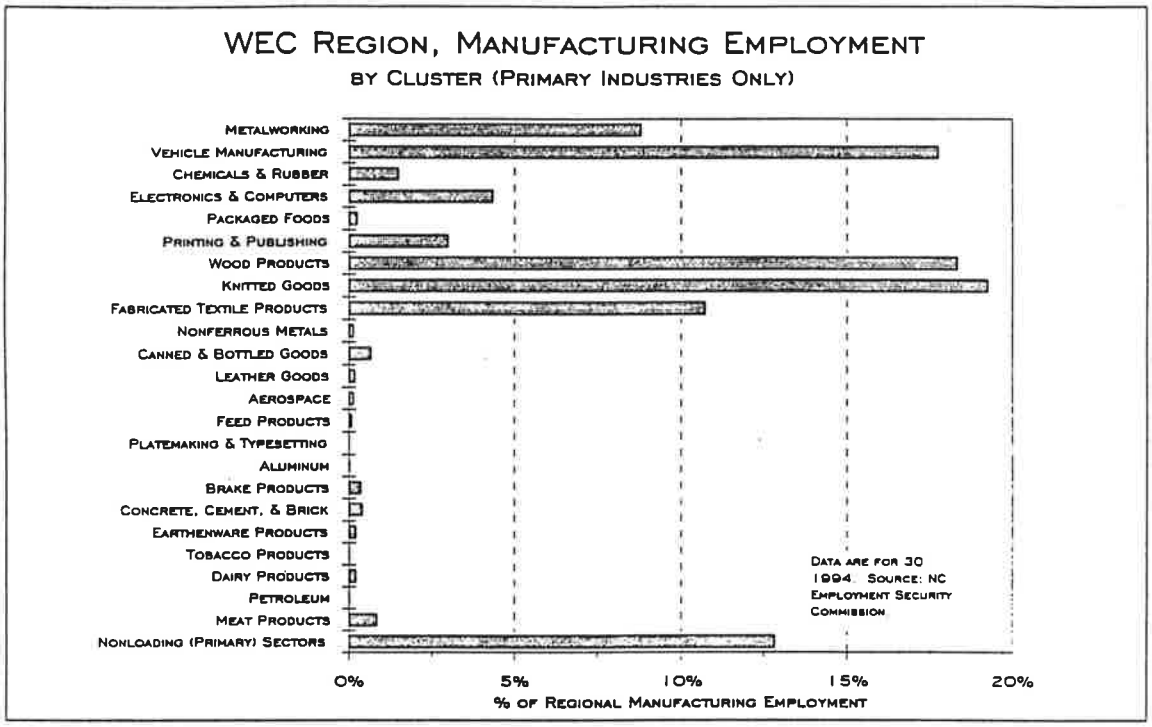

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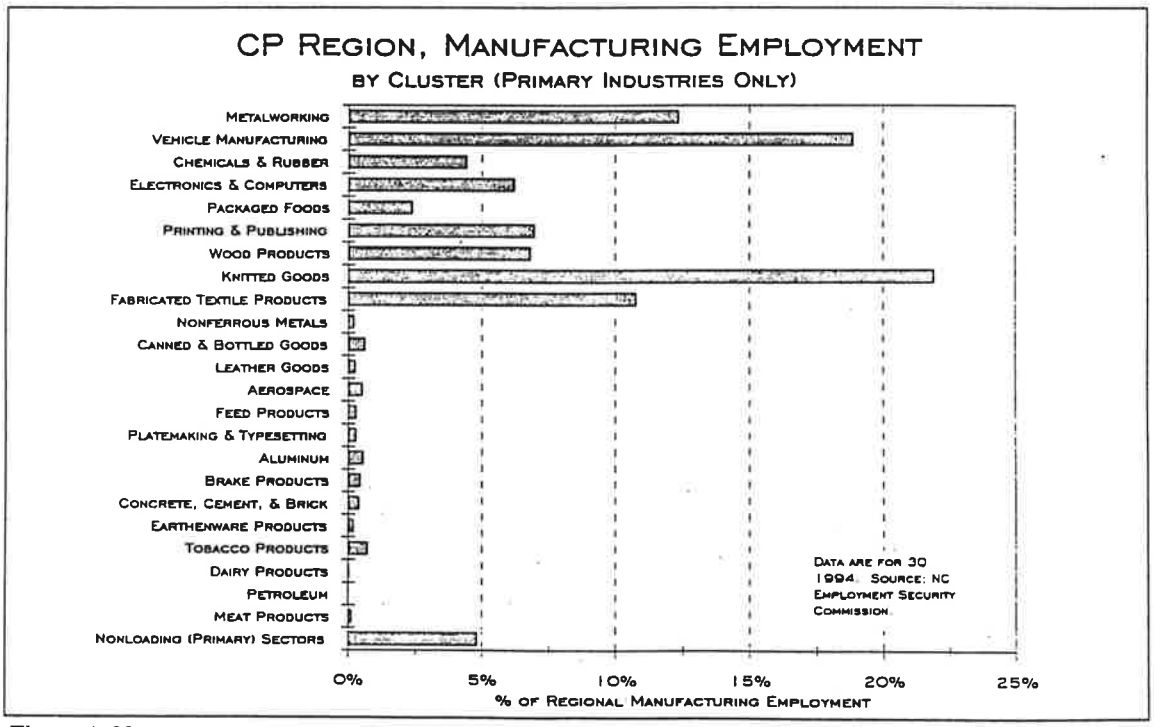

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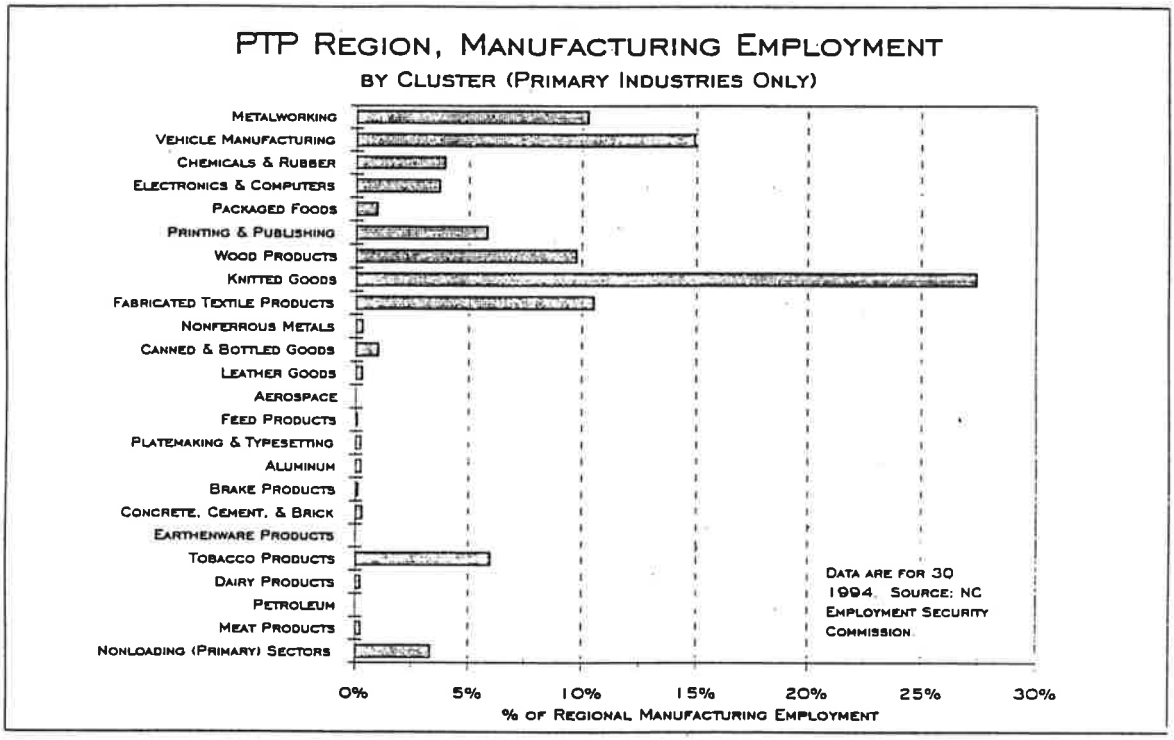

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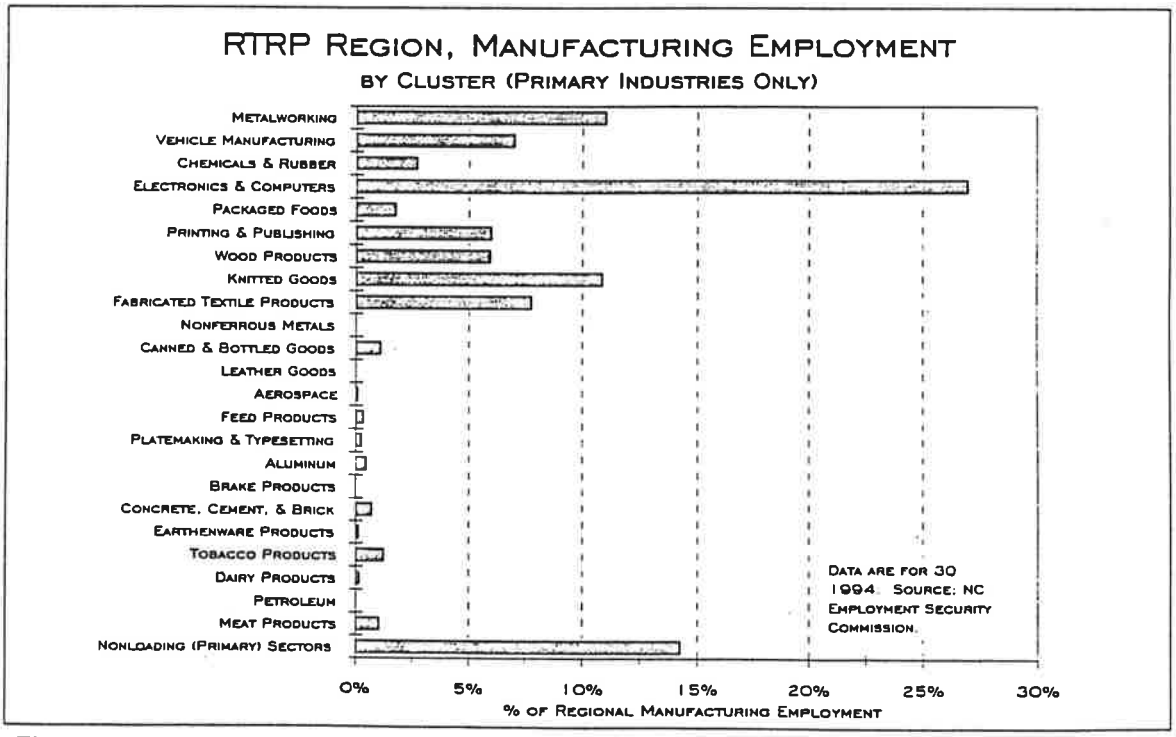

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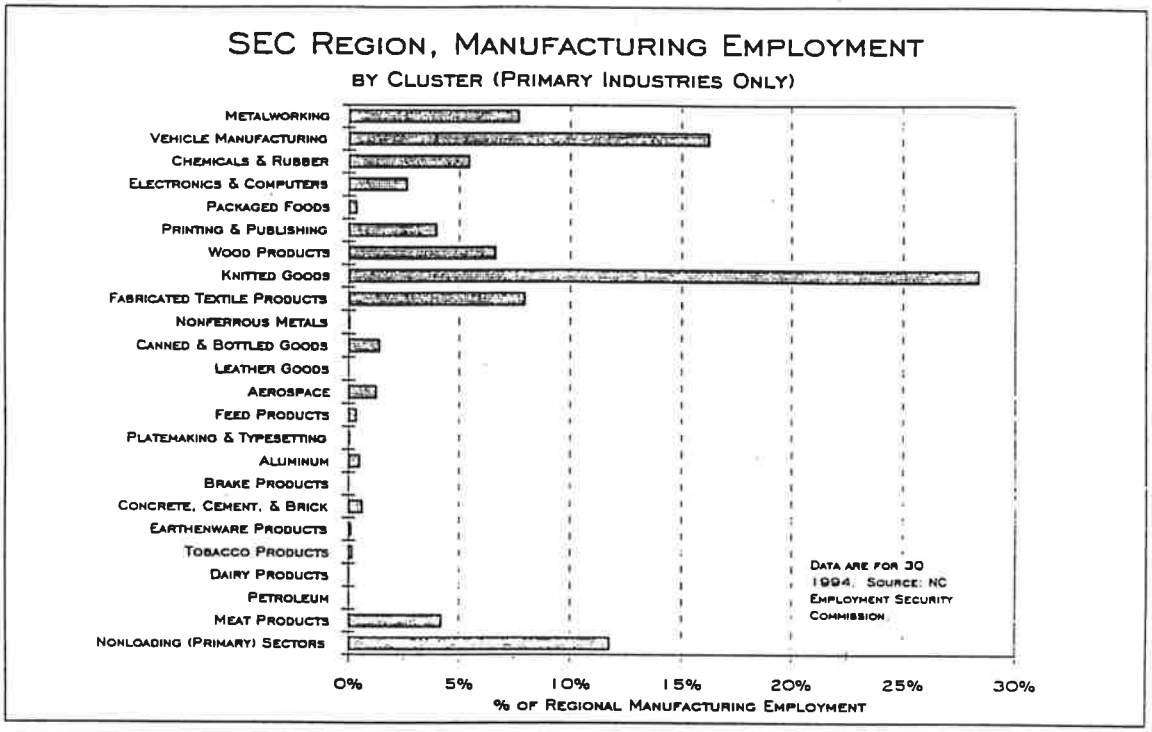

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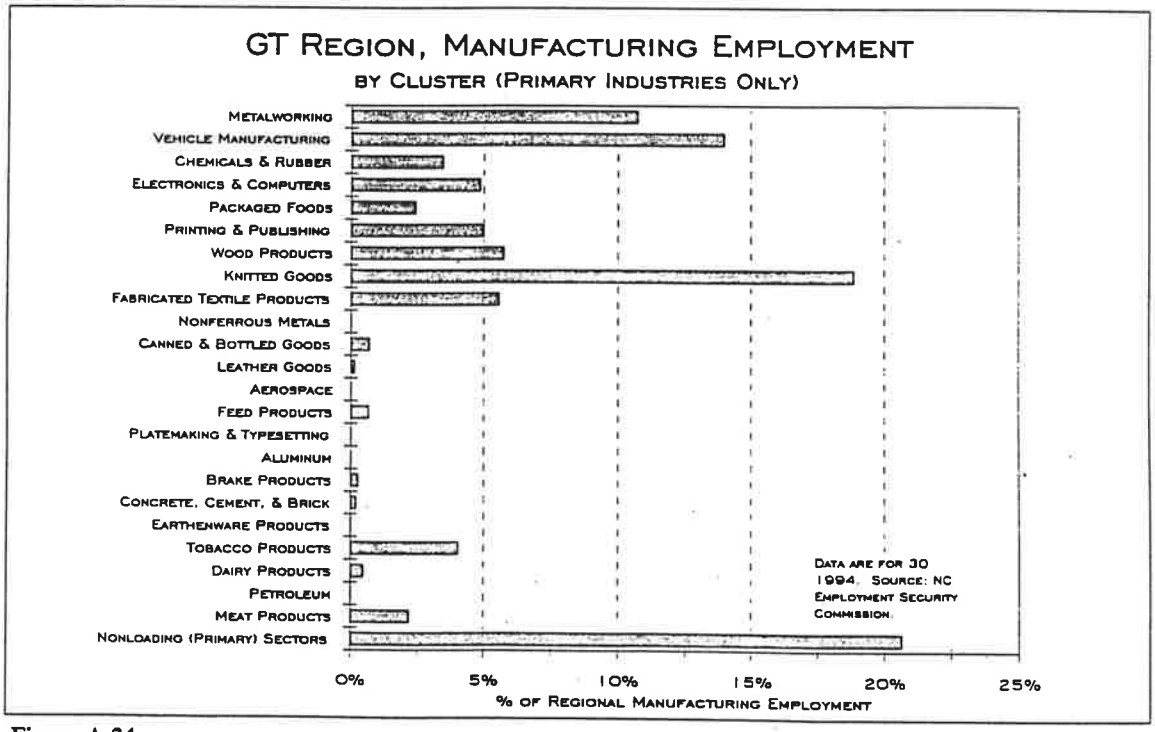

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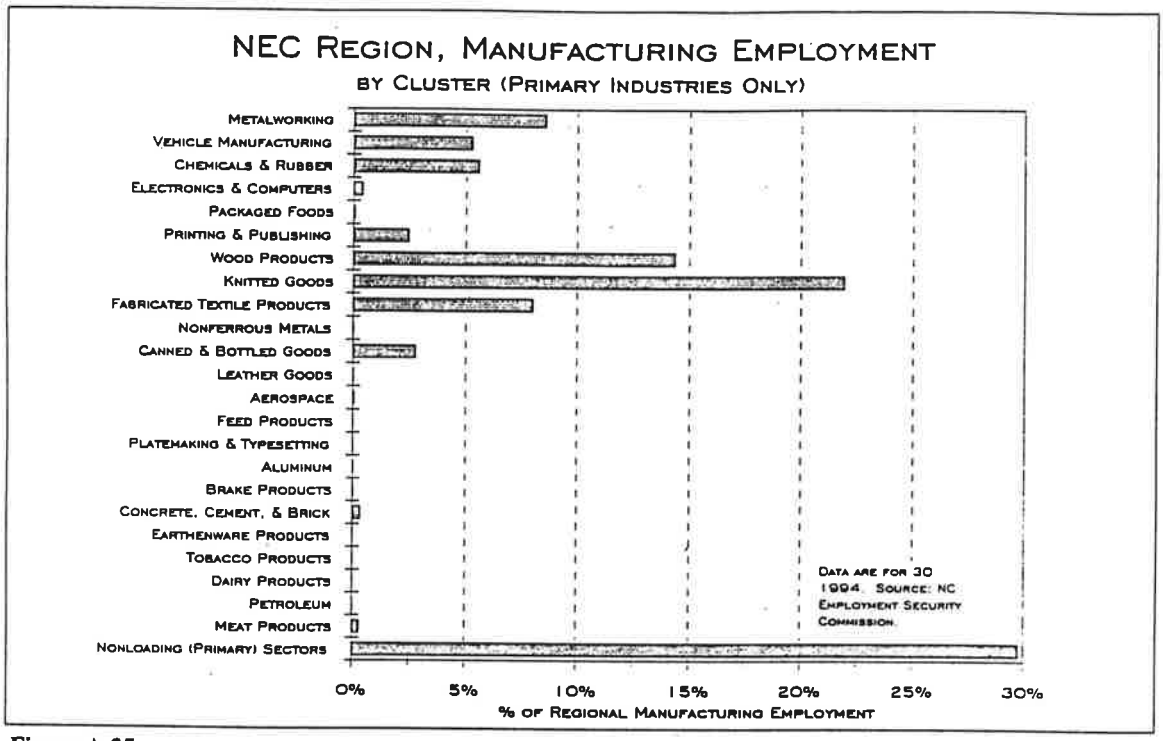

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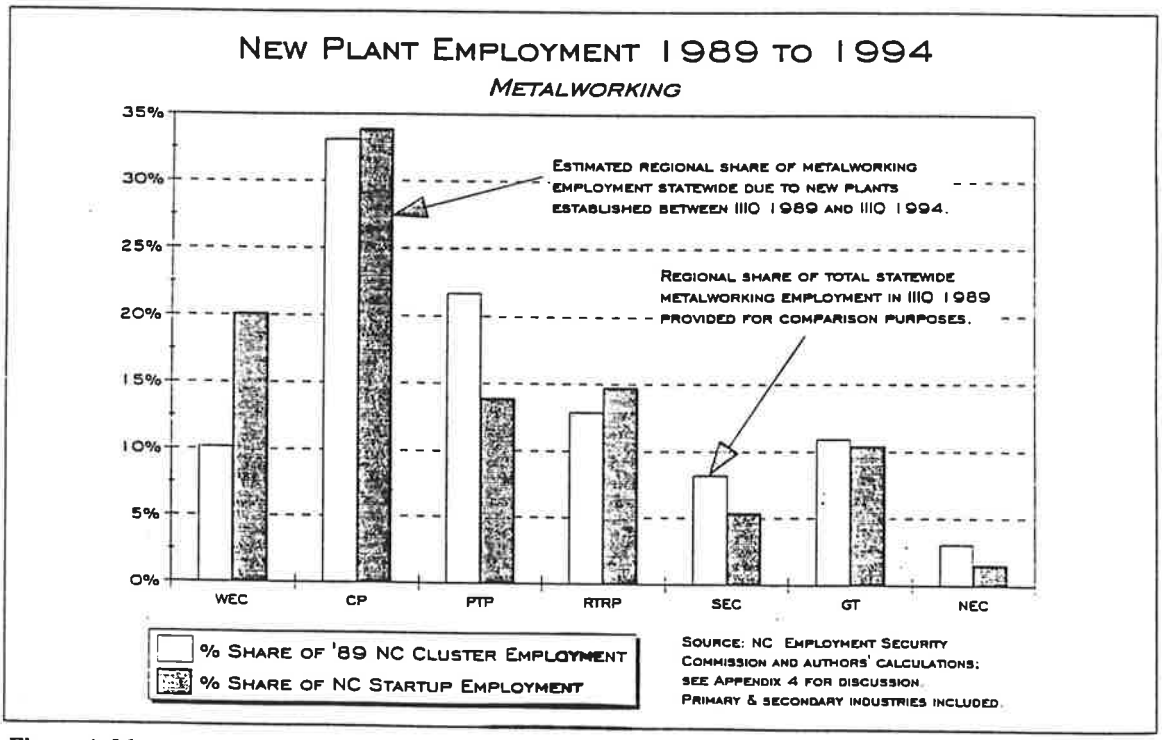

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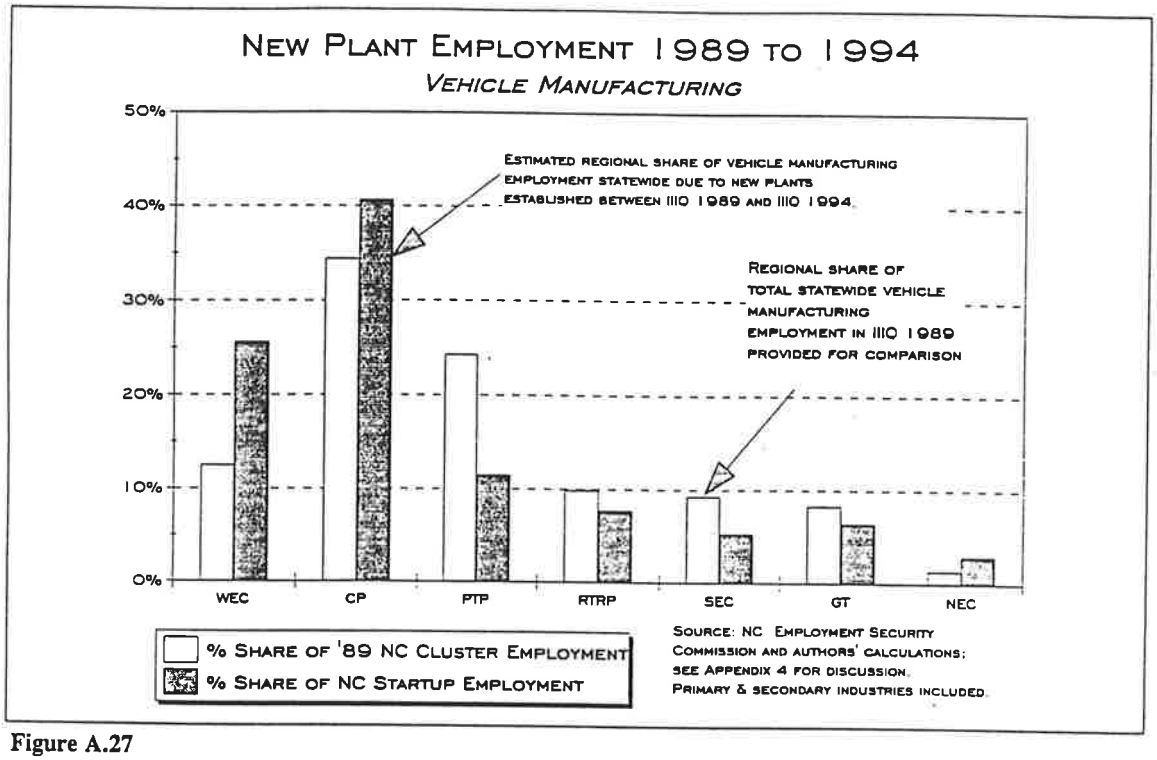

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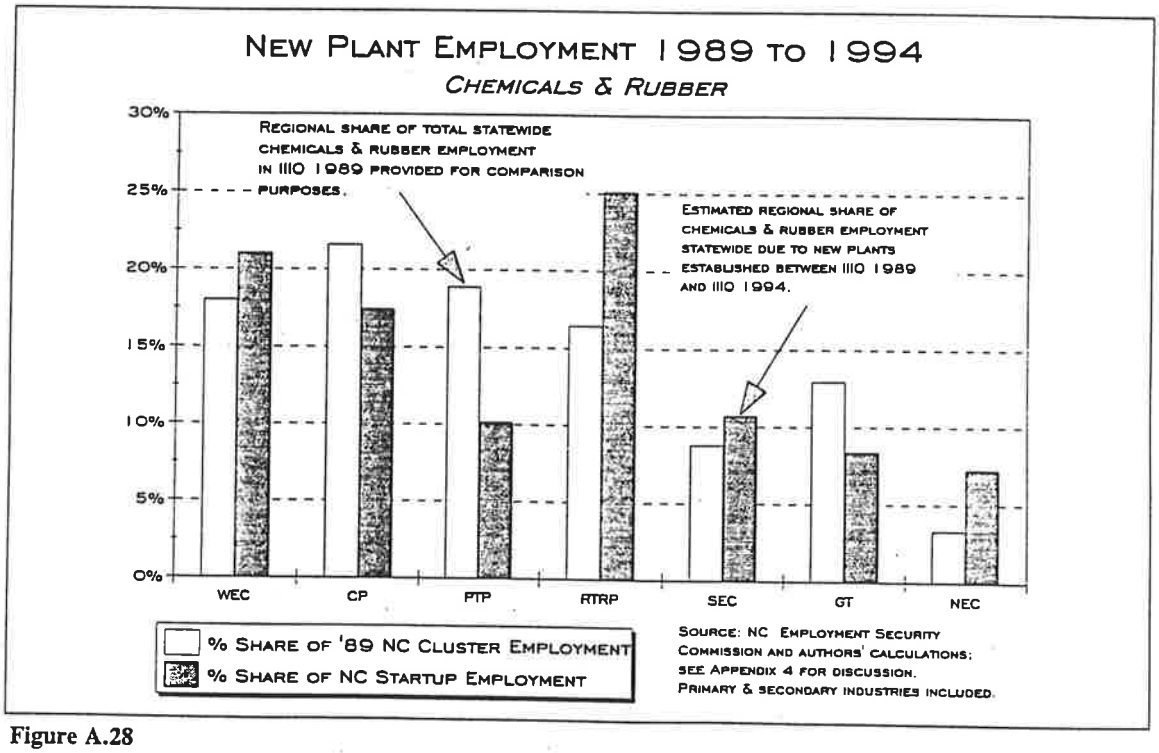

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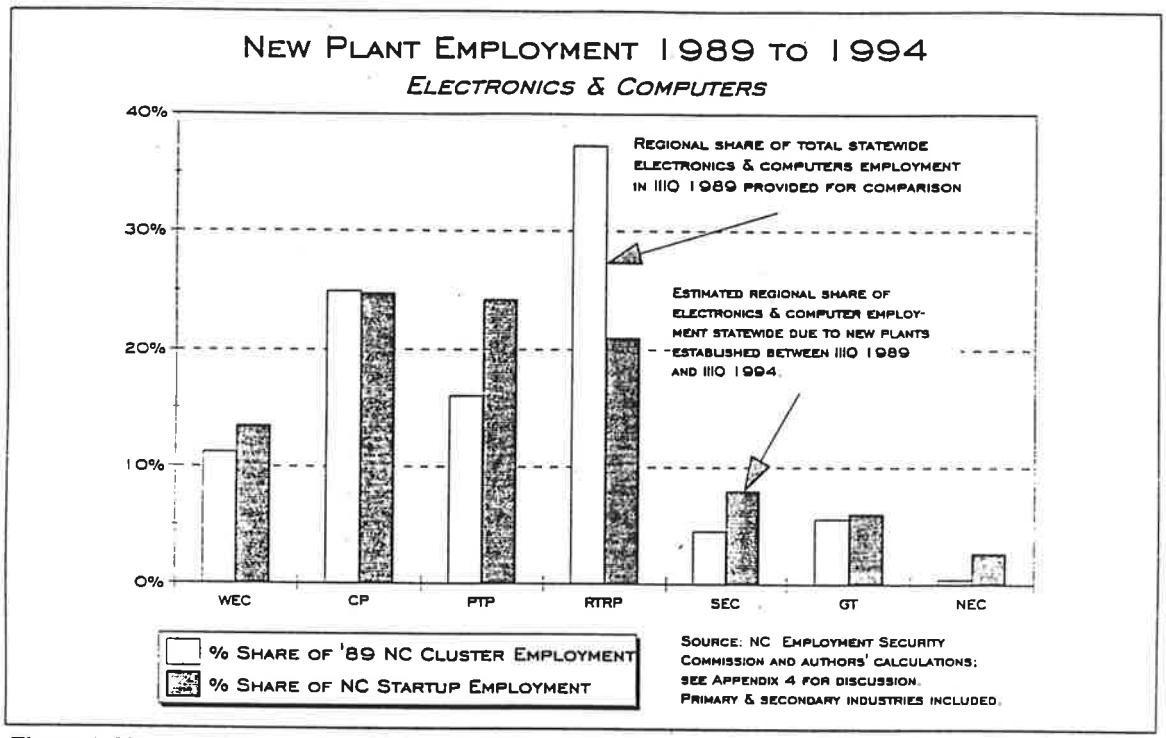

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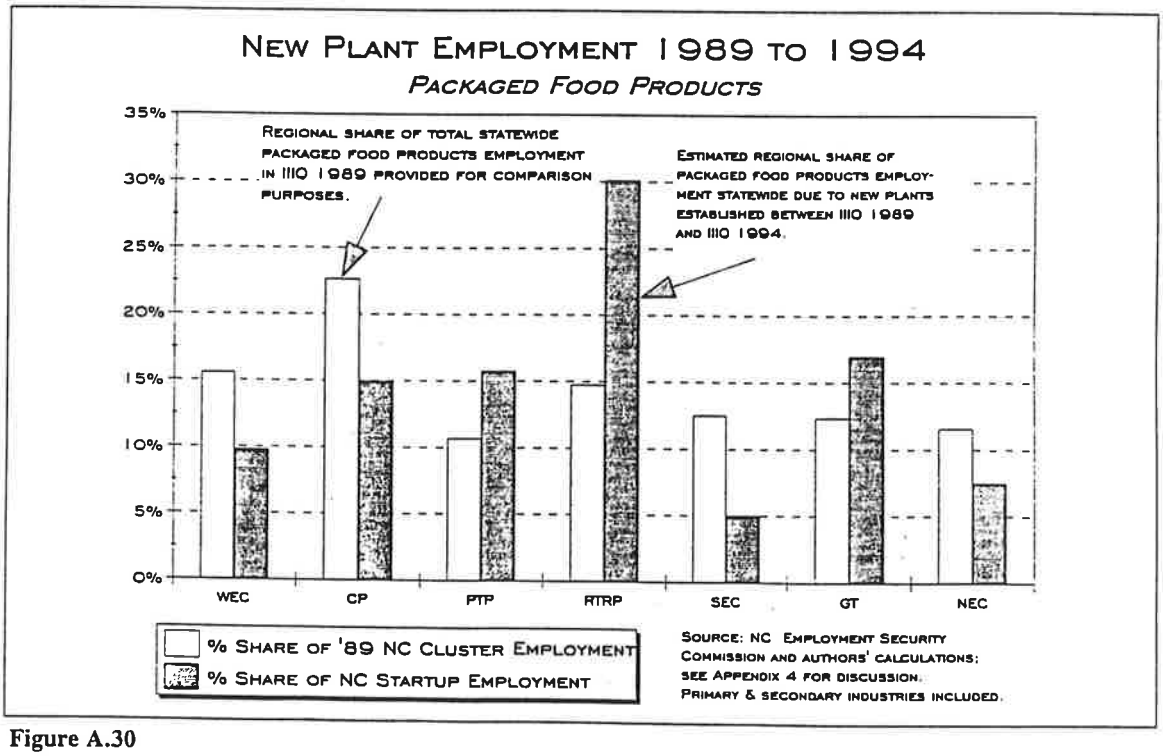
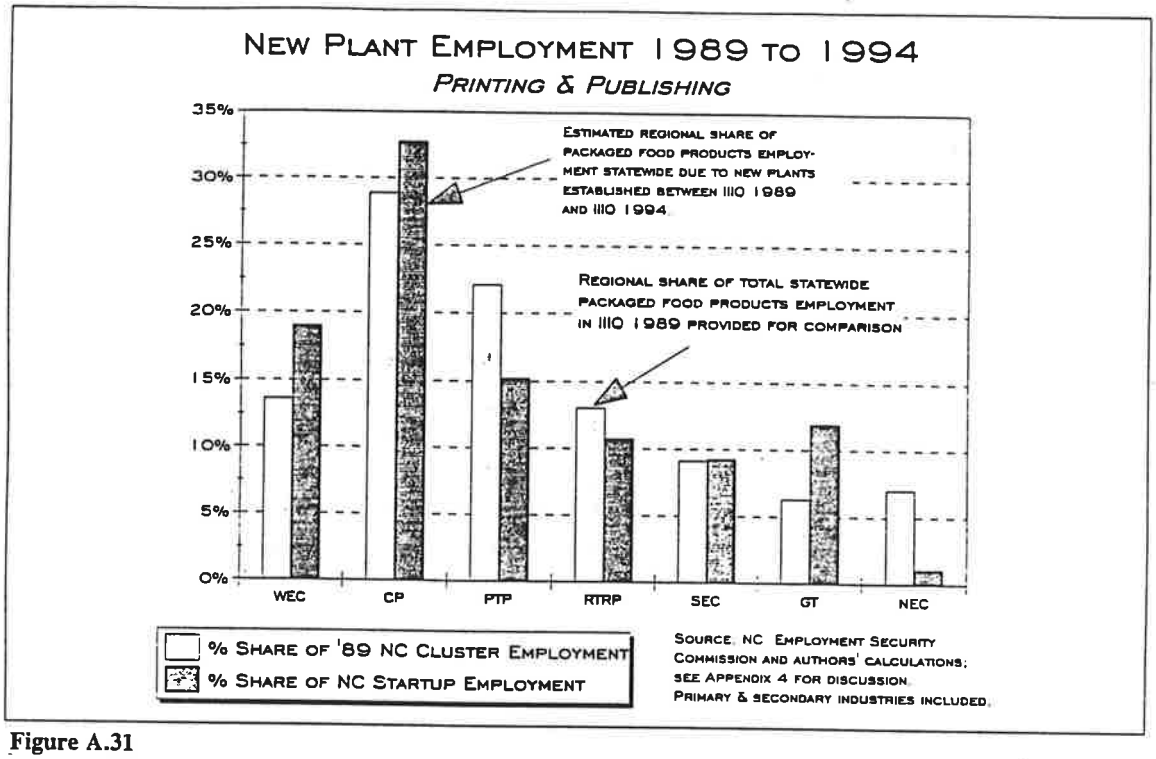


Figure A.30



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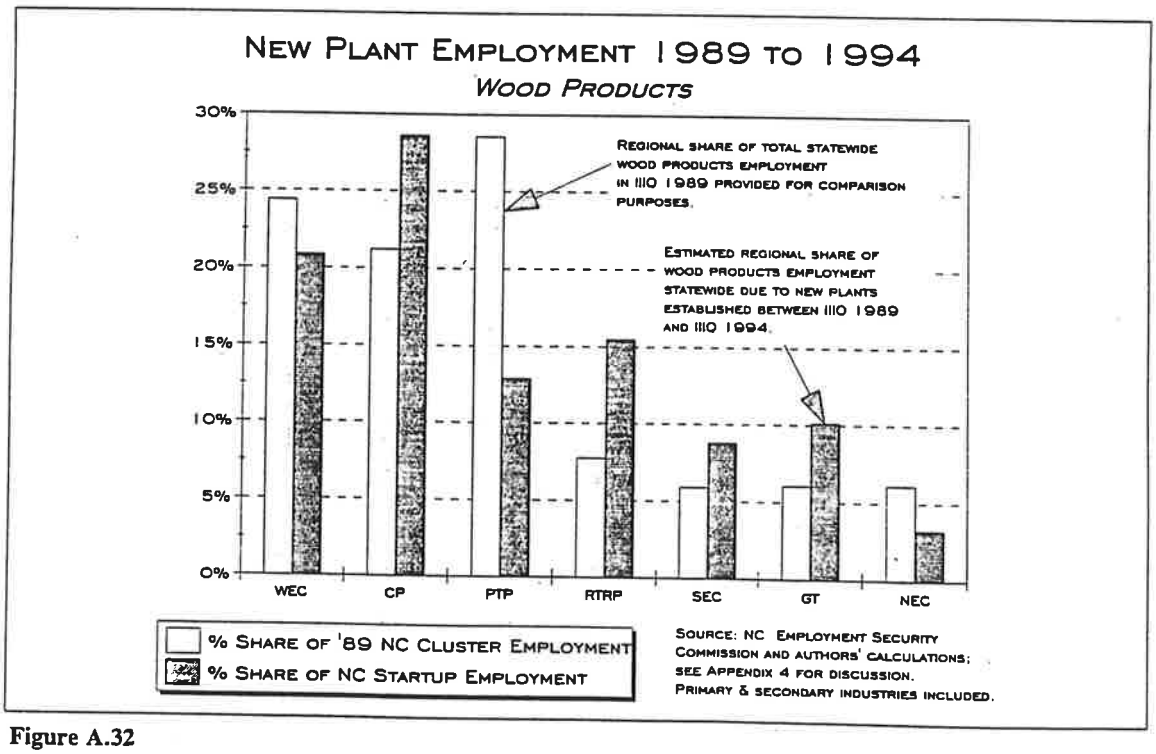

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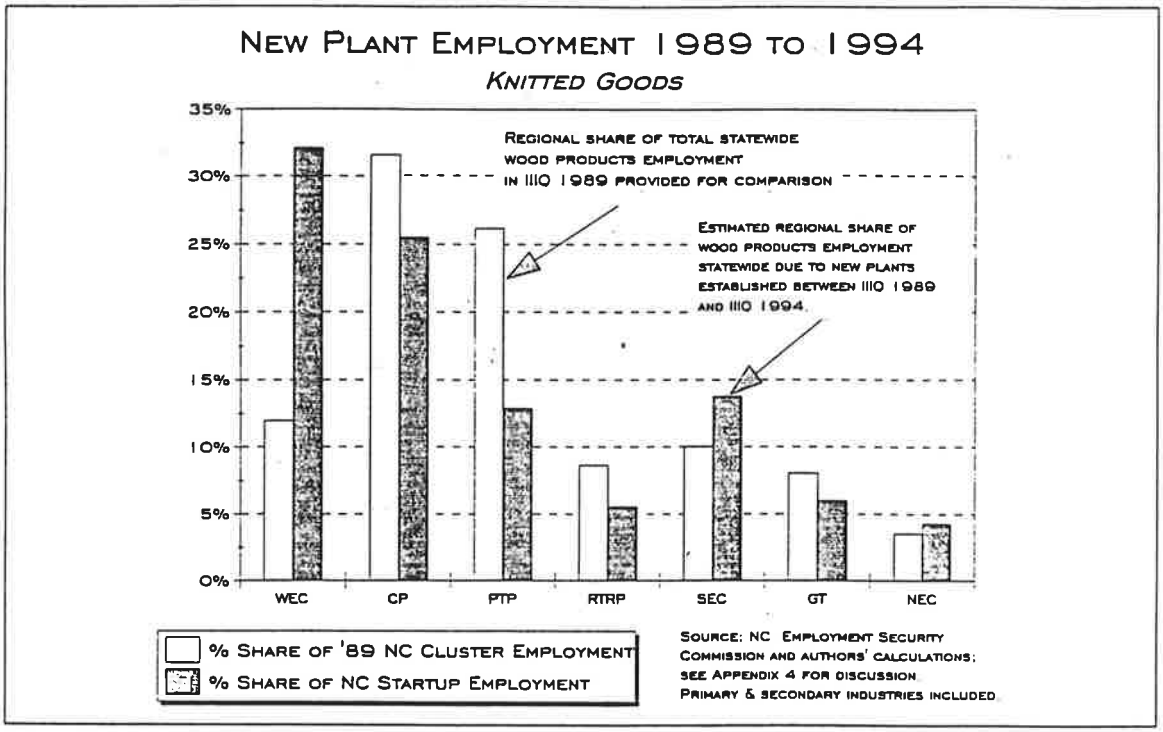

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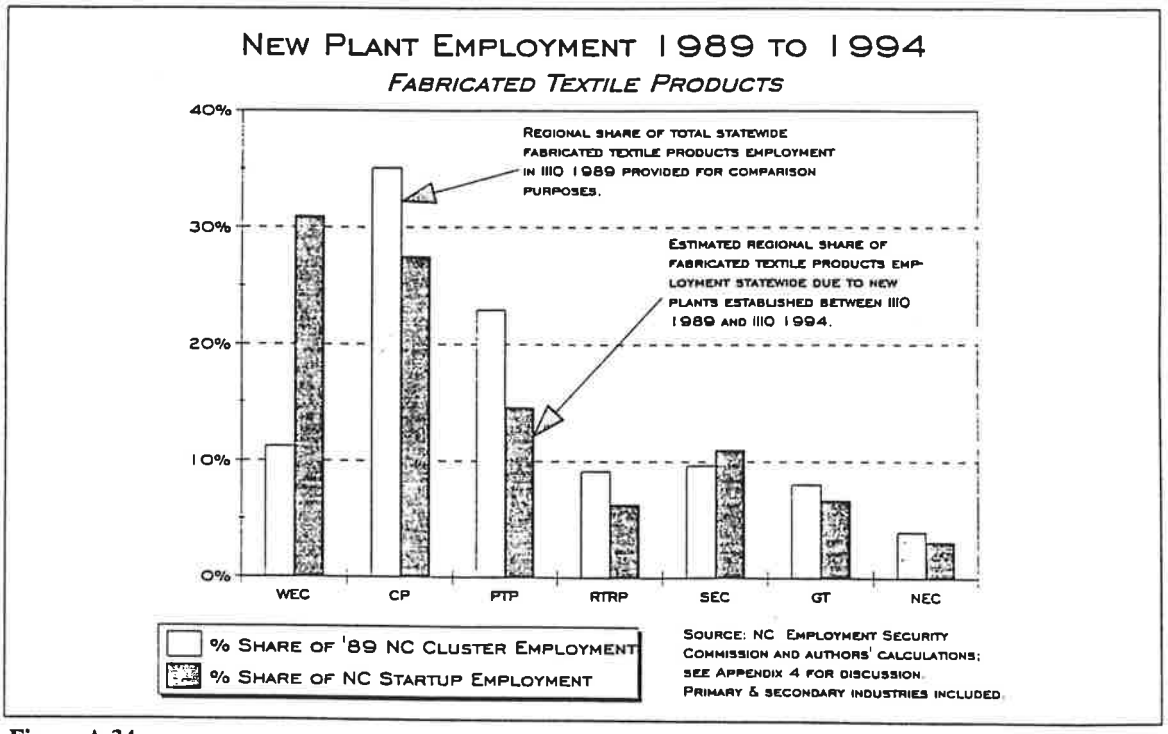


Figure A.34

APPENDIX 3

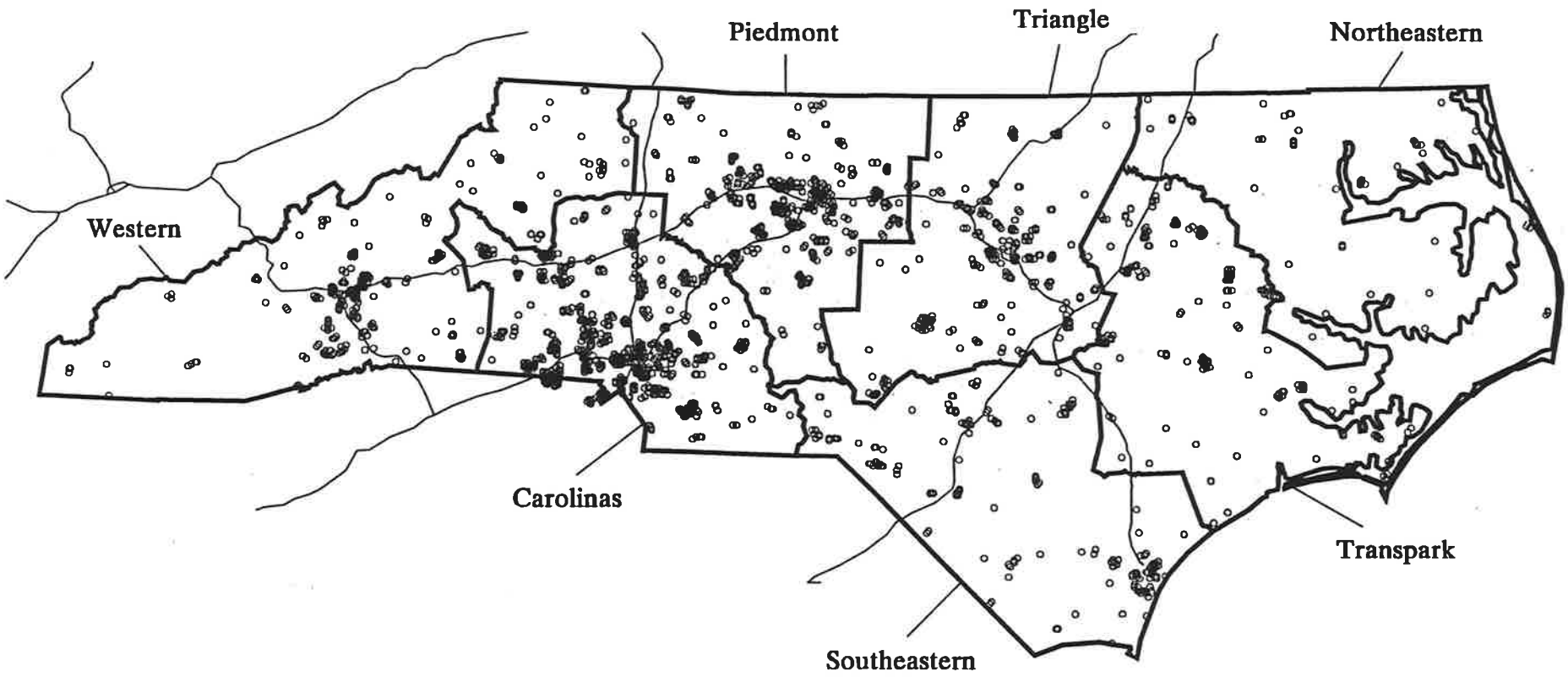
Exhibits

Exhibit 1

Metalworking Cluster

Distribution of Establishments, Total = 2,475

Third Quarter 1994, Primary & Secondary Industries Included



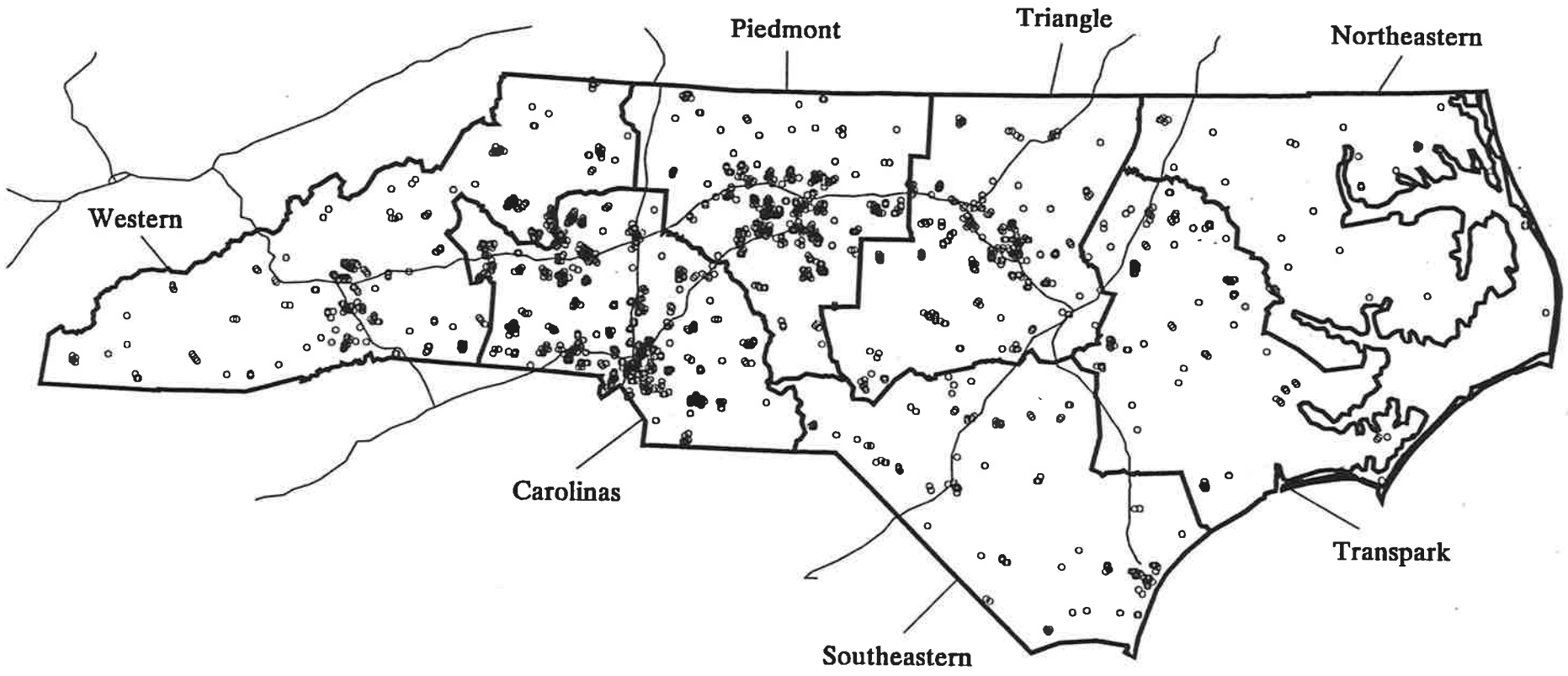
Source: NC Employment Security Commission

Exhibit 2

Vehicle Manufacturing Cluster

Distribution of Establishments, Total = 2,140

Third Quarter 1994, Primary & Secondary Industries Included



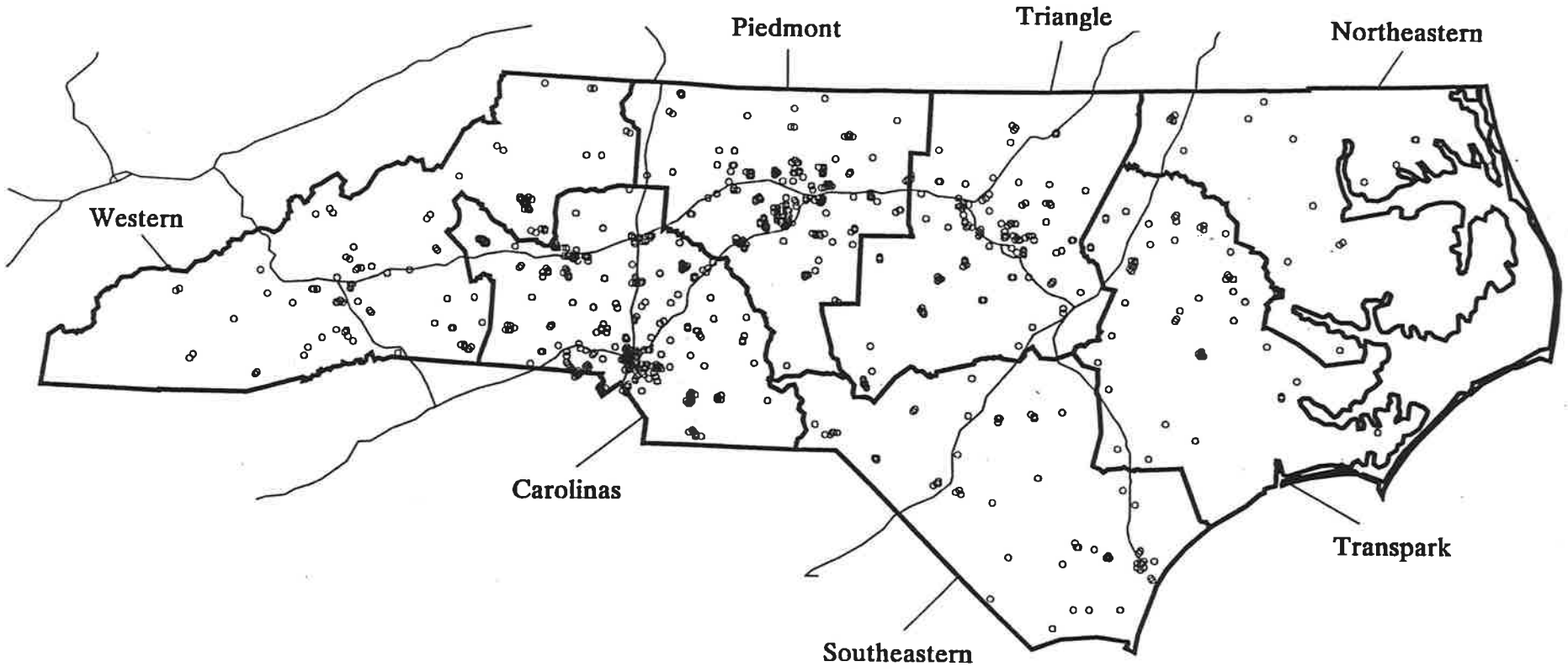
Source: NC Employment Security Commission

Exhibit 3

Chemicals & Rubber Cluster

Distribution of Establishments, Total = 985

Third Quarter 1994, Primary & Secondary Industries Included



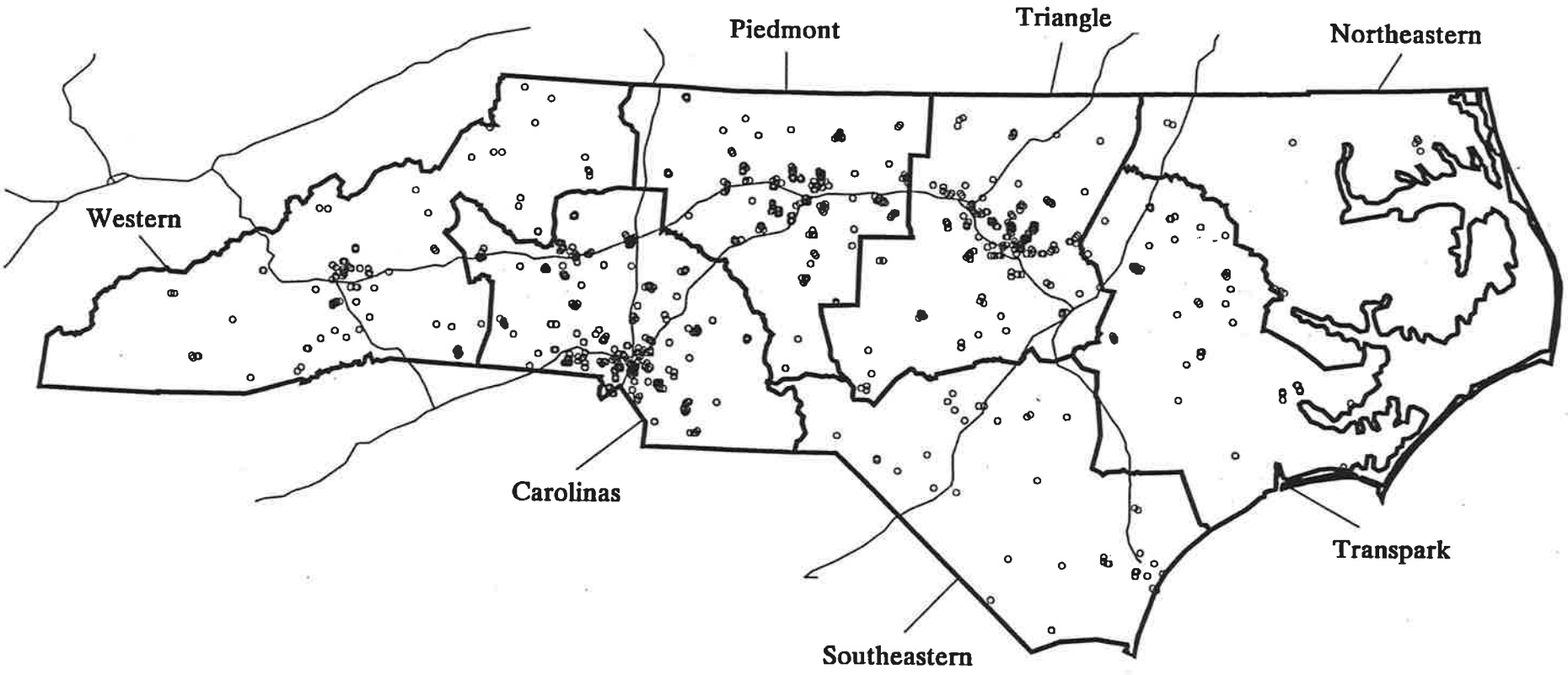
Source: NC Employment Security Commission

Exhibit 4

Electronics & Computers Cluster

Distribution of Establishments, Total = 853

Third Quarter 1994, Primary & Secondary Industries Included



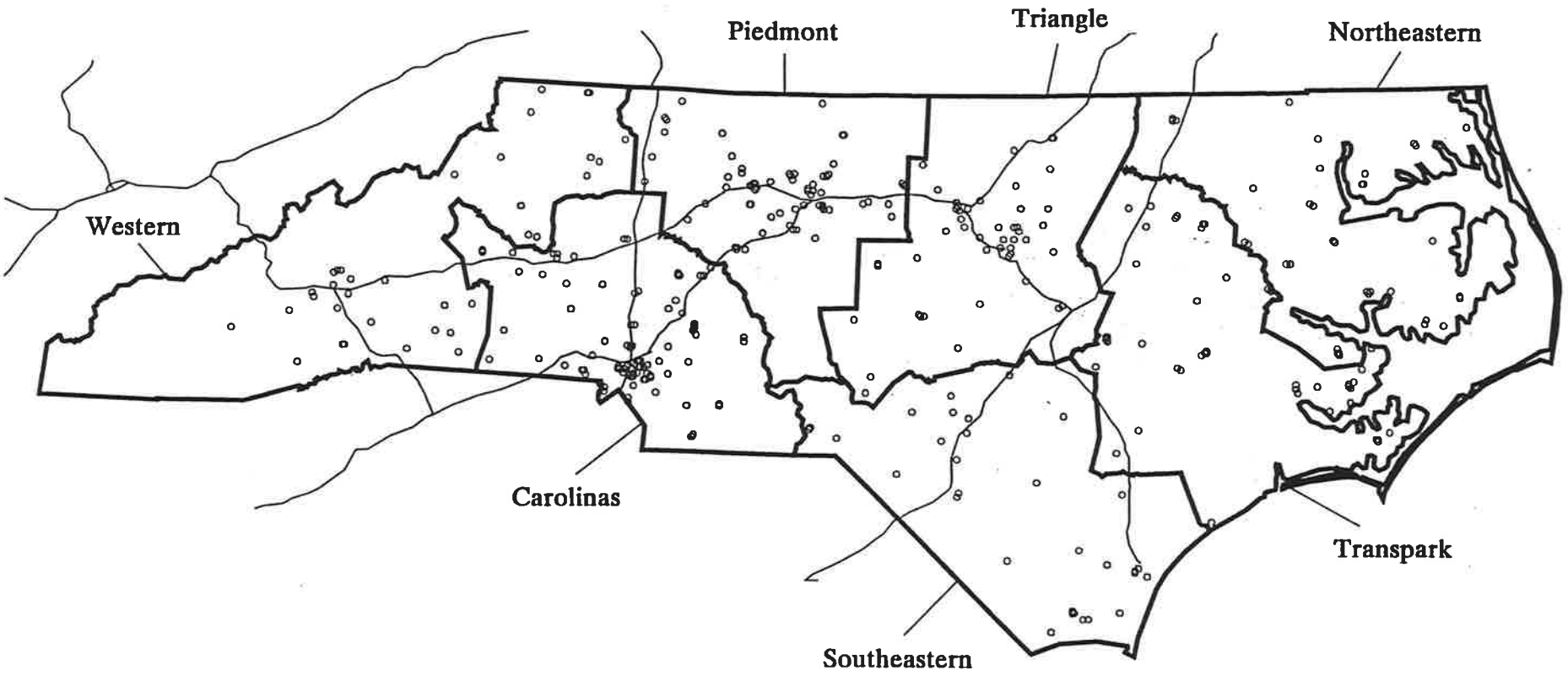
Source: NC Employment Security Commission

Exhibit 5

Packaged Food Products Cluster

Distribution of Establishments, Total = 405

Third Quarter 1994, Primary & Secondary Industries Included



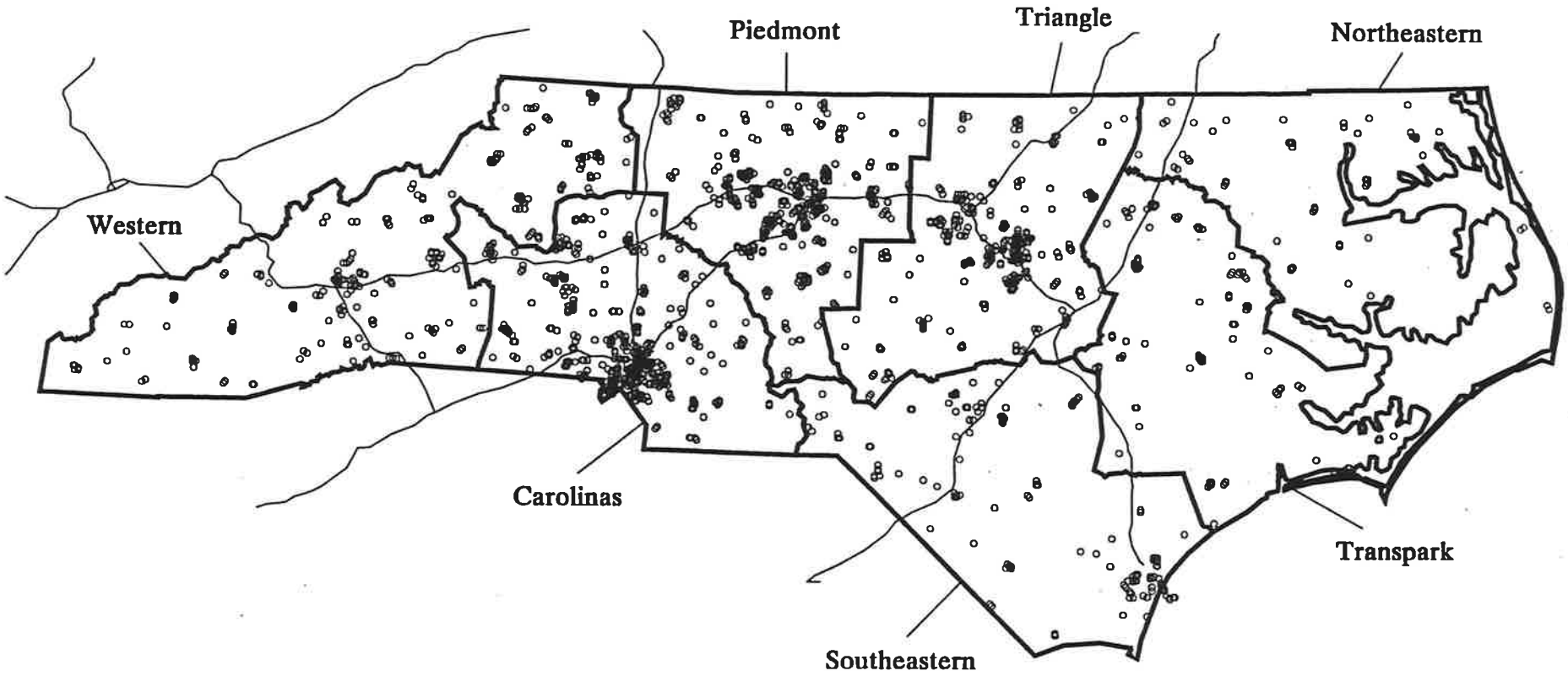
Source: NC Employment Security Commission

Exhibit 6

Printing & Publishing Cluster

Distribution of Establishments, Total = 2,102

Third Quarter 1994, Primary & Secondary Industries Included



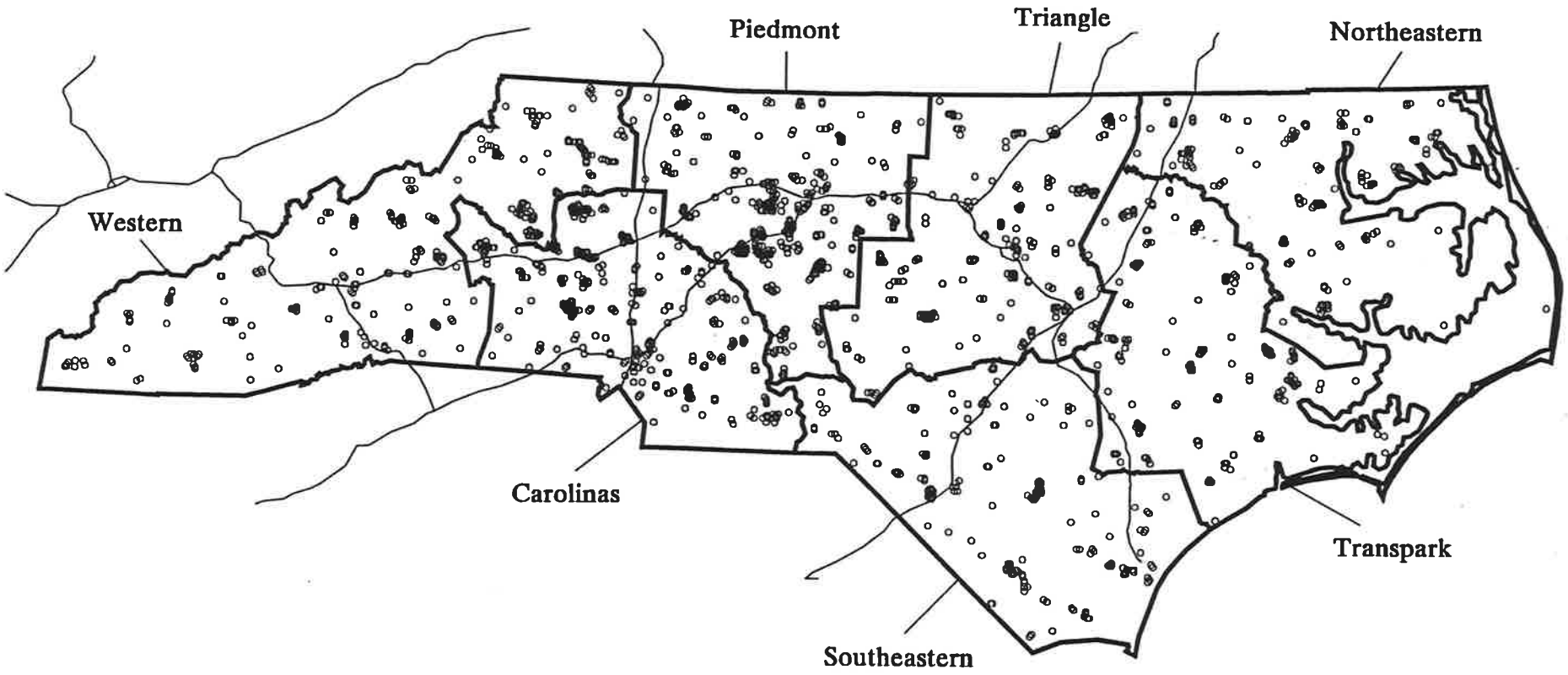
Source: NC Employment Security Commission

Exhibit 7

Wood Products Cluster

Distribution of Establishments, Total = 1,995

Third Quarter 1994, Primary & Secondary Industries Included



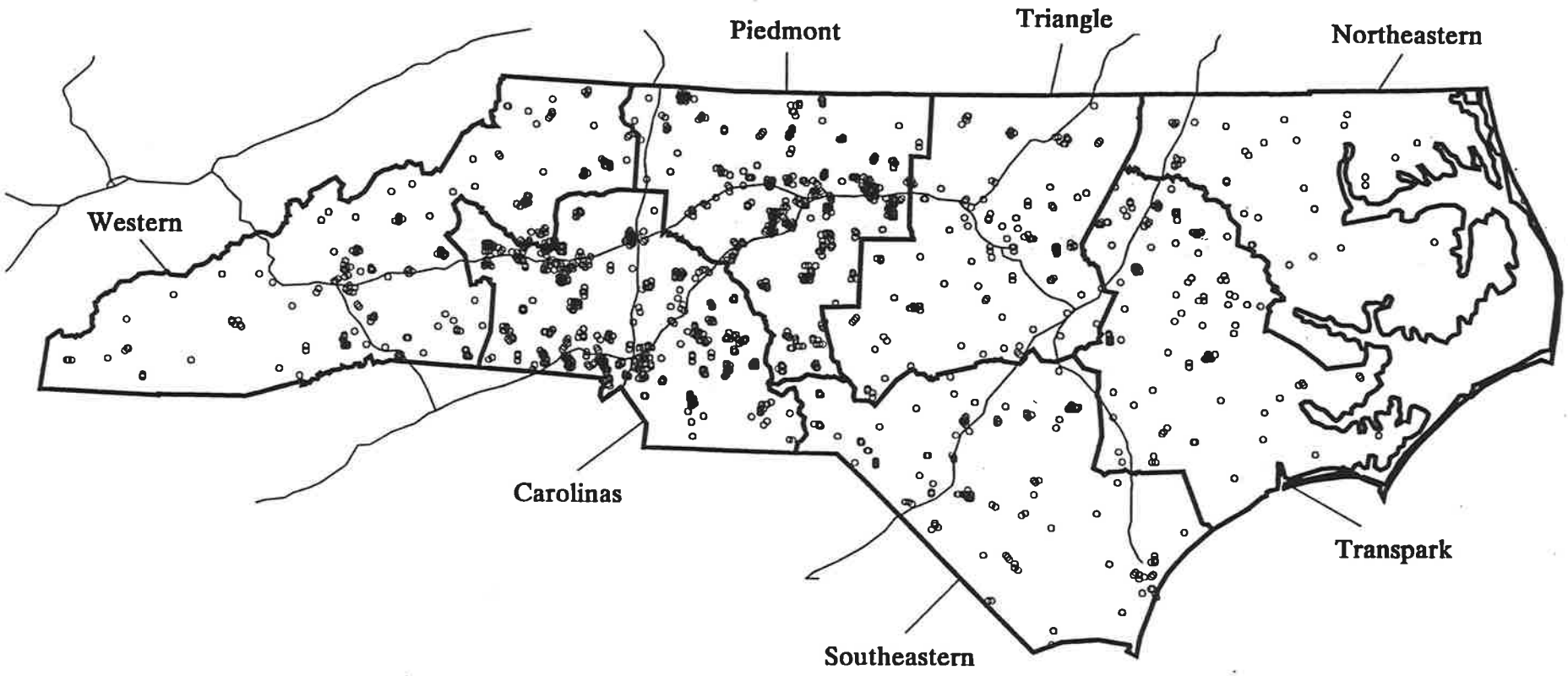
Source: NC Employment Security Commission

Exhibit 8

Knitted Goods Cluster

Distribution of Establishments, Total = 1,831

Third Quarter 1994, Primary & Secondary Industries Included



Interstates
Partnership Regions
Metro Areas
Establishment

Miles
0 20 40 60 80

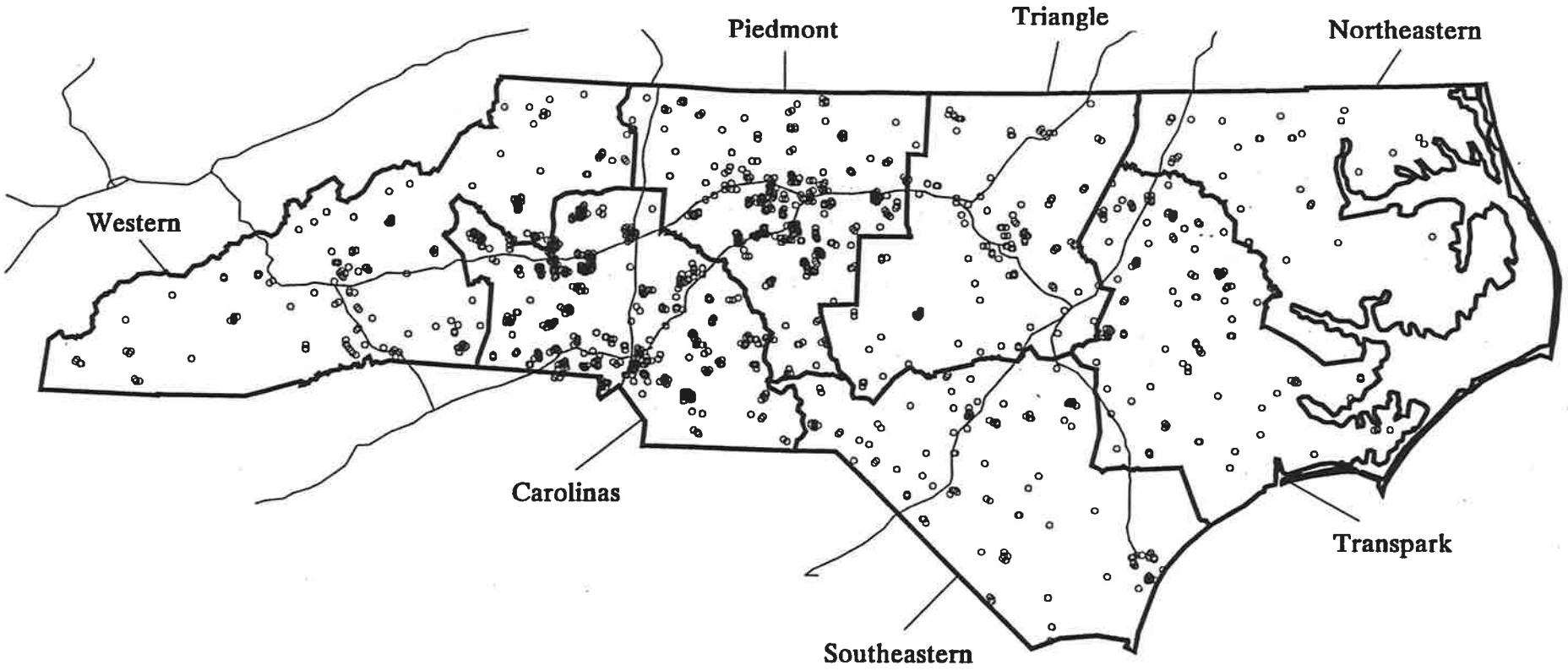
Source: NC Employment Security Commission

Exhibit 9

Fabricated Textile Products Cluster

Distribution of Establishments, Total = 1,607

Third Quarter 1994, Primary & Secondary Industries Included



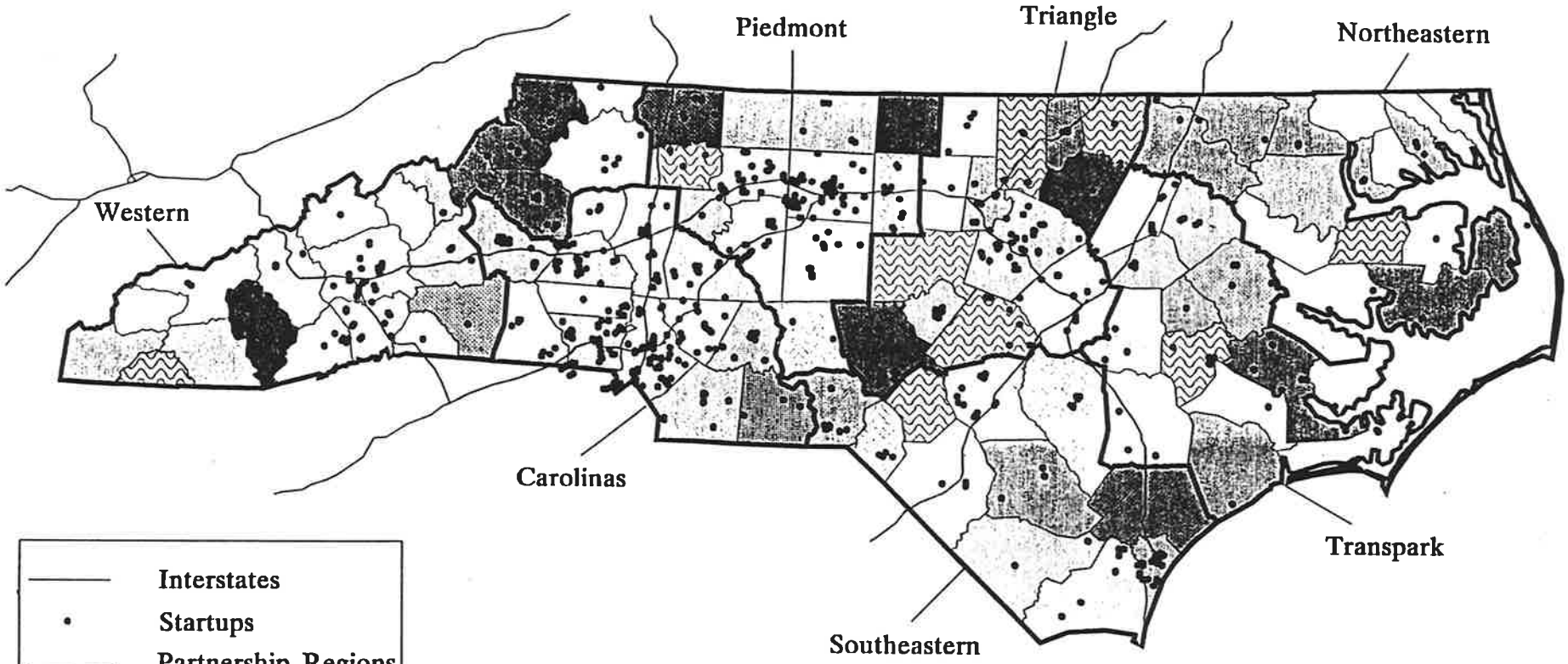
Source: NC Employment Security Commission

Exhibit 10

Metalworking Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



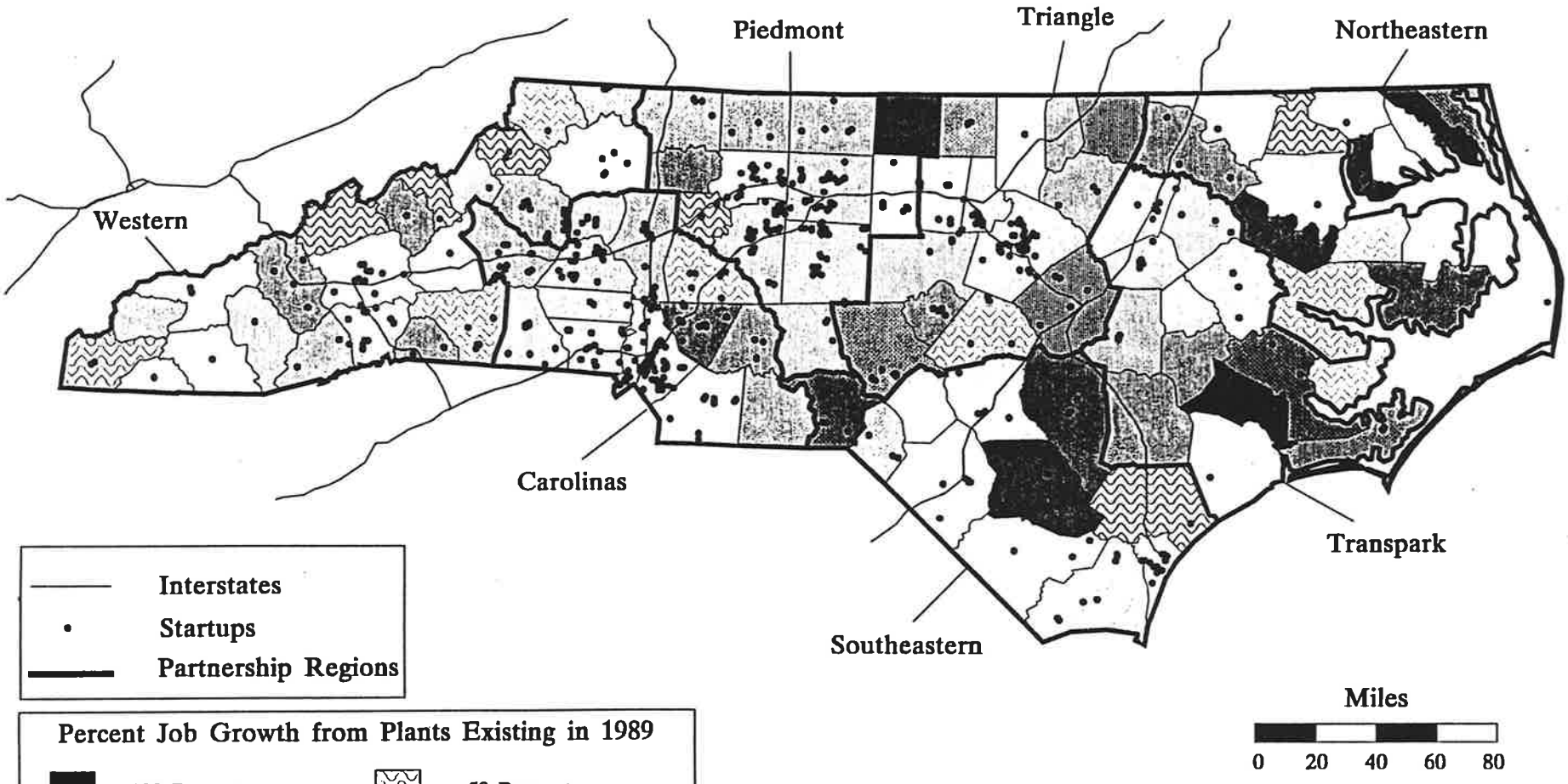
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 11

Vehicle Manufacturing Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



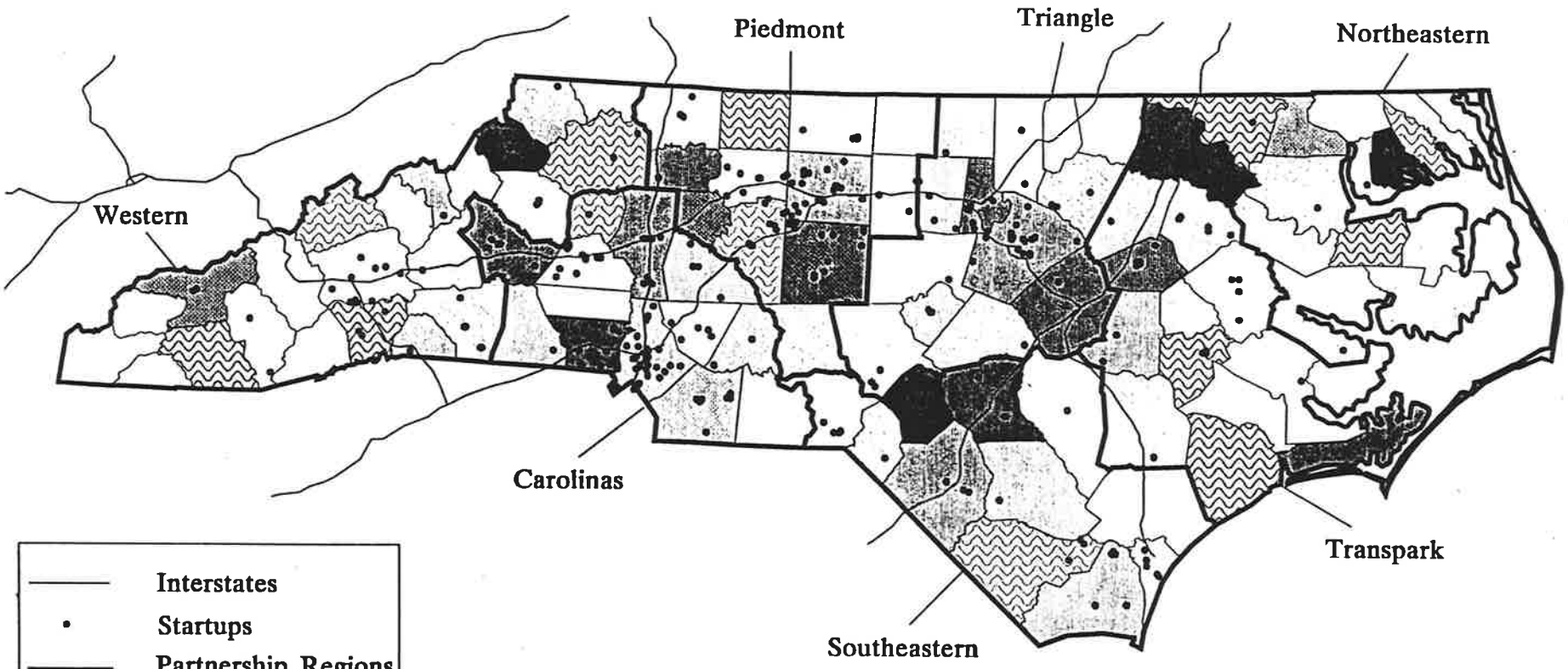
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 12

Chemicals and Rubber Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



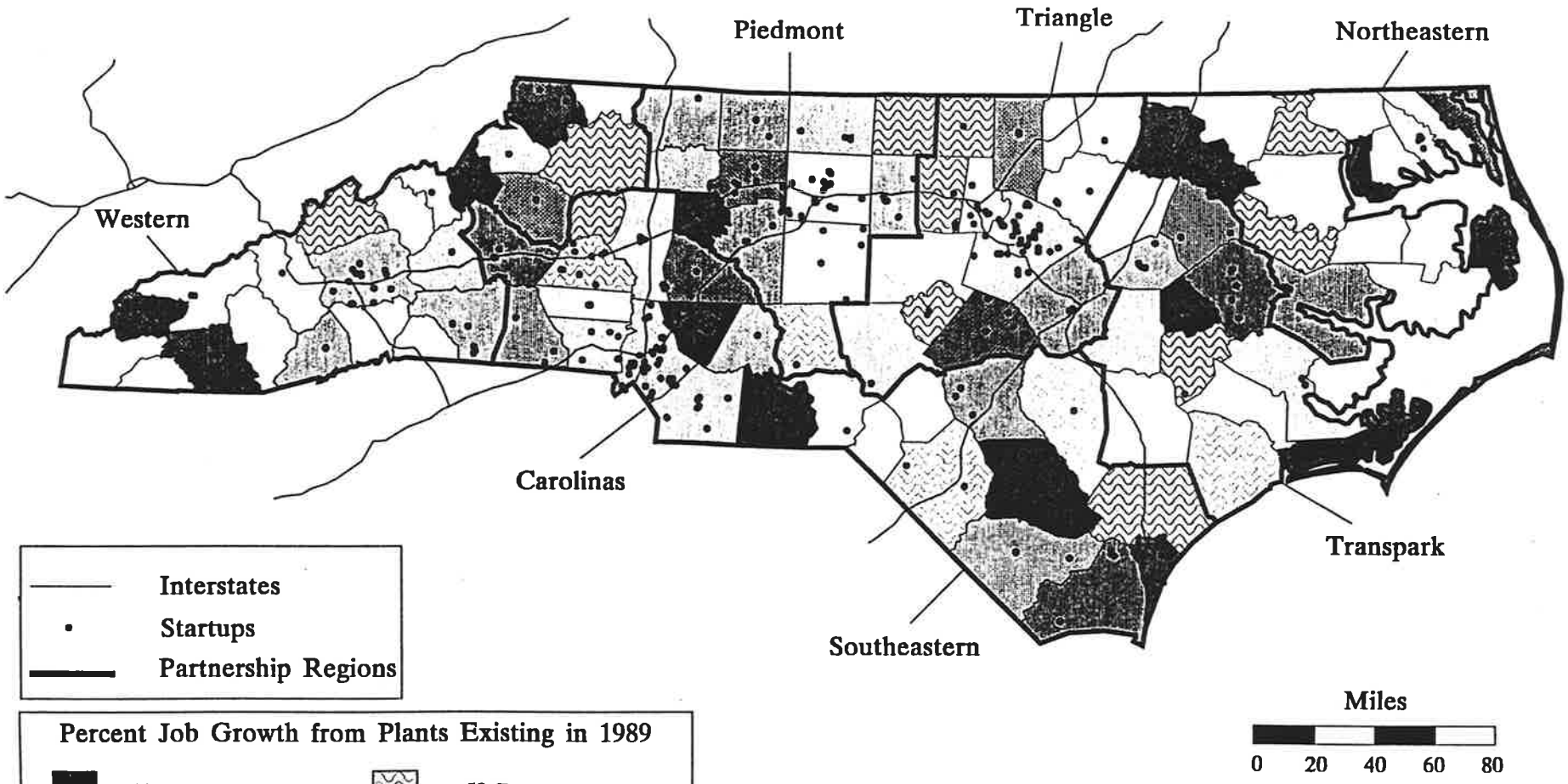
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 13

Electronics & Computers Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



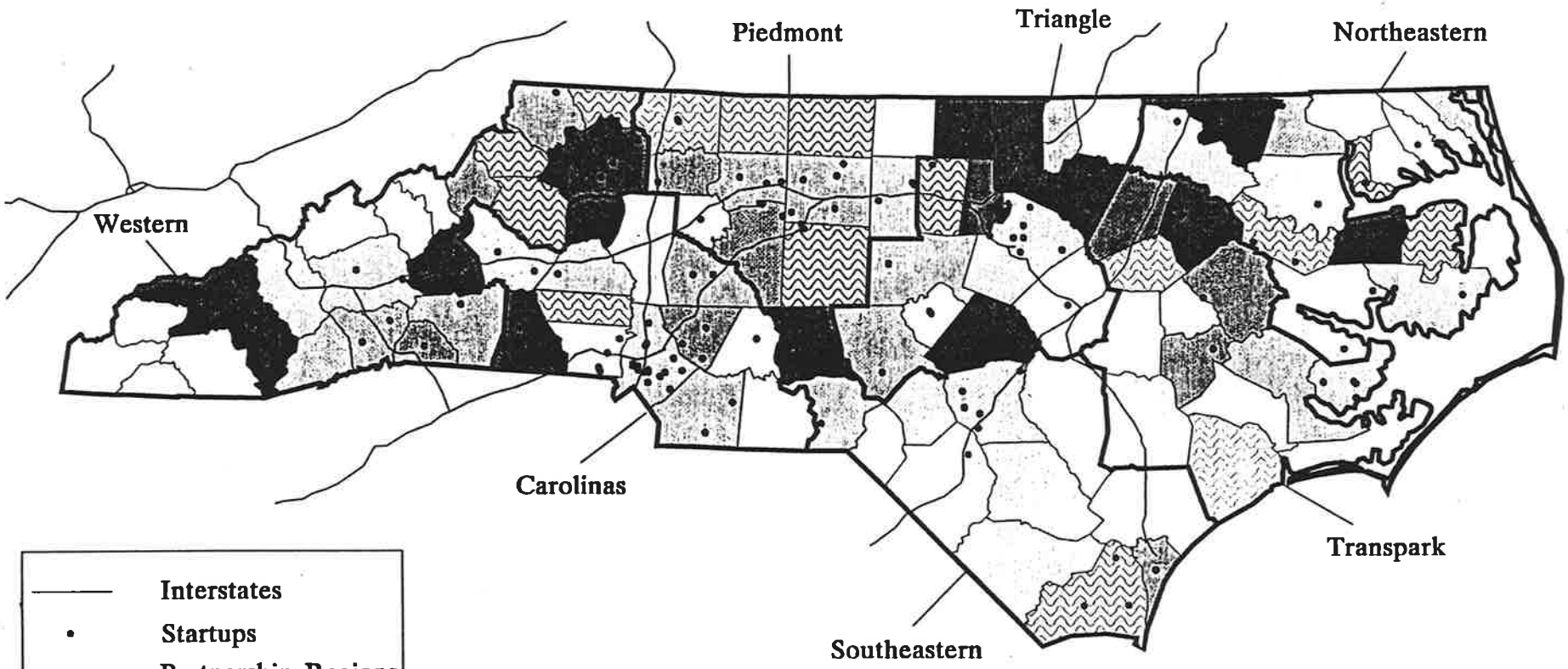
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 14

Packaged Food Products Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



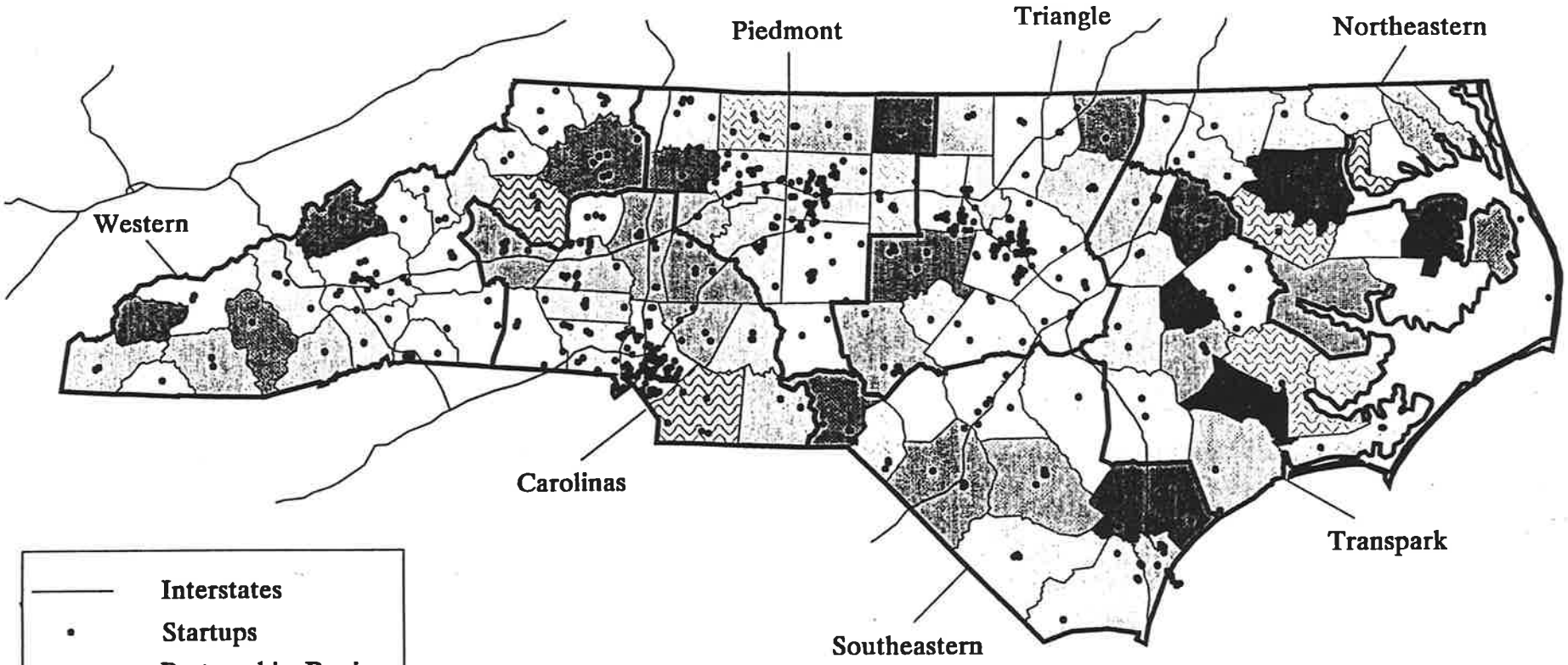
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 15

Printing & Publishing Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



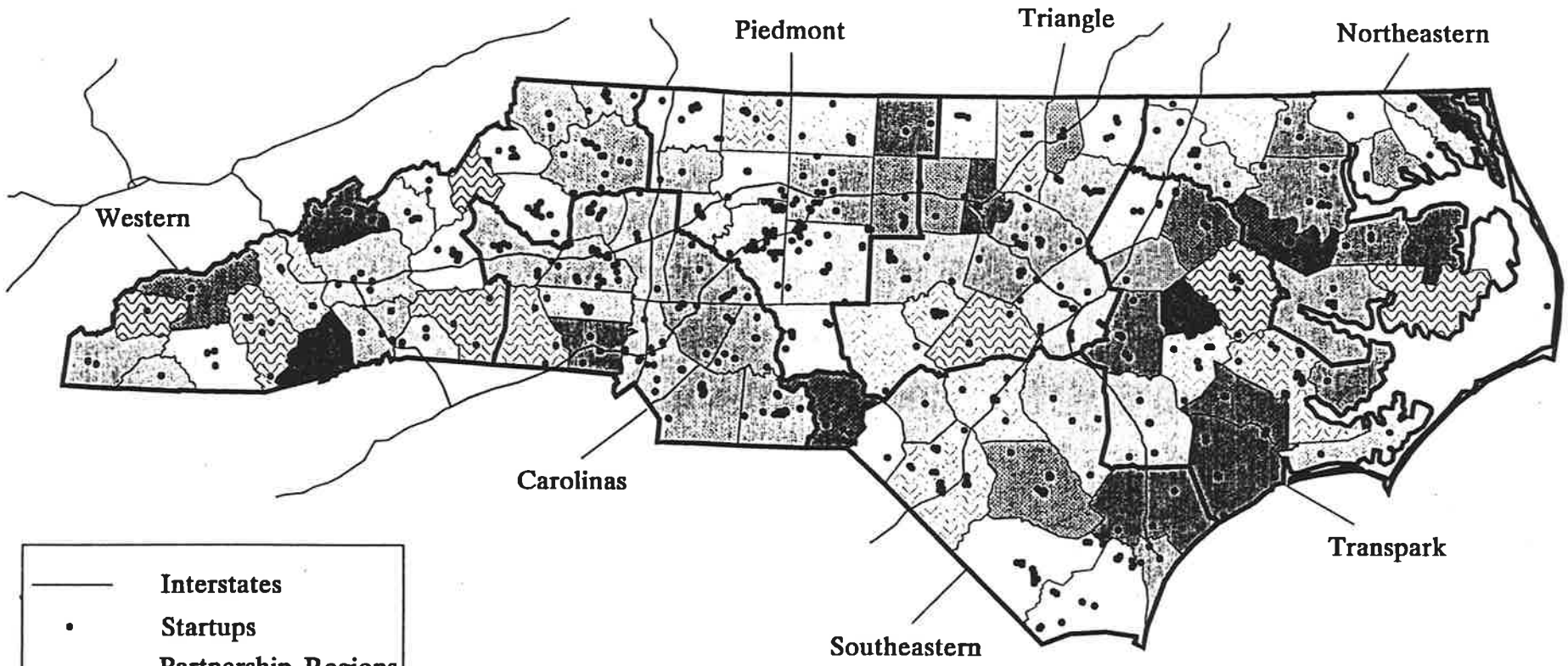
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 16

Wood Products Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



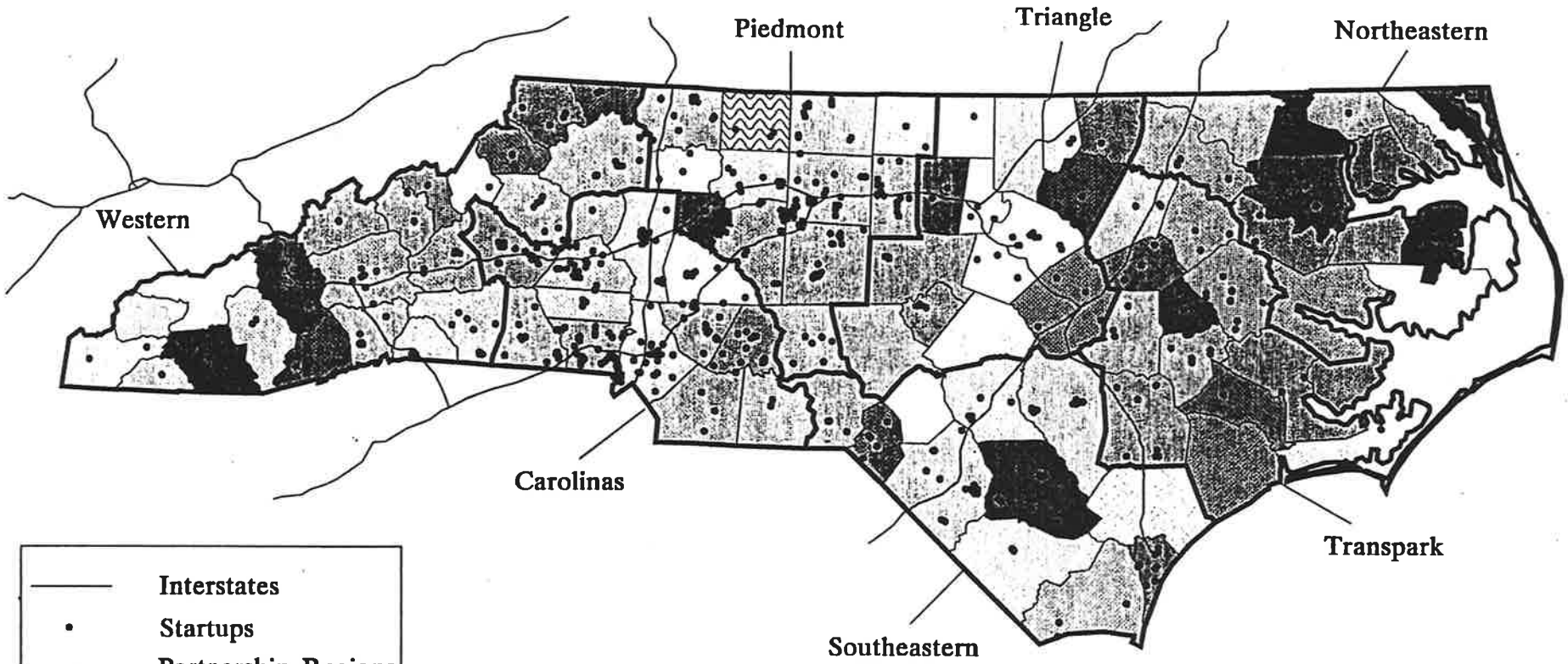
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 17

Knitted Goods Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



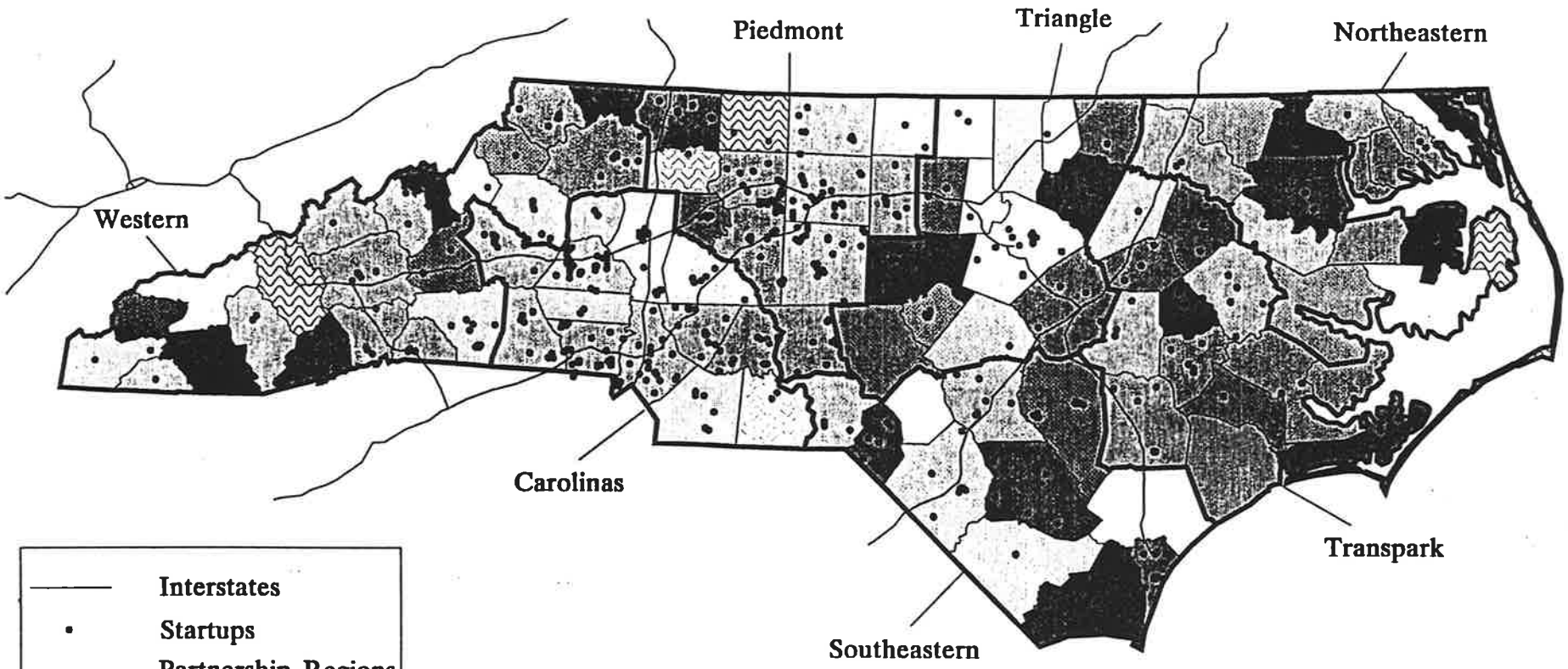
Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

Exhibit 18

Fabricated Textile Products Cluster

Employment Growth and the Distribution of Startups

Primary & Secondary Industries Included



Note: Percent employment change is based on the change between 1989 and 1994 excluding the contribution from startup employment in 1994. Startups are defined as establishments present in 3rd quarter 1994 but absent in 3rd quarter 1989. Data are from the NC Employment Security Commission.

APPENDIX 4

Methodology

Methodology

1. Detailed Clustering Methodology

Several attempts to identify clusters of industries related through input-output (I-O) linkages were made in the early 1970s.[1] Variants of these techniques were undertaken in the course of this study and compared. For the most part, results were similar for each methodology, with the number of derived clusters ranging from 22 to 28. Although no other I-O based, comprehensive cluster analyses of the type performed here have been attempted with recent U.S. input-output accounts, the results of this analysis are strikingly consistent with earlier studies that employed much older tables. Though the number of clusters is fewer in earlier studies (probably given the use of more aggregated I-O tables), the types of clusters are similar to those derived here. This section of the appendix describes the sequence of procedures used in the cluster analysis, including each of the major approaches investigated and the basic measures of sales/purchase relationships used to analyze inter- and intra-cluster linkages.

1.1 Input-Output/SIC Code Concordance

The 1987 benchmark U.S. input-output accounts, released by the Bureau of Economic Analysis (BEA) in late 1994, constitute the basic data source for this analysis.[2] The I-O accounts use two classification systems, one for industries and another for commodities. Although the I-O industry classification system is based on the SIC system, two types of adjustments made by the BEA to that system, called redefinitions and reclassifications, mean that there is an imperfect concordance between I-O industries and SIC industries. The adjustments involved are relatively minor in volume of output terms and the vast majority of manufacturing industries are not affected at all.

Nevertheless, two manufacturing SIC industries, 2819 and 3999, each of which span two I-O industries, had to be assigned to single, unique I-O industries in order to make use of the North Carolina wage and employment data used to compare cluster sizes and growth rates. For the purposes of carrying out the first clustering approach described below, and in the descriptive sections of the report where wages, estimated output, and employment figures (and associated ratios and growth rates) are provided, judgement was used to assign 2819 and 3999 to unique I-O sectors. The issue of SIC/I-O concordance does not affect the final statistical approach used to derive the clusters reported in this document, though the analysis of cluster presence in North Carolina with wage and employment data is still affected for these two manufacturing industries. These classification issues may affect any specific analysis of sectors 2819 and 3999.

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[1] See "Spatial association and economic linkages between industries," by M. E. Streit (*Journal of Regional Science* 9: 177-88, 1969); "A new approach to the identification of industrial complexes using input-output data," by H. Roepke, D. Adams, and R. Wiseman (*Journal of Regional Science* 14: 15-29, 1974); and *Study of Clustering of Industries*, by S. Czamanski (Halifax, Canada: Institute of Public Affairs, Dalhousie University).

[2] *Benchmark Input-Output Accounts of the United States, 1987* (Washington, DC: Bureau of Economic Analysis, U.S. Department of Commerce, November 1994).

1.2 Principal Components Factor Analysis

Earlier studies have used a range of methodologies, including graph theory, triangularization, and factor/principal components analysis for sorting industries into groups based on input-output linkages.[3] This study employed principal components analysis with varimax rotation as the basic methodology to derive clusters. Principal components factor analysis attempts to exploit the common statistical variation among multiple variables to generate a reduced number of "principal components" that represent linear combinations of the original set of variables. For this study, measures of interindustry direct and indirect linkages computed from the input-output accounts for each sector were treated as variables in a principal components analysis. The derived components were then rotated to a varimax solution to facilitate interpretation, where the decision regarding the number of components to rotate was made based on the relative proportion of variance explained by each component, the size of the associated eigenvalues, and scree plots.[4] Multiple analyses were conducted, for each set of interindustry linkage specifications (described below), using alternative assumptions regarding the number of rotated factors. The results were then compared for consistency and interpretability.

1.3 Identifying Industrial Clusters

For each factor, the analysis generates a set of *loadings*, which represent the correlations of the variables with the factor. In the context of this study, the loadings provide a measure of the relative strength of the linkage between a given industry and a derived factor, where the highest loading industries on a given factor are treated as members of an industrial cluster. It is often regarded as standard procedure in factor analysis to regard only loadings greater than .50 (in absolute value terms) as significant or worthy of interpretation.[5] This approach, however, does not provide a means of interpreting gradations in loadings. For example, industries with loadings exceeding .75 on a given cluster might be regarded as closely linked to that cluster, while industries with loadings from .50 to .75 and from .35 to .50 may be viewed as only moderately and weakly linked, respectively. For the reasons described below, this study adopted a combination of rules of this type. The approach achieved several useful objectives and yielded final results which both appeared plausible and facilitated interpretation. But because any approach to delineating cluster industries from factor analysis output is

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[3] See the review "Identification of industrial clusters and complexes: a comparison of methods and findings," by S. Czamanski and L. A. Ablas (*Urban Studies* 16: 61-80, 1979). A more recent study used statistical cluster analysis to cluster sectors for Alberta, Canada ("An analysis of industrial clustering in the Alberta economy," by Peter Roberts, report submitted to the Strategic Planning and Research Branch, Alberta Economic Development and Trade, September 1992). Census researchers also recently used statistical cluster analysis to combine SIC sectors into groups that presumably shared the same production technologies ("The classification of manufacturing industries: an input-based clustering of activity," by T. A. Abbott and S. H. Andrews, Staff Paper 90-7, Center for Economic Studies, August 1990). The most significant practical difference between statistical cluster analysis and factor analysis is that the former yields mutually exclusive groups of industries. Though this aids interpretation, it is unrealistic in the context of clusters based on functional input-output linkages. Due to complex trading patterns, industries tend to belong to multiple clusters (though their links to each cluster vary in strength). Factor analysis accommodates this complexity.

[4] "Uses of factor analysis in counseling psychology research," by H. E. A. Tinsley and D. J. Tinsley (*Journal of Counseling Psychology* 34: 414-24, 1987) provides a summary of factor analysis techniques and assumptions.

[5] "Uses of factor analysis in counseling psychology research, *op. cit.*

necessarily partially arbitrary, loadings are reported to allow readers to draw their own conclusions.[6]

In interpreting the factor analytic results to identify specific industrial clusters, an attempt was made to reconcile several competing objectives. The primary objective of the study was to derive a set of clusters based on the most significant linkages as revealed in the I-O data matrix. According to this objective, the concern is to identify the industries with the tightest linkages to each cluster (i.e. the highest loading industries for each factor), regardless of whether or not some of those industries are also tightly linked to another cluster. A second objective was to identify, to the degree possible, a set of mutually exclusive clusters in the sense that each sector would be assigned to only one cluster. Such a result would facilitate cross-cluster comparisons of size and growth rates. It was not known before the statistical analysis whether this objective could be reasonably met, given the first objective. The third objective was to investigate the linkages both between clusters as well as between industries within each cluster. Such linkages are sometimes revealed by an examination of sectors that are only moderately or weakly related to each cluster, thus competing with the first objective.

The final set of clusters reported and analyzed throughout the text represent a compromise. Each cluster contains a set of "primary" and "secondary" industries. *Primary industries* for a given cluster are those sectors that achieved their highest loading on that factor *and* whose highest loading was .60 or higher.[7] For example, SIC 277 (greeting cards) achieved its highest loading on the printing and publishing cluster (cluster 6), and, since the loading (.90) is greater than or equal to .60, 277 is classified as a primary industry for that cluster. *Secondary industries* for a given cluster are those sectors that achieved loadings on the cluster equivalent to or greater than .35 but less than .60. For example, 3652 (prerecorded records and tapes) achieved a loading of .54 on the cluster 6 and is thus classified as a secondary industry for the cluster. For some clusters, the set of secondary industries also includes industries with loadings exceeding .60 but that achieved their highest loading on a different cluster. While SIC 2677 (envelopes) achieved a loading of .68 on cluster 6, it achieved a still higher loading on cluster 1 (metalworking). Therefore, it is classified as a primary industry for the metalworking cluster and a secondary industry for the printing and publishing cluster.

As a general rule, *primary industries* are those that are most tightly linked to a given cluster while *secondary industries* are those that are less-tightly or moderately linked. Considering only primary industries yields a set of mutually exclusive industrial clusters that can be used for cross-comparison purposes. But some caution should still be exercised in interpreting the clusters derived on this basis since some "secondary" industries (such as SIC 2677 in the above example), are actually more tightly linked to a given cluster than a few of the primary industries in the same cluster.[8] Since only twelve industries fall into this category, and since none of the secondary loadings of these industries exceed .70, the advantages of deriving a set of mutually exclusive clusters were viewed as significant enough to warrant the more pragmatic approach. Nevertheless, clusters both inclusive and

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[6] Loadings are reported for each interpreted cluster in Table A.1 in Appendix 1. Because of space constraints, the full 362 x 28 matrix of rotated factor loadings along with communalities is not reported. These are available upon request.

[7] This is a slightly more rigorous standard than the .50 standard used by Roepke, Adams, and Wiseman, *op. cit.* The column labeled L1 in Tables A.1 reports, for each row industry, the cluster (factor) on which the industry achieved its highest loading.

[8] With a loading of .68, secondary industry SIC 2677 is actually more tightly linked to cluster six than primary industries SICs 274 (loading of .63), 3275 (.63), and 272 (.67).

exclusive of the secondary industries are compared throughout the study where possible.

1.4 Four Alternative Approaches

While principal components factor analysis constitutes the basic methodology used to derive the clusters, alternative subsets of industries and measures of inter-industry linkage were tested and compared. For each approach, an interindustry data matrix was developed, multiple factor analyses were performed using alternative factor rotation assumptions, and the resulting set of clusters was inspected and compared to previous results. In all cases, actual input-output linkages between industries in the clusters were examined to determine the plausibility of the result.

First Approach. As an initial approach, manufacturing industries with non-zero employment in North Carolina were clustered together based on their estimated patterns of commodity use and production, as revealed by the U.S. make and use tables (an assumption of identical technology). This involved the scaling of the use and make tables with North Carolina wage data, followed by the factor analysis on the resulting matrices. Note that no assumptions were made regarding *where*, in geographic terms, North Carolina industries purchase their inputs or sell their outputs.

The 478 x 519 U.S. use matrix (**U**) reports the dollar value of each of 519 commodities used by each of 478 producing U.S. I-O industries.[9] **U** was reduced to a 362 x 519 manufacturing use matrix ($\mathbf{U_M}$) since this study is concerned with clustering only manufacturing industries. Given 362 x 1 vectors of total manufacturing wages by industry for the U.S. ($w_{US,M}$) and North Carolina ($w_{NC,M}$), a 362 x 519 scaled use matrix ($\mathbf{U_{NC}}$) was derived that reports the estimated dollar value of 519 commodities used by 362 North Carolina I-O industries:

$$\mathbf{U_M} \cdot (\mathrm{diag}(w_{US,M}))^{-1} = \mathbf{U_{M,W}}$$

$$\mathbf{U_{M,W}} \cdot (\mathrm{diag}(w_{NC,M}) = \mathbf{U_{NC}}$$

Each cell entry in $\mathbf{U_{M,W}}$ is the ratio of 1987 output of commodity *i* purchased by U.S. I-O industry *j* to the total 1987 wages paid by industry *j*. In deriving $\mathbf{U_{NC}}$, it is assumed that the ratio of commodity use to wages is the same in North Carolina in 1994 as for the nation as a whole in 1987.

In the third quarter of 1994, North Carolina possessed 328 of 362 manufacturing I-O industries. Applying the factor analysis to the resulting 328 x 519 data matrix clustered industries based on commodity use patterns.[10] Repeating similar matrix operations and factor analysis for the make matrix generated clusters based on commodity production patterns.

Second Approach. While the first approach revealed differences in clustering based on commodity use and production patterns, it provided no means of jointly evaluating interindustry

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[9] One of the "industries" in the use table is an inventory valuation adjustment (I-O code 85.0000) and three "commodities" are not directly produced by business enterprises (noncomparable imports--I-O 80.0000, used and secondhand goods--I-O 81.0002, and rest of the world adjustment to final uses--I-O 83.0001).

[10] Note that the reduced 328 x 519 $\mathbf{U_{NC}}$ matrix is identical, in terms of the factor analysis, to a 328 x 519 $\mathbf{U_M}$ matrix (where the industries without a presence in North Carolina are removed); the use of North Carolina wages to adjust the use matrix provides a simple means of performing this basic adjustment.

linkages to derive one set of clusters. Thus it made both the final derivation of clusters considerably more complicated and the interpretation of any final result more difficult. The second approach employed the methodology of Roepke, Adams, and Wiseman.[11] First, a standard 478 x 478 interindustry transactions matrix (**T**) was derived from an adjusted use matrix $\mathbf{U_A}$, a 516 x 1 vector of commodity outputs ($\mathbf{O_C}$), and a 516 x 478 commodity by industry make matrix (**M**):[12]

$$\mathbf{M} \cdot (\mathrm{diag}(\mathbf{O_C}))^{-1} \cdot \mathbf{U} = \mathbf{T}$$

Each cell (a_{ij}), in **T** gives the dollar value of goods and services sold in 1987 by row industry i to column industry j. Since industries may be related by both input and output patterns, a symmetric matrix $\mathbf{L_T}$ was derived from **T** such that,

$$a_{ij} + a_{ji} = t_{ij}$$

Each column in $\mathbf{L_T}$ gives the pattern of total (input and output) linkage between the given column industry and every other (row) industry. Eliminating non-manufacturing industries from the columns of and rows of $\mathbf{L_T}$ and subjecting to the resulting 362 x 362 data matrix to the factor analysis generated 28 clusters.[13]

Third Approach. A detailed inspection of several clusters derived via the second approach revealed that evidence of *indirect* linkages, e.g. relationships between sectors based on links between second and third tier buyers and suppliers, were largely absent from the groupings. The third approach employed a slightly different interindustry linkage measure. Given, for each industry, total intermediate good purchases (p) and sales (s), the type of functional relationship between any two industries, i and j, may be expressed in terms of four coefficients (where a is defined as above):[14]

$$x_{ij} = \frac{a_{ij}}{p_j}, \quad x_{ji} = \frac{a_{ji}}{p_i}, \quad y_{ij} = \frac{a_{ij}}{s_i}, \quad y_{ji} = \frac{a_{ji}}{s_j}$$

Each coefficient is an indicator of dependence between i and j, in terms of relative purchasing and sales links:

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[11] "A new approach to the identification of industrial complexes using input-output data," *ibid.*

[12] This operation invokes the "industry-based technology assumption," which assumes that the total output of a given commodity is provided by industries in fixed proportions. See *Benchmark Input-Output Accounts*, *ibid.*, and *Input-Output Analysis: Foundations and Extensions* by R. E. Miller and P. D. Blair (Englewood Cliffs, NJ: Prentice-Hall, 1985). $\mathbf{U_A}$ is **U** with noncomparable imports, secondhand goods, and rest of the world adjustment to final uses removed. These "commodities" are not reported in the make matrix since they are not produced goods.

[13] Factor analyses were run on both the 362 x 362 data matrix and a 479 x 362 matrix where non-manufacturing industries were not eliminated from the rows of $\mathbf{L_T}$. Retaining non-manufacturing industries in the rows of the data matrix allows manufacturing industries to cluster together based on similarities in their non-manufacturing input/output patterns. These non-manufacturing patterns tended to dominate the analysis such that fewer, larger, and less interpretable clusters resulted.

[14] *Study of Clustering of Industries*, *ibid.*

x_{ij}, x_{ji}: intermediate good purchases by j (i) from i (j) as a proportion of j's (i's) total intermediate good purchases. A large value for x_{ij}, for example, suggests that industry j depends on industry i as a source for a large proportion of its total intermediate inputs.

y_{ij}, y_{ji}: intermediate good sales from i (j) to j (i) as a proportion of i's (j's) total intermediate good sales. A large value for y_{ij}, for example, suggests that i depends on industry j as a market for a large proportion of its total intermediate good sales.

Selecting the largest of the four coefficients for each pair of manufacturing industries yielded a symmetric 362 x 362 data matrix $\mathbf{L}_U$, which, when subjected to principal components analysis, generated 22 clusters largely similar to those derived via the second approach, though a larger number of industries failed to fall into any clusters. Again, indirect linkages between industries were only partially evident.

Fourth Approach. A final clustering approach used correlation analysis to define interindustry linkages between pairs of industries. Rather than measure the functional linkage between two industries in isolation (as in the second and third approaches), correlation analysis permits the assessment of linkages between pairs of industry based on their total patterns of sales and purchases across multiple industries. Each column (**x**) in a matrix of x's, **X**, gives the intermediate input purchasing pattern of the column industry. Each column (**y**) in a matrix of y's, **Y**, gives the intermediate output sales pattern of the column industry. Four correlations describe the similarities in input-output structure between two industries l and m:

$r(\mathbf{x}_l \cdot \mathbf{x}_m)$ measures the degree to which industries l and m have similar input purchasing patterns;

$r(\mathbf{y}_l \cdot \mathbf{y}_m)$ measures the degree to which l and m possess similar output selling patterns, i.e. the degree to which they sell goods to a similar mix of intermediate input buyers;

$r(\mathbf{x}_l \cdot \mathbf{y}_m)$ measures the degree to which the buying pattern of industry l is similar to the selling pattern of industry m, i.e. the degree to which industry l purchases inputs from industries in which m supplies;

$r(\mathbf{y}_l \cdot \mathbf{x}_m)$ measures the degree to which the buying pattern of industry m is similar to the selling pattern of industry l, i.e. the degree to which industry m purchases inputs from industries in which l supplies.

The four correlations were calculated for each pair of industries using two specifications of **X** and **Y**. The first specification consisted of buying and selling patterns for 362 manufacturing industries across all other manufacturing industries (362 x 362 matrices). The second specification consisted of buying and selling patterns for 362 manufacturing industries across all other industries, both manufacturing and non-manufacturing (478 x 362 matrices). Interindustry correlations calculated using the second specification of **X** and **Y** also account for similarities in manufacturing industries' sales/purchase patterns to/from non-manufacturing industries (e.g. construction, wholesaling, services).

Deriving the correlations from the first set of **X** and **Y** matrices and selecting the largest of the

four between each pair of industries yielded a 362 by 362 symmetric matrix, $\mathbf{L_V}$. Each column of $\mathbf{L_V}$ describes the pattern of linkage between the column industry and all other manufacturing industries. Principal components factor analysis with varimax rotation identified 28 factors that together explain nearly 90 percent of the variation in the data matrix. A close examination of several clusters derived from the 28 factors suggested that the approach yielded clusters based on both direct and indirect input-output patterns. The clusters reported in this document are derived from the results of this factor analysis.

Repeating the exercise for the second set of **X** and **Y** matrices generated 18 large and difficult-to-interpret clusters. When correlations were calculated based on non-manufacturing as well as manufacturing input-output patterns, non-manufacturing patterns tended to dominate the analysis for some manufacturing industries. This led some technologically dissimilar industries to cluster together based on similarities in non-manufacturing sales or purchases.

1.5 Deriving the Final Set of 23 Reported Clusters

Although the factor analysis generated 28 distinct factors, 5 of the factors yielded clusters consisting of only a single primary industry and several secondary industries when the criteria described above were applied. Since the linkages among industries in these groupings were especially weak as indicated by the factor loadings, and since the objective of the study is to identify and analyze multi-industry clusters, these single-industry "clusters" are not reported. Eigenvalues as well as the shares of total and common variance accounted for by each factor are reported in Table A.3. Factor loadings for each cluster are too numerous to reproduce here; these are available upon request.

Table A.3

Summary Results: Principal Components Factor Analysis

Factor	Interpretation	Eigen-value	% Total Variance	% Common Variance
Factor 1	Metalworking	90.50	25.0%	28.0%
Factor 2	Vehicle Manufacturing	40.27	11.1%	12.4%
Factor 3	Chemicals & Rubber	30.86	8.5%	9.5%
Factor 4	Electronics & Computers	22.91	6.3%	7.1%
Factor 5	Packaged Food Products	18.30	5.1%	5.7%
Factor 6	Printing & Publishing	15.96	4.4%	4.9%
Factor 7	Wood Products	14.35	4.0%	4.4%
Factor 8	Knitted Goods	12.49	3.4%	3.9%
Factor 9	Fabricated Textile Products	7.54	2.1%	2.3%
Factor 10	(Unreported)	6.05	1.7%	1.9%
Factor 11	Nonferrous Metals	5.64	1.6%	1.7%
Factor 12	Canned & Bottled Goods	5.37	1.5%	1.7%
Factor 13	Leather Goods	5.36	1.5%	1.7%
Factor 14	Aerospace	4.91	1.4%	1.5%
Factor 15	Feed Products	4.37	1.2%	1.4%
Factor 16	Platemaking & Typesetting	4.33	1.2%	1.3%
Factor 17	Aluminum	3.83	1.1%	1.2%
Factor 18	(Unreported)	3.77	1.0%	1.2%
Factor 19	Brake Products	3.59	1.0%	1.1%
Factor 20	Concrete, Cement, & Brick	3.53	1.0%	1.1%
Factor 21	Earthenware Products	3.09	0.9%	1.0%
Factor 22	Tobacco Products	2.82	0.8%	0.9%
Factor 23	(Unreported)	2.67	0.7%	0.8%
Factor 24	(Unreported)	2.47	0.7%	0.8%
Factor 25	Dairy Products	2.37	0.7%	0.7%
Factor 26	Petroleum	2.32	0.6%	0.7%
Factor 27	Meat Products	2.06	0.6%	0.6%
Factor 28	(Unreported)	1.90	0.5%	0.6%
Totals			89.4%	100.0%

2. Estimated Output

Output estimates for the U.S. (1993) and North Carolina (1994) for each industry were derived by multiplying total industry wages in the relevant year and the ratio of U.S. industry output to wages in 1987, the latest year for which detailed output data are available. 1987 wage and output data are from the 1987 U.S. Benchmark Input-Output Accounts; 1993 and 1994 U.S. and North Carolina industry wage data are from the ES-202 program

(NCESC and U.S. Bureau of Labor Statistics). Wage data reported in the U.S. input-output tables are largely derived from information from the ES-202 program.

The estimates of output are intended to provide a uniform metric for comparing the U.S. and North Carolina relative distributions of manufacturing activity. They are conservative estimates for two main reasons. First, not all wages paid by manufacturers are reported to state employment security commissions; wages not covered under employment security law are not reported, including self-employment payments that should reflect overall output in some cluster industries. In addition, there is a minimal amount of undercounting by state employment security commissions in general, primarily due to employment security tax avoidance by some manufacturers. Second, productivity gains made since 1987 are not accounted for since the ratio of output to wages is assumed constant over the period.

3. Employment Record Matching Methodology

In order to develop a conservative estimate of the component parts of net employment change (new plants or start-ups, expansions, contractions, and closures), enterprise-level records from the North Carolina Employment Security Commission ES-202 program were matched between two points in time (third quarters 1989 and 1994). The matching process classified enterprises (records) into one of three categories: businesses reporting data on the files in both time points (successful matches; plants remaining in business over the period), businesses appearing in the ES-202 files in 1994 only (hypothesized start-ups and plant relocations to the state), and businesses appearing in the files in 1989 only (hypothesized business closures over the period). Since the ES-202 data files are not constructed to facilitate the matching of business records over time, a several assumptions regarding the aggregation of plant-level entries were necessary. The final matching procedure was comprised of three major subroutines: data cleaning, initial match/merge, and iterative match/merge.[15]

3.1 Data Cleaning

A subset of variables and industries from the raw ES-202 data sets were first extracted and the records prepared for matching. Double counting of employment due to double-reporting by headquarters of multi-establishment firms and their branch plants was eliminated according to NCESC protocol by deleting all employment for headquarter establishments. Average quarterly employment numbers for each business were then calculated in accordance with the NCESC's practice of determining the number of months in the divisor based on the date at which a business entered the data set (liability date).[16]

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[15] Variables in the ES-202 files are the following: employer account ID; employer liability date; 4-digit SIC code; FIPS county code; employment in each of the three months of the quarter; total quarterly payroll; establishment type (independent, home office, branch plant, sub-branch plant); establishment name; establishment physical and mailing addresses. As of 1991, NCESC has collected the establishment type information at a finer level of detail. The major components are conceptually the same, however, ensuring consistency between 1989 and 1994.

[16] The choice of how to calculate quarterly averages was not an innocuous one. Approximately six percent of the establishments failed to report positive employment data for each of the six months covered by the data (in the ES-202 files, employment counts for each business are provided for each month of a given quarter). The difficulty arises in determining what a zero employment entry for one or more months of a quarter means (i.e. simple missing value, start-up or closure over the period for the record in question, employment levels

The mechanics of a computer generated match of records from the two time points required a some aggregation of establishment-level information. The data merging procedure simply matches any two data records that take on identical values for a set of user-determined variables in each data set (i.e., at each time point).[17] When there are an unequal number of records in the two data sets which share the matching criteria (e.g. same unique employer id), some information in the output data sets may be duplicated. For example, consider the case of a business establishment listed under one entry in IIIQ 1989, and (perhaps because of a voluntary change in its own accounting procedures so that different divisions report to NCESC separately) two entries in IIIQ 1994. Both entries in 1994 share the same employer id. If the records are matched using the employer id, the output data set will include two entries where 1989 data (e.g. employment) from one entry is assigned to both entries in 1994, thereby double counting 1989 information for a single physical establishment.

To avoid this undesirable property of the merge procedure it was necessary to aggregate records in each data set so that matches performed would maintain a one-to-one correspondence. To maintain as much of the original data structure as possible, the initial aggregation was based on a very stringent set of conditions. Records were only aggregated if they had an identical employer identification number, 4-digit SIC code, FIPS code, *and* liability date.[18] With each of the aggregations a new variable was created to keep track of how many establishments were collapsed into a single record. This variable was later used in the estimation of establishments in each sector.

3.2 Initial Merge

An initial merge procedure matched records which shared identical values for four variables: employer identification number, FIPS code, 4-digit SIC code, and liability date. The output data set contained records with shared values for these four variables and a unique set of variables for each of the two study quarters. Each record (establishment) in the output data set was classified into one of five categories: 1) *start-up*--a record in the 1994 data set with no match found in the 1989 data set and a liability date later than third quarter 1989; 2) *expansion*--a matched 1989 and 1994 record with 1994 employment greater than 1989 employment; *contraction*--a matched 1989 and 1994 record with 1994 employment less than 1989 employment; *closure*--a record in the 1989 data set with no match found in the 1994 data set; and 5) *predated*--a record in 1994 data set with no match in the 1989 data set but a liability date that predates third quarter 1989. Although the initial procedure was based on extremely restrictive conditions, it still managed to match over 50 percent of approximately 10,500 records in each year.

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falling below the level of unemployment insurance liability, seasonal employment, etc.). The calculation of average employment for a business for a given quarter will vary depending on whether the sum of the three employment periods is divided by one, two, or three months. An alternative averaging method to the NCESC's would be to construct the divisor so that only positive employment months are counted (implicitly assuming that all missing data are inadvertently unreported data).

[17] These variables may be defined as character, a substring of a character variable, or numeric.

[18] As is discussed below, additional aggregations later became necessary. Note also that any variables used in the analysis that were not dependent on the net employment decomposition were derived from disaggregate data (e.g. net employment levels in each period, wages, etc.). The aggregation is only necessary in the context of the merge procedure to derive components of net employment.

If the initial matching procedure worked perfectly, the non-matched records (not including *predated*) would all represent new or closed plants, depending on the year in which they appear in the ES-202 files. There are, however, known shortcomings with the NCESC data for the purposes of this exercise which warranted additional merge attempts based on other less restrictive criteria. The most significant problem is that establishments that change ownership or even simply restructure their operations or alter internal accounting procedures will often be issued a new employer ID by NCESC. The first merge would miss all these records, effectively assigning to start-ups and closures many plants that remained operating in the state over the study time period. Another problem is that employers are frequently assigned different 4-digit SIC codes over time, i.e. whenever NCESC determines that the change will more accurately reflect the production characteristics and final product of the establishment. This reassignment will also result in no matches based on the initial merge criteria. Finally, the existence of "predated" records can also partially be explained by NCESC policy. When employers failing to comply with unemployment insurance laws are located (delinquent accounts), their NCESC records are retroactively assigned a liability date based on when they should have been liable. This results in records on the 1994 ES-202 data set with a liability date prior to IIIQ 1989 but no record on the IIIQ 1989 data set.

3.3 Iterative Merge

An additional iterative merge subroutine was implemented in an attempt to overcome two of the above problems: 1) the issuance of new employer IDs based on new ownership and other transactions; and 2) the reassignment of SIC codes. To address the first problem, a substring of the establishment name was substituted as a match criteria for the employer identification number. The second problem was resolved by aggregating records to the 3-digit SIC level, while still requiring that they have identical FIPS codes and employer identification numbers. Repeated applications of the merge procedures based on successively less restrictive character substring criteria were then applied to generate lists of matched records which could then be visually inspected for plausibility.

The data set from the initial merge process was first subset into two data sets, one containing matched records (expansions and contractions) and another containing the no-matches (start-ups, closures, and predated records). The no-match data set was then itself subset into two data sets, one containing the 1989 records and the other the 1994 records. These two data sets were then re-merged, matching all records with identical values for a 15 character substring of the establishment name, the same FIPS code, and the same 3-digit SIC code. The smaller number of non-matching records from this process were then subset into 1989 and 1994 data sets and re-matched yet again, this time using identical 10 character substrings of establishment name (and identical FIPS and SIC codes) as the matching criteria. Resulting matches were again visually inspected. The process was then repeated a last time using a identical 5 character substrings of establishment name (and identical FIPS and SIC codes) as the criterion.

Visual inspection of the output from each of the iterations suggested that the procedure was effective. Only three incorrect matches from the first iteration, three incorrect matches from the second iteration, and ten incorrect matches from the third iteration were identified, all of which were then re-allocated to the residual set of no-matches. These were then reclassified as start-ups, closures, and predated records as appropriate, while the correct matches were classified as either expansions or contractions and re-combined with the initial set of matches. Overall, the iterative merge subroutine created 916 additional matches out of the initial pool of no-matches.

3.4 Diagnostics

A final diagnostic procedure was applied to the records classified as predated (those records only appearing in the 1994 data set but with a liability date that pre-dates IIIQ 1989) in order to determine how many were true failed matches and how many were potentially the result of NCESC record keeping procedures. Although, as noted above, the NCESC retroactively assigns liability dates to delinquent taxpayers, a five year statute of limitations on liability may result in a reported liability date that does not reflect the actual time at which a plant should have entered the ES-202 files (the hypothesized business start date). This means that any non-matched records with liability dates prior to 3rd quarter 1984 are outside the range for which retroactive liability dates could be assigned and, therefore, by definition, represent true failed matches and not delinquent accounts. Any records with liability dates between IIIQ 1984 and IIIQ 1989 are potentially true delinquent accounts. Graphs # and # indicate the distribution of establishments and employment in the delinquent category by liability date. After all merge procedures had been completed, the final set of delinquents contained 1,032 establishments employing a total of 51,448 workers. Approximately 48 percent of inconsistent records are within the statute of limitations and could be delinquent accounts.

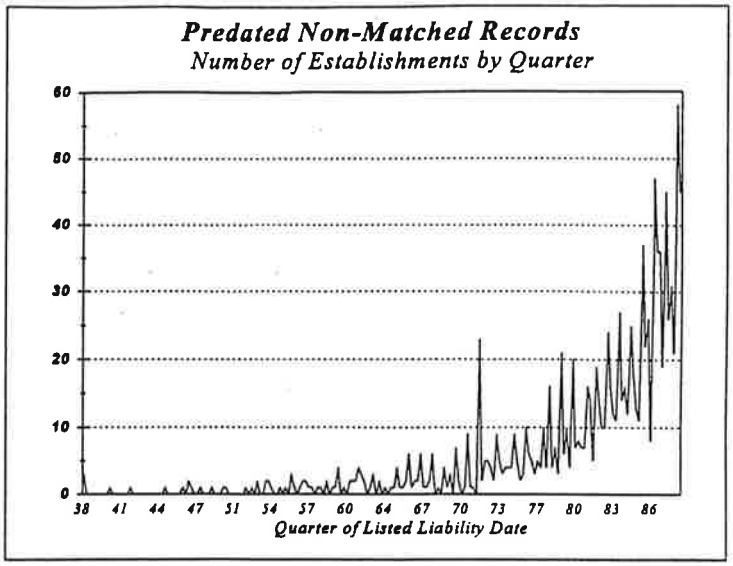

Figure A.35

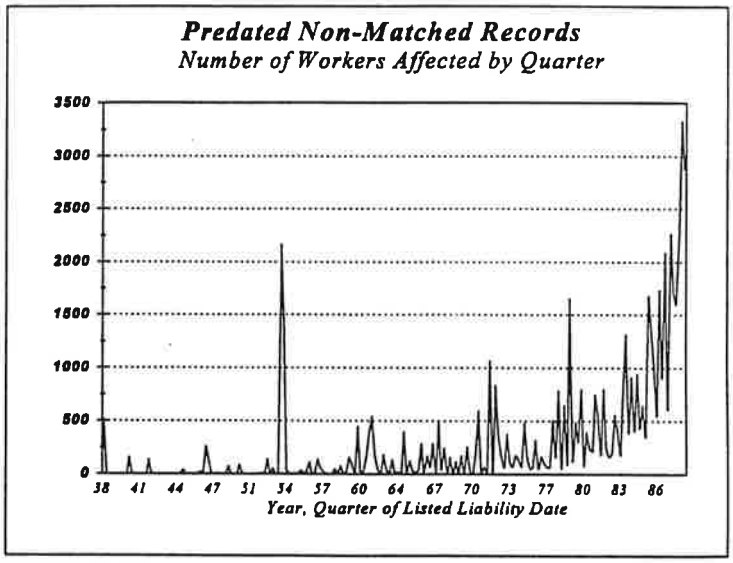

Figure A.36