INTERIM REPORT OF THE
SECRETARY OF TECHNOLOGY

AN INDUSTRIAL CLUSTER ANALYSIS OF THE VIRGINIA ECONOMY

TO THE GOVERNOR AND
THE GENERAL ASSEMBLY OF VIRGINIA

SENATE DOCUMENT NO. 26

COMMONWEALTH OF VIRGINIA
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2000

COMMONWEALTH of VIRGINIA

Office of the Governor

James S. Gilmore, III
Governor

Donald W. Upson
Secretary of Technology

December 15, 1999

The Honorable James S. Gilmore, III
Governor of Virginia
State Capitol
Richmond, Virginia 23219

Members of the Virginia General Assembly
General Assembly Building
Richmond, Virginia 23219

Dear Governor Gilmore and Members of the General Assembly:

On behalf of the multi-agency study group that conducted this effort, I am pleased to submit to you ***An Industrial Cluster Analysis of the Virginia Economy.*** This study fulfills, in part, the directives of Senate Joint Resolution 502 of the 1999 General Assembly.

Cluster analyses are a widely recognized technique for identifying and measuring linkages among and between various sectors of the economy and their supporting institutions, especially the research base, which can be strengthened and exploited to increase the competitive advantage of those industry sectors in the global marketplace. This groundbreaking cluster study of Virginia's economy, which is included as Section III of this report, was conducted by a research team from George Mason University and has identified twelve clusters that exhibit recent growth or growth potential and, therefore, may be promising candidates for additional research and development investment.

It is important to note, however, that this cluster analysis is only a first step in determining where and how the Commonwealth might focus its efforts in attracting or making targeted R&D investments. Final recommendations to the Governor and the General Assembly will be developed as part of a collegial process that involves representatives of the universities, the business community and the Commonwealth. Therefore, in order to complete these initiatives and accomplish the objectives of SJR 502 in total, I request that the 2000 General Assembly extend the timeframe for the completion of all SJR 502 assignments until November 1, 2000.

We trust that you will find the enclosed study report responsive and informative. With the publication of this document (Senate Document No. 26, 2000) and a companion study, *An Assessment of the Intellectual Property Policies and Practices in Virginia's Public Universities and Federal Laboratories* (Senate Document No. 25, 2000), a number of the baseline requirements of SJR 502 have now been fulfilled. However, accomplishing the ultimate goal of that resolution—the development of a coordinated research and technology policy for the

Commonwealth—is a complex assignment requiring several additional efforts that are already underway or will be initiated over the next several months. The overall framework for a Statewide Research and Technology Strategy for the Commonwealth, within which all SJR 502-related efforts will fit, is outlined in Section II of the enclosed report. Our plan for establishing a stakeholder-driven process for defining and then supporting a coordinated R&D policy, involving senior research and technology managers from our universities, federal laboratories located in the state, and Virginia's technology-intensive companies, is also described in Section II.

Respectfully submitted,

Donald W. Upson

Enclosure

c: The Honorable Wilbert Bryant
The Honorable Barry E. DuVal

AN INDUSTRIAL CLUSTER ANALYSIS OF THE VIRGINIA ECONOMY

PREFACE

Authority Directing the Study

Senate Joint Resolution 502 requests that the Secretary of Technology with the assistance of Virginia's Center for Innovative Technology and in consultation with institutions of higher education, federal laboratories, and the private sector, conduct a review of the intellectual property policies and procedures of the institutions of higher education and federal laboratories, incentives to participate in joint ventures, and best practices by which intellectual resources can be linked to commercialization to benefit the economy of Virginia. Finally, the study is to suggest ways that an increased awareness of these assets and mechanisms might result in greater collaborations.

Given the broad scope of the requirements, the organizations assigned responsibility for the study have initiated several research and analysis efforts. This document represents one component of those efforts— how to develop the stakeholder-driven technology strategy development process that results in a comprehensive and coordinated view of research and development goals for industry, academia, and government in the Commonwealth identified in the resolution. A companion document, *An Assessment of the Intellectual Property Policies and Practices in Virginia's Public Universities and Federal Laboratories,* has also been produced in response to SJR 502. As indicated below, follow-on documents, addressing additional components of the SJR 502 requirements, will be produced during the coming year.

Towards a Comprehensive Research and Technology (R&T) Strategy for Virginia

In broad outline, the Secretary of Technology has identified three major strategic research and technology policy goals for the Commonwealth. These are:

- Improve linkages between Virginia's research universities and the private sector, inside and outside Virginia, in order to increase private sector investment in R&D performed in the Commonwealth;
- Increase Federal and state R&D investment in Virginia and in research programs important to Virginia's industries; and,
- Improve the environment and opportunities in our universities for creating innovative start-up companies that will drive new growth.

In order to achieve these goals, the Secretary has initially defined a comprehensive, stakeholder-driven R&T strategy for Virginia, of which this cluster analysis document is a significant component. An overview of this strategy is provided in Section II.

The study of where Virginia's technology-intensive industries could benefit from additional R&D investment is important because of the critical role of the research base in producing innovative new ideas that can be commercialized. The Council on

Competitiveness, a private sector organization with members from industry, education and labor, has identified the ability to innovate as the basis for the United States' competitive advantage in the global economy of the 21st century. The rapid commercialization of a continuous stream of innovative new products, processes, materials, and systems will be the basis for real growth in an economy where competition turns leading edge ideas into commodities in just a few years.

Virginia's research universities are conducting significant research in technical fields including communications, biotechnology, medicine, software and systems integration, agriculture, aeronautics and aerospace, advanced materials, manufacturing processes and a host of others of importance to existing and emerging industries. Strong linkages and effective cooperation between this research base and the industries that can convert research results into products, jobs and revenues are essential to the Commonwealth fully benefiting from our outstanding universities.

During 2000, the Secretary of Technology will empanel a research and technology advisory body composed of leading research managers from industry, academia and the federal labs (see Section II). This group will advise the Secretary on a number of important issues, including developing specific recommendations for the Governor and General Assembly, the Virginia Congressional delegation and the private sector to consider relative to increasing R&D investments in the Commonwealth.

Study Group Membership

Office of the Secretary of Technology
Fred H. Williamson, Assistant Secretary
Chairman

Virginia Commonwealth University
William L. Dewey, Ph.D., Vice President,
Research and Graduate Studies

Litton PRC, Inc.
Jude E. Franklin, Ph.D., Vice President
and Chief Technology Officer

Virginia's Center for Innovative Technology
Robert M. Schwartz, Ph.D., Director,
Intellectual Resources
Maxine Pitter Lunn, Ph.D., Managing Director,
Technology Company Assistance;
Director, R&D Strategy and Policy

Department of Technology Planning
N. Jerry Simonoff, Director
K. C. Das, Ph.D., Director, Office of Innovative
Technology

Acknowledgments

The study group wishes to acknowledge the work of Professor Roger Stough and his research team of Peter Arena, Raj Kulkarni, Jim Riggle and Mark Trice of the Mason Enterprise Center at George Mason University's Institute of Public Policy in producing the study included as Section III of this report, as well as the Executive Summary included in Section I. We also wish to recognize the time and effort of the many private and public sector participants around the Commonwealth who participated in various phases of this study.

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SECTION I

EXECUTIVE SUMMARY

The vision behind this report is that of a Commonwealth research and development strategy that levers the state's scientific and technology resources for economic growth. Such a strategy is important because it is directed at the "new economy" or rapidly growing and changing parts of the state's economy, which are being forced to restructure because of the rapid rise of the technology that underpins the knowledge economy. The research plan developed to accomplish this vision is in three stages:

1. Identify Virginia's major industrial clusters and potential growth sectors in those clusters;

2. Develop a set of recommendations for each cluster through focus group meetings and interviews; and

3. Review and prioritize these recommendations with the R&D Commission that the Secretary of Technology is forming.

The research reported in this study describes the results of the identification and examination of the Virginia industrial clusters, i.e., stage one of the research plan. Work on the 2nd and 3rd stages is reserved for future research initiatives.

Industrial clusters are groups of industries that are highly inter-dependent in that they buy and sell from each other, their products tend to be functionally interrelated and there are supporting institutions, e.g., associations and research institutions related to the cluster functions. Components of such clusters are usually proximate to one another thus they tend to exhibit spatial concentration in specific regions or sub-parts of states. There are different types of industrial clusters ranging from traditional to propulsive to service, etc. Here clusters have been identified in three areas: natural resource, manufacturing and service sector with an emphasis on propulsive clusters.

Propulsive (emergent) clusters and/or their industry components are ones that exhibit recent growth or growth potential and have, or promise to have, relatively high wages. Clusters that have significant growth in employment earnings, wage levels, productivity and large size relative to a national or global base tend to be propulsive. Further, the larger and more interdependent a cluster and its industry components, the greater the policy significance

Major Findings

1. Agricultural services and product cluster: the most promising part of this cluster is in the area of food products and more specifically meat, poultry and dairy products.

2. Three sectors in the wood products cluster show potential for future development: furniture products; paper products; and printing and publishing.

3. The chemicals cluster is composed of several strong sub-sectors: inorganic chemicals; plastics materials and polymers; and medicinal products.

4. The machinery and equipment cluster has several major sub-sectors that are very promising: electronic equipment (especially industrial and communication equipment); scientific equipment and instruments (search and navigation equipment, measuring and controlling devices such as sensors and optical instruments and lenses.

5. The transportation equipment cluster, despite many attributes of the "old economy" has several emergent and fast growing sub-sectors. These include: motor vehicle equipment and space related industries.

6. The transport services cluster has promising sub-sectors in water transport (marine cargo handling, towing and tugboat services, and sea transport) and air transport. Activities in this cluster drive the demand for transportation services, and trucking and warehousing services.

7. The financial services cluster has exhibited considerable growth in non-depository banking. Opportunities lie in this sub-sector as well as in the depository banking services and securitization (e.g., Freddie Mac).

8. The business services cluster is the largest in the state and contains one of the states strongest complexes of continued growth in computer services (programming, integrated systems design, data processing, prepackaged software, maintenance and repair and computer facilities management). Developments in these related sectors creates a continuing demand for professional services and therefore a strong demand for engineers, management consultants and personal services.

9. The communications cluster is one of the more propulsive ones. The strength in this cluster is in telephone communications (wire and wireless), cable, and Internet applications.

10. The tourism cluster is a potentially promising one. While today it is composed primarily of constituent industries such as hotels and motels, entertainment and recreation, by linking it to the states strong computer

services industry, "smart tourist" products could become the foundation of a higher paying and emergent cluster.

11. The health services cluster is one of the largest in the Commonwealth yet relative to the national presence it is quite small. The opportunities in this cluster lie in the area of bio-science and in particular, bio-informatics. By continuing to link bio-science to the Virginia computer services industry, a potentially new and powerful industry may be developed.

12. Legal services also offer some potential in the area of technology law which has surged in the last year in Northern Virginia and Richmond.

The 12 areas discussed above are the potential target clusters and industries for the analysis.

The next stage (stage 2) of the analysis would be to investigate and identify potential improvements in the way the target industries do business through focus groups and interviews. In most cases these potential improvements will be in the areas of better services, technologies and infrastructure. The final stage of the research would be to review and prioritize the proposed improvements with the R&D Commission the Secretary of Technology is forming.

An example of a potential improvement stems from a pattern identified in several industries examined in part through the initial focus group meetings and a few interviews. The pattern is that logistical and transport outsourcing and integration is occurring at a very rapid pace in many industries. It is important to note that this is impacting and will impact many industries in the state. At the same time Virginia probably has the kind of skilled labor force and knowledge base required to produce advanced logistical technologies that could be developed to support Virginia demand and eventually to become an exporter of this technology and related services. A case study of the food products industry, as part of the agricultural services and products cluster, is reported in the concluding chapter of the report to illustrate how this industry is outsourcing most, if not all, of its transportation and logistics functions.

Recommendations

This report has been successful in identifying the major industrial clusters and their high potential industrial components. Future work as described above is needed to move these initial results to the policy and action stage. Thus the overriding recommendation is that research to identify potential improvement or growth strategies for the target industries is needed to complete the development of a "new economy" oriented research and development plan for the Commonwealth. The research needed is that required to complete the 2nd and 3rd stages of the research plan.

SECTION II

TOWARD A STRATEGIC VIEW OF RESEARCH AND TECHNOLOGY IN THE COMMONWEALTH

Elements of a Statewide R&T Strategy for the Commonwealth of Virginia

The Office of the Secretary of Technology believes that developing a statewide research and technology (R&T) strategy for the Commonwealth should be a stakeholder-driven process that results in a comprehensive, coordinated and mutually reinforcing view of research and development goals for industry, academia and government in the Commonwealth. The purpose of such a strategy is to focus coordinating, developmental, and funding efforts on those technologies (including process technologies) which offer the greatest likelihood of generating additional technology-based economic growth for the Commonwealth in the Information Age.

Among the steps necessary to develop such a strategy are the following:

- Appoint a panel of distinguished research leaders to oversee the development, implementation and updating of the Commonwealth R&T strategy and to advise the Governor, the Virginia Congressional delegation and the Secretary of Technology on technology matters.
- Establish a baseline cluster analysis that identifies and provides a clear understanding of existing relationships among technology industries, their research base, suppliers, vendors and supporting organizations (as directed by Sec. 2.1-51.44B7, *Code of Virginia*, and SJR 502).
- Identify the major research strengths of Virginia's universities, private R&D facilities and federal laboratories within the Commonwealth.
- Identify, prioritize and advocate for key federal programs that support significant Commonwealth university or industrial research efforts or major national missions.
- Identify and establish policies to strengthen those elements of Virginia's technology base (i.e., the Commonwealth's major technology industry clusters) that are important in providing global competitive advantage.
- Use the strategic direction and focus resulting from the strategy to direct public investments and attract private investments in order to fund additional research to: (a) generate new discoveries in existing and emerging technologies; and (b) foster and improve commercialization of advanced stage technologies (as directed by SJR 502).
- Develop policies and programs that leverage the competitive advantage afforded by Virginia's exceptional public and private high-speed data networks to encourage and support collaborative research among Virginia's universities.

The long-term goals for this strategic approach include the following:

- Two Virginia universities ranked in the top 50 of US research institutions by 2010.
- 20% increase in federal R&D spending in Virginia (adjusted for inflation) by 2004 and 50% increase by 2008.
- 7.5% compound annual growth rate in federal Small Business Innovation and Research funding of Virginia firms (adjusted for inflation).
- At least one major, world-renowned research facility (public, private or federal) in Virginia for each of our major technology industry clusters by 2010.

Virginia Research and Technology Advisory Commission

The Virginia Research and Technology Advisory Commission (ViRTAC) will be chartered by the Secretary of Technology under the authority granted him in Section 2.1-51.50 of the *Code of Virginia*. The Commission will be composed of not more than 30 senior research and technology managers drawn from Virginia's universities, federal laboratories located in Virginia and, predominantly, from Virginia's technology-intensive companies.

The mission of the Commission will be to work with the Secretary of Technology, as well as the Secretary of Education and the Secretary of Commerce and Trade, as appropriate, on all matters related to the development and implementation of the statewide research and technology strategy.

Specific goals of ViRTAC include:

- Creating closer linkages between Virginia's research universities and the private sector (both inside and outside of Virginia) with an eye to increasing private sector support to research in the Commonwealth;
- Advising the Governor and the Virginia Congressional delegation, as appropriate, on priorities for state and Federal research programs; and,
- Helping to create an environment in the Commonwealth that results in a dramatic growth in the number of innovative, high-tech start-up companies commercializing research discoveries.

Specific tasks will include: evaluating proposals for the competitive award of state R&D funds, preparing and helping to present an annual presentation to members of the Virginia Congressional delegation on priorities for federal R&D programs, and hosting events designed to bring together private sector and federal research managers with Virginia's university research community.

The chair and members of the Commission will be appointed by the Secretary and will serve for a renewable two-year term. Meetings will be held at the call of the Chair and may include working groups or other subsets of the Commission established to address specific issues and tasks. The Assistant Secretary of Technology will serve as Executive Director of the Commission. Staff support will be provided by the Special Assistant to

the Secretary for Media and Events, the Center for Innovative Technology and the Department of Technology Planning. Members will not receive compensation for their service but will be reimbursed for travel and other direct expenses.

SECTION III

CONSULTANT'S REPORT ON CLUSTER ANALYSIS OF THE VIRGINIA ECONOMY

Chapter 1

Introduction: Virginia Industrial Cluster Analysis

Industrial clusters are groups of industries that are highly inter-dependent in that they buy and sell from each other, their products tend to be functionally interrelated and there are supporting organizations, e.g., associations, research institutions, etc., related to the cluster functions. As such, the components (e.g., sectors or industries) of industrial clusters are usually geographically concentrated in specific regions or in specific parts of states or countries. Industrial sectors in the core of a cluster, for the most part, produce for the market outside the local region or area of concentration and therefore tend to be export-base industries. There are different types of industrial clusters including, but not limited to, traditional clusters (the dominant industry or group of related industries in a region) or to new emergent or propulsive clusters or to service-based clusters, etc.

The purpose of this report is to identify, describe and analyze industrial clusters in the Commonwealth of Virginia. Herein all major clusters have been identified and assessed to determine the degree to which they are emergent and/or potentially propulsive. The analysis includes an assessment of the geographic concentration or location of the clusters.

Propulsive (emergent) clusters and/or their industry components are ones that exhibit recent growth or growth potential and have, or promise to have, relatively high wages. Clusters that have significant growth in employment earnings, wage levels, productivity and large size relative to a national or global base are propulsive. The larger and more interdependent a cluster and its industry components, the greater the policy significance. Propulsive clusters and sectors more generally have attributes associated with the "new economy," rather than the "old" economy of the industrial period (see Table 1.1)

Industry cluster analyses focusing on propulsive clusters of industries can be used to develop policies aimed at investing in the emergent industries of the future. When successfully implemented, such an approach can result in job growth in higher wage and salary sectors, and can help to fuel increasing returns to employees, companies and the state economy in general as well as to specific sub-state regions. With such an approach the focus is on identifying propulsive clusters of industries in general and on the interdependence among these and their supporting industries and institutions and especially the research base.

The ultimate goal of the research that supports this report is to provide guidance for a technology policy and investment program in Virginia that is focused on the development of propulsive or "new economy" clusters of industries. This report is a first step to toward this end. Additional research will be required to fully understand the supply chain structure of industry clusters and the breadth and extent of their supporting institutions. All of this information will be needed to adequately inform technology and investment practice in the state.

The New Economy

Over the past several years, observers (e.g., Atkinson, 1999) have coined the concept of the "new economy." This concept expresses the transformation that the economy has gone through as it moved from an industrial to a knowledge-based economy. The importance of the "new economy" idea for this report is that the focus here is upon identifying and describing emergent and propulsive industrial clusters that can become the focus of a technology policy and investment strategy. "New economy" industries are, among other things, also emergent and propulsive.

A full range of attributes of the "old economy" and "new economy" appear in Table 1.1. Some of the broad attributes of the "old economy" are that its organization was more hierarchical or vertically integrated, it was more national in scope, and subject primarily to competition at the regional and or national level with government in the role of providing goods and services.

Table 1.1. Attributes of the Old and New Economies*

Issue	Old Economy (Fordist)	New Economy (Neo-Fordist)
Economy-Wide Characteristics:		
Organizational form	Vertically integrated	Horizontal networks
Scope of competition	National	Global
Markets	Stable	Volatile
Competition among Sub-national	Medium	High
Geographic mobility of business	Low	High
Role of government	Provider	Steer/row/end
Labor and Workforce Characteristics:		
Labor-Management relations	Adversarial	Collaborative
Skills	Job-specific skills	Global Learning skills and cross-
Requisite education	Task specialization	Lifelong learning and learning by
Policy goal	Jobs	Higher wages and incomes (productivity)
Production Characteristics:		
Resource orientation	Material resources	Information and knowledge resources
Relation with other firms	Independent ventures	Alliance and collaboration
Source of competitive advantage	Agglomeration economies	Innovation, quality, time to market and
Primary source of productivity	Mechanization	Digitization
Growth driver	Capital/labor/land	Innovation, invention and
Role of research and innovation in the	Low moderate	High
Production methodology	Mass production	Flexible production
Role of governemnt	Infrastructure provider	Privitization
Infrastructure Characteristics:		
Form	Hard (physical)	Soft (information and
Transport	Miles of highway	Travel time reduction via application of
Power	Standard generation plant	Linked power grid (co-generation)
Organizational flow	Highly regulated	Deregulation
Telecommunication	Miles of copper wire	Wireless and fiber
Learning	Talking head	Distance learning

* For a more extended discussion see: Jin D. and R. R. Stough

The "new economy" exhibits organizational structure and structures that are more horizontal and networked in form, more global in scope, more volatile and dynamic, with businesses more mobile and under more competitive pressure, and government is

increasingly steering or partnering rather than producing services. Beyond these general distinctions there are a variety of other characteristics that are different, including labor relations, production process and infrastructure demand. The new economy relies heavily, for example, on information technology, telecommunications and, increasingly, the Internet.

In summary, however, successful organizations of the "new economy" tend to be fast adjusting, flexible and agile in the face of change, networks tend to dominate organizational structure, relations between customers and producers tend to be more reflexive, soft infrastructure tends to be more important than hard, and government is increasingly getting out of the business of providing more than a limited set of core services. It is possible to use state R&D and technology policy as a tool to support the development of industrial clusters with these "new economy" attributes.

Methodology

Industrial cluster analysis has become one of the new tools for guiding and informing technology policy (Feser, forthcoming). Industrial cluster analyses have recently been conducted at the metropolitan and state level, not just in the U.S., but throughout the world (Humphrey Institute, 1998; Rosenfeld, 1997; Glasmeier and Harrison, 1997; Bergman, Feser and Sweeney, 1996; Bosworth, Brian and Broun, 1996; Held, 1996; Jacobs, Dany and Ard-Dieter De Man, 1996; Rosenfeld, 1996; Doeringer, Terkla, 1995; Rosenfeld, 1995; Saxenian, 1994; Sternberg,1991; Porter, 1990). However, this is a relatively new analytical approach and there is no standard methodology. Investigators have utilized a variety of approaches both quantitative and qualitative with the more useful ones utilizing both approaches. The quantitative approaches typically analyze industrial sector data using methods that range from measures of industry size and change (e.g., employment, wage level, establishments and related dynamics) to measures of inter-industry linkage levels (e.g., input-output models). Qualitative analysis (interviews, focus groups and surveys) is needed, however, to learn about the structure of supply chains and to describe supporting hard and soft infrastructure (see, for example, Stough, et. al., forthcoming for a description of one approach called Multi-Sector Qualitative Analysis). This report, however, describes and evaluates primarily the results of the quantitative analysis of Virginia's industrial clusters. While one round of focus group meetings and interviews with industry, government and university officials has been held in all 9 of the state's technology regions, more of this kind of work will be required to adequately understand the supply chain structure of the clusters and their supporting hard and soft infrastructures.

The report defines three types of clusters, depending upon whether they are resource, manufacturing or service-based. Clusters are defined by examining each 2-digit SIC sector to determine which other 2-digit SIC sectors are highly related to the sector being considered. An input-output table for the Commonwealth of Virginia was developed for this purpose using the IMPLAN methodology (U.S. Forest Service, 1997). A cluster is defined by combining all highly interdependent 2-digit sectors with the sector under consideration. In all, four resource-based, five manufacturing and eleven service-based

clusters were identified. Consequently, the analysis is organized into three chapters that deal with the three different groups of clusters. These chapters are followed by a chapter that identifies and explores the potential of high growth clusters.

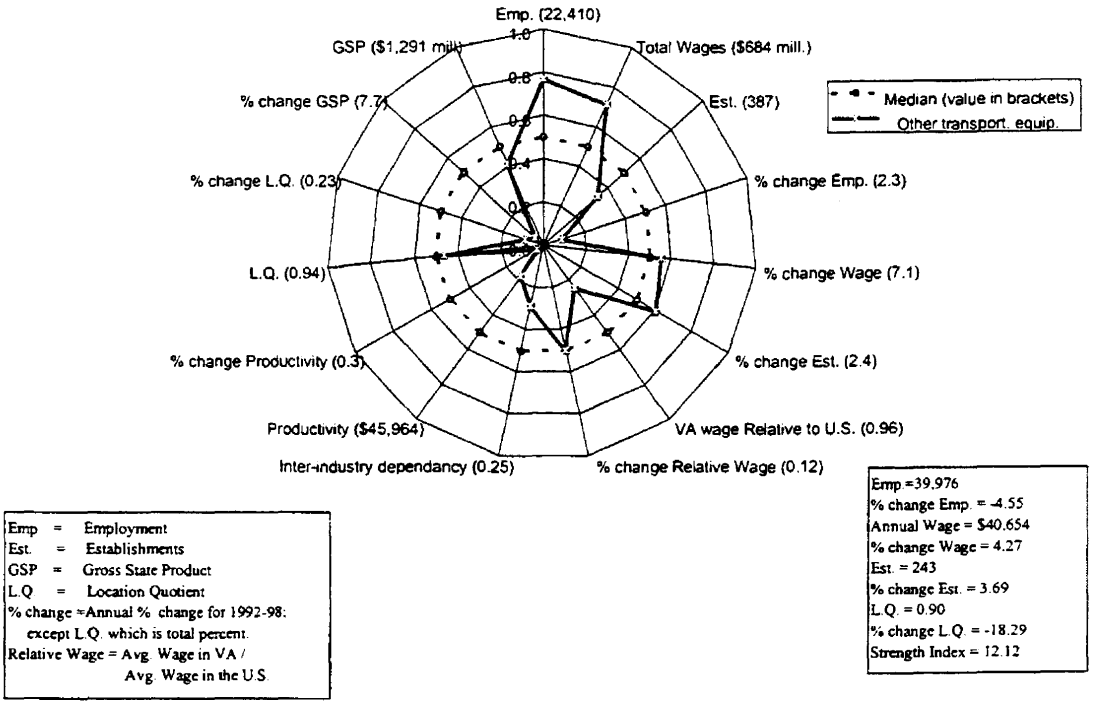
The cluster evaluation and assessment process is based upon 15 economic performance measures. These are:

- Employment
- Employment change
- Annual average wage
- Rate-of-change in the annual average wage
- Establishments
- Rate of change in the number of establishments
- Wage level relative to the national industry wage level
- Rate of change in relative wage
- Inter-industry dependency
- Productivity
- Rate of change in productivity
- Contribution to gross state product
- Rate of change in contribution to gross state product
- Location quotient
- Change in location quotient (1992-1998)

Coordinating and conducting an analysis using 15 different measures is complicated and can be confusing. To facilitate the analysis, spider diagrams were created with 15 spokes, one for each measure as illustrated in Figure 1.1.

Spider diagrams present a large amount of information on each of the industrial clusters. While interpretation of the strength of a cluster is facilitated by each of the 15 data points on the spokes of the diagrams, the amount of data can still be confusing. However, the shape of the diagram and the amount of area encompassed are good indicators of the strength of the cluster both in terms of size and growth. Thus, spider diagrams that are full in shape (i.e., not characterized with several sharp edges or points) and that fill up sizeable amounts of the total space (area) available are larger and generally more propulsive sectors.

Figure 1.1. Transportation Equipment Manufacturing Sector in Virginia: 1998

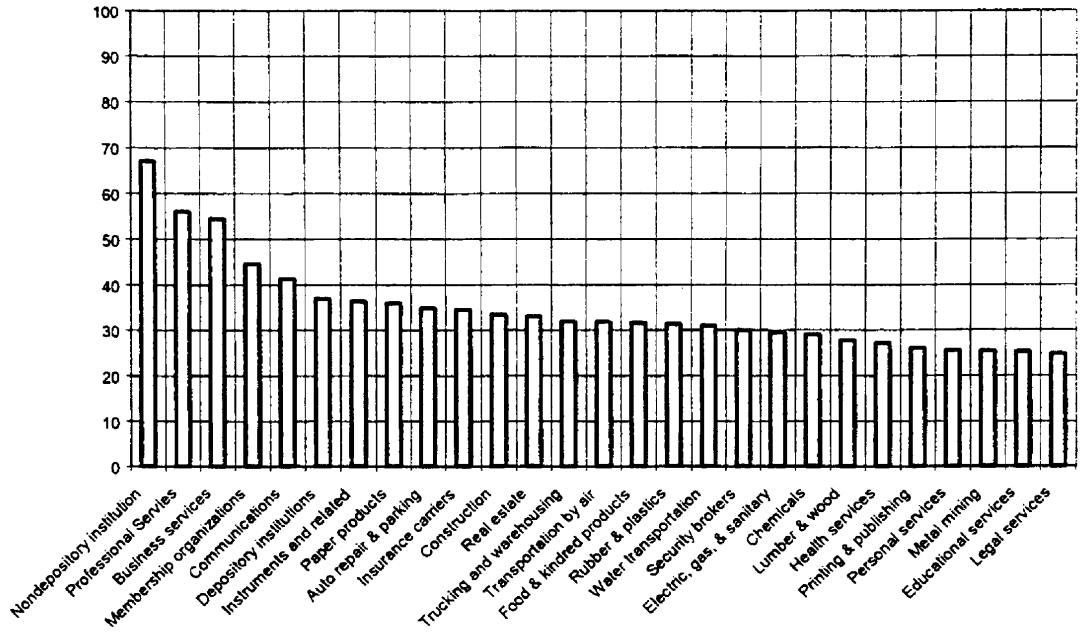


Further, a cluster strength index value appears on the diagram for each cluster and in Figure 1.2. These values are computed as the ratio of the area inside the spider diagram to the total area available multiplied by 100. Thus, the larger the index value, the larger and more growth oriented the cluster and vice versa, e.g., in Figure 1.1 the strength index for the transportation equipment manufacturing cluster is 12.12 indicating that it is a relatively weak cluster. This is further confirmed by the diagram's irregular shape. Finally, four somewhat interrelated size or scale variables are arrayed at the top of the diagrams. These scale variables are employment, total wages, number of establishments and contribution to the gross state product. For large sectors, the upper part of the diagram will tend to encompass a large amount of the space or area available. Another parameter or measure of the overall size and propulsiveness of the clusters can be computed by counting the number of spokes for which the values are greater than the median value for all Virginia clusters. Dividing this value by 15 (the number of spokes) and multiplying by 100 would be another way to create a size and propulsiveness cluster index. This measure has not, however, been computed as it is highly correlated with the Cluster Strength Index and, moreover, the reader can easily compute it if desired.

Each of the 15 variables was measured in terms of its own metric, which meant that few measures had comparable metrics. Consequently, it was necessary to create standardized scores to ensure metric for the spider diagrams. This was accomplished by ranking each 2-digit SIC sector from the smallest to the largest and assigning a score of 0.0 to the smallest and 1.0 to the largest and scores in-between according to the rank of the sector. This helps to interpret the full performance of a given sector. However, it does require

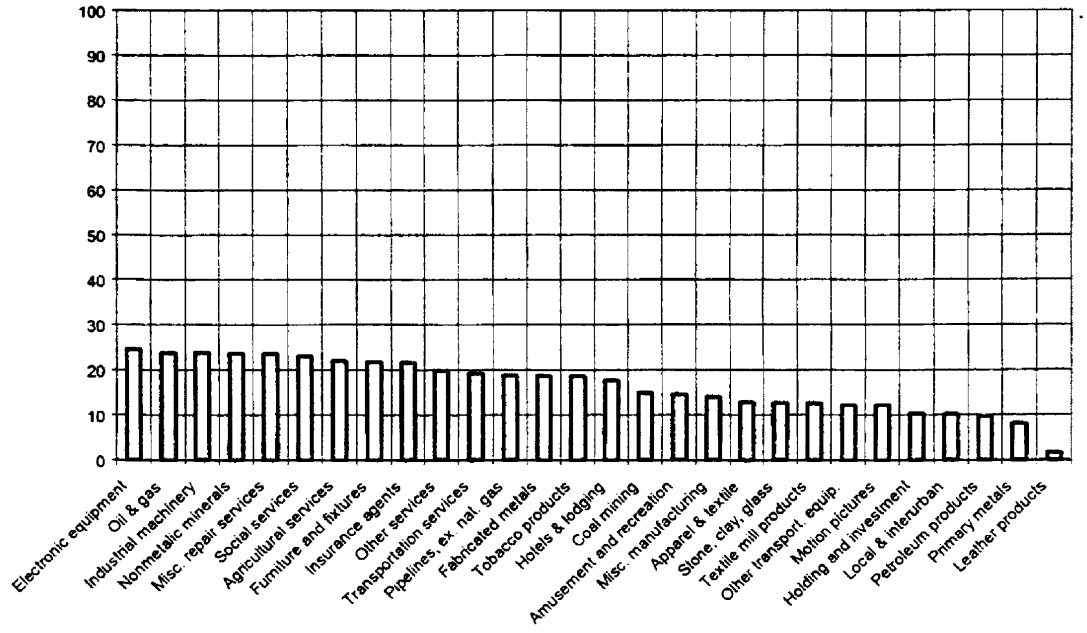
care in the interpretation of the relative wage measure as this variable is referenced (or base-lined) nationally, not locally.

Figure 1.2. Cluster Strength Index*



*Cluster Strength Index = [(area inside spider diagram/total possible area) x 100]

Figure 1.2. Cluster Strength Index* (Contd.)



*Cluster Strength Index = [(area inside spider diagram/total possible area) x 100]

Data for export trade by 2 digit SIC sector in Virginia was collected, but not included, in the analysis. There are two reasons for this. First, the data exists only for manufactured goods, thus limiting the range of applicability. Second, the research team has not been able to identify comparable data at the national and global level. Export trade data can be used to provide a measure of global competitiveness.

Variables and Data

As noted above, there are 15 variables that form the basis of the analysis. These are described and interpreted below.

Employment and Employment Change

Table 1.1 presents the employment data for the Virginia 2-digit SIC classifications. Employment levels range from 277,800 for the largest sector, business services, to 80 for the lowest, pipelines. The annual rate of change of employment for the study period ranges from over 100 percent per year for two very small industries to negative 11.3 for the leather products industry. Most sectors have been experiencing employment growth as indicated by the median rate of employment change, which is 2.4 percent per year. If employment growth was stable, with some industries increasing their employment and a similar number decreasing, the median value would have been nearer 0.0 percent. That the median is 2.4 percent, in this case, indicates that most industries have been experiencing increasing employment.

Annual Wages in Virginia

The wage data is presented in Table 1.2. The total wage measure is closely associated with employment level in the sectors. More interesting is that the annual rate of change in wages is positive for most sectors, with the median level of change at 7.1 percent per year.

Establishments in Virginia

Table 1.3 presents establishment data for the 2-digit SIC sectors. Again, the number of establishments tends to be associated with employment level. However, some industries are more oligopolistic and therefore may be exceptions to this rule. The median rate of establishment formation is 2.4 percent per year. Establishment data helps interpret industrial structure. The change data is a measure of churn which is an important indicator of competitiveness.

Table 1.2. Employment in Virginia: 1998			
SIC2	Industry	Employment	Annual % Change 1992-98
07	Agricultural services	24,522	7.96
12	Coal mining	6,309	-6.51
13	Oil & gas	671	21.37
14	Nonmetalic minerals	3,322	4.27
15	Construction	42,100	2.01
20	Food & kindred products	39,501	0.69
21	Tobacco products	9,523	-3.97
22	Textile mill products	34,448	-2.29
23	Apparel & textile	15,765	-6.66
24	Lumber & wood	27,367	2.78
25	Furniture and fixtures	22,410	0.72
26	Paper products	17,561	0.10
27	Printing & publishing	38,406	2.50
28	Chemicals	22,584	-3.40
30	Rubber & plastics	20,576	4.71
32	Stone, clay, glass	12,327	-0.69
33	Primary metals	12,208	-0.69
34	Fabricated metals	17,027	-1.89
35	Industrial machinery	29,937	4.55
36	Electronic equipment	32,843	0.54
37	Other transport. equip.	39,976	-4.55
38	Instruments and related	10,432	3.93
39	Misc. manufacturing	4,182	7.15
41	Local & interurban	10,677	6.90
42	Trucking and warehousing	42,206	2.55
44	Water transportation	6,339	1.90
45	Transportation by air	28,571	8.90
47	Transportation services	10,573	7.83
48	Communications	50,184	0.98
49	Electric, gas, & sanitary	22,257	-1.06
60	Depository institutions	51,168	0.16
61	Nondepository institution	26,066	16.20
62	Security brokers	8,789	15.63
63	Insurance carriers	30,617	2.07
64	Insurance agents	12,637	0.95
65	Real estate	41,338	2.43
67	Holding and investment	3,305	-6.52
70	Hotels & lodging	48,435	0.93
72	Personal services	36,148	0.87
73	Business services	277,800	12.25
75	Auto repair & parking	27,600	6.16
76	Misc. repair services	9,080	2.82
78	Motion pictures	10,336	5.82
79	Amusement and recreation	43,254	4.35
80	Health services	234,067	2.39
81	Legal services	21,000	2.09
82	Educational services	276,521	2.70
83	Social services	68,494	6.01
84	Other services	5,306	6.17
86	Membership organizations	29,747	5.82
87	Professional Services	130,190	3.68
Source: ES202, Virginia Employment Commission, 1992 and 1998			

Table 1.3. Annual Wages in Virginia by 2 digit SIC: 1998			
SIC2	Industry	Total Wages ($)	Annual % Change 1992-98
07	Agricultural services	458,104,816	13.34
10	Metal mining	4,609,900	185.66
12	Coal mining	267,123,352	-5.08
13	Oil & gas	35,241,416	30.66
14	Nonmetalic minerals	112,833,696	9.52
15	Construction	1,248,342,952	6.20
16	Heavy Construction Eg. Building	1,187,384,004	7.97
17	Special Trade Contractors	3,176,842,116	11.79
20	Food & kindred products	1,071,389,396	5.36
21	Tobacco products	545,482,632	-0.23
22	Textile mill products	844,159,500	0.37
23	Apparel & textile	270,461,528	-4.40
24	Lumber & wood	695,173,096	8.32
25	Furniture and fixtures	529,227,068	6.37
26	Paper products	769,419,392	3.93
27	Printing & publishing	1,267,401,776	7.28
28	Chemicals	1,109,785,000	0.64
29	Petroleum products	27,959,248	2.12
30	Rubber & plastics	683,643,592	7.59
31	Leather products	7,462,404	-9.65
32	Stone, clay, glass	391,823,432	4.11
33	Primary metals	491,008,016	2.33
34	Fabricated metals	590,488,596	0.58
35	Industrial machinery	1,014,991,428	8.94
36	Electronic equipment	1,497,407,148	5.09
37	Other transport. equip.	1,625,188,884	-1.45
38	Instruments and related	414,075,676	12.06
39	Misc. manufacturing	111,130,044	9.21
41	Local & interurban	271,401,880	7.36
42	Trucking and warehousing	1,162,194,992	6.19
43	U.S. Postal Service	951,974,896	9.65
44	Water transportation	244,840,136	8.67
45	Transportation by air	1,123,657,292	12.32
46	Pipelines, ex. nat. gas	4,329,392	3.73
47	Transportation services	305,064,612	11.38
48	Communications	2,748,488,296	9.11
49	Electric, gas, & sanitary	1,122,706,368	3.11
50	Wholesale-Durable Goods	3,739,053,104	8.84
51	Wholesale-Nondurable Goods	1,970,722,636	4.77
52	Buidling Materials & Garden Supplies	507,282,344	6.63
53	General Merchandising Stores	1,220,166,252	5.83
54	Food Stores	1,385,764,268	3.96
55	Auto Dealers and Service Station	1,833,101,480	8.44
56	Clothing Stores	340,419,564	1.98
57	Furniture & Homefurnishing Stores	886,503,576	10.37
58	Eating & Drinking Places	2,158,943,332	8.09
59	Eating & Drinking Places (Drug Stores)	1,230,714,452	6.53
60	Depository institutions	1,756,761,676	7.22
61	Nondepository institution	1,336,473,280	26.74
62	Security brokers	744,037,612	22.24
63	Insurance carriers	1,229,723,168	7.09
64	Insurance agents	451,813,032	5.77
65	Real estate	1,184,135,064	8.50
67	Holding and investment	301,033,952	4.99
70	Hotels & lodging	725,093,700	4.81
72	Personal services	604,933,728	5.63
73	Business services	10,111,988,636	26.97
75	Auto repair & parking	645,715,232	11.22
76	Misc. repair services	249,519,820	7.70
78	Motion pictures	149,299,840	10.44
79	Amusement and recreation	605,756,500	8.94
80	Health services	7,159,448,620	5.74
81	Legal services	885,071,388	6.45
82	Educational services	7,549,261,024	5.53
83	Social services	1,197,123,804	10.29
84	Other services	107,678,404	7.09
86	Membership organizations	930,009,876	12.52
87	Professional Services	6,434,831,532	9.31
Source: ES202, Virginia Employment Commission, 1992 and 1998			

Table 1.4. Establishments in Virginia: 1998			
SIC2	Industry	Establishments	Annual % Change 1992-98
07	Agricultural services	2,954	6.06
12	Coal mining	160	-5.69
14	Nonmetalic minerals	82	1.08
15	Construction	6,636	1.63
20	Food & kindred products	344	0.65
21	Tobacco products	13	1.39
22	Textile mill products	107	1.17
23	Apparel & textile	253	0.07
24	Lumber & wood	1,282	1.63
25	Furniture and fixtures	183	2.40
26	Paper products	106	2.75
27	Printing & publishing	1,329	0.57
28	Chemicals	150	-1.23
30	Rubber & plastics	178	6.88
32	Stone, clay, glass	278	0.31
33	Primary metals	73	1.49
34	Fabricated metals	381	0.68
35	Industrial machinery	739	3.86
36	Electronic equipment	256	2.47
37	Other transport. equip.	243	3.69
38	Instruments and related	206	9.54
39	Misc. manufacturing	165	4.49
41	Local & interurban	387	4.27
42	Trucking and warehousing	3,475	4.70
44	Water transportation	216	0.00
45	Transportation by air	267	5.47
47	Transportation services	1,023	4.20
48	Communications	733	9.49
49	Electric, gas, & sanitary	360	7.14
60	Depository institutions	519	-0.68
61	Nondepository institution	854	9.26
62	Security brokers	729	12.26
63	Insurance carriers	820	8.00
64	Insurance agents	2,687	2.13
65	Real estate	5,081	1.42
67	Holding and investment	358	2.40
70	Hotels & lodging	1,266	2.14
72	Personal services	4,571	1.33
73	Business services	12,681	9.69
75	Auto repair & parking	4,009	3.94
76	Misc. repair services	1,749	3.10
78	Motion pictures	648	1.76
79	Amusement and recreation	2,021	4.40
80	Health services	9,091	0.71
81	Legal services	3,393	2.14
82	Educational services	1,095	6.23
83	Social services	2,292	5.34
84	Other services	99	2.75
86	Membership organizations	2,287	2.56
87	Professional Services	10,040	7.12
Source: ES202, Virginia Employment Commission, 1992 and 1998			

Table 1.5. Annual Wage per Employee in Virginia: 1998			
SIC2	Industry	Annual Wage ($)	Annual % change wage 1992-98
07	Agricultural services	18,681	3.64
10	Metal mining	38,416	8.62
12	Coal mining	42,340	2.35
13	Oil & gas	52,521	4.07
14	Nonmetalic minerals	35,966	4.18
15	Construction	29,652	3.74
20	Food & kindred products	27,123	4.48
21	Tobacco products	57,281	4.91
22	Textile mill products	24,505	3.09
23	Apparel & textile	17,156	3.77
24	Lumber & wood	25,402	4.75
25	Furniture and fixtures	23,616	5.42
26	Paper products	43,814	3.81
27	Printing & publishing	33,000	4.16
28	Chemicals	49,140	5.08
29	Petroleum products	40,936	3.30
30	Rubber & plastics	33,225	2.25
31	Leather products	17,234	5.15
32	Stone, clay, glass	31,786	5.00
33	Primary metals	40,220	3.16
34	Fabricated metals	34,680	2.79
35	Industrial machinery	33,904	3.46
36	Electronic equipment	45,593	4.41
37	Other transport. equip.	40,654	4.27
38	Instruments and related	39,693	6.58
39	Misc. manufacturing	26,573	1.44
41	Local & interurban	25,419	0.32
42	Trucking and warehousing	27,536	3.16
44	Water transportation	38,624	6.08
45	Transportation by air	39,329	2.23
46	Pipelines, ex. nat. gas	54,117	6.03
47	Transportation services	28,853	2.42
48	Communications	54,768	7.68
49	Electric, gas, & sanitary	50,443	4.44
60	Depository institutions	34,333	6.99
61	Nondepository institution	51,273	5.35
62	Security brokers	84,656	3.41
63	Insurance carriers	40,165	4.47
64	Insurance agents	35,753	4.56
65	Real estate	28,645	5.29
67	Holding and investment	91,084	18.91
70	Hotels & lodging	14,970	3.67
72	Personal services	16,735	4.53
73	Business services	36,400	8.48
75	Auto repair & parking	23,395	3.69
76	Misc. repair services	27,480	4.17
78	Motion pictures	14,445	3.42
79	Amusement and recreation	14,005	3.64
80	Health services	30,587	2.94
81	Legal services	42,146	3.88
82	Educational services	27,301	2.44
83	Social services	17,478	3.14
84	Other services	20,294	0.68
86	Membership organizations	31,264	4.97
87	Professional Services	49,426	4.62
Source: ES202, Virginia Employment Commission, 1992 and 1998			

Relative Wage

The relative wage is measured by computing the ratio of the average Virginia wage to the average national wage for the industry being considered (Tables 1.4 and 1.5). Thus, if the Virginia industry wage is greater than the national industry wage, the ratio will be greater than 1.0, e.g., see SIC 26, paper products. If the industry wage in Virginia is less than the corresponding wage at the national level, then the resulting ratio will be less than 1.0, e.g., see SIC 23, apparel products. It is important to note that the median relative wage ratio for Virginia is 0.95, indicating that the majority of industries in Virginia have wage levels below the national industry average. This is both a strength and a weakness. It is a strength because it makes the state more wage competitive. It is a weakness because it indicates that the state is dominated by lower wage industries. In fact, only 18 2-digit SIC industries have wage levels above their national industry average wage level. Moreover, most of the industries that have higher relative wages have ratios just barely greater than 1.0. The industry with the largest ratio, 1.36, is membership organizations; the next largest is business services at 1.15 percent of the national wage. All other industries with positive ratios are just barely greater than 1.0.

Table 1.5 presents annual rate of change data for the relative wage in Virginia by industrial sector. This data is presented as a ratio of the national annual rate of change to obtain a measure of wage level change in Virginia relative to the rate of change in the industry nationally (Table 1.5). The median value for this ratio is 0.96.

Inter-industry Dependency

An input-output model measures, among other things, the impact of expenditures in one industry on all other industries. Inter-industry dependency for a sector is measured by summing all of the individual expenditures created in other industries by expenditures in the industry being considered. Table 1.6 presents the inter-industry dependency data. Going to the table and focusing on sector 28, chemicals, one finds a value of 0.3447. This means that when one dollar is spent by the chemical product sector, it results in 34.47 cents of purchases in the other sectors of the Virginia economy. On the other hand, the dependency level for oil and gas is only 0.1254, indicating that this sector is highly vertically integrated and not well horizontally connected to other Virginia industries. Therefore, expenditures in the oil and gas industries tend to leak out of the Virginia economy much more quickly than for many other sectors, e.g., chemicals. In short, industries that have higher levels of inter-industry dependency levels have higher multiplier effects on the state's economy.

Productivity

The measure of productivity used here is labor productivity. Capital and/or total factor productivity measures could have been used but for the purposes of this study it was felt that labor productivity was more important. Labor productivity as measured in this study is the annual value of the production of a worker. Thus, the data presented in Table 1.7 represents the value of a worker's annual production. This measure is important because productivity level is a good measure of competitiveness.

Table 1.6. Relative Wage by sector in Virginia and U.S.: 1997					
SIC2	Industry	VA wage ($)	US wage ($)	VA wage relative to U.S. Wage	Annual change Relative Wage
07	Agricultural services	19,156	20,708	0.91	-1.72
10	Metal mining	39,664	47,451	0.83	-0.26
12	Coal mining	37,297	46,245	0.80	-0.87
13	Oil & gas	NA	44,616	0.00	0.00
14	Nonmetalic minerals	33,605	37,304	0.92	1.79
15	Construction	27,566	31,915	0.86	-0.01
20	Food & kindred products	25,641	27,963	0.92	0.27
21	Tobacco products	NA	46,672	0.00	0.00
22	Textile mill products	23,832	24,642	0.96	-0.55
23	Apparel & textile	16,299	18,528	0.88	-0.25
24	Lumber & wood	23,816	24,964	0.96	1.00
25	Furniture and fixtures	21,488	25,817	0.85	1.27
26	Paper products	41,502	38,606	1.08	0.92
27	Printing & publishing	31,937	32,869	0.97	0.19
28	Chemicals	44,473	46,900	0.95	0.39
29	Petroleum products	NA	52,766	0.00	0.00
30	Rubber & plastics	31,285	29,626	1.05	-0.47
31	Leather products	NA	21,378	0.00	0.00
32	Stone, clay, glass	28,476	32,971	0.86	-0.68
33	Primary metals	33,712	39,420	0.83	-2.50
34	Fabricated metals	32,537	33,624	0.97	0.73
35	Industrial machinery	32,682	38,934	0.84	0.38
36	Electronic equipment	38,904	38,660	1.01	0.67
37	Other transport. equip.	38,813	44,639	0.87	0.12
38	Instruments and related	42,560	44,540	0.97	1.74
39	Misc. manufacturing	26,752	27,347	0.96	-2.32
41	Local & interurban	NA	17,220	0.00	0.00
42	Trucking and warehousing	26,885	28,618	0.95	0.80
44	Water transportation	35,847	35,793	1.01	0.70
45	Transportation by air	37,199	36,193	1.01	-2.09
46	Pipelines, ex. nat. gas	NA	54,855	0.00	0.00
47	Transportation services	29,638	29,450	1.01	-0.08
48	Communications	48,622	44,862	1.10	1.19
49	Electric, gas, & sanitary	51,651	50,298	1.04	1.12
60	Depository institutions	34,372	35,073	1.00	1.97
61	Nondepository institution	46,936	42,329	1.12	1.58
62	Security brokers	77,227	101,201	0.75	-1.41
63	Insurance carriers	38,855	41,509	0.93	-0.38
64	Insurance agents	33,352	36,419	0.92	-0.01
65	Real estate	25,878	25,633	1.02	0.90
67	Holding and investment	53,789	58,205	0.93	0.32
70	Hotels & lodging	13,937	16,476	0.83	-1.46
72	Personal services	14,003	14,031	1.00	0.08
73	Business services	31,022	26,652	1.15	-0.90
75	Auto repair & parking	22,290	20,882	1.08	0.79
76	Misc. repair services	27,185	28,023	0.97	-0.18
78	Motion pictures	14,618	24,106	0.57	-3.77
79	Amusement and recreation	15,284	20,277	0.74	-1.76
80	Health services	30,343	30,722	0.99	0.02
81	Legal services	43,901	49,387	0.89	0.33
82	Educational services	19,547	21,717	0.89	-0.69
83	Social services	14,610	15,240	0.96	-0.06
84	Other services	20,052	20,161	1.00	0.44
86	Membership organizations	20,631	15,329	1.36	1.68
87	Professional Services	45,769	41,581	1.11	0.88
Source: County Business Pattern, U.S. Bureau of Census, Dept. of Commerce, 1992-1997.					

Table 1.7. Inter-industry Dependancy in Virginia: 1998		
SIC2	Industry	Connectivity
07	Agricultural services	0.0395
10	Metal mining	0.1820
12	Coal mining	0.2934
13	Oil & gas	0.1254
14	Nonmetalic minerals	0.2120
15	Construction	0.2595
20	Food & kindred products	0.3332
21	Tobacco products	0.3678
22	Textile mill products	0.4354
23	Apparel & textile	0.4278
24	Lumber & wood	0.3011
25	Furniture and fixtures	0.2774
26	Paper products	0.2728
27	Printing & publishing	0.2221
28	Chemicals	0.3447
29	Petroleum products	0.1872
30	Rubber & plastics	0.3593
31	Leather products	0.1632
32	Stone, clay, glass	0.2921
33	Primary metals	0.2284
34	Fabricated metals	0.1742
35	Industrial machinery	0.2537
36	Electronic equipment	0.2349
37	Other transport. equip.	0.1952
38	Instruments and related	0.3192
39	Misc. manufacturing	0.2257
41	Local & interurban	0.1798
42	Trucking and warehousing	0.3822
44	Water transportation	0.3800
45	Transportation by air	0.1835
46	Pipelines, ex. nat. gas	0.2482
47	Transportation services	0.2381
48	Communications	0.1639
49	Electric, gas, & sanitary	0.1649
60	Depository institutions	0.1427
61	Nondepository institution	0.2812
62	Security brokers	0.0911
63	Insurance carriers	0.2189
64	Insurance agents	0.2147
65	Real estate	0.2029
67	Holding and investment	0.0000
70	Hotels & lodging	0.3061
72	Personal services	0.3024
73	Business services	0.2329
75	Auto repair & parking	0.2475
76	Misc. repair services	0.2865
78	Motion pictures	0.4627
79	Amusement and recreation	0.3130
80	Health services	0.2301
81	Legal services	0.1478
82	Educational services	0.3372
83	Social services	0.2496
84	Other services	0.0000
86	Membership organizations	0.3020
87	Professional Services	0.2523
Source: USDA Forest Service and Minnesota IMPLAN Group, 1997.		

Table 1.8. Productivity by sector in Virginia: 1998			
SIC2	Industry	1998 Productivity ($/worker)	Annual % Change 1992-98
07	Agricultural services	27,676	-1.57
10	Metal mining	76,832	16.67
12	Coal mining	77,995	0.91
13	Oil & gas	206,043	12.55
14	Nonmetalic minerals	58,496	-0.22
15	Construction	41,836	0.07
20	Food & kindred products	72,117	3.12
21	Tobacco products	352,691	0.65
22	Textile mill products	31,605	-2.34
23	Apparel & textile	22,778	3.01
24	Lumber & wood	40,643	-0.49
25	Furniture and fixtures	31,627	2.30
26	Paper products	71,832	1.48
27	Printing & publishing	45,195	-0.42
28	Chemicals	150,216	7.13
29	Petroleum products	129,010	1.90
30	Rubber & plastics	57,365	2.75
31	Leather products	33,143	-0.64
32	Stone, clay, glass	41,787	-0.55
33	Primary metals	45,966	0.23
34	Fabricated metals	64,532	2.87
35	Industrial machinery	45,253	-0.26
36	Electronic equipment	63,218	-2.12
37	Other transport. equip.	28,875	-4.32
38	Instruments and related	52,949	0.92
39	Misc. manufacturing	43,155	0.92
41	Local & interurban	37,723	-2.05
42	Trucking and warehousing	40,517	0.40
44	Water transportation	57,184	1.23
45	Transportation by air	57,856	2.50
46	Pipelines, ex. nat. gas	811,761	5.56
47	Transportation services	42,649	-1.25
48	Communications	131,430	-1.45
49	Electric, gas, & sanitary	186,842	-0.12
60	Depository institutions	96,009	1.45
61	Nondepository institution	126,607	4.25
62	Security brokers	102,449	3.04
63	Insurance carriers	74,040	6.49
64	Insurance agents	53,470	-0.39
65	Real estate	515,348	-0.97
67	Holding and investment*	NA	NA
70	Hotels & lodging	26,778	1.11
72	Personal services	28,185	0.35
73	Business services	45,880	-1.24
75	Auto repair & parking	47,088	0.28
76	Misc. repair services	44,790	1.06
78	Motion pictures	19,900	-0.74
79	Amusement and recreation	20,928	-1.15
80	Health services	36,690	-0.30
81	Legal services	66,335	0.26
82	Educational services	29,491	-0.03
83	Social services	17,836	-0.01
84	Other services	24,875	0.70
86	Membership organizations	32,039	-0.09
87	Professional Services	61,550	-0.28
Source: Bureau of Economic Analysis, Commerce Dept, 1997.			
Virginia Employment Commission, ES202, 1998 2qtr.			
* Not Available			

Gross State Product

Gross state product is the value of all goods and services produced in a state during a given time period (one year in the case of this study). The contribution that each 2-digit industry made to the Virginia gross state product in 1998 appears in Table 1.8. This measure is important because indicates the importance of the industry to the state economy. The percent of annual change in gross state product contribution is also presented in Table 1.8 and used to measure the trend.

Location Quotient

The location quotient is a measure of the importance of an industry in a state compared to a reference area, e.g., the national economy. The location quotient data is presented in Table 1.9. A location quotient of 1.0 indicates that the industry is just as important in the state as it is in the national economy. When the location quotient is greater than 1.0, e.g., SIC 21 tobacco products, it signifies that the sector is more important in the state than nationally and implies that the state has a competitive advantage. The opposite tends to occur when the value of a location quotient is less than 1.0, e.g., SIC 31, leather products.

Conclusions

As illustrated above, a wide variety of measures has been compiled to support a broad and varied assessment of Virginia's industrial clusters and their dominant industries. Specific data is occasionally cited in the text and can be referenced to the tables referenced in this chapter. Generally, however, the analysis uses the spider diagrams as the basis of interpretation.

The report is organized into five chapters. The first is this introduction. The second, third and fourth are assessments of the natural resource-based, manufacturing and serviced-based clusters, respectively. The fifth chapter outlines a set of potential emergent industries/clusters that could be the focus of a technology investment strategy.

Table 1.9. Gross State Product (GSP) by sector in Virginia: 1998			
SIC2	Industry	GSP ($ millions)	% Annual Change GSP 1992-98
07	Agricultural services	880	8.25
10	Metal mining	2	0.00
12	Coal mining	700	-3.78
13	Oil & gas	153	45.11
14	Nonmetalic minerals	248	9.01
15	Construction	9,439	9.99
20	Food & kindred products	3,414	9.41
21	Tobacco products	4,581	0.23
22	Textile mill products	1,291	-1.69
23	Apparel & textile	470	-2.06
24	Lumber & wood	1,288	6.26
25	Furniture and fixtures	754	7.27
26	Paper products	1,587	7.77
27	Printing & publishing	2,105	5.61
28	Chemicals	3,977	6.96
29	Petroleum products	104	1.01
30	Rubber & plastics	1,490	11.57
31	Leather products	25	-8.64
32	Stone, clay, glass	610	3.74
33	Primary metals	616	2.48
34	Fabricated metals	1,524	8.62
35	Industrial machinery	1,579	6.72
36	Electronic equipment	2,335	-0.13
37	Other transport. equip.	956	-5.95
38	Instruments and related	687	16.84
39	Misc. manufacturing	203	9.64
41	Local & interurban	279	8.18
42	Trucking and warehousing	2,057	4.78
44	Water transportation	342	4.08
45	Transportation by air	1,883	15.46
46	Pipelines, ex. nat. gas	75	13.33
47	Transportation services	541	9.56
48	Communications	7,420	7.68
49	Electric, gas, & sanitary	4,593	2.26
60	Depository institutions	5,590	7.98
61	Nondepository institution	3,257	31.41
62	Security brokers	1,117	37.28
63	Insurance carriers	2,625	14.05
64	Insurance agents	839	4.57
65	Real estate	25,205	5.84
67	Holding and investment*	NA	NA
70	Hotels & lodging	1,583	5.55
72	Personal services	1,312	5.45
73	Business services	12,220	15.82
75	Auto repair & parking	1,584	10.20
76	Misc. repair services	458	7.67
78	Motion pictures	259	9.94
79	Amusement and recreation	928	5.81
80	Health services	9,385	5.08
81	Legal services	1,895	5.56
82	Educational services	1,212	9.74
83	Social services	1,095	10.54
84	Other services	9,220	9.75
86	Membership organizations	1,691	9.18
87	Professional Services	18,833	8.92
Source: Bureau of Economic Analysis, Commerce Dept, 1997.			
Virginia Employment Commission, ES202, 1998 2qtr.			
* Not Available			

Table 1.10. Location Quotient (L.Q.) by Sector in Virginia: 1998			
SIC2	Industry	L.Q. 98	Period % Change L.Q. 1992-98
07	Agricultural services	1.22	16.95
10	Metal mining	0.05	0.52
12	Coal mining	3.58	-15.48
13	Oil & gas	0.11	96.96
14	Nonmetalic minerals	1.37	2.85
15	Construction	1.28	-1.29
20	Food & kindred products	0.92	-3.97
21	Tobacco products	8.80	-52.33
22	Textile mill products	1.96	-2.87
23	Apparel & textile	1.20	-1.56
24	Lumber & wood	1.36	-1.77
25	Furniture and fixtures	1.55	-13.74
26	Paper products	1.07	4.53
27	Printing & publishing	0.94	2.57
28	Chemicals	0.96	-23.48
29	Petroleum products	0.28	10.86
30	Rubber & plastics	0.84	4.29
31	Leather products	0.36	-47.31
32	Stone, clay, glass	0.96	-3.86
33	Primary metals	0.47	-6.05
34	Fabricated metals	0.45	-8.71
35	Industrial machinery	0.60	5.60
36	Electronic equipment	0.68	4.30
37	Other transport. equip.	0.90	-18.29
38	Instruments and related	0.69	-7.98
39	Misc. manufacturing	0.49	7.59
41	Local & interurban	0.67	43.95
42	Trucking and warehousing	0.89	1.61
44	Water transportation	1.34	6.79
45	Transportation by air	1.04	0.59
46	Pipelines, ex. nat. gas	0.16	19.53
47	Transportation services	0.80	-0.98
48	Communications	1.28	-6.06
49	Electric, gas, & sanitary	0.94	-5.42
60	Depository institutions	1.09	13.80
61	Nondepository institution	1.41	5.43
62	Security brokers	0.51	7.68
63	Insurance carriers	0.75	-5.59
64	Insurance agents	0.88	12.87
65	Real estate	0.99	-12.29
67	Holding and investment	0.78	-33.34
70	Hotels & lodging	0.97	-5.54
72	Personal services	1.23	1.17
73	Business services	1.26	0.73
75	Auto repair & parking	0.95	0.23
76	Misc. repair services	1.05	-3.76
78	Motion pictures	0.71	23.42
79	Amusement and recreation	0.89	-2.21
80	Health services	0.84	0.10
81	Legal services	0.84	0.45
82	Educational services	0.82	12.81
83	Social services	0.89	-2.39
84	Other services	1.68	-4.68
86	Membership organizations	1.20	11.29
87	Professional Services	1.57	1.14
Source: ES202, Virginia Employment Commission, 1992 and 1998			

Chapter 2

Natural Resource Based Clusters

There are four natural resource based clusters. These include the agricultural products and services cluster, coal mining, tobacco, and wood and paper products.

Agricultural Products and Services Cluster

This cluster is composed of 4 sectors including agricultural services, food and kindred products, farm (produce) and commercial fisheries. Only the agricultural services, and the food and kindred products sectors are sufficiently large enough to be considered.

Economic Performance of Dominant Industries

Spider diagrams for the agricultural services (Figure 2.1) and food products (Figure 2.2) industries show the relative performance of the dominant sectors in this cluster. The condition and performance of agricultural services are best described as ambiguous. On the positive side, it has 24,522 employees and employment is increasing, it has a relatively large and increasing number of establishments and, while its contribution to gross state product is lower than expected, given the employment base, its contribution has been increasing. Further, this industry has a relatively high location quotient that has been increasing. On the other hand, wages are low, wage relative to the national wage is low, and productivity is low and not increasing. Further, this sector is not well inter-connected with other sectors in the Virginia economy, as indicated by the low score on the inter-industry linkage scale. The major growing sub-sectors are veterinarian and landscaping services.

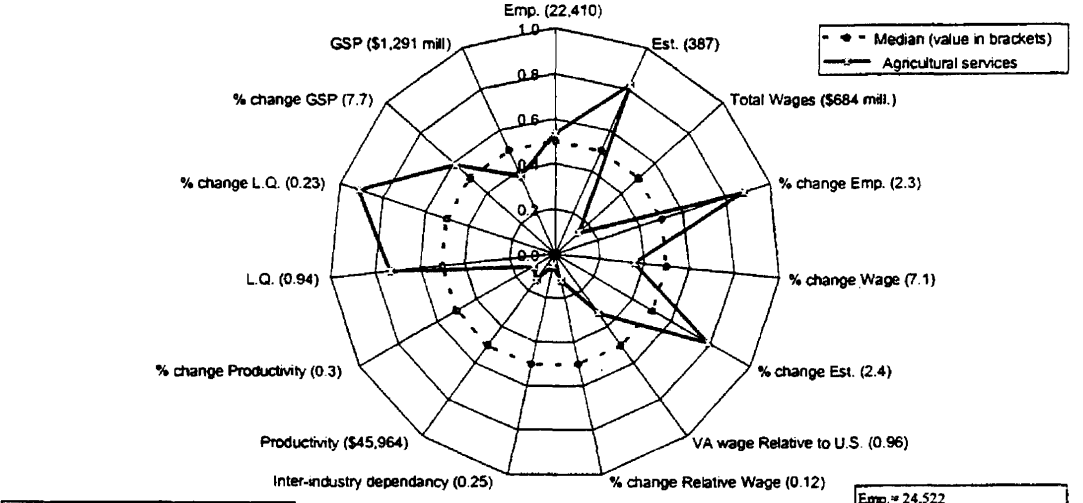
The food products sector employs nearly 40,000 (Figures 2.2). While employment is growing slowly and the wage level is low, wages are increasing both in the state and relative to the national wage level. The inter-industry dependency score indicates that this sector is well linked to other sectors of the Virginia economy. Further, productivity is high and increasing, and its contribution to gross state product is relatively high and increasing also.

In summary this cluster is generally performing positively. However, as noted, there are some shortcomings in the performance of both of its dominant industries.

There are a number of sub-sectors in this cluster that are relatively large and are exhibiting growth. However, only one of these has a location quotient that is greater than 1.0, which is meat products. Employment is growing at a rate of 9 percent per year. The growing sub-sectors are:

- Meat products (meat packing plants, sausages/other prepared meats, poultry)
- Dairy products

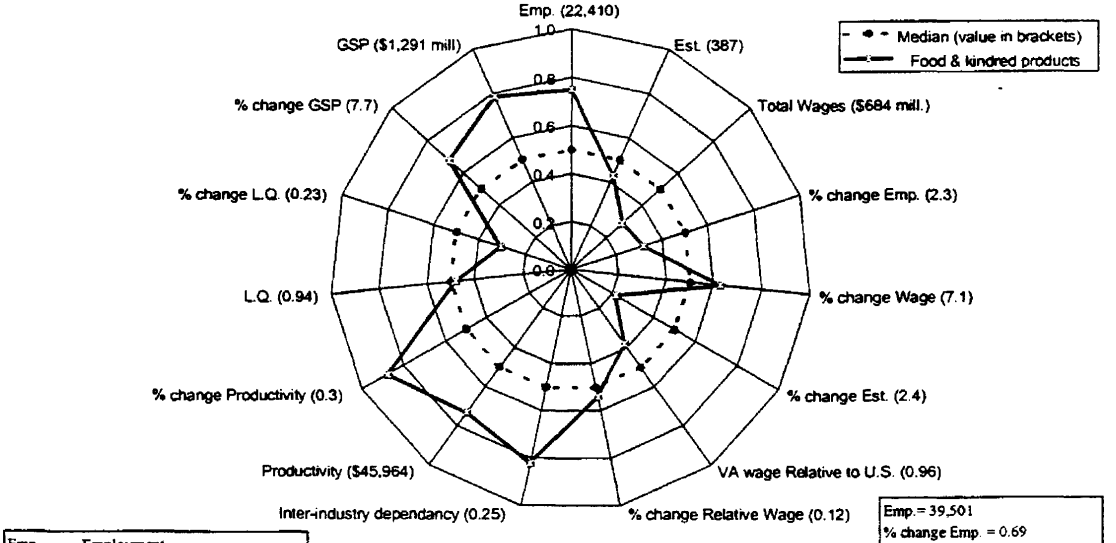
Figure 2.1. Agriculture Service Sector in Virginia: 1998



Emp. = Employment
Est. = Establishments
GSP = Gross State Product
L.Q. = Location Quotient
% change = Annual % change for 1992-98; except L.Q. which is total percent.
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp.= 24,522
% change Emp. = 7.96
Annual Wage = $18,681
% change Wage = 3.64
Est. = 2,954
% change Est. = 6.06
L.Q. = 1.22
% change L.Q. =16.95
Strength Index = 21.99

Figure 2.2. Food & Kindred Products Sector in Virginia: 1998



Emp. = Employment
Est. = Establishments
GSP = Gross State Product
L.Q. = Location Quotient
% change = Annual % change for 1992-98; except L.Q. which is total percent.
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp.= 39,501
% change Emp. = 0.69
Annual Wage = $27,123
% change Wage = 4.48
Est. = 334
% change Est. = 0.65
L.Q. = 0.92
% change L.Q. = -3.97
Strength Index = 31.60

- Preserved fruits and vegetables
- Bakery products (bread, cake and related products)
- Sugar and confectionery products (candy)
- Beverages

Misc. food products

Supporting Industries

This cluster has a number of important supporting industries. These include:

- Business services
- Wholesale trade
- Trucking and warehousing
- Construction
- Chemicals
- Textiles
- Utilities
- Water transport
- Rail roads and related services

Geographic Distribution

The geographic distribution of the Agricultural Services and Products cluster is different for the two dominant sectors. The major sub-sectors in the agricultural services industry, veterinarian and landscaping services, are distributed similar to the population. However, they are more concentrated in Northern Virginia than in other parts of the state, suggesting that income level may be a factor. Of greater interest is that food products are highly concentrated in the Hampton Roads and Shenandoah regions (about two thirds of all food products are produced in these two regions). As noted above, the largest and most propulsive sub-sector is meat products, which is heavily concentrated in these two regions also.

Related Technology Infrastructure

The agricultural products and services cluster is not particularly dynamic. However, it does have a number of healthy sub-sectors that could be strengthened.

Tobacco Products

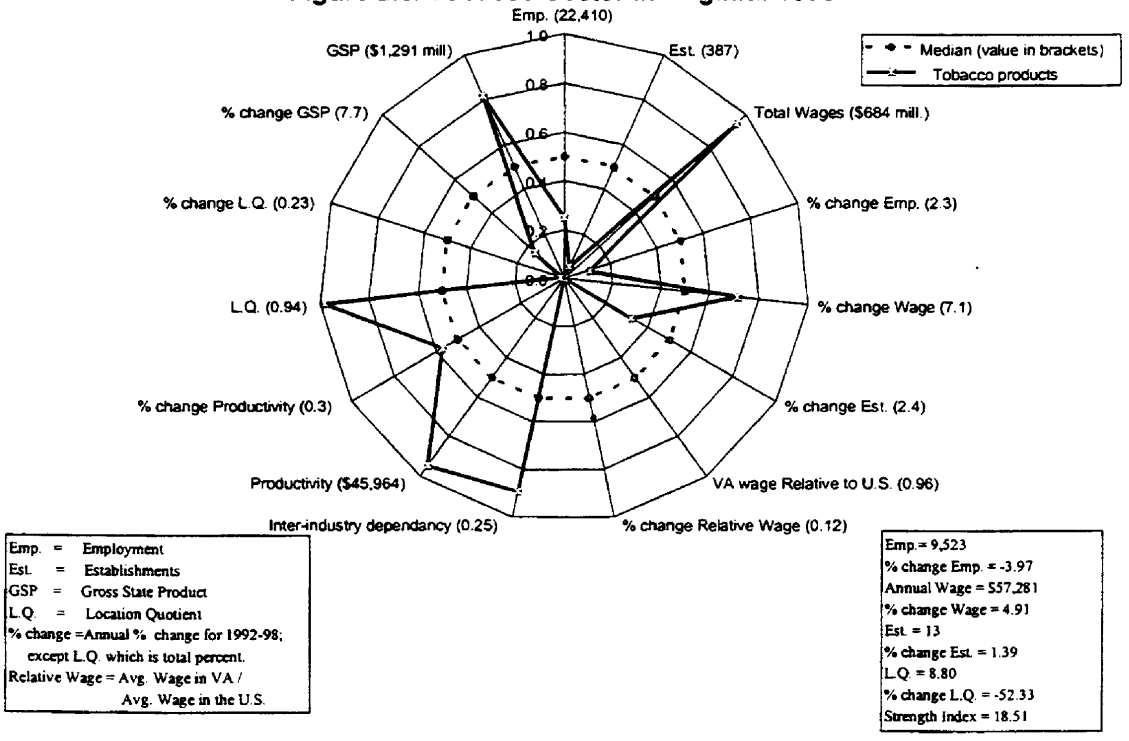
The tobacco cluster is composed of one dominant industry, tobacco. The primary product is cigarettes which supports up about 85 percent of all employment in the cluster.

This is a declining industry due to prevailing preferences toward smoking and to the major payments tobacco companies are being required to pay as a consequence of the health impacts of smoking.

Economic Performance of Dominant Industry

Employment is 9,523 and decreasing, however it is a high wage industry and wages are increasing (see Figure 2.3). Tobacco is highly integrated into the Virginia economy and has a high level of productivity that continues to increase, due to increasing capital investment in mechanization. Further, it has the highest location quotient of any sector in the Virginia economy and it makes a significant contribution to the gross state product. This is a major old economy industry of Virginia.

Figure 2.3. Tobacco Sector in Virginia: 1998



Supporting Industries

There are several supporting industries for the tobacco cluster. These include:

- Farms
- Chemical products
- Business services
- Wholesale trade
- Legal services
- Printing and publishing

- Communications
- Retail trade

Geographic Distribution

All but a very small amount of the employment in this sector is located in the Richmond region. The only other region that has any employment in tobacco production is the Southern Piedmont region but this is only a few hundred employees.

Conclusions

As noted above, this was a defining industry of the old economy but one that is now in decline for a variety of reasons. Consequently, other parts of the Virginia economy must grow to compensate for declining employment and earnings, and declining contributions to the gross state product.

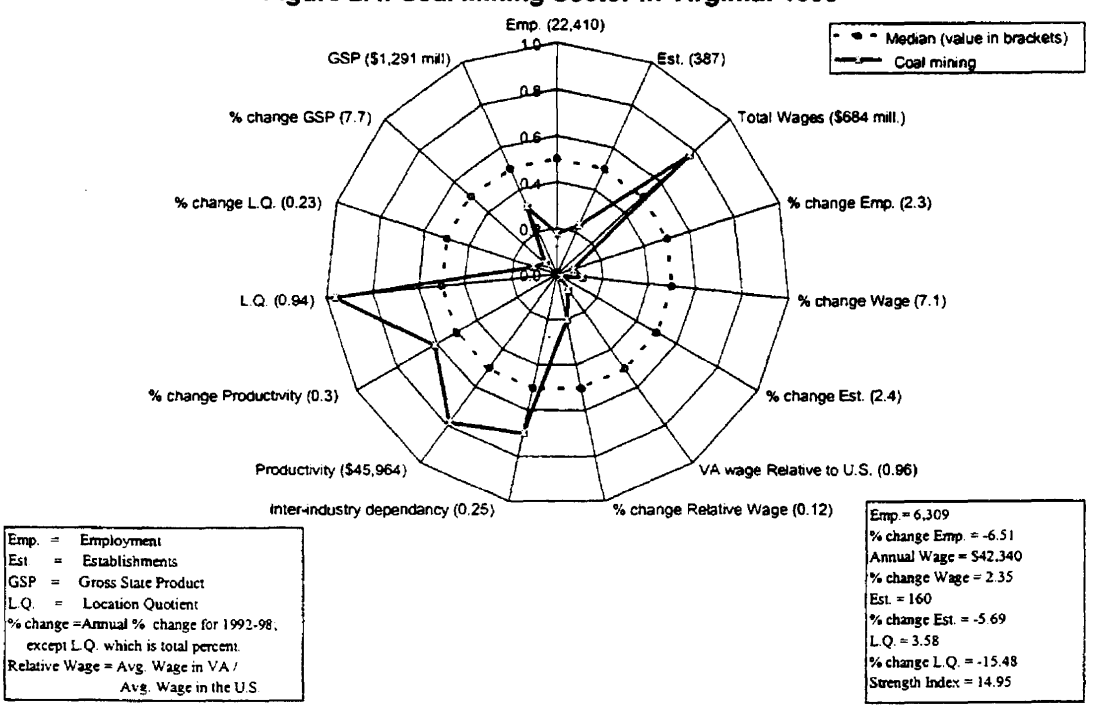
Coal Mining

Coal mining is the only dominant industry in this cluster. Like tobacco, it is a declining industry and was one of the old economy foundations of the Virginia economy.

Economic Performance of the Dominant Industry

Coal mining employs 6,309, has a high wage level, is heavily connected to other industries in the state economy (thus it has a high multiplier effect) and has one of the largest location quotients of all industries (see Figure 2.4).

Figure 2.4. Coal Mining Sector in Virginia: 1998



At the same time it is a declining industry. It has a low employment level that is decreasing and it no longer makes a particularly large contribution to the gross state product.

Supporting Industries

The support industries for coal mining are:

- Chemical products
- Industrial machinery
- Wholesale trade
- Utilities
- Rail road and related services
- Trucking and warehousing
- Real estate

Geographic Distribution

Coal mining is concentrated in the Southwestern Part of Virginia with a major concentration in the Far Southwest region and a very minor concentration in the Roanoke Region. There is no coal mining in any other region.

Coal mining has been one of the corner stones of the economic base of the Virginia economy. As such it was a major part of the old economy but is now in decline. New industries must continue to be developed to compensate for loss of employment, earnings and contribution to the gross state product.

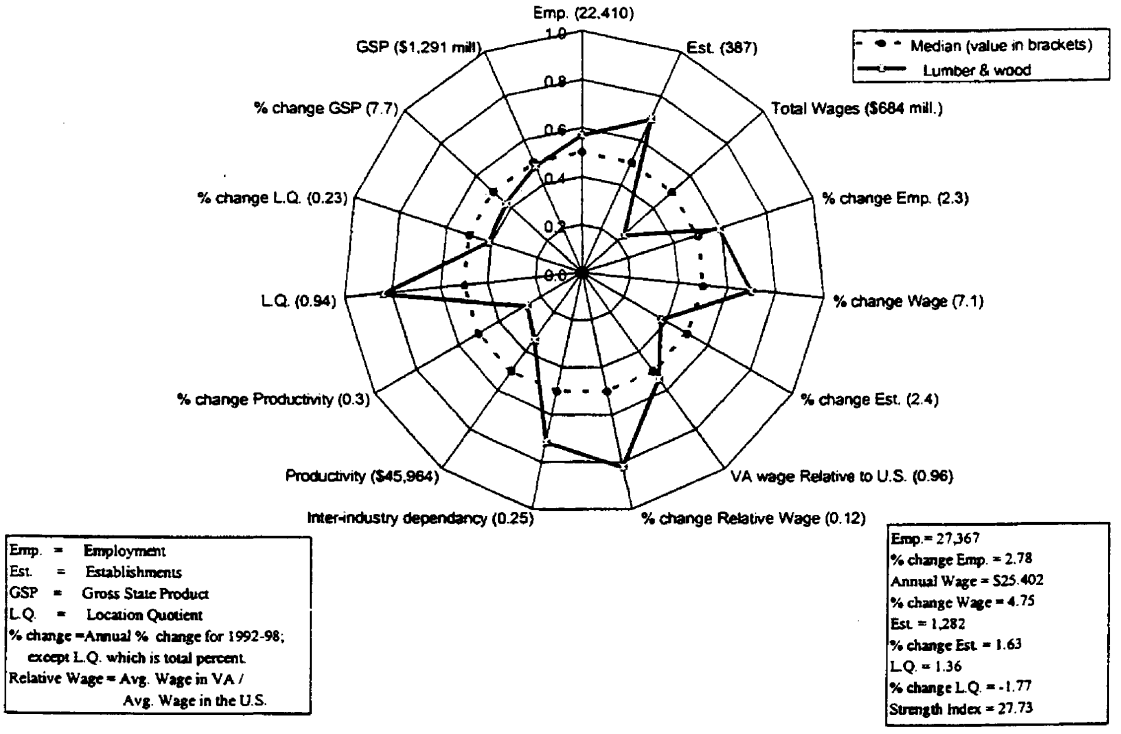
Wood and Paper Products Cluster

The wood and paper products cluster is fairly complex with several dominant industries. These include lumber and wood products, furniture, pulp and paper products and printing and publishing. Figures 2.5 through 2.8 describe the economic condition and performance of these sectors.

Economic Performance of the Dominant Sectors

Lumber and wood products employ 27,367 and employment is increasing. It has a low wage level, but one that is increasing fairly rapidly and one that is at about parity with the national average wage level for this industry (Figure 2.5). It is highly interconnected to other industries in the economy and has a high location quotient.

Figure 2.5. Lumber and Wood Sector in Virginia: 1998

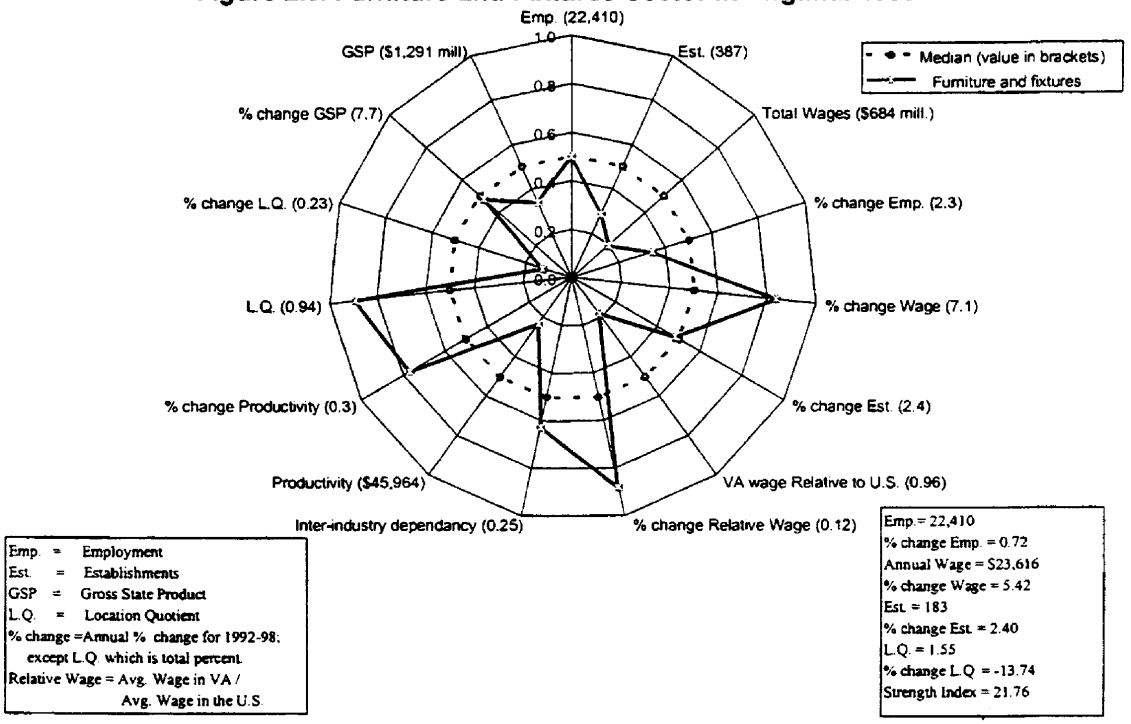


This industry has several sub-sectors with positive location quotients and increasing employment. These include:

- Logging
- Sawmills and planing mills
- Millwork including plywood and structural members and cabinets
- Wood containers

Furniture products employ 22,410 with a stable employment level and has a low annual wage that is rising quite rapidly (Figure 2.6). The same wage pattern exists when benchmarked against national industry data: the wage level is low but increasing. The location quotient is high, indicating that the industry is more important to the Virginia economy than it is to the national economy. While the productivity level is low, it is rising as is the contribution to the gross state product. Finally, the furniture products industry is well connected to other industries in the Virginia economy. Most of the employment is in household furniture production, which has a location quotient of 2.7 and is growing at 3.5 percent per year.

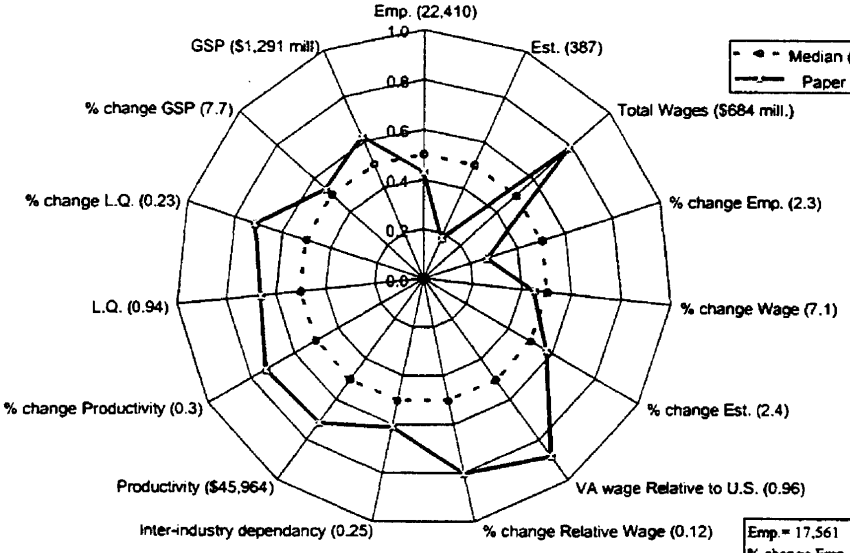
Figure 2.6. Furniture and Fixtures Sector in Virginia: 1998



Paper products employ 17,561 with a stable employment level (Figure 2.7). Wages are high and increasing, both within Virginia and compared to national industry data. This industry is well connected to other industries in the Virginia economy, has high and increasing productivity levels and contributions to the gross state product. Further, the location quotient is high and increasing. Paper mills and paperboard mills, and paperboard containers/boxes form the major sub-sectors of this industry.

Printing and publishing employs 38,406 with growing employment (2.5 percent per year). The wage level in this sector is about at the statewide median but the relative wage is near parity at the national level and is increasing (Figure 2.8). The location quotient is positive and increasing. While the contribution to gross state product is fairly high, the change is below the median rate of change and productivity levels are low and not increasing rapidly. This industry is not as well connected to other parts of the Virginia economy as are the other dominant industries in this cluster. Major sub-sectors include newspapers and books, both of which have location quotients at or near 1.0 and that are increasing rapidly. Commercial printing is also a sector that is interesting in that its components have location quotients greater than 1.0 and have grown between 3.4 and 3.5 percent over the study period.

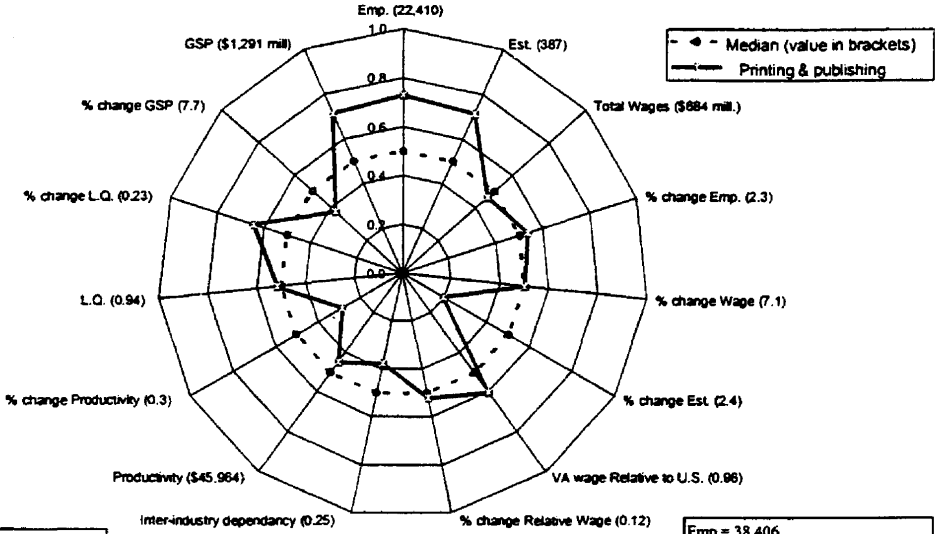
Figure 2.7. Paper Products Sector in Virginia: 1998



Emp.	Employment
Est.	Establishments
GSP	Gross State Product
L.Q.	Location Quotient
% change	Annual % change for 1992-98, except L.Q. which is total percent.
Relative Wage	Avg. Wage in VA / Avg. Wage in the U.S.

Emp. = 17,561
% change Emp. = 0.10
Annual Wage = $43,814
% change Wage = 3.81
Est. = 106
% change Est. = 2.75
L.Q. = 1.07
% change L.Q. = 4.53
Strength Index = 35.95

Figure 2.8. Printing and Publishing Sector in Virginia: 1998



Emp.	Employment
Est.	Establishments
GSP	Gross State Product
L.Q.	Location Quotient
% change	Annual % change for 1992-98; except L.Q. which is total percent.
Relative Wage	Avg. Wage in VA / Avg. Wage in the U.S.

Emp. = 38,406
% change Emp. = 2.50
Annual Wage = $33,000
% change Wage = 4.16
Est. = 1,329
% change Est. = 0.57
L.Q. = 0.94
% change L.Q. = 2.57
Strength Index = 26.01

Printing and publishing is most heavily concentrated in Northern Virginia, Richmond and Hampton Roads. There is some spillover from Northern Virginia, explaining a sizeable concentration in the Shenandoah region. This industry appears to be mostly demand driven, given that the significant concentrations are in the larger population areas and tied to capital city functions in the Northern Virginia and Richmond regions.

Supporting Industries

The wood and paper products industry has a broad set of linkages to many parts of the Virginia economy. Thus it is no surprise that the list of supporting industries is quite large. These are:

- Chemical products
- Construction
- Rail road and related services
- Utilities
- Trucking and warehousing
- Professional services
- Business services
- Educational services
- Food processing
- Farms
- Agricultural services

Geographic Distribution

The geographic focus of employment in the lumber and wood products industry is distributed fairly evenly throughout the state. However, it is more intense in non-urban areas with major concentrations occurring in the Roanoke, Shenandoah, Southern Piedmont and Far South West regions. Furniture production is most heavily concentrated in the Southern Piedmont region, with notable concentrations in the Far South West, Lynchburg and Roanoke regions. The largest concentrations of paper products and especially the paper mill base of this industry are located in the Richmond and Hampton Roads regions, with a smaller concentration in the Roanoke region. This is an expected outcome, given that water is a major input for paper production and these regions all have large supplies of water. Paper production in other parts of the state is negligible.

Summary and Conclusions

While the resource-based clusters are not particularly propulsive, there are several resource-based subsectors that have growth potential. These are food products, furniture, paper products, and printing and publishing.

There are other resource-based industrial sectors than the ones considered in this chapter. However, several of these are very small and others produce almost entirely for local in-state markets. Consequently, spider diagrams for these sectors (stone and clay products, non-metallic minerals, petroleum products, oil and gas, metal mining and pipelines) have not been included in the report.

Chapter 3

Manufacturing Based Clusters

In this chapter Virginia's manufacturing based clusters are identified and analyzed. Seven clusters are examined: textiles, chemical products; metals and metal products; industrial machinery and electrical equipment; transportation equipment, scientific instruments and communications.

Textile Cluster

This cluster is composed of two sectors: textile mill products and apparel products. Textiles is a good example of an industry group that is part of the old economy.

Economic Performance of Dominant Industries

Both textile mill products and apparel have sizeable employment (about 50,000 each), low wage levels, high interconnectedness with other industries in the economy, a high location quotient and low productivity (Figures 3.1 and 3.2). Moreover, the wage level relative to the national industry wage level is low and not increasing.

There are some sub-sectors in both textile mills and apparel that are growing. Regarding textile mills and products, broadwoven fabric mills have experienced major employment growth over the study period, along with some other highly specialized products such as weft knit fabric mills, and carpets and rugs. For the apparel industry the large growth sector has been men and boys furnishings, which employs about 60 percent of all employment in this industry and has been growing at a rate of more than 15 percent per year.

Supporting Industries

There are a number of supporting industries, given that this is an older industry and quite well connected to other sectors in the Virginia economy. The supporting industries are:

- Chemicals
- Farms
- Wholesale trade
- Utilities
- Trucking and warehousing
- Business services
- Construction
- Real estate

Fig 3.1. Textile Mill Products Sector in Virginia: 1998

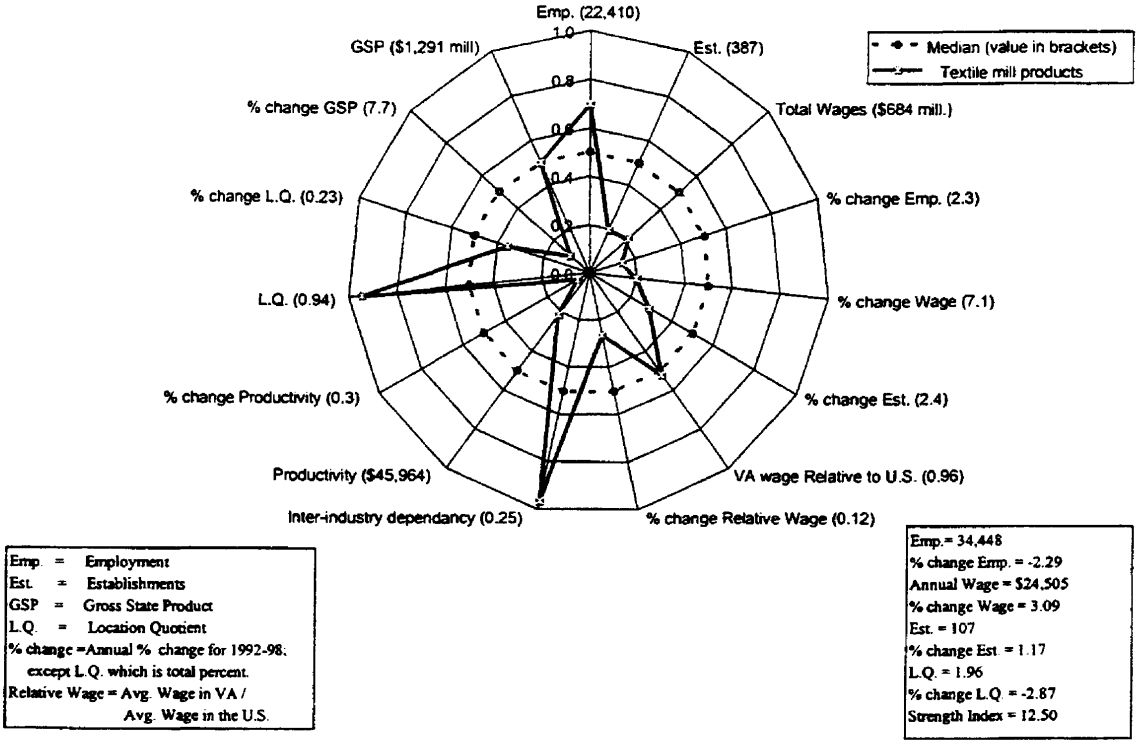
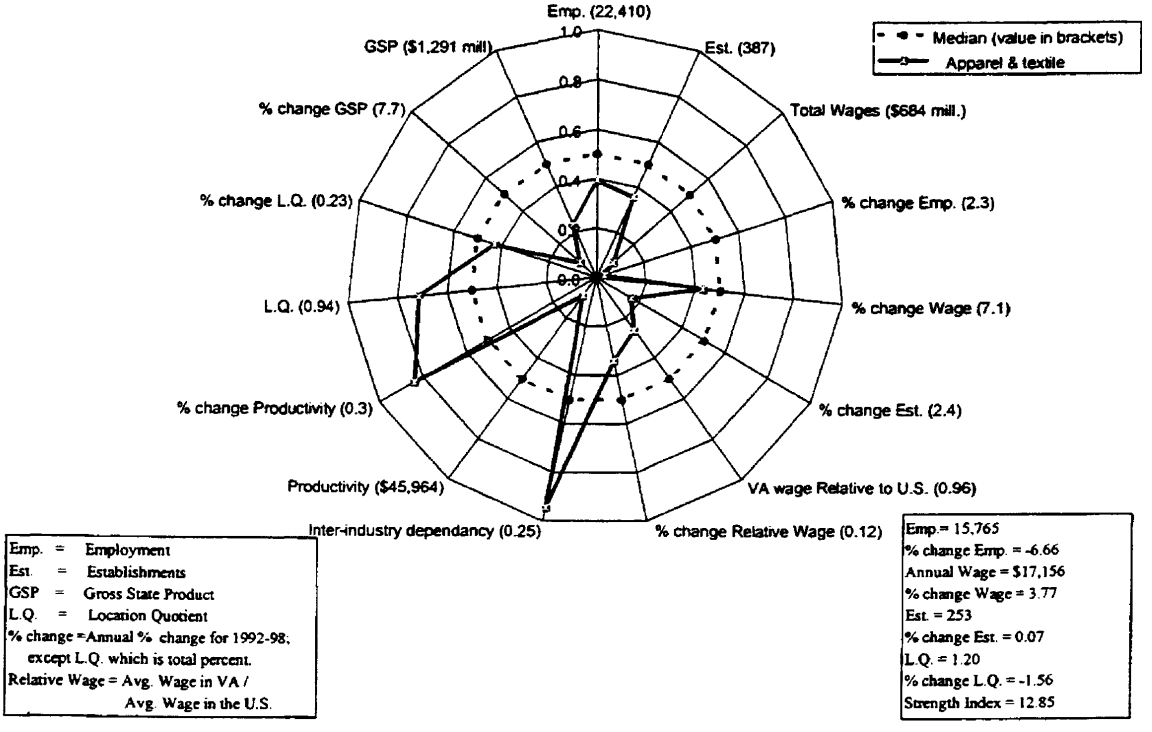


Figure 3.2. Apparel & Textile Sector in Virginia: 1998



Geographic Distribution

Nearly half of all textile mill employment is located in the Southern Piedmont region. Other concentrations, but much less than in the Southern Piedmont region, are found in the Roanoke, Far Southwest and Shenandoah regions. Employment in the apparel sector is concentrated in the same regions. In short, textile mills and apparel production is concentrated in the piedmont and western parts of Virginia.

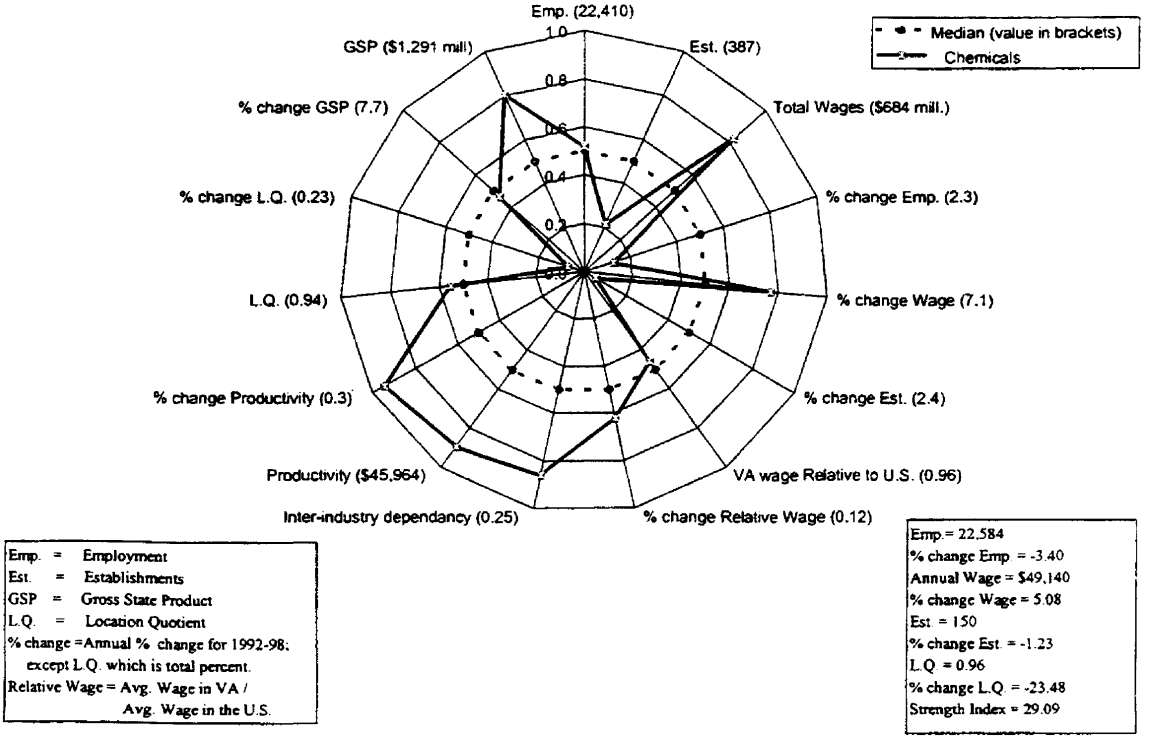
Chemical, Rubber and Plastic Products Cluster

This cluster is composed of two sectors: chemicals, and rubber and plastic products. The chemical industry is older and thereby exhibits a somewhat different pattern than rubber and plastics.

Economic Performance of Dominant Industries

The **chemicals industry employs** 22,584 (Figure 3.3). Employment has been decreasing as have several other attributes such as establishments, contribution to gross state product and the location quotient which is now slightly below 1.0. On the other hand, the wage level is high and has been increasing at a rate of more than 5 percent per year, indicating that restructuring is underway to improve efficiency and productivity.

Figure 3.3. Chemicals Sector in Virginia: 1998



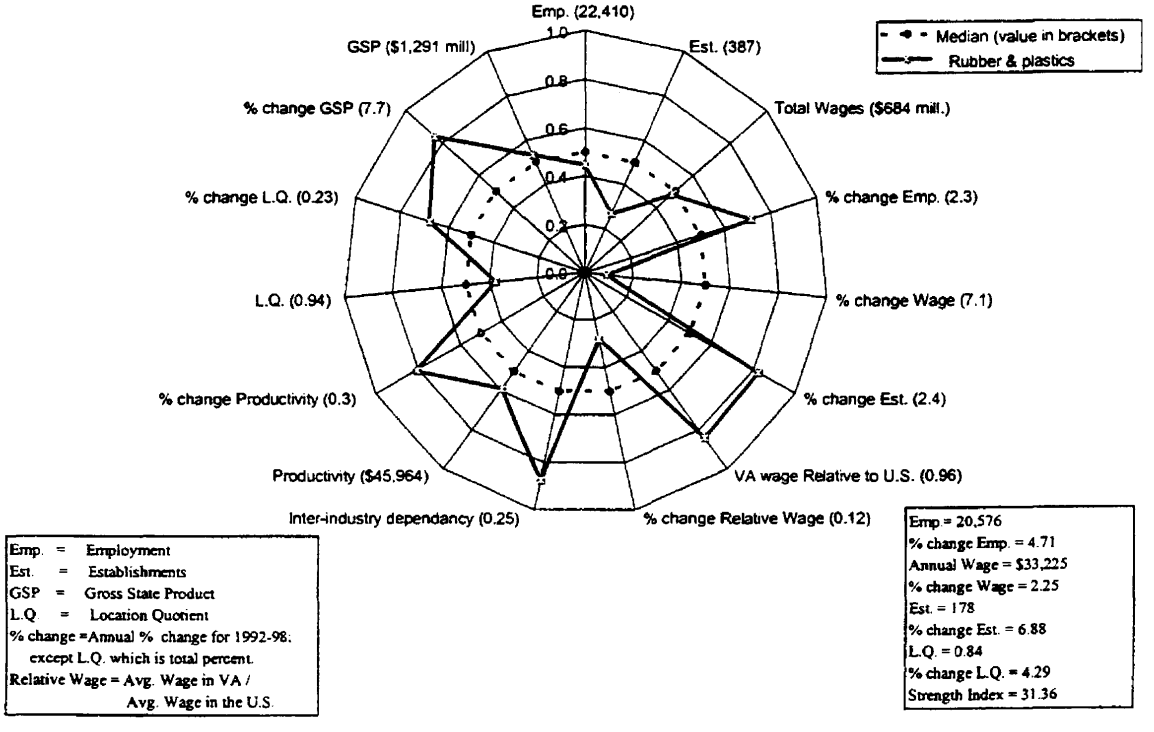
The relative wage is near parity with the national industry average and wage increases have been sufficient to hold this position. The chemical industry is highly

interconnected to other Virginia industries. Further, it makes a sizeable contribution to the gross state product and has high productivity levels that have been increasing. While the chemical industry is part of the old economy, it is exhibiting signs of conversion to a new economy industry, i.e., high relative wages and high productivity. Further, as discussed later in the report, it is a supporting industry for emergent developments in the materials and pharmaceutical industries.

Several sub-sectors in the chemical industry are exhibiting growth tendencies. The more prominent among these are industrial inorganic chemicals, plastics materials and synthetics (organic fibers, noncellulosic; and cellulosic manmade fibers), medicinals and botanicals, and miscellaneous chemical products. It is of interest to note that 1,760 are employed in the production of explosives, which has a location quotient of 9.0 but employment has been decreasing at a rate of 5 percent per year.

The **rubber and plastics industry** is somewhat smaller than the chemicals industry at 20,576 employees (Figure 3.4). However, employment has been growing at a rate of nearly 5 percent per year. The wage level is much lower than for chemicals and is not increasing. At the same time, the wage level relative to the national industry average is competitive. The industry is highly interconnected to other sectors of the Virginia economy, productivity levels are high and increasing and the contribution to gross state product is high relative to other industries and is increasing. Finally, the location quotient is only 0.84 but has increased 4.8 percent over the study period. So this industry also shows signs of growth and propulsion.

Figure 3.4. Rubber and Plastic Product Sector in Virginia: 1998



The rubber and plastics industry has a set of growing sub-sectors. The largest of these is the miscellaneous plastic products sub-industry (which includes unsupported plastics film and sheet, plastic foam products and other assorted plastic products) which employs 14,779. Additionally there are 2,610 employed in the production of tires and inner tubes. Other rubber products include: hoses, belting and gaskets; gaskets, packing and sealing devices; and other fabricated rubber products. All of the sectors noted above have been experiencing increasing employment. One aspect of "New Economy" industries is that they create products that are often difficult to classify into the SIC system. That the largest growing sub-sector is miscellaneous plastic products suggests that this industry is characterized by "New Economy" elements.

Supporting Industries

The chemical, rubber and plastic products cluster has a number of supporting industries as listed below.

- Wholesale trade
- Trucking and warehousing
- Business services
- Rail road and related services
- Utilities
- Professional services
- Construction

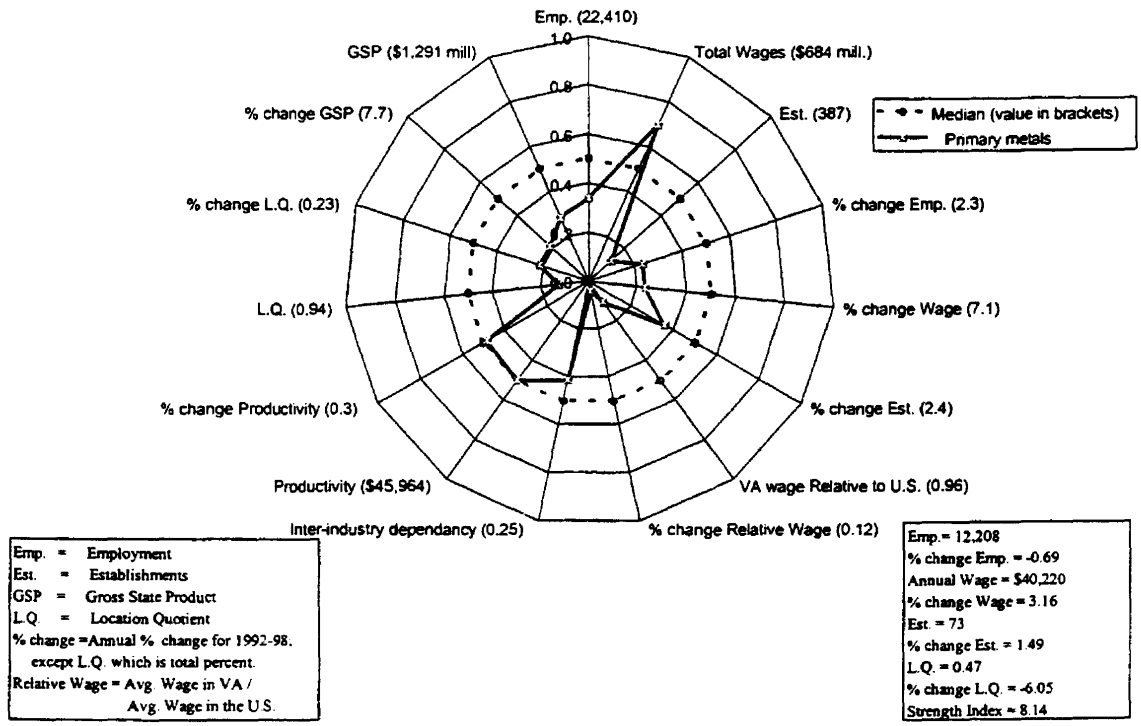
Primary and Fabricated Metals Cluster

This cluster is composed of the primary and fabricated metals industries. These two industries are in many ways part of the old economy of Virginia.

Economic Performance of Dominant Industries

The **primary metals industry** employs 12,208 (Figure 3.5). The employment level is low and decreasing. Despite a high wage level compared to other Virginia industries, its wage level is well below the national industry average. Productivity is near the state median and is increasing, but this sector makes only a small contribution to the gross state product. While it has a degree of connectivity to other industries, it is not nearly as connected as many other industrial sectors. Finally, the location quotient for this sector is low and declining. Major sub-sectors include iron and steel foundries, gray and ductile iron foundries, nonferrous rolling and drawing works, and nonferrous wiredrawing and insulating.

Figure 3.5. Primary Metals Sector in Virginia: 1998



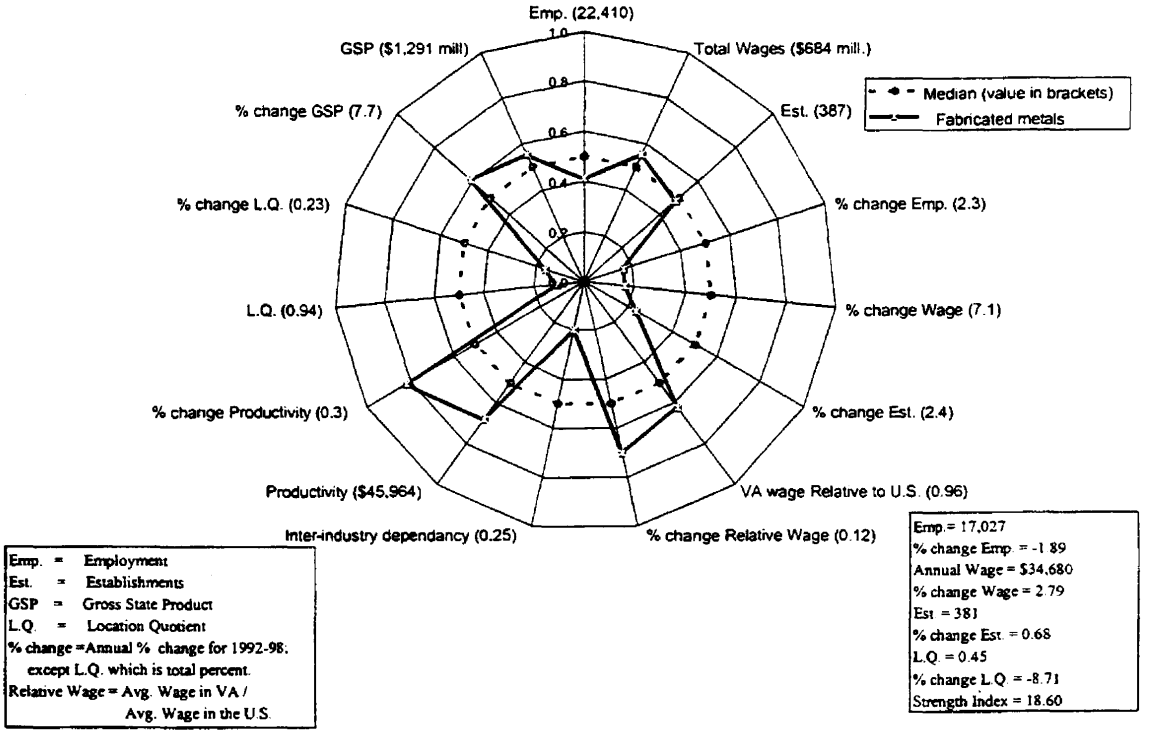
The **fabricated metals industry** employs 17,027 and employment has been decreasing (Figure 3.6). The wage level is high compared to other industries in Virginia and is at parity with the national industry average wage level. Productivity is high as is contribution to gross state product. The location quotient is low and decreasing and, like the primary metals sector, the connectivity level with other industries is low.

Supporting Industries

There are several supporting industries for this cluster. These include:

- Industrial machinery
- Chemical products
- Wholesale trade
- Utilities
- Business services
- Rail road and related services

Figure 3.6. Fabricated Metals Sector in Virginia: 1998



Geographic Distribution

Primary metals employment is concentrated in the Shenandoah, Richmond, Hampton Roads, Roanoke and Lynchburg regions, ordered respectively from largest to smallest. A similar pattern emerges with fabricated metals, with Richmond, Lynchburg, Shenandoah, Far South West, and Hampton Roads regions having the greatest concentrations. This pattern is consistent with a hypothesis that argues that primary metals and fabricated metals are either input or part of the production process for a wide variety of manufacturing enterprises. Manufacturing is most intensive in the regions where the dominant industries of this cluster are located.

Machinery and Equipment Cluster

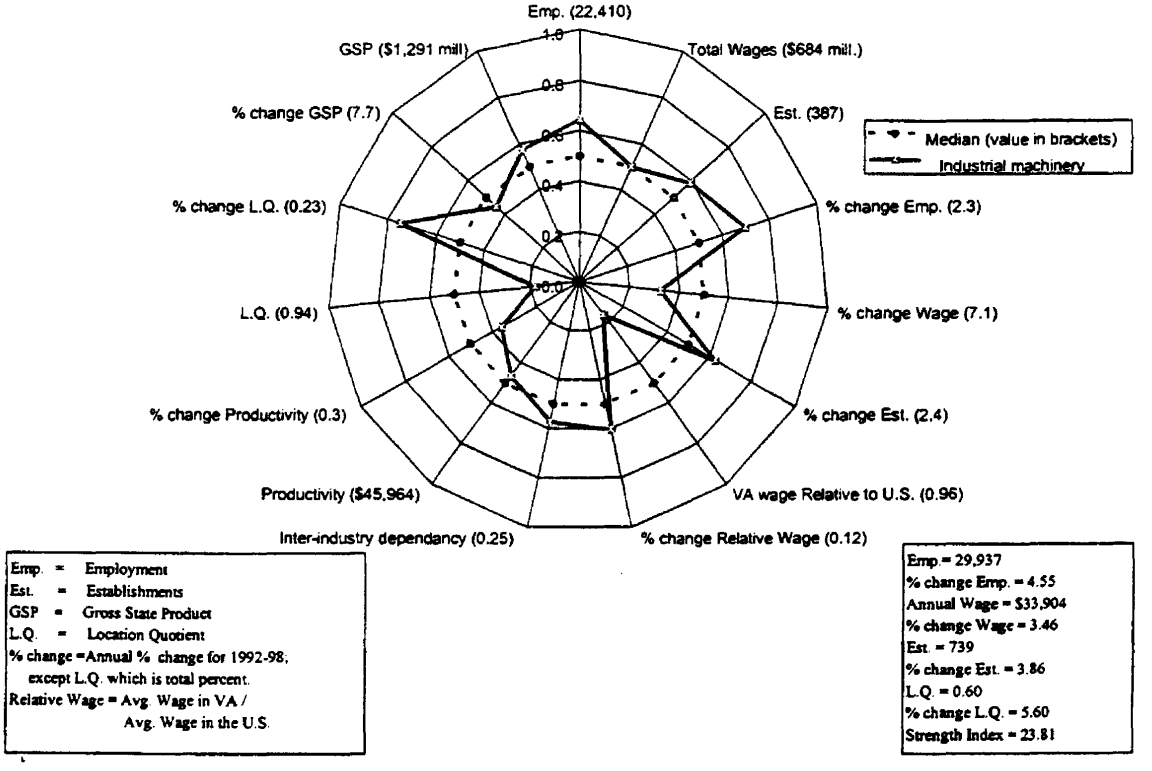
This cluster is composed of three dominant industries: industrial machinery, electronic equipment and instruments and related scientific equipment. Combined these industries employ more than 70,000.

Economic performance of the Dominant Industries

The **industrial machinery** sector employs 29,937 and employment is increasing at 4.6 percent per year (Figure 3.7). The wage level is at the median for all industries in the state and wages are increasing at about 3.6 percent per year. However, the wage relative to the national industry average is low although it has been increasing. While this sector is fairly well connected to the other parts of the Virginia economy, its

productivity level and contribution to gross state product are at about the median, as are the rates of change for these attributes. The location quotient is low but increasing.

Figure 3.7. Industrial Machinery Sector in Virginia: 1998

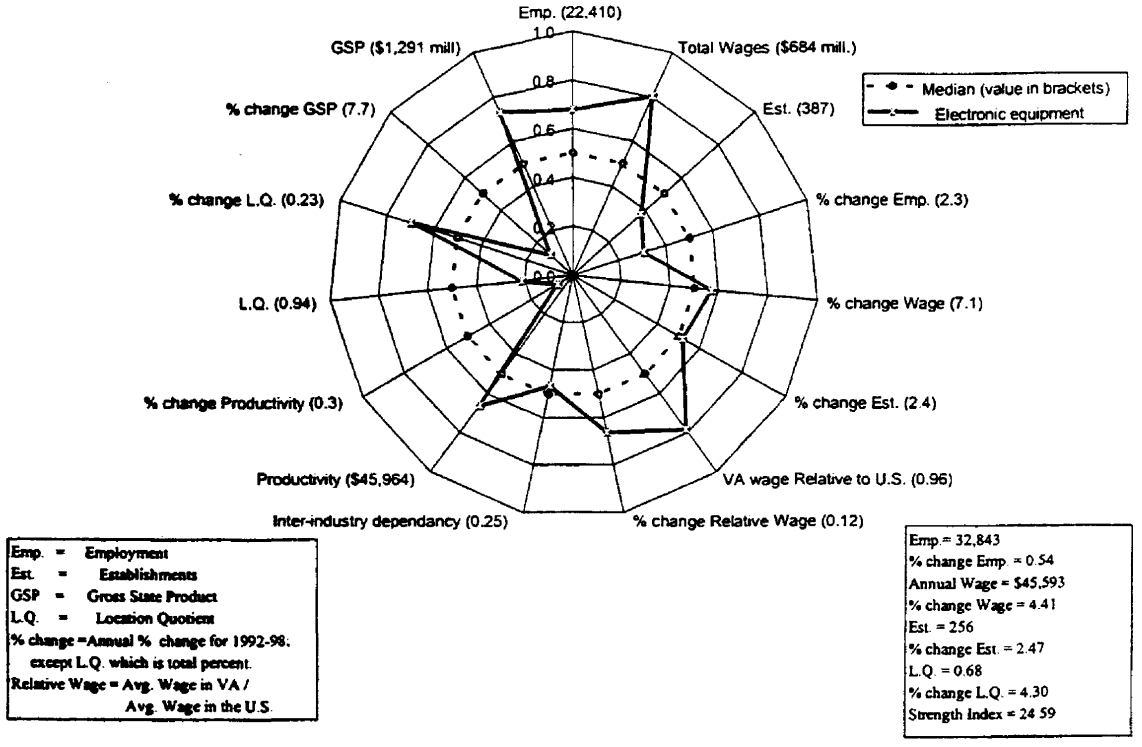


It is important to reiterate that the location quotient for this sector is small. With the exception of construction machinery (employment of 4,041 but declining) that has a location quotient of 1.0, none of the sub-sectors listed below has location quotients that are at all near 1.0, and thus the industrial machinery industry is relatively unimportant compared to its presence in the national economy. Nonetheless there are several sub-sectors that are growing. These include: metal working machinery (much of this sector's output goes to the textile, and paper printing trades), general industrial machinery (much of this sector's output goes to the auto industry and other mechanically intensive industries), and computer and office equipment (computers, storage devices, terminals, peripheral equipment, and calculating and accounting equipment) which is growing at a rate of 25.3 percent per year. Refrigeration machinery has about 25 percent of the employment in this sector and is growing at a rate of 24.5 percent per year. This sector includes production related to auto vehicle heating and cooling systems.

Electronic equipment employs 32,843 with employment remaining stable over the study period (Figure 3.8). The wage level is high compared to other industries in Virginia and the nation and it is increasing in both cases. Connectivity of the electronic equipment sector to other parts of the Virginia economy is fairly strong. Productivity and contribution to gross state product are high, although growth of these factors is stagnant. Finally, the location quotient is 0.68 but has been increasing quite rapidly. In sum, this is

an industry that has some new economy attributes (high relative wage and high productivity).

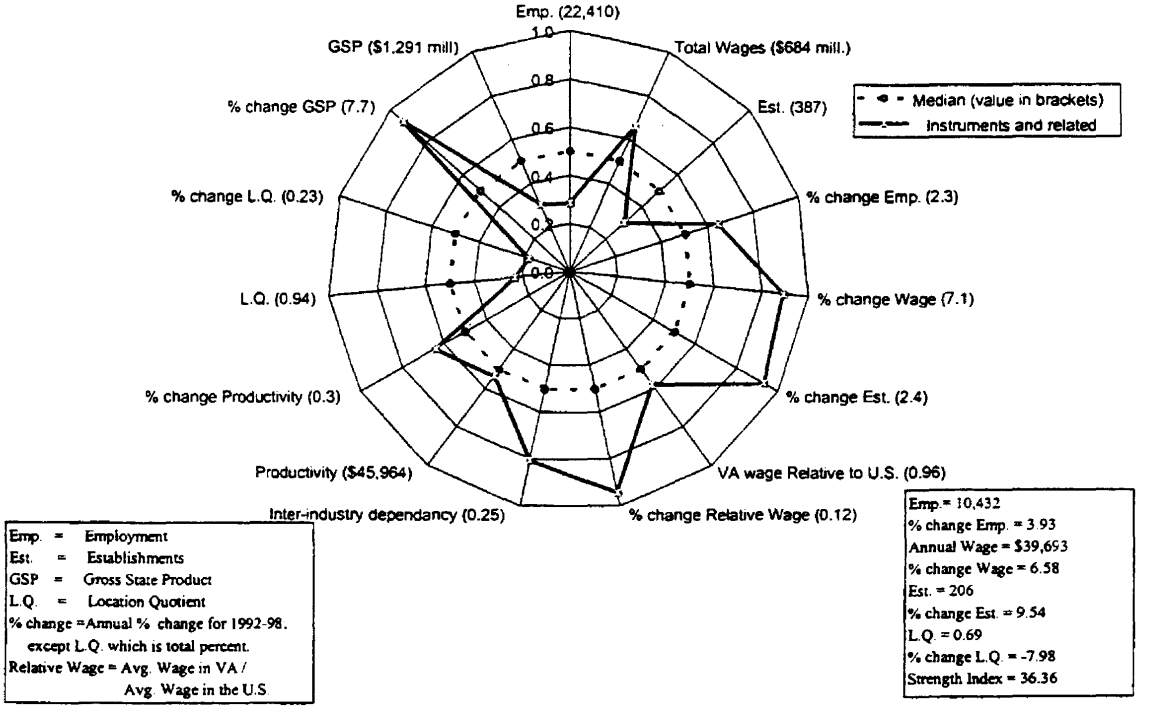
Figure 3.8. Electronic Equipment Sector in Virginia: 1998



The electronic equipment sector has a number of interesting sub-sectors that are relatively important and growing. These include electrical industrial apparatus (motors and generators, and relays and industrial controls), electrical lighting and wiring equipment, communications equipment (telephones, radio and TV equipment), electronic components and accessories (printed circuit boards, semiconductors, electronic capacitors, electronic coils and transformers, electronic connectors).

The instruments industry includes scientific equipment manufacturing. This sector employs only 10,432 (Figure 3.9). Despite the relatively low level of employment, many other indicators are quite positive. Wages are high relative to both other industries in Virginia and to the national industry average wage. Connectivity and productivity are high and while the contribution to gross state product is low, it is increasing at a rapid rate. The location quotient is low and is not growing.

Figure 3.9. Instruments and Related Scientific Equipment Manufacturing Sector in Virginia: 1998



The instruments industry has several significant and growing sub-sectors. These are: search and navigation equipment, measuring and controlling devices, laboratory equipment, environmental controls, process control instruments, fluid meters and counting devices, and optical instruments and lenses. There is also a diversity of medical equipment related instruments and devices that are produced (surgical and medical instruments, surgical appliances, and dental equipment).

Supporting Industries

The dominant industries in this cluster have a number of supporting industries. These are:

- Wholesale trade
- Business services
- Trucking and warehousing
- Construction
- Professional services
- Utilities

Geographic distribution

The geographic distribution of employment in this cluster varies somewhat by dominant industry. Industrial machinery is most concentrated in the Hampton Roads Region. However, significant concentrations of more than 4,000 employees are found in the Far Southwest and Richmond Regions. Given that much of the production in this sector is tied to the automobile parts industry, it would appear that there is a belt of vehicle parts manufacturing that spreads in a broad arc from the Hampton Roads Region across the southern part of Virginia through the Richmond region and across the west central part of the state to Far South West Virginia.

Electronic equipment employment is most concentrated in the Northern Virginia, Roanoke, Richmond and Lynchburg Regions (all have more than 4,000 employees). Further, Charlottesville and Hampton Roads regions have more than 2,000 employees.

The geographic distribution of the instrument industry employment is most concentrated in Northern Virginia, with significant other concentrations appearing in the Roanoke, Shenandoah, Hampton Roads and Charlottesville Regions.

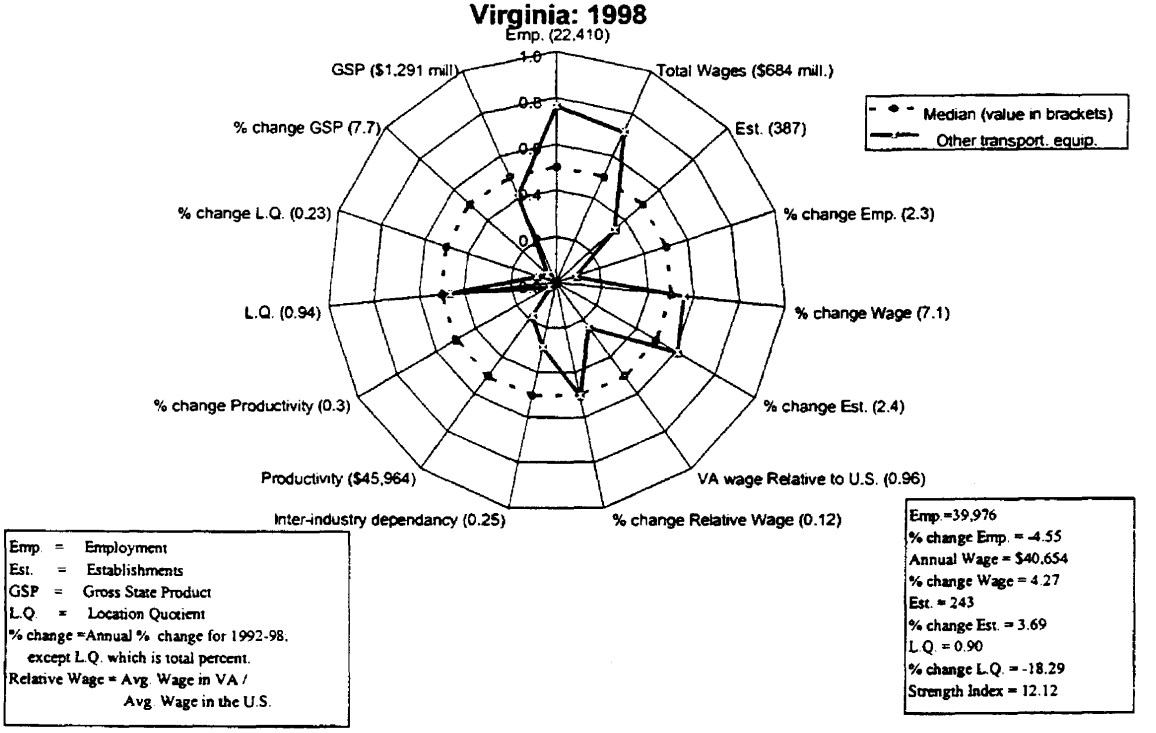
The Transportation Equipment Cluster

This cluster has one dominant industry: transportation equipment manufacturing. All of the industries in the machinery and equipment cluster (discussed above) are closely tied to transportation equipment. Thus, transportation equipment could have been treated as part of that cluster. However, it is a sufficiently different industrial activity to warrant treatment as a separate cluster.

Economic Performance of the Dominant Industry

The transportation equipment industry employs nearly 40,000 across the state (Figure 3.10). Despite a fairly high employment level, employment has been decreasing. The wage level relative to other state industries is high and has been increasing. However, the wage level relative to the national industry average is low. Inter-dependence of transportation with other industries in the state is low, as is the productivity level and the industry's contribution to the gross state product. The location quotient is near the median for all industries in the state at 0.9. While this industry was a cornerstone in the economy of the past, it will need significant reengineering to become a driver of the economy of the future. Despite its old economy look, it does employ a large number and does have a relatively high average wage level at $40,654 per year.

Figure 3.10. Transportation Equipment Manufacturing Sector in Virginia: 1998



The motor vehicle equipment (car bodies and motor vehicle parts and accessories) sub-sector of the transportation cluster has been growing at a rate of 13.0 percent per year. The largest sub-sector is ship building and repairing which employs 22,925. However, employment has been declining at a rate of 4.4 percent per year.

Supporting Industries

The supporting industries show the close relationship of the transport equipment cluster to the machinery and equipment cluster. Supporting industries are:

- Wholesale trade
- Electrical equipment
- Industrial machinery
- Automobile services
- Scientific instruments
- Business services
- Trucking and warehousing

Geographic Distribution

There are three major sub-sectors in the transportation equipment cluster. The largest is ship and boat building and repair, which is located almost entirely in the Hampton Roads Region. This makes up nearly two-thirds of all the employment in this sector. At the same time motor vehicles and equipment employs more than 14,000 and is growing in most regions. This activity is widely spread with concentrations from the highest to the lowest in the Hampton Roads, Roanoke, Far Southwest, Shenandoah, Northern Virginia and Richmond regions. The third important sub-sector is guided missiles which is concentrated largely in the Northern Virginia region, with some new development occurring in the Hampton Roads region in connection with the Langley Research Center and the Wallops Island space launching facility.

Summary and Conclusions

Several emergent or potentially propulsive clusters and industry components were identified. In the chemicals cluster inorganic substances, plastics and synthetics and medicinal products were identified as high potential areas. The manufacturing and equipment cluster has several strong potential sub-parts. These are in the areas of electronic equipment (specialized industrial and communications equipment) and scientific instruments (search and navigation equipment, measuring and controlling devices such as sensors, and optical instruments). Finally, the transportation equipment cluster, while not generally a "new economy" cluster, has two strong potential sub-sectors: motor vehicle equipment and space related equipment.

Several manufacturing sectors were eliminated from the analysis because they were either quite small or were, for the most part, local consumption goods producing industries. These include: construction, utilities, miscellaneous manufacturing and leather products.

Chapter 4

Service Industry Clusters

In the old economy manufacturing was viewed as the basic economic activity because, with large scale integrated mass production systems, a major portion of the services needed in the value delivery chain were internalized. For example, in the mass production era General Motors and Ford produced and fabricated vehicles and then managed the marketing and distribution process, with only franchising to retail dealers outsourced. Today some have observed that the only thing the big auto manufacturers produce is the drive train, while most of the peripherals, e.g., fuel injectors, axles, body stamping, etc., are outsourced. Further, not only has much of the production been outsourced but most of the services also. Consequently, it is important to examine Virginia's economy to identify and analyze the potential of service based clusters.

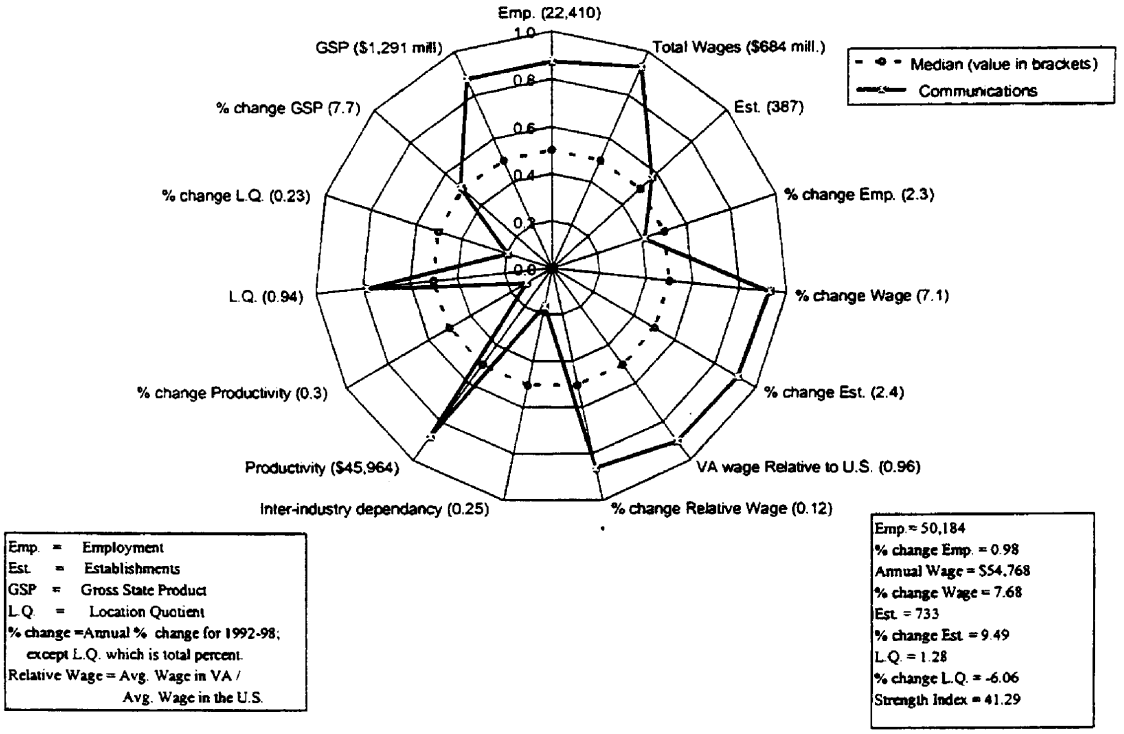
There is more employment in the services than in resource-based industry and manufacturing combined. Consequently, there are a large number of possible clusters. The service clusters that have been identified are those that appear to offer the most potential for future development in Virginia. Two of the larger service sectors that have been omitted are retailing and real estate. These activities are primarily produced to support local requirements. This is the reason that construction, a large sector in the Virginia economy, was dropped as a possible cluster also.

Ten service-based clusters have been identified. These include: communications; transport services; finance and insurance; business services; tourism; motion pictures; membership organizations; professional services; health services; and educational services.

The Communications Cluster

Communications employs 50,184 with employment growing at about 1.0 percent per year (Figure 4.1). It has 733 establishments that have an average annual growth rate of 9.5 percent, indicating that there is a good bit of churn (birth and death of companies), which is a good competitiveness indicator. The wage level is high and increasing relative to the state and the national industry average. It has a relatively high location quotient, a high productivity level and makes a sizeable contribution to the gross state product. The communications industry is relatively new to the Virginia economy and is an example of a "new economy" sector. The major sub-sectors in communications are wireless and wire telephone communication, radio and television broadcasting, and cable and other pay TV services. All of these have location quotients greater than 1.0 and have growing employment bases.

Figure 4.1. Communications Sector in Virginia: 1998



Supporting Industries

The supporting industries for the communications sector are:

- Motion pictures
- Construction
- Business services
- Recreation services
- Electronic equipment

Geographic Distribution

This industry is heavily concentrated in the Northern Virginia region with more than half of the employment in communications located there. Most employment is in telephone communications, public and TV broadcasting and cable TV. Sizeable concentrations are found in the Richmond, Hampton Roads regions with employment respectively at 6,326 and 7,124. Both the Roanoke and Shenandoah regions have notable concentrations at 1,985 and 1,793 employees, respectively.

The Transportation Services Cluster

One would expect transportation equipment manufacturing to be tied to other transportation intensive sectors. This however is not the case in Virginia. There are five transportation service industries that are weakly linked to one another and share similar other services. These are:

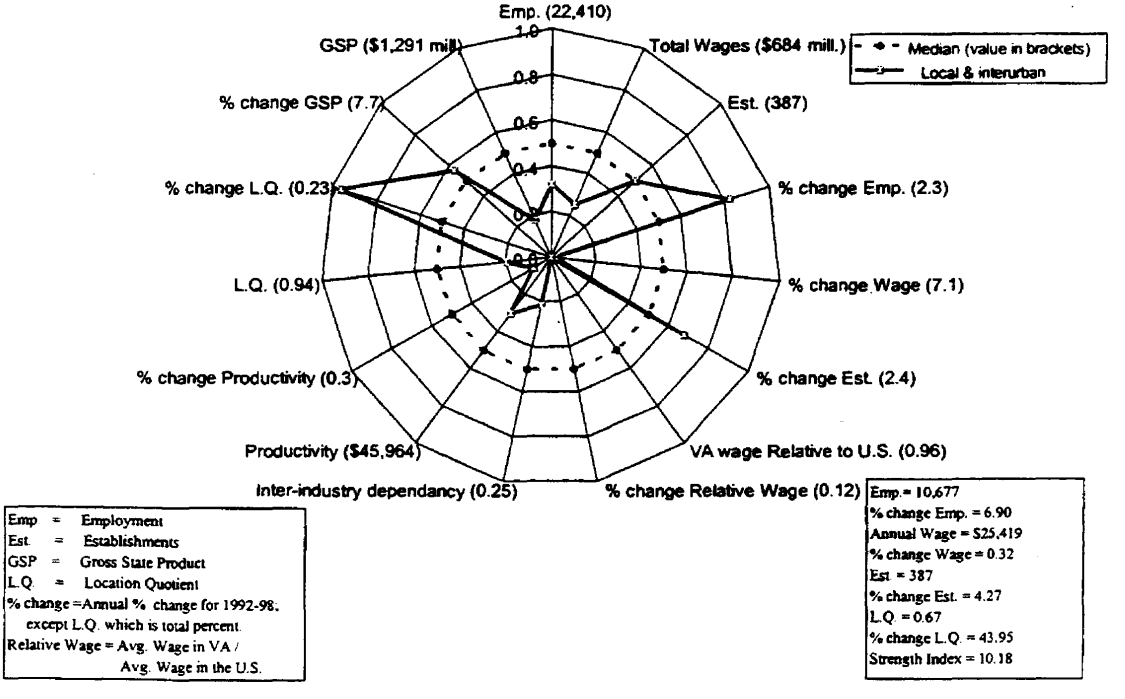
1. Local and interurban transport
2. Water transport
3. Trucking and warehousing
4. Air transport
5. Transportation services

These are the dominant service industries for the transport service cluster.

Economic Performance of the Dominant Industries

The **local and interurban transport** industry employs 10,677 (Figure 4.2) and employment is increasing (6.9 percent per year). Wages are low in this industry, even for Virginia and extremely low when compared to the national industry average. All other indicators are low, except that the location quotient which is low, is increasing at a rapid rate. This is occurring because the base location quotient is so low that even a small change upward will create a large percentage increase. In short, employment is

Figure 4.2. Local and Interurban Transport Sector in Virginia: 1998



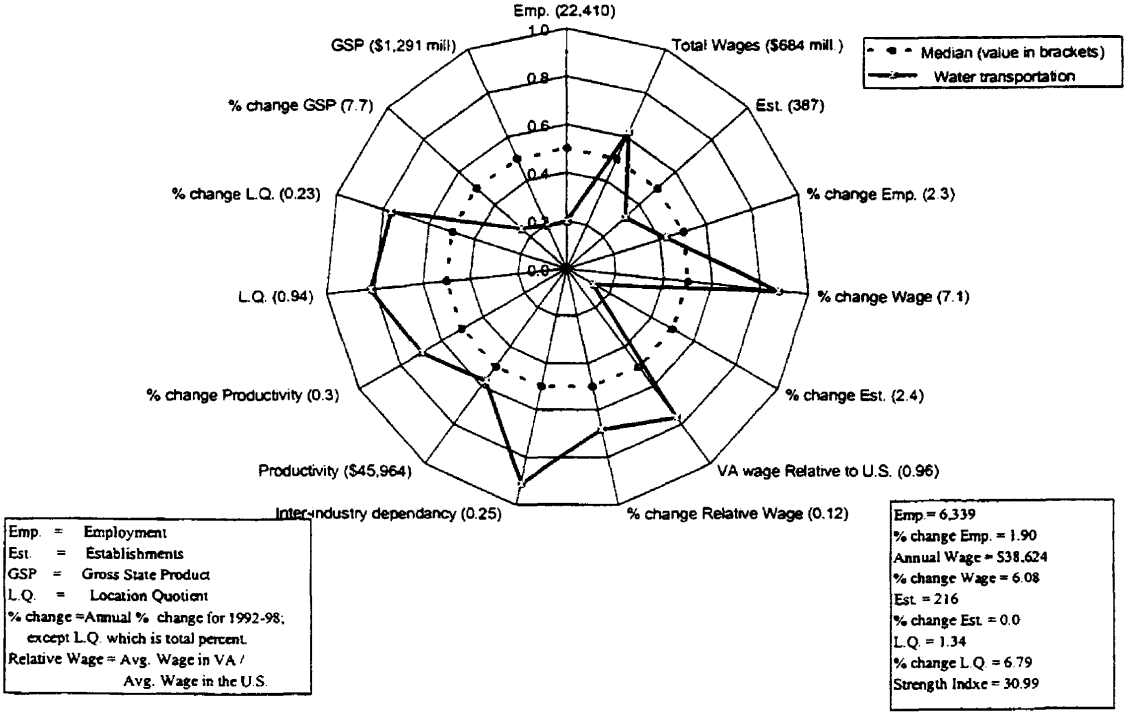
increasing quite rapidly in this sector but wages are very low. Sub-sectors with growing employment are local and suburban transportation, local and suburban transit, and local passenger transportation.

The primary supporting industries are :

- Wholesale trade
- Business services
- Automotive repair and parking
- Trucking and warehousing

Water transportation employment is 6,339 and is increasing at a rate of 1.9 percent per year (Figure 4.3). The wage level is high and growing both relative to Virginia wage levels and to national wage levels in the industry. There is a high level of interdependency with other industries in Virginia and productivity is high and increasing. Because this is a small sector the contribution to gross regional product is small. However, the location quotient is large and growing. In sum, this is a quite interesting sector that exhibits growth potential. The largest and growing sub-sectors are marine cargo handling, towing and tugboat services, and marinas. Other growing sectors are sea freight transport and water passenger transport. All of these sectors have location quotients above 1.0.

Figure 4.3. Water Transport Sector in Virginia: 1998

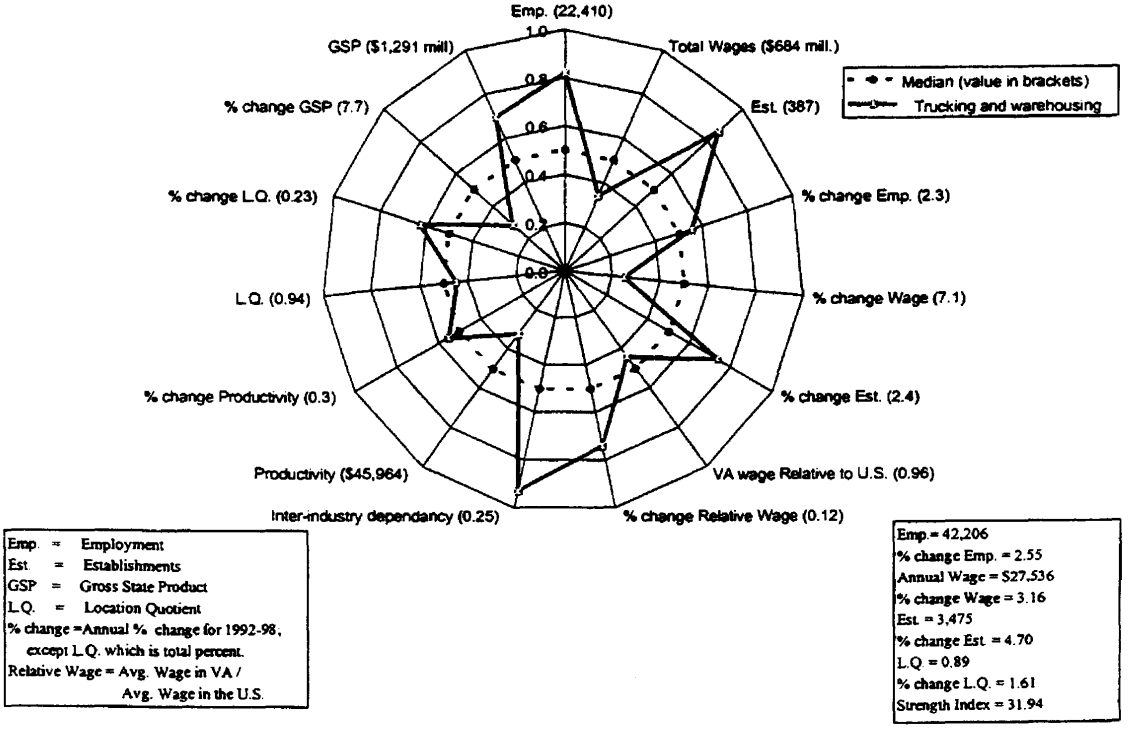


The supporting industries for the water transport industry are:

- Professional services
- Business services
- Transportation services
- Wholesale trade
- Industrial machinery

The **trucking and warehousing industry** is a large expanding service sector with 42,206 employees that is growing at a rate of 2.6 percent per year (Figure 4.4). The wage level is relatively low both when compared to Virginia and to the U.S. industry average. However, this sector is one of the highest interdependent industries in the Commonwealth. Productivity is low but increasing. Because this is a fairly large sector its contribution to gross state product is well above the median. Despite the size of this sector it has a small location quotient but one that is rising. This is an important supporting sector for transport services and for other industries as noted by the many times it has been listed as a supporting industry for different clusters. Most of the employment is in the trucking and courier services sub-sector.

Figure 4.4. Trucking and Warehousing Sector in Virginia: 1998



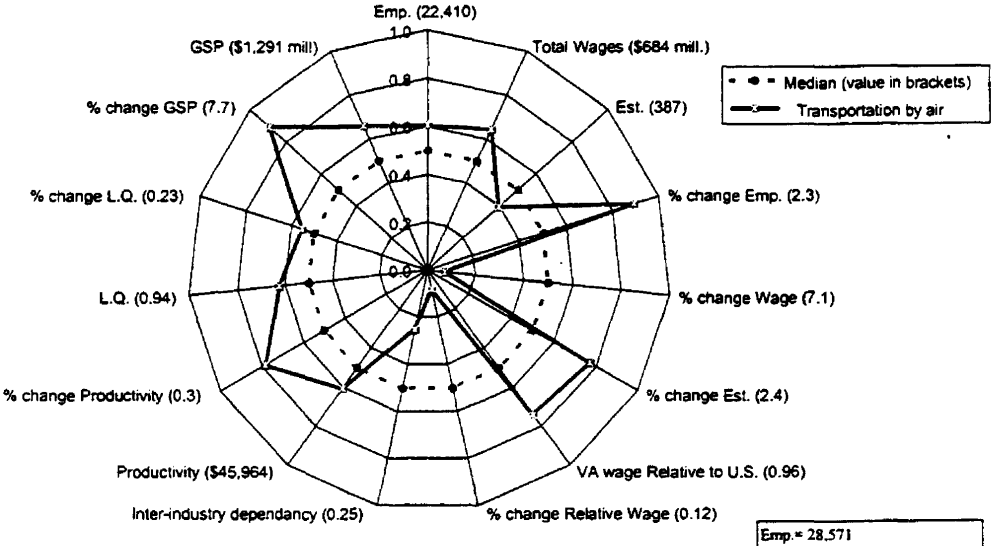
Supporting Industries

The following industries are support industries for trucking and warehousing.

- Auto repair and parking
- Transportation services
- Wholesale trade
- Utilities
- Real estate
- Business services

Air Transport provides employment for 28,571 and employment is growing at a rate of nearly 9 percent per year (Figure 4.5). The annual wage is high but stable in comparison to both the Virginia and national industry average wage level. This sector is not well interconnected with other industries in Virginia. Yet productivity and the contribution to gross state product are high and continues to grow. The location quotient is 1.0 and slowly increasing. A very large majority of employment in this sector is in the scheduled air transportation sub-sector where employment has been increasing at a rate of 12.2 percent per year. More than 3,000 are employed in the airports and related services sub-sector where employment is also increasing rapidly.

Figure 4.5. Air Transport Sector in Virginia: 1998



Emp. = Employment
Est. = Establishments
GSP = Gross State Product
L.Q = Location Quotient
% change = Annual % change for 1992-98, except L.Q. which is total percent
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp.= 28,571
% change Emp. = 8.90
Annual Wage = $39,329
% change Wage = 2.23
Est. = 267
% change Est. = 5.47
L.Q. = 1.04
% change L.Q. = 0.59
Strength Index = 31.88

The supporting industries for air transportation are:

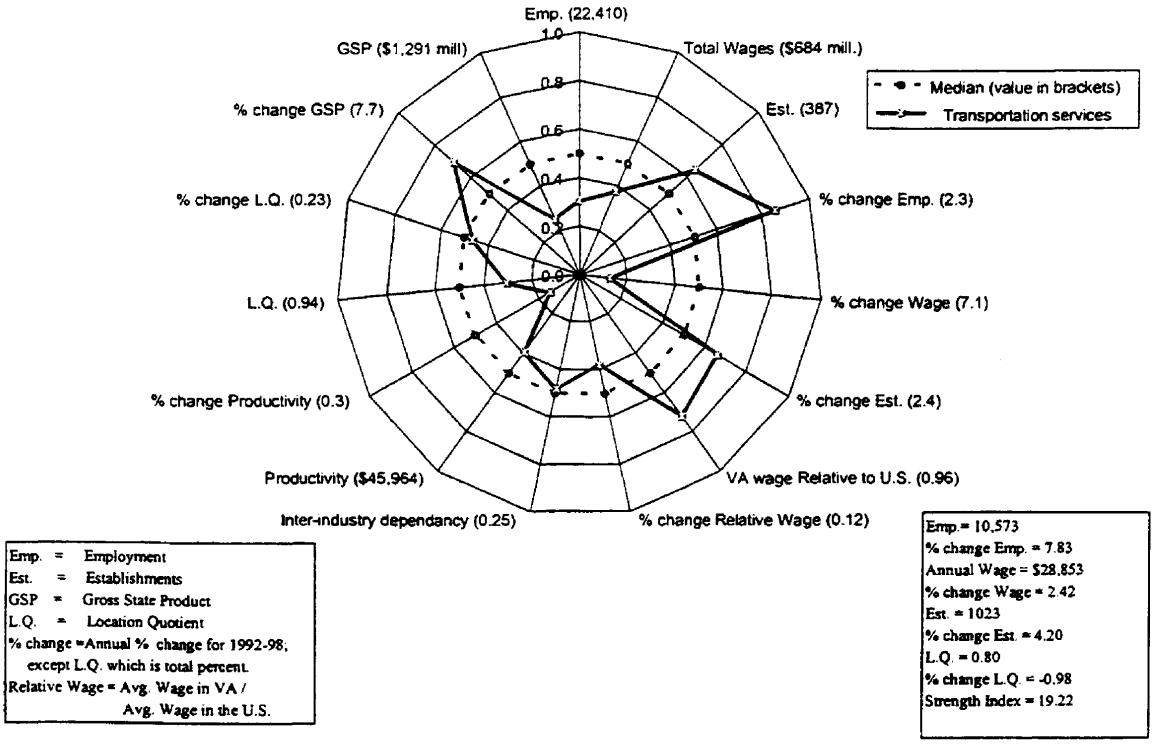
- Transportation services (including maintenance)
- Business services (including food services)

The **transportation services** industry employs 10,573 (Figure 4.6) with rapidly increasing employment (7.8 percent per year). The annual wage is low but increasing compared to other Virginia industries; the wage level relative to the national industry average is high. All other performance attributes for this sector are at best at modest levels, although its contribution to the gross state product is increasing. The major and growing sub-sectors are passenger travel arrangement, travel agencies and freight transport arrangement.

The support industries for this sector are:

- Business services
- Legal services
- Communications
- Transport services
- Professional services
- Real estate
- Banking
- Printing and publishing

Figure 4.6. Transportation Services Sector in Virginia: 1998



Geographic Distribution

Local and interurban transportation is concentrated in the three major urbanized areas of the state as are air transportation and transportation services: the Richmond, Hampton Roads and Northern Virginia Regions. By far the largest concentration of employment in air transport is in the Northern Virginia Region where Reagan National and Dulles International Airports are located. Water transportation is overwhelmingly located in the Hampton Roads Region. Trucking and warehousing is distributed similar to the population; in short it is available everywhere, but generally in about proportion to the population.

Supporting Services

Although the supporting services have been listed above with each dominant industry they are listed here again in aggregate to illustrate the full range of support industries in the cluster.

- Wholesale trade
- Business services
- Automotive repair and parking
- Professional services
- Real estate

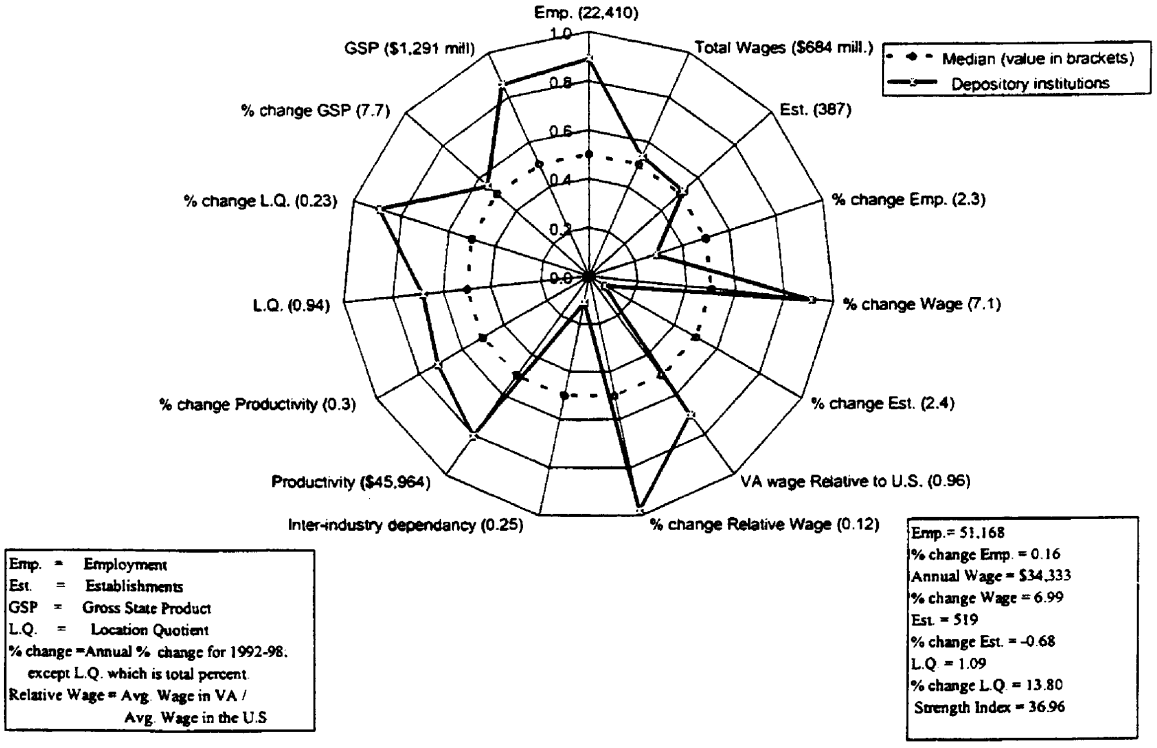
- Industrial machinery
- Utilities
- Legal services
- Professional services
- Banking
- Printing and publishing
- Communications

Financial and Insurance Institutions Cluster

This cluster has five dominant industries: depository institutions, non-depository institutions, security brokers, insurance carriers, and insurance agents. Cluster employment is more than 100,000.

The **depository banking institutions** sector employs 51,168 (Figure 4.7). However, employment is not growing, wages are below the median for all industries in Virginia, but growing rapidly, reflecting the increasing adoption of information technology as this industry undergoes consolidation. Moreover, the wage level relative to the national industry average is well above the median for Virginia industries and increasing rapidly. The level of inter-industry connectedness is, however, very low. All other indicators are above the median, except the rate of increase in the gross state product is slightly below the median. This is a strong sector that is exhibiting all the signs of an industry that is going through a structural shift to adapt to new conditions. Rapid growth in wage level and productivity is coupled with stable or decreasing employment and establishments. The major sub-sectors are commercial banks (employment is increasing at 3 percent per year), credit unions (employment is increasing at 10 percent per year), central reserve depository (employment is increasing at 13.4 percent per year) and other functions closely related to banking (employment is increasing at 11.3 percent per year). Employment in foreign bank branches is quite low, but has been increasing at more than 200 percent per year.

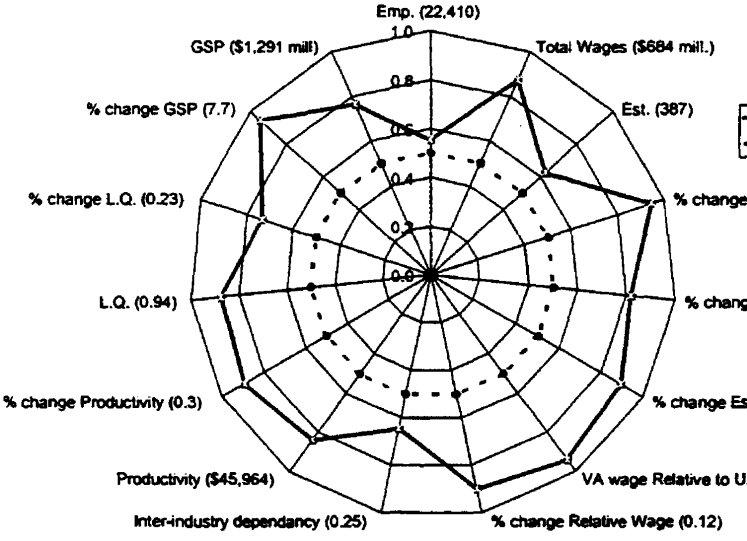
Figure 4.7. Depository Institutions Sector in Virginia: 1998



Non-depository bank institutions employ more than 26,000 (Figure 4.8). Employment is increasing at 5.4 percent per year. All indicators are above the median value and most are well above it. In short, this is a booming part of the banking industry. Federally sponsored credit and business credit institutions are two of the largest sub-sectors and they are both growing at a rate of more than 35 percent per year.

The **security brokers** industry employs 8,789 with employment growing at a rate of 15.6 percent per year (Figure 4.9). The annual wage level is far above the Virginia median but quite low relative to the wage for the industry nationally. This is a dynamic sector, given that the number of establishments is increasing at 12.3 percent per year. Further, productivity is high and increasing. While contribution to gross state product is below the median for all industries, it is growing rapidly. The location quotient is low,

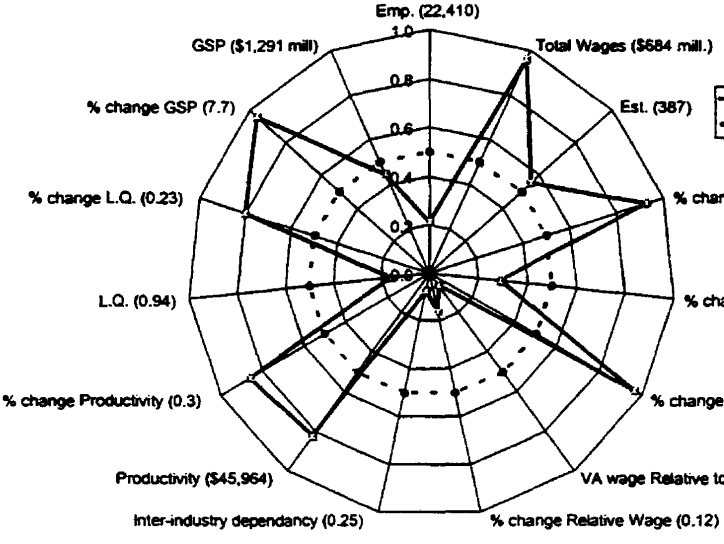
Figure 4.8. Non-Depository Institutions Sector in Virginia: 1998



Emp. = Employment
Est = Establishments
GSP = Gross State Product
L.Q. = Location Quotient
% change =Annual % change for 1992-98; except L.Q. which is total percent.
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp.= 26,066
% change Emp. = 16.20
Annual Wage = $51,273
% change Wage = 5.35
Est. = 854
% change Est. = 9.26
L.Q. = 1.41
% change L.Q. = 5.43
Strength Index = 67.01

Figure 4.9. Security Brokers Sector in Virginia: 1998



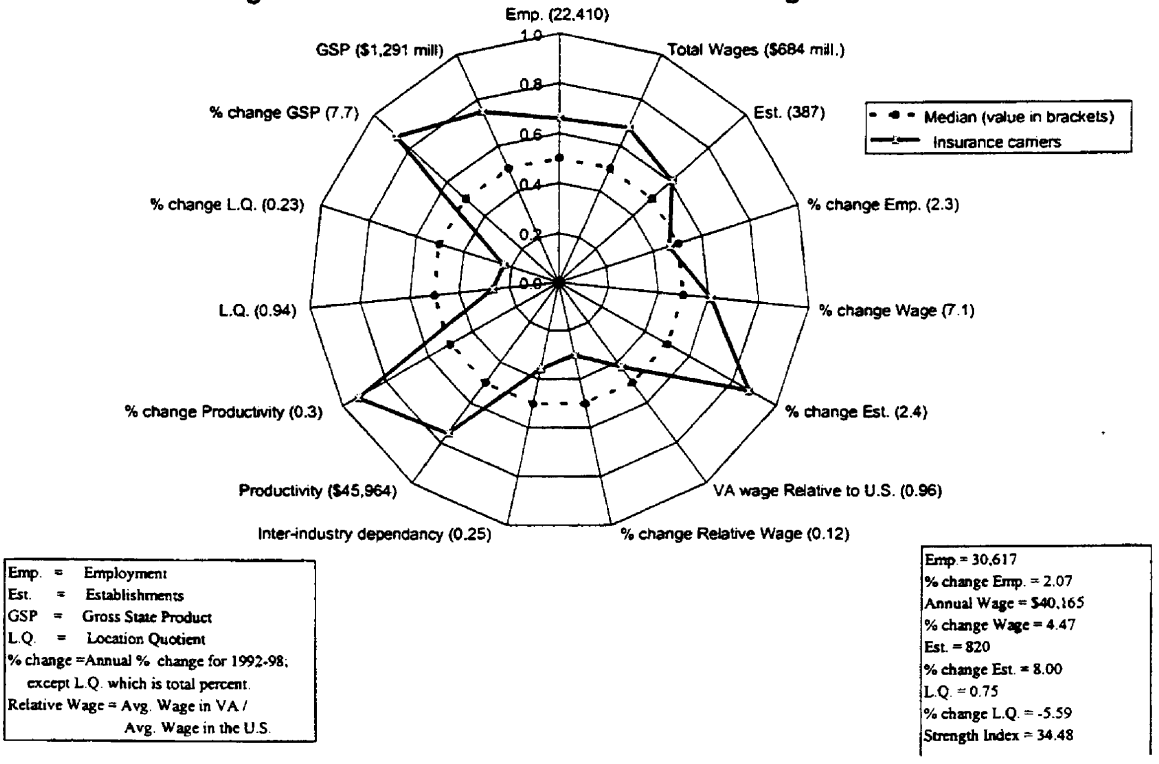
Emp. = Employment
Est. = Establishments
GSP = Gross State Product
L.Q. = Location Quotient
% change =Annual % change for 1992-98; except L.Q. which is total percent.
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp.= 8,789
% change Emp. = 15.63
Annual Wage = $84,656
% change Wage = 3.41
Est. = 729
% change Est. = 12.26
L.Q. = 0.51
% change L.Q. = 7.68
Strength Index = 29.99

but increasing rapidly. However, connectivity to the rest of Virginia's industries is low. The growth of this industry reflects the generally prosperous economic conditions of the past 8 years. The two major sub-sectors are security brokers and dealers and security and commodity services.

The **insurance carriers** industry employs 30,617 and is growing at 2.1 percent per year (Figure 4.10). While the wage level is high locally and growing it is well below the national industry average. Productivity and contribution to the gross state product are high and increasing. Interdependency with other industries in Virginia is low as is the location quotient which is stable and unchanging. The location quotient for all sub-sectors is well below 1.0 and in only one case above 0.8, indicating that insurance activities in the state are less important than in the national economy. The major sub-sectors in the order of employment level are: life insurance; fire, marine and casualty; and medical.

Figure 4.10. Insurance Carriers Sector in Virginia: 1998



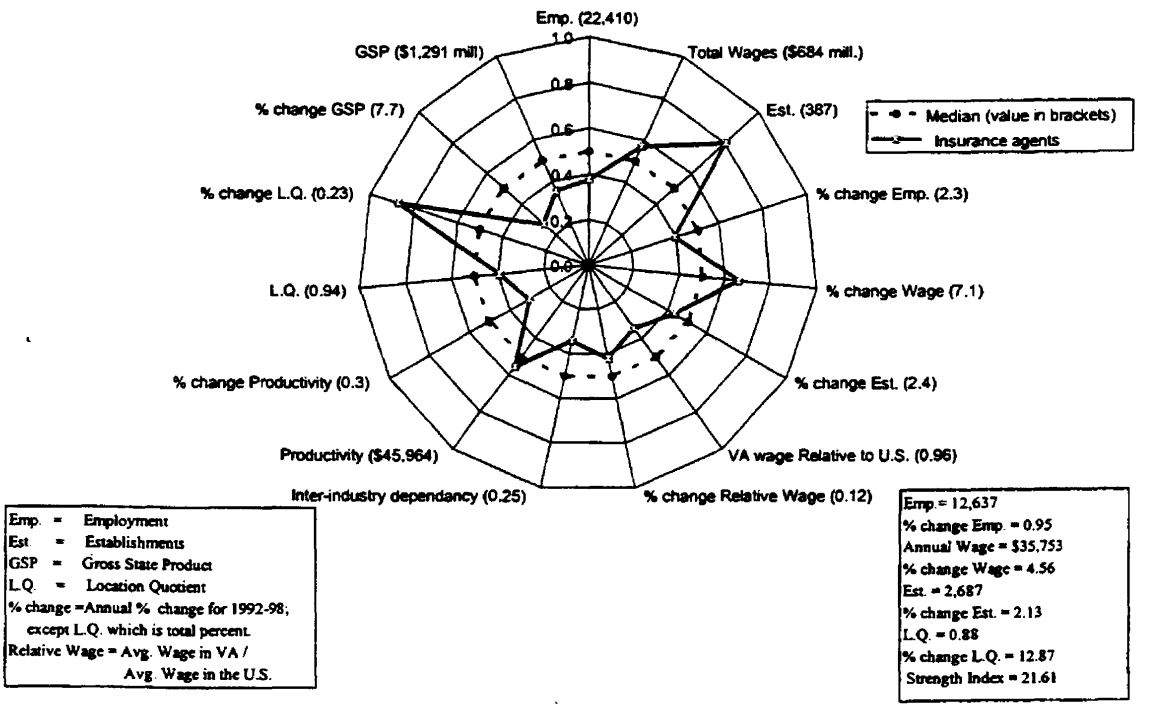
The **insurance agent** sector employs 12,637 and employment growth is stable at less than 1 percent per year (Figure 4.11). While the wage is above the state industry median and is increasing, all other indicators show that this is a stable rather than dynamic part of the finance cluster.

Supporting Industries

The major supporting industries for the finance and insurance cluster are listed below.

- Business services
- Professional services
- Real estate
- Communication
- Hotels and lodging places
- Auto repair services and parking

Figure 4.11. Insurance Agents Sector in Virginia: 1998



Geographic Distribution

Generally the distribution of the employment in finance and insurance is similar to the population distribution in Virginia, i.e., most is in urbanized areas. It is important to note that non-depository employment is increasing at more than 33 percent per year in the Richmond Region due most likely to expansion connected with the Federal Reserve Bank there. The Hampton Roads and Northern Virginia regions are also experiencing growth in this sector but at the much slower rate of about 6 percent per year. Increased employment in federally supported credit institutions like Freddie Mac are probably fueling the growth in Northern Virginia. Growth in security brokerage activity is

increasing in most regions with the exception of the more rural regions like Shenandoah, Southern Piedmont and far Southwest Virginia.

The Business Services Cluster

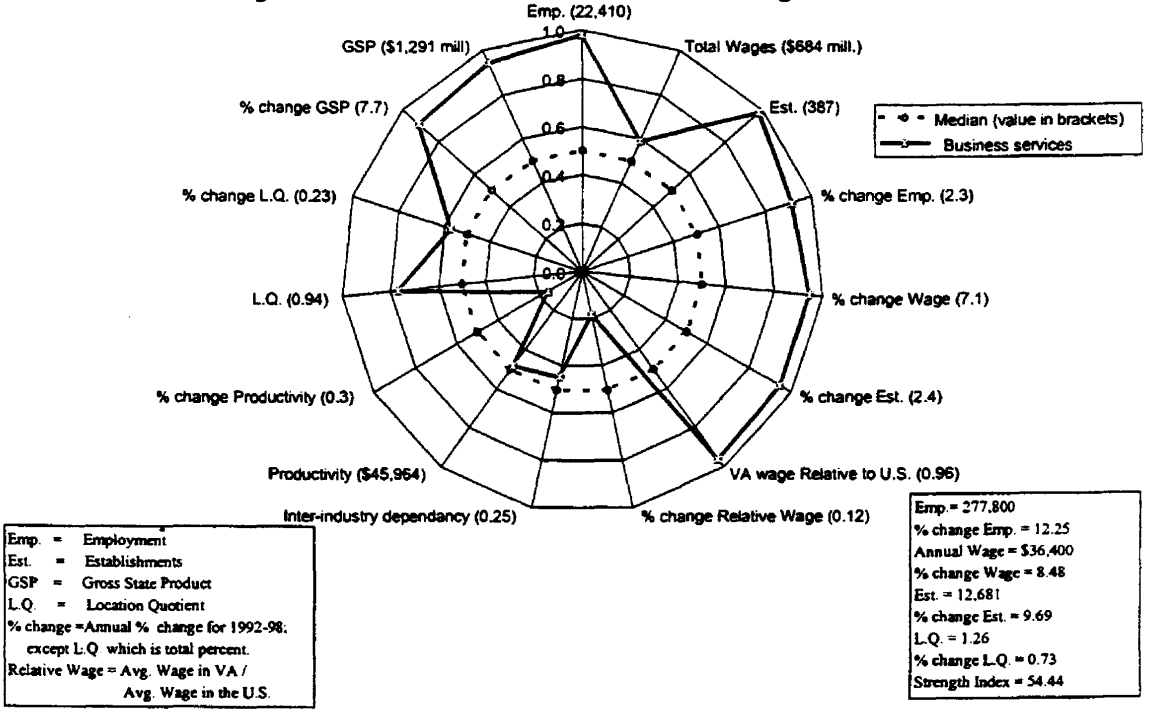
The business service industry which is the only dominant industry, has the largest employment of all industry sectors at the 2 digit SIC level in Virginia and it is growing at a rate of 12.3 percent per year. There are several reasons for this growth, ranging from strong economic conditions over the study period, to major restructuring to a more service oriented economy.

This sector includes activities ranging from specific local services like shoe repair shops and cleaners to very sophisticated services like those found in support of the communications and electronics sectors. A major task in this highly dynamic sector will be to separate out the new economy components from the more traditional ones.

The Economic Performance of the Dominant Industry

The business services sector is one of the strongest with a large employment base that is increasing at a rapid rate (Figure 4.12). The wage level is above the Virginia median and increasing rapidly and is 115 percent of the national industry average, although this measure of relative strength has been decreasing slowly over the study period. There is considerable firm formation activity in this sector, with a net formation rate of nearly 10 percent. Because this is a big industry its contribution to gross state product is large and increasing rapidly. The relative importance of business services is quite high (the location quotient is 1.26 and growing). Despite these strong indicators the interconnectedness of business services is not quite at the median for all state industries and productivity levels are at about the median.

Figure 4.12. Business Service Sector in Virginia: 1998



As noted above, not all business services are producer or intermediate services, i.e., services provided and sold to producers of other goods or services. Many, probably 30-40 percent, end up as point of sale services that should be classified as retail. The most prominent among the producer services is computer and data processing services, which employ 88,934. Employment in this set of services has been growing at nearly 10 percent per year. The location quotient for this sector is 2.8 and all sub-parts have similarly large location quotients. In order of employment size the sub-sectors are: computer programming services; computer related services not elsewhere classified; computer integrated systems design; data processing and preparation; prepackaged software; information retrieval services, computer maintenance and repair; and, computer facilities management.

The next largest sub-sector of the business services sector is personnel supply services, which employs 65, 828 and is growing at a rate of more than 16 percent per year. Sub-parts of this activity are employment agencies and help supply services. This sector is growing because unemployment levels are low and the demand for workers is high. Consequently, there is a premium paid for organizations that can find qualified workers and can help in outsourcing and hiring temporary workers. While this is a statewide phenomenon it is most acute in the Northern Virginia Region where unemployment has been below 2 percent for the past year. Building services employs more than 35,000 and employment is growing at 4.6 percent per year. Mailing and reproduction services employs more than 10,000 and is growing at nearly 10 percent per year. Finally, nearly 20,000 are employed in other business services (not elsewhere

classified) where growth is nearly 15 percent per year. Employment in this "unable to classify" sector is so high because many of the new economy jobs that are being filled do not easily fit into the SIC classes that were developed to suite activities in the old economy.

Supporting Industries

The business services sector is supported by a variety of other sectors including both manufacturing and services. These are:

- Real estate
- Professional services
- Industrial machinery
- Communications
- Electronic equipment
- Printing and publishing
- Wholesale trade

Given that computer services is the largest sub-sector of the business services and growing rapidly, it is no surprise that it is closely linked to professional services (engineering), communications and electronic equipment sectors.

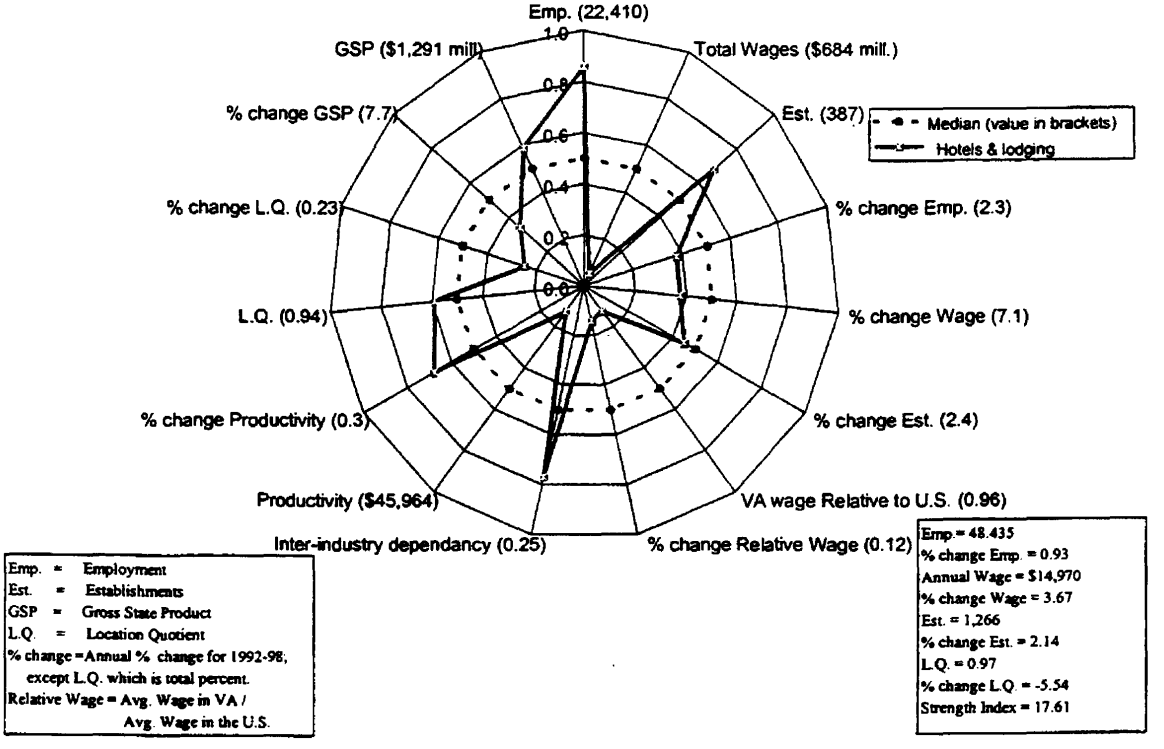
Geographic Distribution

Well over half of the business services jobs are located in Northern Virginia. This is also the case for sub-sectors such as computer services (where nearly one third of all business services are in computer services) and personnel services. A secondary concentration of computer services exists in the Hampton Roads Region. All other parts of the state have minor concentrations in computer services. Finally, all parts of the state have a significant employment presence in personnel services, with Northern Virginia and Hampton Roads having the largest concentrations, although for different reasons. In Northern Virginia the reason is labor a shortage, while in Hampton Roads the unemployment rate is somewhat higher than the demand for finding work.

The Tourism Cluster

The tourism cluster has two dominant industries: hotels and lodging, and amusement and recreation services. Data for these two industries appears in Figures 4.13 and 4.14. While these are defining industries for the tourism cluster, they are by far not the only ones. Many other industries contribute, as indicated by the very high level of interconnectedness shown in Figures 4.13 and 4.14. Other important tourist activities not included in the dominant industries are restaurants, retail trade, transportation services, real estate, resorts, etc.

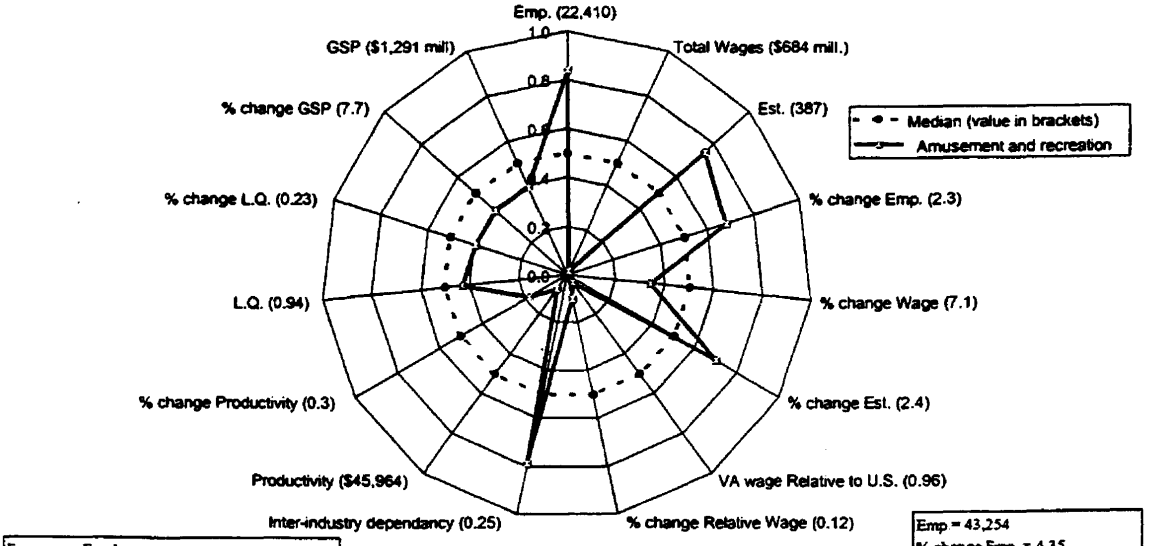
Figure 4.13. Hotels and Lodging Sector in Virginia: 1998



Emp. = Employment
Est. = Establishments
GSP = Gross State Product
L.Q. = Location Quotient
% change = Annual % change for 1992-98, except L.Q. which is total percent.
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp. = 48,435
% change Emp. = 0.93
Annual Wage = $14,970
% change Wage = 3.67
Est. = 1,266
% change Est. = 2.14
L.Q. = 0.97
% change L.Q. = -5.54
Strength Index = 17.61

Figure 4.14. Amusement and Recreation Sector in Virginia: 1998



Emp. = Employment
Est. = Establishments
GSP = Gross State Product
L.Q. = Location Quotient
% change = Annual % change for 1992-98, except L.Q. which is total percent.
Relative Wage = Avg. Wage in VA / Avg. Wage in the U.S.

Emp. = 43,254
% change Emp. = 4.35
Annual Wage = $14,005
% change Wage = 3.64
Est. = 2,021
% change Est. = 4.40
L.Q. = 0.89
% change L.Q. = -2.21
Strength Index = 14.56

Economic Performance of the Dominant Industries

The most important attributes of the dominant industries are that they employ a large number (more than 58,000), employment is growing (particularly fast in amusements and recreation), and these tourism industries are highly connected to the other industries that make up the economy. On the downside, wages are low locally, and, in comparison to national industry averages and location quotients, are below 1.0. While the contribution to gross state product is high for hotels and motels and productivity is increasing, the opposite holds for amusement and recreation services.

Most employment in the hotel and lodging industry is in hotels and motels, with a much smaller amount in camps and recreation vehicle parks. This indicates that, at least in this industry, Virginia is dominated by the higher (hotel) end of the industry. The major employment concentrations in the amusement and recreation industry are: membership sports and recreation clubs; other amusements and recreation activities (i.e., not classifiable); physical fitness facilities; and, amusement parks. This amusement and recreation industry is not well defined given the current classification system in that the largest single sub-sector is miscellaneous amusement and recreation services (25,785 employees).

Supporting Industries

The primary supporting industries for the tourism cluster are:

- Business services
- Utilities
- Real estate
- Construction
- Professional services
- Banking
- Credit agencies
- Communication
- Transportation services

Geographic Distribution

The distribution of employment in the dominant industries parallels, to some extent, the population distribution. However, the largest concentrations are in Northern Virginia and Hampton Roads, but for different reasons. The attractions in Northern Virginia are spillovers from the attraction of the nation's capital, and relatively high levels of amusement employment because of the high-income effect on the behavior of the local population. A high level of hotel employment stems from high levels of business visits and the attraction to museums, monuments and performing arts in the national capital. While some business travel supports the hotel industry in Hampton

Roads, there are also two major attractions: the Virginia Beach resort area and Historic Williamsburg.

Perhaps the most interesting finding is that Richmond, compared to Northern Virginia and Hampton Roads, has relatively less presence in the two dominant tourism industries. In fact, employment in hotels and motels is much less than half that of the other two regions.

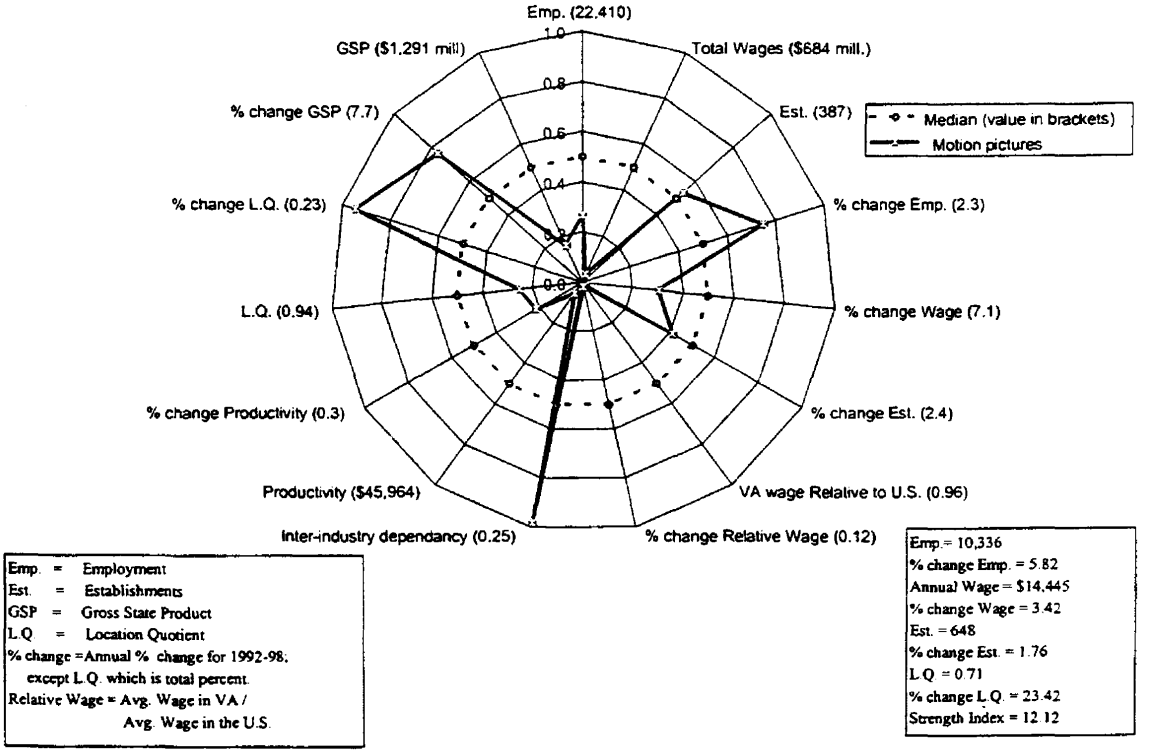
Three other regions provide significant attractions. These are the Roanoke and Shenandoah regions, with the Blue Ridge Mountains and related heritage as the primary attractions. Charlottesville appears to have disproportionately large amounts of employment in the dominant industries. This may be due to historic attractions in the region and the University of Virginia. The Lynchburg, Southern Piedmont and Far South West Regions have a modest amount of employment in the two tourist related sectors.

The Motion Picture Cluster

The Economic Performance of the Dominant Industry: Motion Pictures

While the employment level in this industry is low, it is growing rapidly. Likewise the location quotient is low at 0.7, but increasing quite rapidly (Figure 4.15). The inter-industry dependency level is the highest of any industry but productivity is low. Further, the wage is low but increasing somewhat. What is interesting about this sector is that employment is growing rapidly, as is the location quotient, at the same time the level of inter-industry linkage is high. It is also interesting that the largest and fastest growing sub-sector is in the area of motion picture production and services.

4.15. Motion Picture Sector in Virginia: 1998



Supporting Industries

The major supporting industries for the motion picture industry are:

- Business services
- Real estate
- Wholesale trade
- Electronic equipment
- Communications

Geographic Distribution

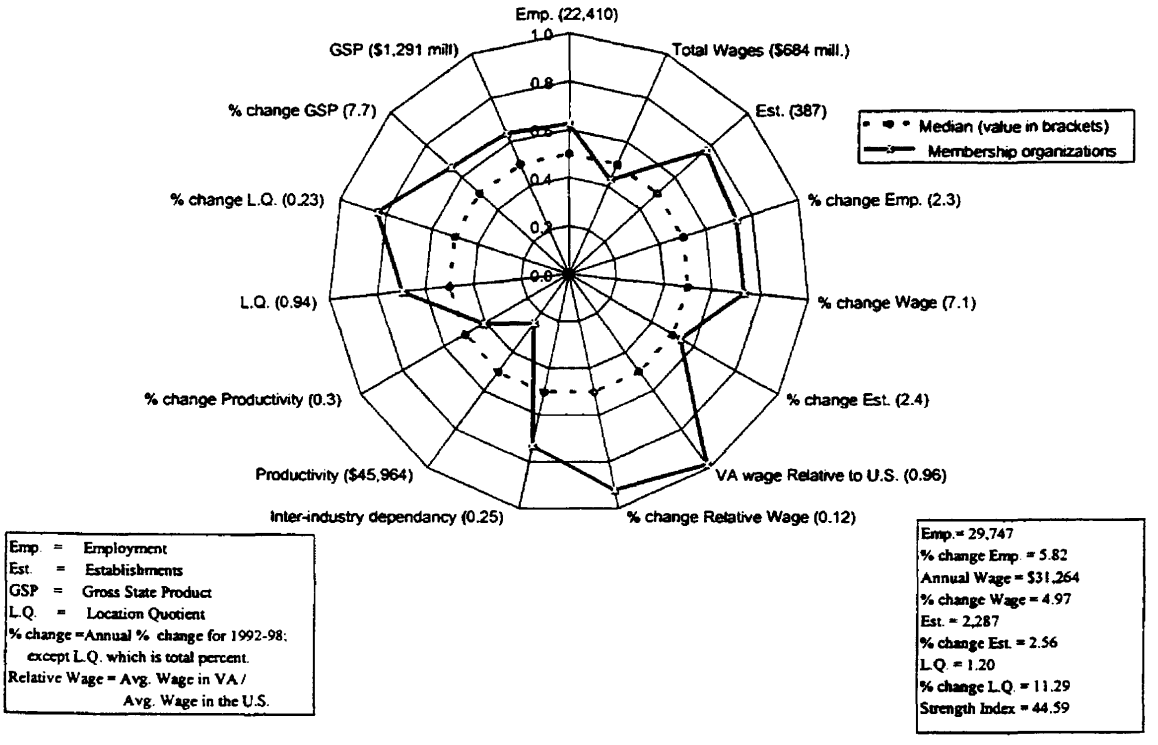
The geographic distribution of employment in this industry is a mirror image of the population distribution in Virginia. Larger motion picture related employment is in the urbanized areas, and less is located in rural dominated regions.

The Membership Organizations Cluster

The membership organization industry employs 29,747, with employment growing at a rate of 5.8 percent per year (Figure 4.16). While the level of productivity is low, all other indicators are well above the median for all industries in Virginia. This industry is growing, wages are fairly high, and the location quotient is 1.2 indicating that this is a relatively important industry. Several sub-sectors are important and growing. These are:

civic associations, business associations and professional associations. The largest single sub-sector is religious organizations, with a location quotient greater than 1.0, where employment is growing at 3.9 percent per year.

Figure 4.16. Membership Organization Sector in Virginia: 1998



Supporting Industries

There are six major supporting industries. These are:

- Real estate
- Business Services
- Construction
- Printing and publishing
- Professional services
- Federal, non-military

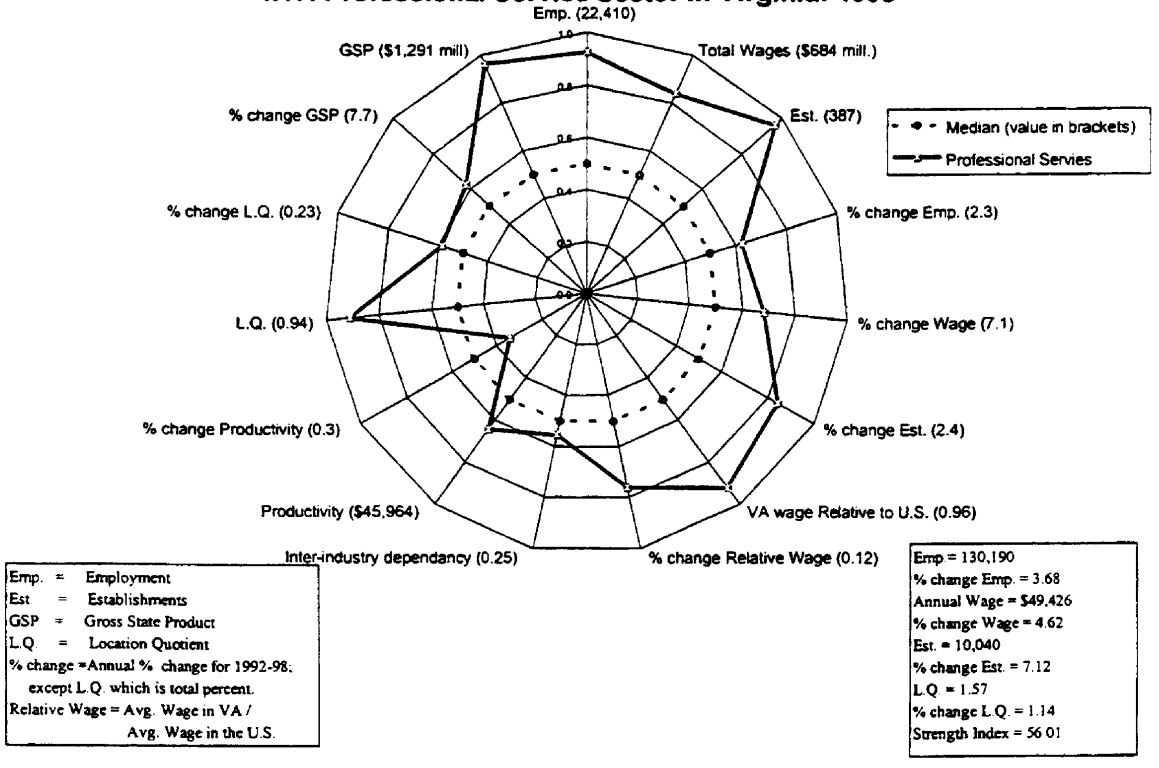
Geographic Distribution

There are 18,327 employees in the membership industry in Northern Virginia, which is nearly two-thirds of the Virginia total. The reason for this is the locational spillover into Northern Virginia of national associations attracted to the National Capital Region. All other regions in Virginia have employment in this sector that is similar to their population level.

Professional Services Cluster

This is a large and growing sector, with 130,190 employees and growth at 3.7 percent per year (Figure 4.17). Wages are high and increasing, regardless of whether the base is Virginia or the Nation. It is well connected to the industrial structure of Virginia, has productivity above the median and is making one of the largest contributions to the state gross regional product of any industry in the state. In short, this is one of the strongest industries in the Virginia economy. The primary sub-sectors are engineering (engineering and architectural services), accounting, research and testing services (commercial physical research, commercial nonphysical research, noncommercial research and testing laboratories), and management and public relations (management services, management consulting services, public relations services, facilities support services and other business consulting. All of these sectors have location quotients near or well above 1.0, and all have employment growth that is between 2.0 and 10 percent per year.

4.17. Professional Service Sector in Virginia: 1998



Supporting Industries

The major supporting services are:

- Business services
- Professional services
- Real estate

- Communications
- Printing and publishing

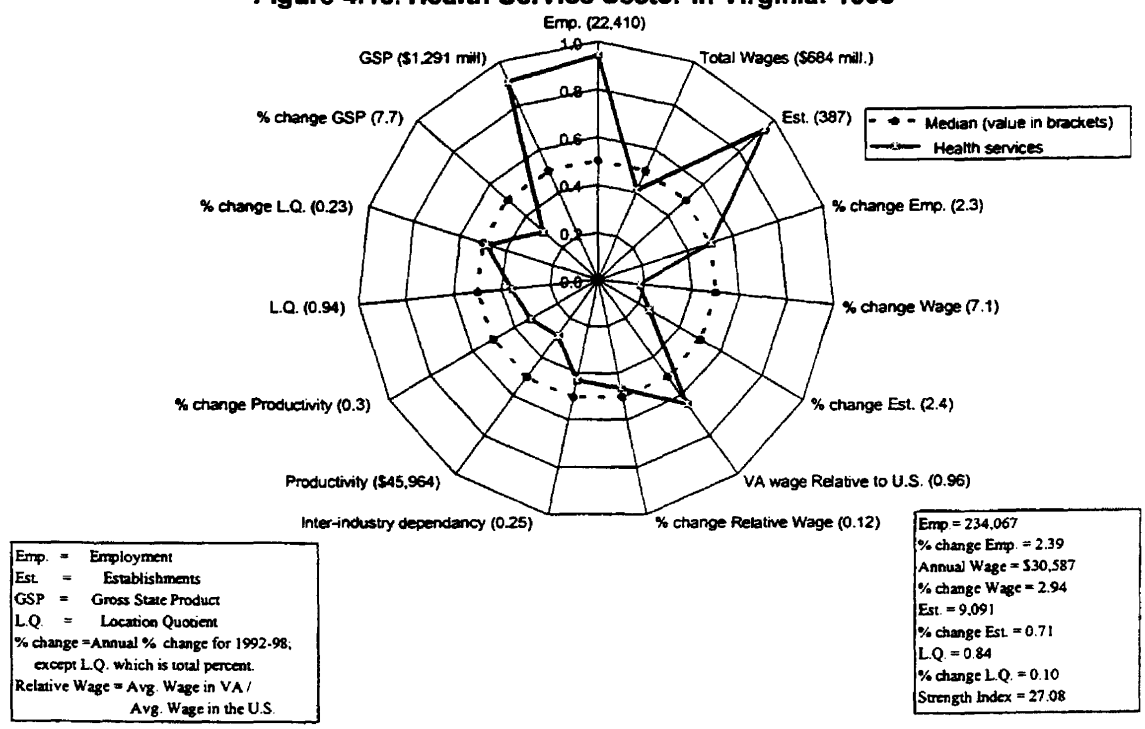
Geographic Distribution

More than two-thirds or all employment in the professional services is located in the Northern Virginia Region (87,040). There are 22,674 employed in the Hampton Roads Region and 10,608 in Richmond. In all three of these regions employment is increasing at about 5 percent per year. The next largest concentrations are in Roanoke (3,820), Lynchburg and Charlotte, where in all cases employment is declining at a rate between 5 and 15 percent per year. Employment in the professional services is slightly over 1,000 in the remaining regions, where it is increasing. The overwhelmingly large concentration in Northern Virginia is tied to the large and growing technology services industry located there. Many professionals are needed to fuel the growth of the information and communications technology based economy there.

The Health Services Cluster

The health service sector is a very large industry, with employment at 234,067 and growing at 2.4 percent per year (Figure 4.18). There are many reasons for the large size of this industry, not the least of which are the aging of the population and rising incomes. Both continue to accelerate demand for medical and health services, along with technological development, which is driving demand from the supply side.

Figure 4.18. Health Service Sector in Virginia: 1998



Economic Performance of the Dominant Industry

The health services industry has the third largest employment after business and education services. The average annual wage level is low and not increasing, although it is a competitive wage compared to the national industry average (Figure 4.18). Because of the massive size of this sector it makes a large contribution to the gross state product. Its linkage to other industrial sectors in the Virginia economy is below the median level, and productivity levels are below the median of all industries in the state. Despite the absolute size of this sector, its location quotient of 0.84 is small, indicating that relative to the nation Virginia has less activity in the health services.

The large majority of employment is in hospitals with nearly 110,000 employees and employment has been increasing at a rate of 5.8 percent per year. About another 75,000 are employed in medical offices (doctors, dentists, health practitioners, optometrists, podiatrists). Nursing and personal care facilities employ more than 40,000. All of these sub-sectors have employment growth rates between 1.0 and 8.0 percent per year. More than 9,000 are employed in medical and dental laboratories and employment is growing in these areas also. The fastest growing sub-sector is home health care services (16,00 employees growing at a rate of 15.2 percent per year). The second fastest growing sub-sector is health and allied services not elsewhere classified, with nearly 9,000 employees.

It is important to note that, with two minor exceptions, none of the sub-sectors mentioned above has a location quotient above 1.0. This indicates that most of the activity in health services is to meet demand of those seeking medical services. While there may be one or two small windows that are tied to technology and research, e.g., University of Virginia and Virginia Commonwealth Medical Schools, Virginia does not appear to have more than niche opportunities for future development in this industry. However, it is a large sector in absolute numbers, so there is reason to search for and develop these niches.

Supporting Industries

There is one manufacturing sector and a number of services that are the major support industries for the health services cluster. These are:

- Real estate
- Business services
- Chemical products
- Professional services
- Federal, non-military
- Wholesale trade

Geographic Distribution

The distribution of health services across Virginia is almost a mirror reflection of the population distribution. The only exception is for employment in medical

laboratories in Northern Virginia. The location quotient for this industry there is 1.5 and employment is growing at a rate of nearly 4 percent per year. There are minor concentrations of growing employment in the health practitioner sub-sector in the Roanoke and Hampton Road Regions and location quotients are greater than 1.0.

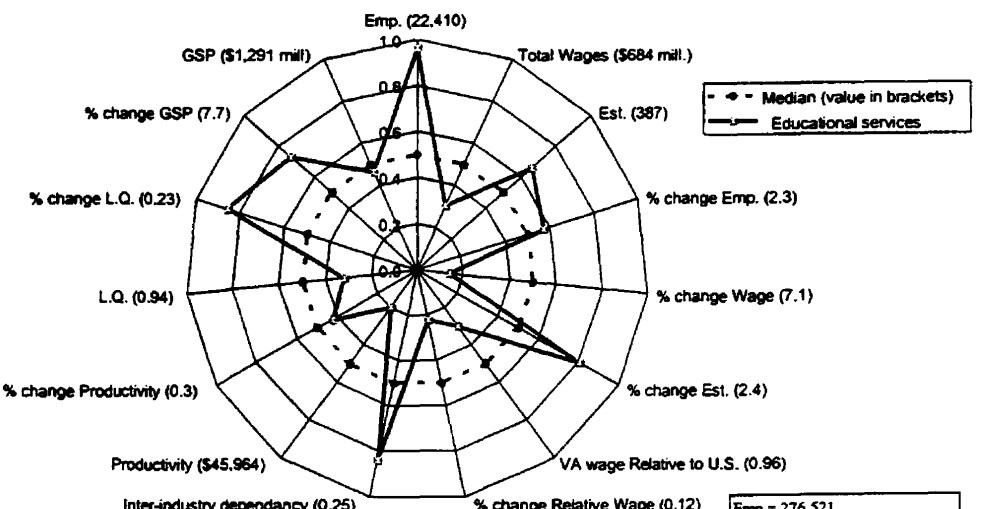
The Educational Services Cluster

Educational services is the only dominant industry in this cluster and it is the second largest industry in Virginia with 276,521, employees. This cluster illustrates the importance of the public sector which is the dominate organizational form for this cluster.

Economic Performance of the Dominant Industry

Employment has been increasing at above the median level in Virginia, but relative to educational services nationally, it is a low wage industry that shows little sign of increasing wages (Figure 4.19). It is highly intertwined with other industries in the state, as indicated by the high interdependence score. Productivity in this industry is low and its contribution to gross state product is low. The location quotient is low but has been exhibiting fairly rapid growth, at a12.8 percent per year. This is not surprising given the low wage in Virginia in the face of increasing demand. The major sub-sectors are primary and secondary education and colleges/universities. Secondary concentrations appear in vocational schools and other educational services.

Figure 4.19. Educational Service Sector in Virginia: 1998



Supporting Industries

The major supporting industries for the education services industry are:

- Construction
- Real estate
- Business services
- Professional services
- Printing and publishing
- Communications
- Wholesale trade
- Utilities

Geographic Distribution

Education services are generally distributed much as is the population of the state, with major concentrations in urbanized areas. However, there are a few exceptions when one considers only post secondary education. The Roanoke, Lynchburg, Shenandoah and Charlottesville Regions have significantly more employment in this sector than would be expected given their population levels. This, of course, is due to the presence of the University of Virginia in the Charlottesville Region and several colleges and universities in the Roanoke Region, not the least of which is Virginia Tech University. Lynchburg has several colleges and academies, which when taken together boost employment significantly in education. James Madison University in Harrisonburg provides a major employment center in education in the Shenandoah Region.

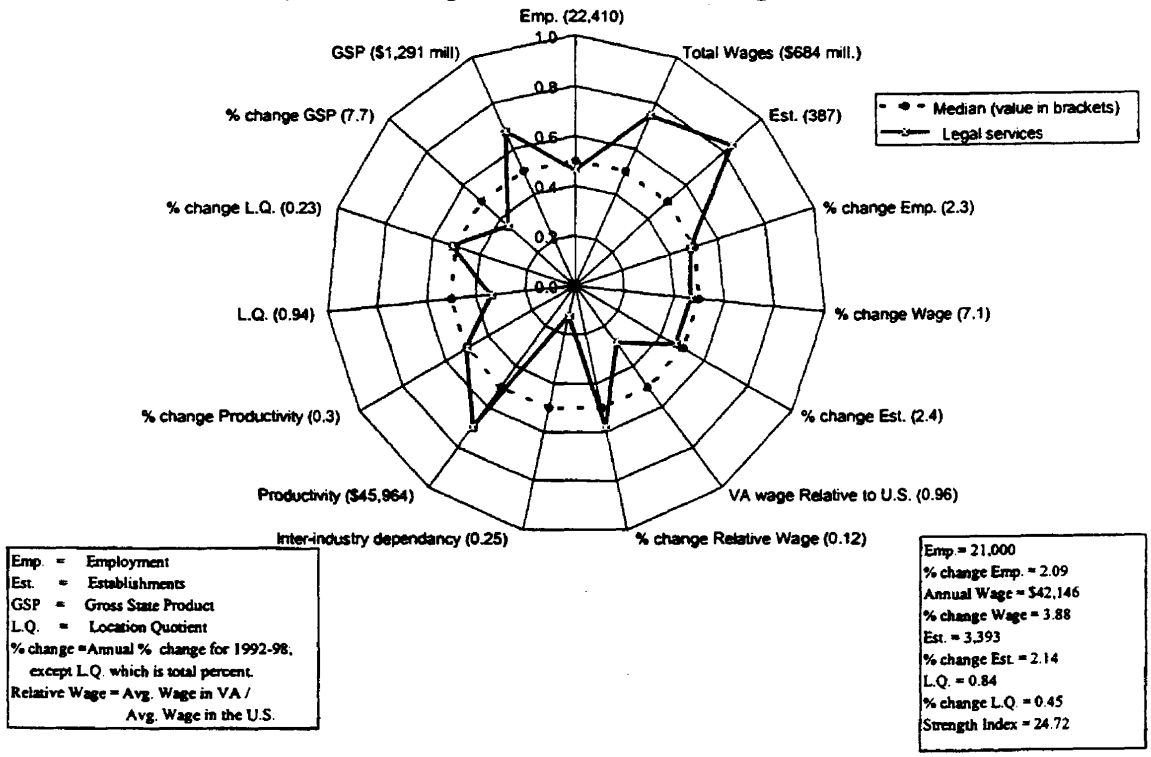
The Legal Services Cluster

The legal services cluster has one dominant industry: legal services. This is not an industry that would normally be considered as the basis of a cluster because it has traditionally existed to provide service to local residents and businesses. However, like many of the other services (e.g., business services) in the new economy, new legal services and products are being developed for it to remain competitive. Some of these are potentially powerful export base type activities, such as the many firms in the Northern Virginia Region that have opened new divisions in technology law.

Economic Performance of the Dominant Industry

The legal services industry employs 21,000 in Virginia (Figure 4.20) and employment is growing at about the median for all industries in the state (2.1 percent per year). The wage level is high and growing at the state industry median and, although the wage level relative to the national industry level is low, its rate of increase is higher than

Figure 4.20. Legal Service Sector in Virginia: 1998



many other industries in Virginia. This industry exhibits a high level of productivity and makes a significant contribution to the gross state product. However, it has a low location quotient and its connectivity level to other industries in the state is relatively low.

Supporting Industries

The major supporting industries of this cluster are:

- Real estate
- Professional services
- Business services
- Hotels and lodging places
- Federal, non-military
- Communications
- Printing and publishing
- Banking

Geographic Distribution

The largest concentrations of legal service employment are in the Northern Virginia (7,350), Richmond (5,024) and Hampton Roads (4,624) Regions. The demand

in Northern Virginia is in support of the new technology business sector and spillover from legal services demanded in support of national public policy making. The Northern Virginia figure is probably understated in that many lawyers are working in other sectors (e.g., membership associations, larger management and engineering firms, and government). This problem in measurement is similar to the measurement problems with IT workers because so many are increasingly embedded in other sectors. The demand in Richmond is in part in support of government and administrative activities that concentrate there because it is the state capital. For the Hampton Roads Region demand is driven in part by port, shipping and international trade functions. Generally, however, legal services employment parallels the distribution of the population

Summary and Conclusions

The services industry provides several high potential growth opportunities. First, the transport services cluster offers significant potential in several sub-sectors, such as marine cargo handling, towing and tugboat services, sea freight transport, trucking and warehousing and related logistical services. The air services sector also is an important component for future development.

The financial and insurance institutions cluster shows considerable potential in its non-depository banking services sector. The high potential in the large business services cluster resides largely in computer services (programming, systems design and integration, data processing, software, maintenance and facility management) and communications (telephone services, cable and Internet related services). Professional services (e.g., engineering) and management services are also important sub-sectors of the business services industry that are linked to computer and communications services.

The tourism cluster offers a potentially strong development opportunity through the future development of "smart tourist services" that could emerge from interfacing with the computer and communications services and from the continued development of the motion picture industry. These potential developments are, however, at only a very nascent stage of development.

The health services cluster offers some potential in the area of bio-science. Bio-science in Virginia is an emergent, but small sector. Virginia appears to have a significant opportunity in the area of bio-informatics that could develop, by continuing to interface bio-science applications with computer and information technology, capabilities that already exist. Finally, the legal services cluster offers an opportunity for the development of a new legal technology services industry.

Several services sectors were not included in this analysis because they were either very small or provided services largely for in-state consumption. These are: social services, real estate, personal services, auto repair and parking, miscellaneous repair services, other services, and holding and investment services.

Chapter 5

Identifying Emergent Clusters and Industries

The purpose in this chapter is to identify potentially emergent industries and clusters that can become the focus of a state technology investment strategy. This analysis is erected primarily on the analyses presented in Chapters 2, 3 and 4 and on interviews and focus groups conducted in Virginia's technology regions. The discussion is organized around the three state-level cluster groupings: resource-based, manufacturing and service-based. Maps supporting the analysis and description of spatial concentrations of cluster activity in the text appear in Appendix B.

Resource-Based Clusters and Industries

Despite the fact that the resource based clusters are not particularly propulsive there are sub-parts that offer potential. The first of these is the food and kindred products industry in general, and specifically meat and dairy products. Major concentrations occur in the Shenandoah and Hampton Roads regions. The promotion and development of this sector could have spillover impacts on business services, wholesale trade, trucking and warehousing industries, to name a few.

Three sectors in the wood and paper products industry may offer development potential. The first is furniture, despite the low wage level in this industry. Given that furniture is well down the chain from timber growing and harvesting, and given that the wage is low in Virginia relative to the nation, furniture production could be fruitfully expanded. The second sector for potential development is the paper products industry. Here the wage is high relative to Virginia's all industry wage level and competitive nationally. This industry is located at an intermediate point in the value added chain, suggesting that it is a competitive industry in Virginia and that it should be promoted. Finally, the third is printing and publishing. Here the opportunities are more focused on book publishing and commercial printing. This activity is concentrated in the major population centers in Northern Virginia, Richmond and Hampton Roads.

Manufacturing Clusters and Industries

The chemicals industry is a foundation industry in Virginia given its high level of inter-industry dependency. Further it has a high wage level, despite the fact that the wage is not high relative to the chemical industry wage level nationally. Three sub-sectors offer the most potential: inorganic chemicals; plastics materials and synthetics; and, medicinals. Concentrations are greatest in the Hampton Roads, Richmond, Roanoke and Southern Piedmont regions.

The machinery and equipment cluster also offers some promise for future development. Most interesting are opportunities for the development of the electronic equipment and scientific equipment (instruments) industry segments. Both are quite propulsive and have

high wage levels compared to both Virginia and the national wage level. Important sub-sectors of the electronic equipment sector are industrial apparatus and communications equipment. Strong sub-sectors in the instruments sector are search and navigation equipment, measuring and controlling devices (sensors) and optical instruments and lenses.

Transportation equipment, despite many "old economy" attributes, has a high wage level and an emergent sector in motor vehicle equipment that is present in many parts of the State. The thin, but widespread distribution of this activity, suggests a potentially major industry for the future. Another important and emerging sub-sector is related to the space industry. Data for tracking this potential new industry's development are scant, but observers indicate that there is considerable new business formation in the Hampton Roads Region (near Wallops Island where the State's space launching facility is located) and in the Northern Virginia area. One of the reasons for equivocating a bit here is that the components of this industry are often embedded in other sectors, making it difficult to measure and understand exactly what the potential is. More research is needed to better understand the opportunity here.

Service-Based Clusters

There are a large number of service-based clusters as that is where most of Virginia's employment is found. Despite the view of services as low wage and having a supporting industry role, there are a number of major and important opportunities for Virginia in this major industry sector.

The first of these service sector opportunities is in the transport services sector. Water transportation is very important in the Hampton Roads Region. Further, it is important to note that the port at New Port News is the 3rd largest in the U.S. in terms of volume of shipments. Two other ports in the area are in the top 12. Together the port complex in the Hampton Roads Region is one of the largest in the U.S. and is growing rapidly. The largest sub-sectors are marine cargo handling, towing and tugboat services, and sea freight transport. This activity is an important driver of the transportation service and the trucking and warehousing industry, not to mention business services and warehousing.

Air transport is also an important growth industry, given the cluster of major airports in the Northern Virginia region. But all of the potential is not located just in this region. There is a huge demand for better air service in all parts of Virginia. Thus, given the high frustration level in almost every region other than Northern Virginia, there may be a great opportunity for the state to provide leadership to improve this service and in so doing expanding in-state air service. This could have a large multiplier effect on many of the state's regional economies, especially outside of the Northern Virginia Region. Perhaps a state supported network to link its major cities could lead to a new model. Of course, there are considerable linkage opportunities in expansion of the air transport sector as it is tied strongly to transport services (especially logistical services), business services and trucking and warehousing. In short, given the opportunities in water and air transport, the transport services sector is an important growth industry.

The financial and insurance institutions cluster offers potential development opportunities. Perhaps the greatest is in the non-depository banking sector. Although there will be a continuing opportunity in the depository sub-sector, it appears this will be most effectively developed if a major bank can be grown or attracted to the state.

The business services cluster is the largest in the state. The most propulsive sub-part of the cluster is the computer services sector, with nearly 90,000 employees. The opportunities for continued growth are in computer programming services, computer integrated systems design, data processing and preparation, prepackaged software, information retrieval services, computer maintenance and repair, computer facilities management and other computer related services. Finally, as long as there are workforce issues there is continued opportunity for growth in the professional (engineering and management) and personnel services sectors.

The communications cluster is one of the "new economy" sectors that is underpinning the state's economy. The major sub-sectors of potential are telephone communication, and Internet and E-commerce related businesses. The Internet and E-commerce business developments are embedded in several sectors other than communications including the computer services sector (see above), thus, making it difficult to measure.

The tourism industry is composed of many other industries and, in this sense, it is a derivative industry. There are, however, significant opportunities in this area for the state. One that could be developed would be to link the attractions, amusements and recreational services industry to the computer services industry to create a new set of "smart tourist" services. This could also be an approach to propel the motion picture industry in the state, which is in a nascent stage of development.

The professional services cluster is composed primarily of engineering services and management services. While this is a significant growth industry, the growth is largely derived from developments in other sectors including transport, communications, computer services, chemicals, and so on.

Health services is a large industrial cluster in Virginia, yet its importance relative to this industry nationally is small. At the same time there is a fledgling bio-technology industry emerging in the Richmond and Northern Virginia areas that could serve as a springboard to a "new economy" component in the health services. The bio-medical/technology development in Northern Virginia is creating a new industry at the interface of the information technology industry that is heavily concentrated there. This industry is called bio-informatics.

Legal services offers some promise with the rise of the development of a new industry segment in technology law. This segment is developing quite rapidly in the Northern Virginia region where it is not only serving local demand but also becoming an export base activity.

Research and Development Plan: Needed Research

The overall goal of the research reported in this document is to provide the information necessary to leverage technology to better support economic growth in Virginia. The vision of the research needed to accomplish this with efficiency and effectiveness is a sequentially staged process. The first is to identify Virginia's industrial clusters and to assess their potential for growth in the era of the "new economy". This report has identified these industrial clusters and their more propulsive components. In short, most of the potential targets have been identified.

The second stage will develop a set of recommendations for each cluster through additional focus group meetings and interviews with industry experts and officials. Acquiring an understanding of what services the targets use and how they acquire them, what technologies they use or could use and what infrastructure improvements they need is a necessary requirement for completing stage 2. Results of this effort would identify potential improvements that could be promoted. Work in support of this report has only made an initial dent in the research needed to identify these potential improvements. To date, nine focus groups have been held in each of Virginia's technology regions to begin this process. Further, one case study has been conducted for the agricultural products cluster that illustrates the type of work and information that is needed to achieve stage two and subsequent goals. This case study is briefly described below.

In the third stage the potential improvements will be reviewed and prioritized in collaboration with the R&D Commission the Secretary of Technology is forming. For example, analyses in stage 2 may result in a conclusion that private companies in some or all parts of the state need access to large-scale band-width. Or, a conclusion that significant increases in logistical support organizations are needed to propel the development of Virginia's port or even its E-commerce industries may be adopted. Or, it may also be concluded that Virginia Tech needs to invest more in genetic crop or animal related research to ensure that the food products sector in the Shenandoah Valley remains competitive or even increases its competitiveness. Each of these conclusions about potential improvements will have been based on a research based understanding of the context within which such programmatic or policy initiatives stand. To better understand the three-stage process, a case study of the food products cluster is described below.

During stage one of the research it was discovered that there is a significant concentration of agricultural products and services activity focused in the Shenandoah Valley. Further research showed that the strongest and largest growing parts of this cluster were the meat, poultry and dairy sub-sectors. The data provided the potential industry targets for more detailed research required to establish potential improvement hypotheses. A focus group meeting with regional economic officials and intensive interviews with specialists in these target sectors and their supporting industries and institutions provided considerable insight into the broader economic context and related processes. Below we discuss this story.

In the focus group meeting a central issue of discussion was the degree of interconnection among businesses required to define industrial clustering. A representative from one of the major food producing corporations in the region made the point that her firm had begun to take actions to focus more on their core business and had just contracted out all of the firm's transportation functions. Her point was that the food products industry was becoming more integrated with non-food industries than historically had been the case. This became a major focus for the continuing investigative research.

Research into business and industry publications and newsletters identified a large contract made in April 1999 between the Virginia food products company and a Michigan firm that specializes in "total logistics control." Thus, outsourcing by the Virginia firm—in an industry considered to be highly integrated historically—was much more than just its trucks and transport-related divisions. The contractor is responsible for optimizing the delivery of diverse inputs and outputs across the company's supply chain at production facilities in four states. Moreover, the Michigan firm is now "exporting" advanced logistics services into Virginia that are heavily embedded with new technologies. So at this point we have uncovered a business trend in the food products industry that breaks with the traditional perception of how the food products industry functions and is organized. Further, it is believed that the kinds of skills and knowledge that are required to produce advanced logistical technologies and services are those that are heavily represented in Virginia technology firms and that could be developed to support demand in Virginia. However, this conclusion is only a hypothesis at this point, because we have pieced the story together much as an investigative journalist .

The next step will be to test this hypothesis which would require a focus group session with regional economic and industry specialists and a number of in-depth face-to-face interviews, all of which would occur in stage two of the process. Assuming that the hypothesis is supported by the test then the next step (stage 3) would be for the R&D Commission the Secretary of Technology is forming to review the conclusion and make recommendations. One approach or action would be to try to attract a major logistics provider to Virginia. Another approach, might be to assess the need for advanced logistics in other industries like vehicle production where there is some indication from the stage one analysis that this is an emergent and widely distributed industry in the state. In fact, the potential need for advanced logistics is likely to be widespread in Virginia. Adopting policies to promote the development of a logistics industry could be one of the more fundamental initiatives for the Commonwealth.

The case study illustrates the process that is being developed to provide carefully researched potential R&D related improvements for consideration in Virginia. Such an approach can result in well-developed policy aimed at promoting the future development of the "new economy" of Virginia. The overriding recommendation is that additional work be conducted to address the remaining but necessary research to support development of policies and programs.

References

Bergman, E., E. Feser, and S. Sweeny. 1996. *Targeting North Carolina Manufacturing: Understanding the State's Economy through Industrial Cluster Analysis.* Chapel Hill, NC: UNC Institute for Economic Development.

Bosworth, Brian and Daniel Broun. 1996. "Connect the Dots: Using Cluster-Based Strategies to Create Urban Employment." *Firm Connections* 4(2): 1,6.

Doeringer, P.B., and D.G. Terkla. 1995. "Business strategy and cross-industry clusters." *Economic Development Quarterly* 9: 225-37.

Feser, E. 1998b "Old and new theories of industry clusters," in *Clusters and Regional Specialisation,* edited by M. Steiner, 18-40 , Pion, London.

Glasmeier, Amy K., and Bennett Harrison. 1997. "Response: Why Business Alone Won't Redevelop the Inner City: A Friendly Critique of Michael Porter's Approach to Urban Revitalization." *Economic Development Quarterly* 11(1): 28-38.

Held, J.R. 1996. "Clusters as an Economic Development Tool: Beyond the Pitfalls." *Economic Development Quarterly* 10: 249-61.

IMPLAN, 1997. USDA Forest Service and Minnesota Planning Group. Jacobs, Dany and Ard-Pieter De Man. 1996. "Clusters, Industrial Policy and Firm Strategy: A Menu Approach." *Technology Analysis and Strategic Management* 8(4): 425-437.

Jin, D. and R.R. Stough. 1998. "Learning and learning capability in the Fordist and post-Fordist age: an integrative framework," *Environment and Planning A*, Vol. 30, pp. 1255-1278.

Porter, Michael. "New Strategies for Inner-City Economic Development." *Economic Development Quarterly* 11(1): 11-27.

Porter, Michael. 1990. *The Competitive Advantage of Nations*. New York: Basic Books.

Rosenfeld, Stuart A. 1997. "Bringing Business Clusters into the Mainstream of Economic Development." *European Planning Studies* 5(1): 3-23.

Rosenfeld, Stuart A. 1996. *Overachievers, Business Clusters that Work: Prospects for Regional Development*. Chapel Hill, NC: Regional Technology Strategies.

Rosenfeld, Stuart A. 1995. *Industrial Strength Strategies: Regional Business Clusters and Public Policy*. Aspen Institute.

Saxenian, AnnaLee. 1994. *Regional Advantage: Culture and Competition in Silicon Valley and Route 128.* Massachusetts: Harvard University Press.

State and Local Policy Program, Hubert H. Humphrey Institute of Public Affairs. *Twin Cities Industry Cluster Project.* http://www.hhh.umn.edu/Centers/SLP/edweb/cluster.html; Internet. Accessed Feb. 10, 1998.

Sternberg, E. 1991. "The Sectoral Cluster in Economic Development Policy: Lessons from Rochester and Buffalo, New York." *Economic Development Quarterly* 5: 342-56.

Stough, Roger R., Robert J. Stimson and Brian Roberts, forthcoming. "Merging Quantitative and Expert Response Data in Setting Regional Economic Development Policy: Methodology and Application." *Applied Geographic Studies,* New York, Wiley.
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APPENDIX A

SENATE JOINT RESOLUTION NO. 502

Requesting the Secretary of Technology to conduct a study that results in a coordinated research and development (R&D) policy for the Commonwealth.

Agreed to by the Senate, February 8, 1999
Agreed to by the House of Delegates, February 16, 1999

WHEREAS, the Commonwealth of Virginia has extensive assets in its institutions of higher education and federal laboratories which can significantly impact economic, social, and educational opportunities of the 21st century; and

WHEREAS, within the confines of Virginia's institutions of higher education and federal laboratories, a wealth of knowledge, information, and experience has accumulated; and

WHEREAS, efforts have been made to establish and maintain intradepartmental and interdepartmental and intrainstitutional and interinstitutional sharing and collaboration across departments and institutions and organizations, including the private sector; and

WHEREAS, the Secretary of Technology is a newly created cabinet position, which is the first such cabinet-level position for technology in the nation and which is charged with monitoring trends and advances in fundamental technologies of interest and importance to the economy of the Commonwealth and directing and approving a stakeholder-driven technology strategy development process that results in a comprehensive and coordinated view of research and development goals for industry, academia, and government in the Commonwealth; and

WHEREAS, there is currently no comprehensive plan for the collaborative utilization of these valuable research and development assets; and

WHEREAS, a statewide effort to integrate the valuable wealth of knowledge, information, and experience, especially as they relate to the research and development of science and technology assets housed within the confines of the institutions of higher education, federal laboratories, and the private sector, would result in greater collaborations; and

WHEREAS, such an effort would enhance the facilitation of resources, capture the opportunities, and optimize the use of resources to benefit the economic prosperity of the Commonwealth; now, therefore, be it

RESOLVED by the Senate, the House of Delegates concurring, That the Secretary of Technology, in consultation with institutions of higher education, federal laboratories, and the private sector, and with the assistance of Virginia's Center for Innovative Technology, be requested to study and develop a coordinated research and development (R&D) policy for the Commonwealth. Included among the Secretary's findings and recommendations shall be the identification of assets and opportunities for collaboration and coordinated efforts, the identification of mechanisms already in place that facilitate such goals, and the identification of any barriers and obstacles for greater collaboration; and, be it

RESOLVED FURTHER, That the Secretary's study shall include a review of the intellectual property policies and procedures of the institutions of higher education and federal laboratories, incentives to participate in joint ventures, and best practices by which intellectual resources can be linked to commercialization to benefit the economy of Virginia. In addition, the study findings and recommendations shall suggest ways that an increased awareness of these assets and mechanisms might result in greater collaborations.

All agencies of the Commonwealth shall provide assistance to the Secretary for this study, upon request.

The Secretary shall complete his work in time to submit his findings and recommendations to the Joint Commission on Technology and Science, the Governor, and the 2000 Session of the General Assembly as provided in the procedures of the Division of Legislative Automated Systems for the processing of legislative documents.

APPENDIX B

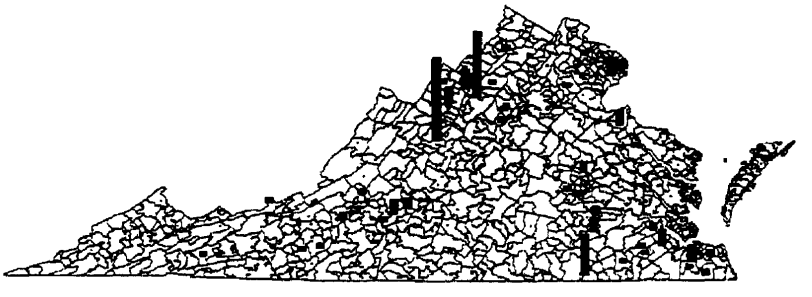
Sectoral Geographic Concentration Maps

This appendix presents maps showing the geographic distribution of employment in many of the sectors discussed in the body of the report. Maps that are included are for the more propulsive and/or emergent sectors of the state's economy.

Map 5.1. Food and Kindred Products

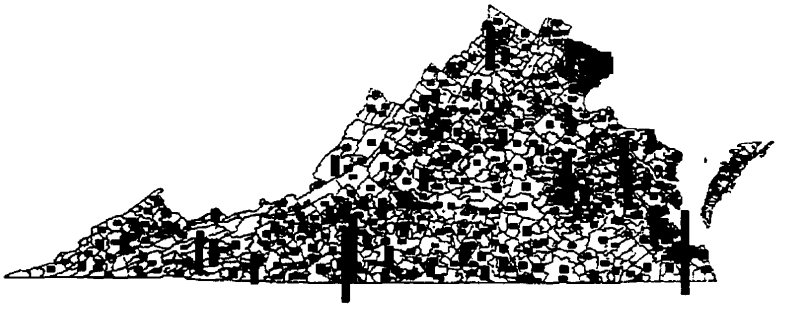
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.2. Meat and Dairy Products



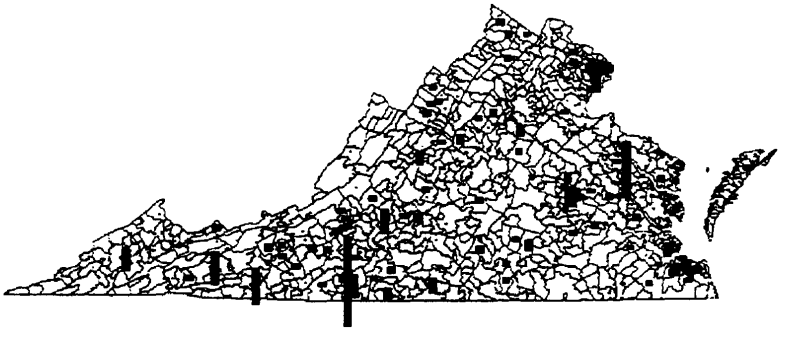
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.3. Wood, Furniture, Paper Products and Publishing



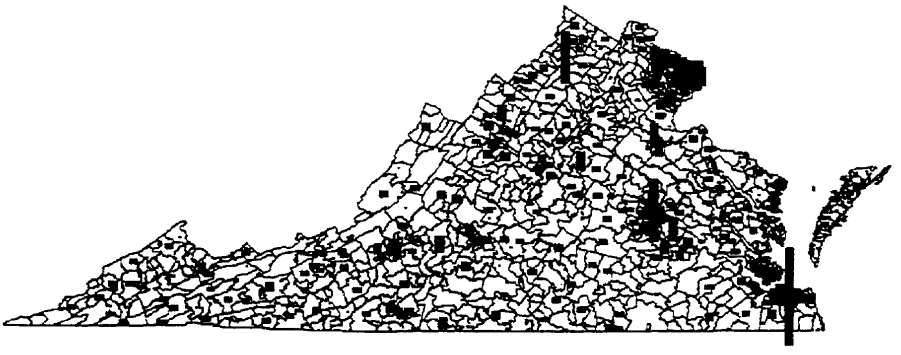
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.4. Furniture and Fixtures



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.5. Printing and Publishing



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

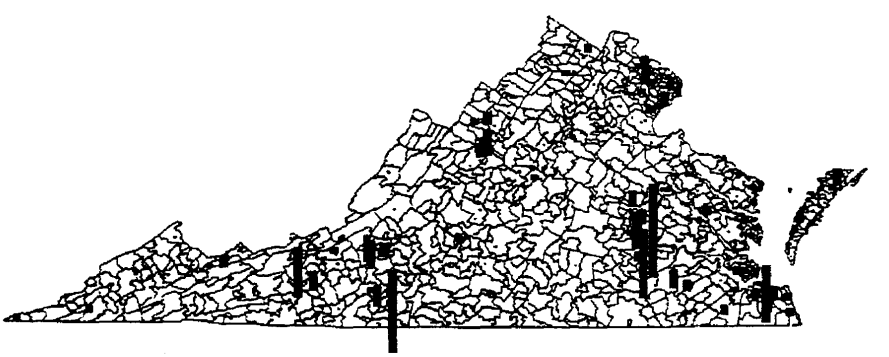
Map 5.6. Book Publishing

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.7. Commercial Printing

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.8. Chemicals and Allied Products

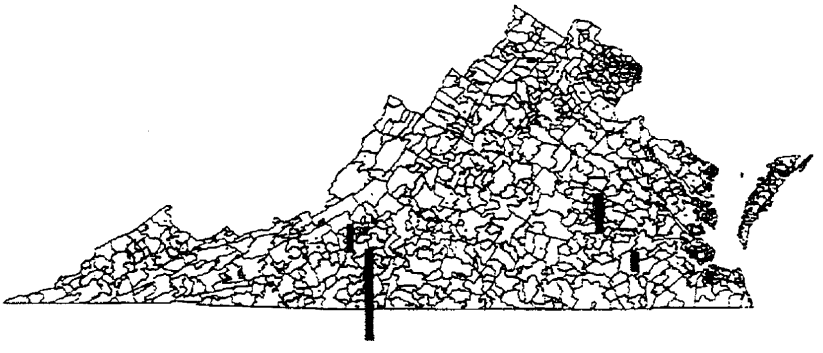


Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.9. Inorganic Chemicals and Products

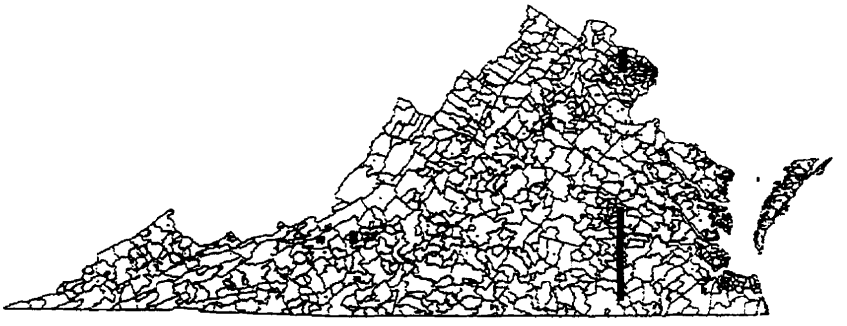
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.10. Plastics Materials and Synthetics



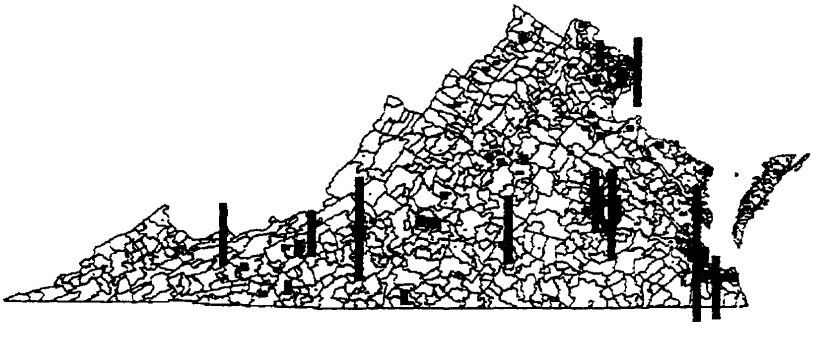
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.11. Medicines and Drugs



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.12. Electronics Equipment

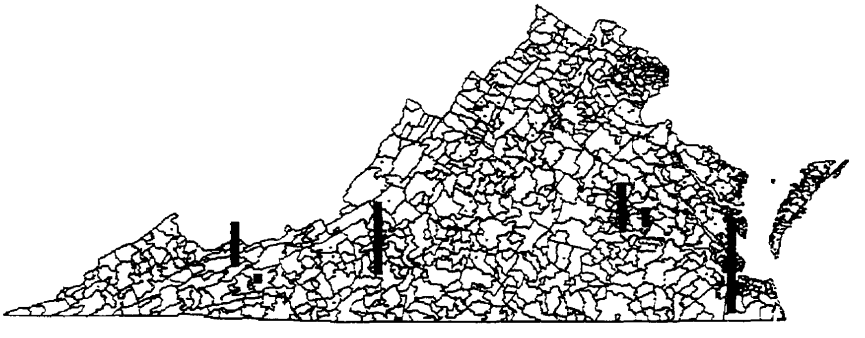


Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.13. Scientific Instruments and Related Products

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.14. Electrical Industrial Apparatus



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

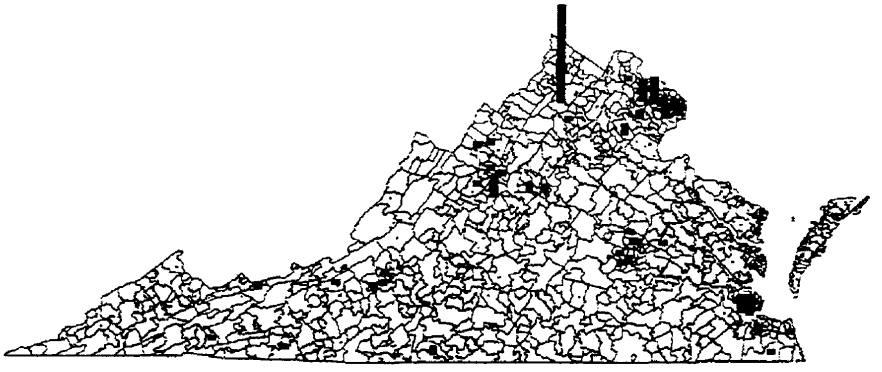
Map 5.15. Communication Equipment

Source: Mason Enterprise Center, The Institute of Public Policy, GMU. 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.16. Search and Navigation Equipment

Source: Mason Enterprise Center, The Institute of Public Policy, GMU. 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.17. Measuring and Controlling Devices



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.18. Optical Instruments and Lenses

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

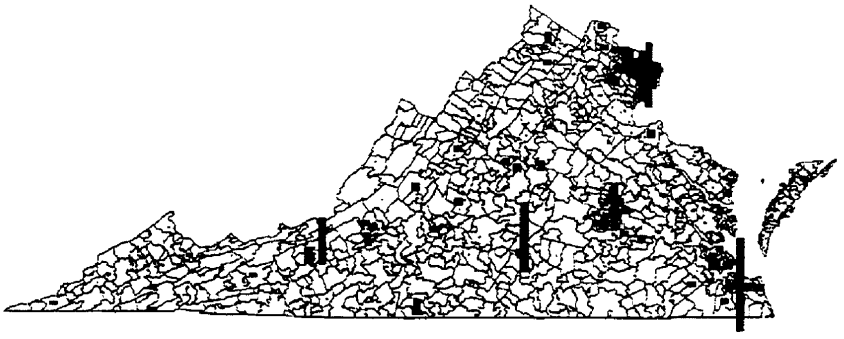
Map 5.19. Transportation Equipment

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.20. Motor Vehicle Equipment

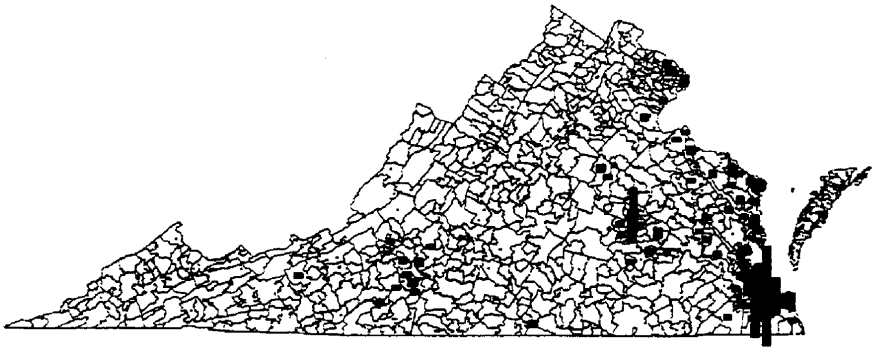
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.21. Aerospace Equipment



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.22. Water Transportation



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.23. Air Transportation

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.24. Non-depository Institutions

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.25. Computer Software and Services

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.26. Computer Programming Services

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

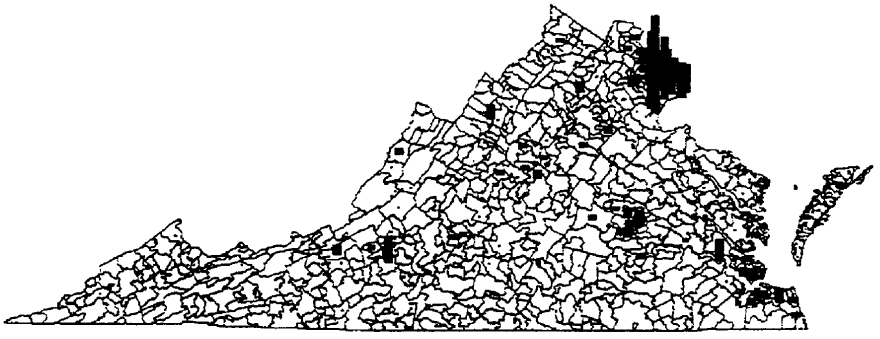
Map 5.27. Computer Integrated Systems Design Services

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.28. Data Processing and Preparation Services

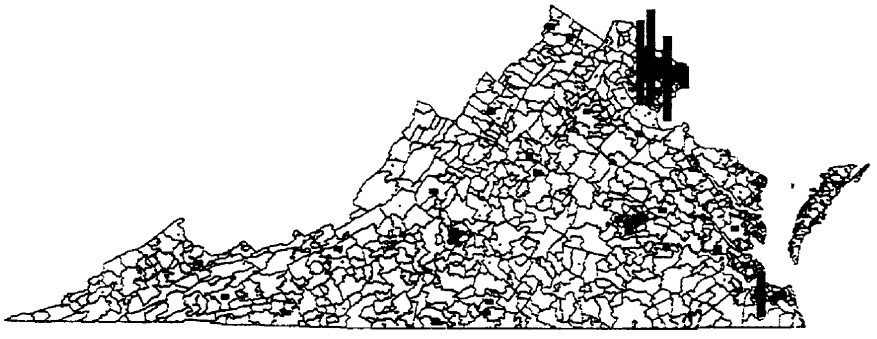
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr. Virginia Employment Commission.

Map 5.29. Prepackaged Software Services



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.30. Information Retrieval Services

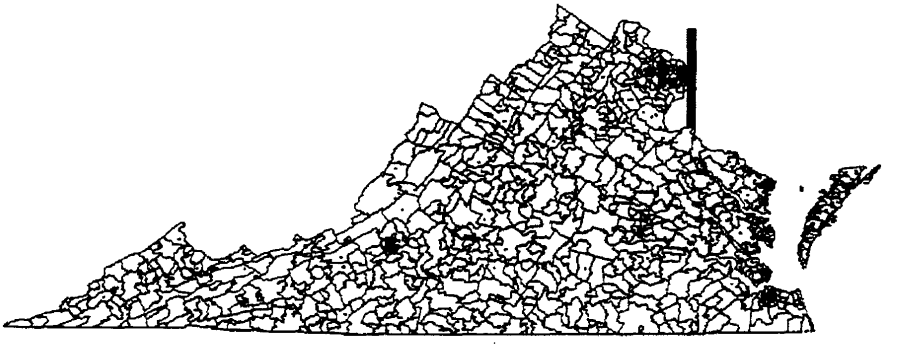


Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.31. Computer Maintenance and Repair Services

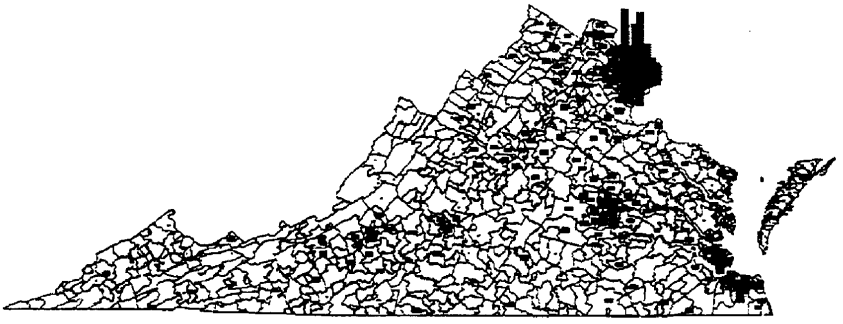
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.32. Computer Facilities Management Services



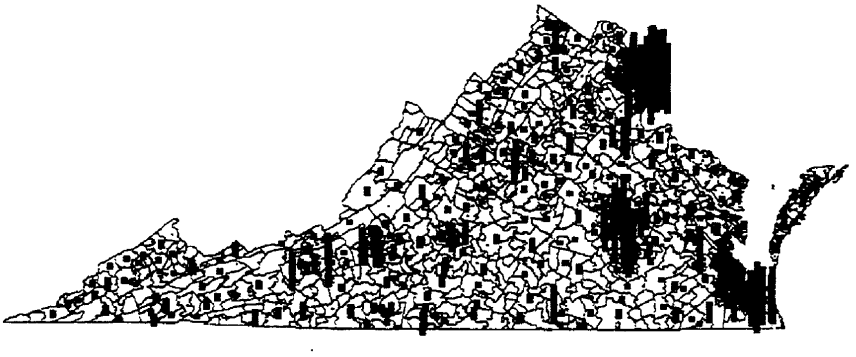
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.33. Computer Related Services



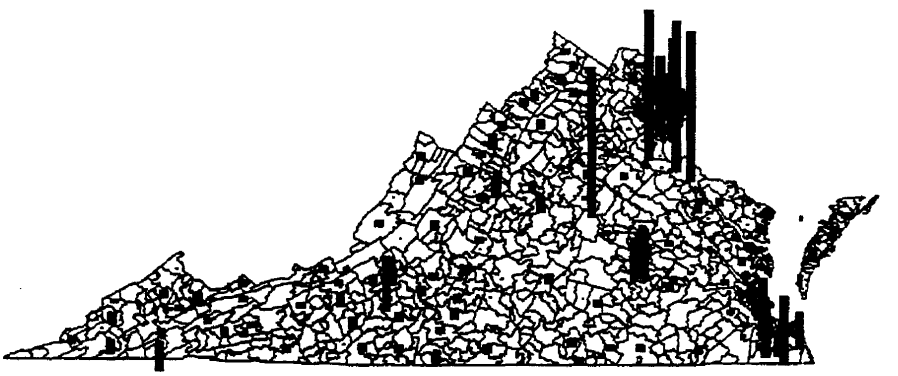
Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.34. Personal Services



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.35. Communications



Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.36. Telephone Communications

Source: Mason Enterprise Center, The Institute of Public Policy, GMU, 1999.
ES202, 1998 2d qtr, Virginia Employment Commission.

Map 5.37. Cable, TV and Radio

Source: Mason Enterprise Center. The Institute of Public Policy, GMU. 1999.
ES202. 1998 2d qtr. Virginia Employment Commission.

Map 5.38. Engineering Services

Source: Mason Enterprise Center. The Institute of Public Policy, GMU. 1999.
ES202. 1998 2d qtr. Virginia Employment Commission.

Map 5.39. Management Services

Source: Mason Enterprise Center. The Institute of Public Policy, GMU. 1999.
ES202. 1998 2d qtr. Virginia Employment Commission.