Kentucky Clusters: Industrial Interdependence and Economic Competitiveness

Kentucky Clusters
Industrial Interdependence and Economic Competitiveness

This report prepared for

Kentucky Science and Technology Corporation

in cooperation with

Kentucky Chamber of Commerce,
Kentucky Council on Postsecondary Education,
Kentucky Cabinet for Economic Development,
Kentucky EPSCoR, and
Kentucky Manufacturing Assistance Center

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Preface

Even before the ink is dry, this report already has generated thoughtful discussions of Kentucky's relative position in the new economy, which is based on knowledge, innovation and speed. Today there is an unprecedented interest in asking the hard questions about how Kentucky can best understand and grow its competitive advantage in this new type of economy that is driven more by the knowledge base of Kentucky's people than by its natural resources.

This report cautions that "the past is a poor barometer of future success, particularly in the area of innovation." So even as Kentucky makes investments in our greatest strengths, this is not enough to sustain an edge in an economy that thrives on what once would have been considered "risky" investments in new arenas -- or in cross-sector activities that in the traditional economy would never have been thought of as having anything in common. While we cannot predict the next "winners" in this new economy, we can be informed about our current realities through reports such as this one, and begin to make informed investments in areas that show the greatest promise when benchmarked against U.S. industry clusters demonstrating significant growth.

Policymakers should not overlook investments in linkages between clusters that may open up opportunities even where Kentucky's existing base is relatively small. An example is information services and software supporting the transportation and shipping or vehicle manufacturing clusters.

A focus on local innovation need not mean focusing exclusively on "high tech" industry as conventionally defined. There remain opportunities for developing higher technology, higher wage segments of traditional industries such as metalworking, industrial machinery, construction materials, chemicals and plastics, and wood products and furniture.

At the same time, Kentucky must invest in broad-based initiatives that grow the entrepreneurial culture and economy and the technological and creative capacity of <u>all</u> of its companies (not just the "high tech" companies), from which are emerging higher-wage, technology-based jobs requiring higher order skills.

Kentucky's workforce development policy should be designed to "ratchet up" the skill level of Kentucky workers by targeting training to growing sectors that have workforce skill requirements slightly higher than those of declining industries. The report contains data that can help inform such an effort.

Moreover, the new economy calls for sustained, targeted investments in R&D and state-of-the-art technology to gain a deeper competitive stronghold in areas of existing, technology-intensive strength. Without this, Kentucky won't be able to hold onto the competitive advantage of its current higher tech industry clusters, as other states move rapidly down the innovation pipeline to nurture spin-offs and start-ups in these same areas.

The authors remind us to "not focus on what is successful within the narrow confines of Kentucky, but rather Kentucky's competitive position *vis-à-vis* the national economy." While we recognize that the data are necessarily limited to U.S. industries, everyday we are reminded that the global economy is as relevant to Kentucky as the national economy. Company headquarters and R&D houses, often the source of "technology and innovation," are not only out-of-state, many times they are offshore.

The findings from the report illustrate how successful Kentucky's efforts have been in attracting external investment. Key high tech clusters are all in heavier industry (appliances, vehicles, industrial machinery). The motor vehicle manufacturing cluster, in particular, is large, diverse, and continues to expand. It has been a major source of higher wage jobs for workers displaced from the declining textiles, mining, and tobacco industries.

In general, though, there is comparatively little locally-based technology-related activity or growth even in these higher tech sectors. Historically, economic development strategies focused on business recruitment have proven most successful when they have been used to leverage a sizable branch-oriented manufacturing economy to nurture innovation and entrepreneurship.

At present, Kentucky's most promising technology-oriented cluster strategy may be to promote innovation and local start-ups in the vehicle manufacturing cluster and related clusters (such as metalworking and industrial machinery). A longer-term strategy might seek to boost innovation and growth in information technology and communications services/software; both clusters that are central to the U.S. technology economy yet remain very small in Kentucky.

The biotechnology survey findings, though based on a small sample, suggest that highly innovative companies see a need for greater state efforts to solve impediments to technology-related growth (including venture capital availability, workforce development, and supplier issues). Given the explosive growth of the biotechnology and life science industry, the Commonwealth should continue to take aggressive steps to support and build this area.

While the report contains a considerable volume of secondary data at a high level of industrial and geographic detail, it also underscores the need for better primary data on Kentucky's industrial base. Unknown are differential

rates of technology adoption across industries, specific impediments to growth and competitiveness by sector, and the degree to which industries engage in joint problem solving and other forms of networking. Many states are finding that focused industry surveys and case studies are a necessary adjunct to studies based on secondary federal and state data.

The scope of Kentucky's innovation challenge is huge, given the relatively small size of its technology base and the comparative lack of locally based innovation. Although the Kentucky Innovation Act is bold in concept and design, many more resources will be needed to appreciably grow the state's high tech industries. *Kentucky Clusters* offers a perspective that is hard to ignore.

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KSTC wishes to thank the other members of the *Clusters* local project team for their guidance and support in completing this study. They represented Kentucky Chamber of Commerce, Kentucky Cabinet for Economic Development, Kentucky EPSCoR, Kentucky Council on Postsecondary Education, and Kentucky Manufacturing Assistance Center.

This report is available on-line at www.kstc.com.

Summary and Recommendations for Action

Interdependence is a critical feature of the modern knowledge economy. Businesses are part of extended product value chains comprising their primary and secondary suppliers, producer services providers, and sources of capital equipment and external R&D. They share innovations and ideas with other businesses, some of whom are direct competitors, and hire personnel who gained valuable training and experience while working in other firms and industries. They face joint challenges in the form of increasing globalization and foreign competition, increasing complexity in workforce and environmental regulation, and the growing scarcity of technically trained workers. They share the benefits of publicly-financed infrastructure, quality primary and secondary schools, and well-planned communities that can attract and hold skilled personnel and their families. The notion of solitary businesses competing in isolation is a myth. Businesses do indeed compete. Nevertheless, their competitiveness is jointly determined with that of many other enterprises and organizations.

This study had its genesis in the view that private sector, state and local government, educational institutions, and other organizations involved in assisting and supporting firms in Kentucky can design and implement more effective and efficient programs by better understanding the link between interdependence and competitiveness. *Kentucky Clusters* characterizes economic interdependence in Kentucky through an industry cluster analysis. Industry cluster analysis helps reveal unique areas of strength and weakness in the state's economy along with potential points of intervention for technology, entrepreneurship, or other development programs. Ultimately, state agencies, local development organizations, and educational institutions must work collectively and in an integrated fashion if they are to broaden and expand existing clusters, as well as nurture those that are emerging or potential in the state.

Background

The recent Kentucky Innovation Act seeks to broaden and diversify Kentucky's economy so that more knowledge- and technology-based industries grow and

reach critical mass. The precursor to the Act, *Kentucky's Science and Technology Strategy*, noted: "Using clusters as one means to help build economic capacity in Kentucky does not imply a traditional means of assessing strengths. Analyzing the strength or potential strength of a cluster means evaluating its real assets—not necessarily its current or historical products—but its knowledge base or technology, both of which could lead to multiple future economic scenarios." More to the point, the Act emphasizes the need to better understand the potential of the Kentucky economy and envision scenarios of broadbased strengths when it states that:

> The General Assembly finds that the general welfare and material well-being of the citizens of the Commonwealth depend on immediate action to develop a strong, entrepreneurial economy, characterized by knowledge, innovation, and speed and that it is in the best interests of the Commonwealth to promote research, innovation and high-technology enterprises that utilize the higher-order skills of an educated workforce (Kentucky Innovation Act, 2000).

In support of searching out these new economic scenarios, *Kentucky Clusters* was commissioned by the Kentucky Science and Technology Corporation (KSTC) in conjunction with its project partners. Those partners, which include the Kentucky Chamber of Commerce, Kentucky Council on Postsecondary Education, Kentucky Cabinet for Economic Development, Kentucky EPSCoR (Experimental Program to Stimulate Competitive Research), and Kentucky Manufacturing Assistance Center, are now lead players in implementing the interrelated programs under the Kentucky Innovation Act. *Kentucky Clusters* is offered as a timely resource to help inform the priority-setting for the use of targeted funding.

Methodology

Kentucky Clusters provides a detailed profile of Kentucky's major manufacturing and non-manufacturing industry clusters. At the core of the analysis is a quantitative methodology, termed *benchmark cluster analysis*, that has been used to investigate inter-industry relationships and trends in other regions and states in the U.S. and Europe. Here, the original methodology is extended to include a systematic look at the geographic location of key clusters in Kentucky and neighboring border counties in Ohio, Indiana, Illinois, Missouri, Tennessee, Virginia and West Virginia. Also included are brief case studies of three technology-oriented clusters believed to be of keen importance for Kentucky's economic future: motor vehicle manufacturing, information technology, and biotechnology.

Industry clusters have become an increasingly preferred means of understanding state and regional economies and organizing development activities. An industry cluster may be defined very generally as a group of firms in which each member's competitive success depends on one, some, or all other members of the group. Also often included in clusters are related organizations (e.g., industry associations, training providers, educational institutions, development and technical assistance agencies). The principal features of an industry cluster are interdependence and shared benefits. Businesses in large, well-developed industry clusters ideally enjoy ready access to supplies and equipment, skilled labor, specialized infrastructure, and top-quality technical and scientific personnel. Evidence suggests that businesses in clusters benefit from working jointly to solve collective problems while also engaging in direct competition.

There are a wide variety of approaches and methods for detecting industry clusters. This study's "benchmark" approach identifies clusters based on value-chain and labor skill ties irrespective of location (i.e., for the entire U.S.). The benchmark cluster definitions are then ap-

plied to a detailed analysis of industrial trends in Kentucky, with a view toward uncovering unique economic strengths, weaknesses, and potential development opportunities. Three types of clusters are identified for the state—value-chain clusters, high-technology value-chain clusters, and labor-based clusters—and the results compared to develop an overall set of findings. Data from the report come primarily from the U.S. Bureau of Labor Statistics and the Kentucky Department for Employment Services, supplemented with interviews of industry and public officials and a survey of Kentucky biotechnology firms. The principal advantage of the benchmark approach is the analytical support it can provide for strategic planning for technology development, industrial modernization, recruitment and retention, and workforce training.

Findings

Overall, the picture of the state's economy that emerges from the report is as follows:

- Through its focus on attracting export-oriented industries to the state, Kentucky is showing some success in replacing its traditional nondurable manufacturing base with higher-wage, higher-technology heavy industry and distribution activities. That shift has meant better wages and stable job opportunities for Kentucky workers.

- Significantly under-developed in Kentucky are knowledge-intensive industries (such as information technology, software, electronics, and pharmaceuticals) that are driving output and wage growth elsewhere in the U.S.

- The state's leading clusters are therefore in light and heavy manufacturing (some of which are in decline both locally and nationwide), rather than technology-oriented areas. There are prospects for developing higher-wage elements of some traditional clusters but the state must also seek to nurture higher-technology clusters that are currently nascent at best.

- Much of the state's recent growth has come from the location of branch manufacturing facilities of major U.S. and foreign companies, particularly in vehicle manufacturing. Anecdotal evidence suggests that headquarters and R&D facilities are comparatively few. Policy attention must therefore address the limitations in the state's capacity to host a diversity of economic functions.

- Kentucky's major challenge over the next decade will be to develop the R&D and innovation capacity, as well as an entrepreneurial climate, that will support the creation of more locally-based companies in all existing and emerging clusters. Only then will Kentucky begin to realize the full benefits of its successful export-led development strategy of the 1980s and 1990s.

Kentucky's Value-Chain Clusters. An evaluation of three criteria—absolute size, relative size, and depth (a diversity of underlying sectors)—identifies six specific value-chain clusters as *existing* or current industrial strengths in Kentucky: tobacco manufacturing, fabricated textiles, motor vehicle manufacturing, aluminum, metalworking and industrial machinery, and transportation, shipping, and logistics. The motor vehicle manufacturing and industrial machinery industries are diverse and well-developed across both high-tech and low-tech segments of their respective value chains. Transportation and shipping activity in the state, led by the UPS hub in Louisville, is a growing strength.

Among the six existing value-chain clusters, aluminum and fabricated textiles employ the

fewest workers. Growth in the aluminum cluster over the 1990s has been very modest while net employment in tobacco and textiles has declined precipitously. Nevertheless, tobacco and textile manufacturing remain significant concentrations of activity in the state and comprise many efficient, competitive businesses. The two clusters as a whole, however, are likely to continue to contract as many producers seek lower cost locations in Latin America and overseas.

Emerging clusters are those that are growing strongly and show signs of obtaining critical mass (if current trends continues) while *potential* clusters are those posting high rates of growth but that remain relatively small. Construction materials, food manufacturing, and wood products/furniture are emerging clusters that are likely employing many semi-skilled workers displaced from the declining tobacco, textiles, and apparel industries. Also emerging are hospitals/labs/specialized medical services, chemicals and plastics, and boat building (one of the state's leading rural-based clusters). Information technology

Table 1
Kentucky Value Chain Clusters

		Trend
Existing	Tobacco manufacturing	Decline
	Fabricated textiles	Decline
	Motor vehicle manufacturing	Growth
	Aluminum	Growth
	Metalworking and industrial machinery	Growth
	Transportation, shipping and logistics	Growth
Emerging	Hospitals, labs, specialized medical	Growth
	Construction materials	Growth
	Chemicals and plastics	Growth
	Packaged food products	Growth
	Wood products and furniture	Growth
	Boat building	Growth
Potential	Information processing and instruments	Growth

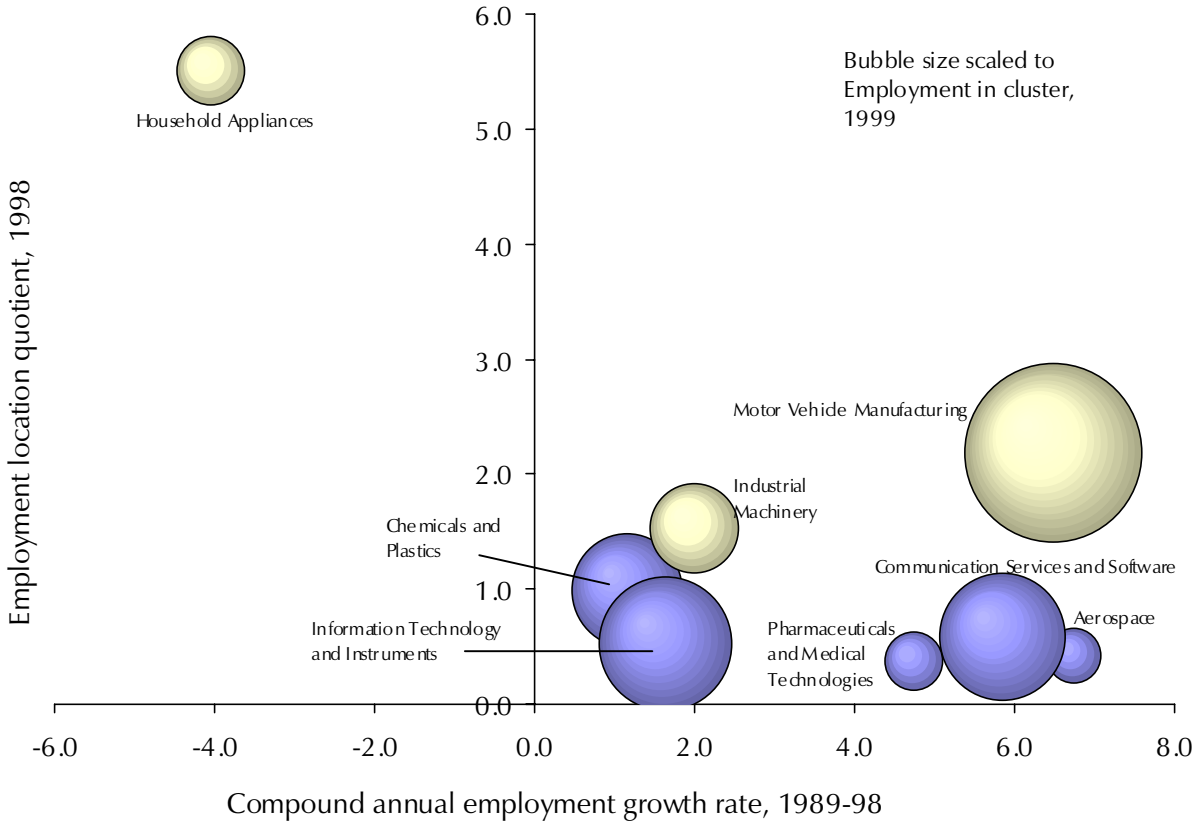

Figure 1
Kentucky technology value chain cluster trends

has only a modest presence in the state, though its high rate of growth (due partly to its small size) warrants its consideration as a potential cluster.

Technology and Labor-Based Clusters. Defining clusters strictly among high-technology industries or on the basis of shared labor requirements generates insights complementary to that of the core value-chain analysis. For example, the state's three existing technology-intensive clusters are all composed of heavy industries (household appliances, motor vehicles, and industrial machinery), while IT clusters (communications services/software and information technology/instruments) are classified as potential. The study identified no emerging high-technology clusters, that is, high-technology clusters that appear to be approaching critical mass. Two of the state's emerging labor skill clusters pay comparatively low wages: building products manufacturing and specialized labor intensive (mobile homes, furniture, fabricated metals, tires). The third, distribution and freight handling, pays high wages and closely parallels growth in the transportation and shipping value chain.

Under-represented in Kentucky are labor clusters with higher skill demands such as information processing (life insurance, computer and data processing, accounting), high end information/business services (publishing, advertising, legal services), electronics and measuring devices, chemicals and pharmaceuticals, telecommunications and banking, securities, and science-intensive (aerospace, communications services, engineering services, and R&D labs). However, three of those clusters—securities, science-intensive, and information processing, grew rapidly during the 1990s. Employment in the securities cluster expanded by over 14 percent annually between 1989 and 1998, while the science-intensive and information processing clusters each grew by nearly 6 percent annually.

Clusters, Development Opportunities, and Potential Replacement Industries. *Kentucky Clusters* is a working document designed to support additional analysis by state and local development agencies. The benchmark clusters are useful for identifying either development opportunities in existing supply chains or growing industries with the same basic skill requirements as those currently in decline. For example, the information technology value-chain cluster in Kentucky is dominated by relatively low-value, low-wage segments such as information services (back office processing and call centers) and a single hardware sector (peripheral devices, an industry dominated by one company). Under-represented industries such as electronic computers, software, and computer integrated systems design are potential development targets where technical and market conditions permit. The benchmark clusters help identify gaps in value chains that might be filled with various development strategies, from technology and entrepreneurship programs to traditional recruitment.

The benchmark labor clusters can be used to get a sense of the kinds of industries (and at what wages) likely to employ displaced workers given those workers' average skill set. Twenty industries posted significant net job losses in

Table 2
Supplementary Cluster Definitions

Technology-intensive Clusters		**Trend**
Existing	Household appliances	Growth
	Motor vehicle manufacturing	Growth
	Industrial machinery	Growth
Potential	Communications services and software	Growth
	Information technology and instruments	Growth
Labor Skill Clusters		
Existing	Health services	Growth
	Standardized heavy industry	Growth
	Low skill, non-durable manufacturing	Decline
	Food and tobacco manufacturing	Growth
Emerging	Distribution and freight handling	Growth
	Building products manufacturing	Growth
	Specialized labor intensive	Growth

Technology-intensive clusters are made up of high technology sectors only.

Kentucky between 1989 and 1999. Over 12,000 jobs were lost in two industries alone: miscellaneous office machines and knit underwear mills. The average wage across all twenty declining industries is $34,299, 112 percent of the $30,724 private sector average. The good news for Kentucky is that declines in comparatively low-wage industries are being offset by job gains in comparatively high-wage industries. The twenty sectors with the largest net increases in employment between 1989 and 1999 pay an overall average wage of $47,847, 156 percent of the private sector average and 139 percent of the average among the top declining sectors.

A problem, however, is that workers from some declining sectors may not have the skills necessary to obtain employment in the state's growth industries. The study found, for example, that while the plastics and appliances industries constitute higher-wage employment options for displaced apparel workers, the growing food manufacturing industry offers good employment opportunities for displaced tobacco workers, but at lower wages.

Spatial Clusters and Cross-Border Linkages. It is useful to know which clusters are more localized in specific areas of the state versus distributed more widely or with a more even rural-urban distribution. Kentucky's economy should also be understood in the context of a broader region that encompasses parts of neighboring states. The economies of the northern Kentucky counties of Kenton, Campbell, and Boone have close ties to southern Ohio and the Cincinnati metro area as well as southeastern Indiana. Likewise, the economies of southern and southwestern Indiana (particularly in the Louisville and Evansville areas) and northern Tennessee (north of Nashville) are linked to nearby Kentucky cities and counties, though to a more limited extent than in the case of the Cincinnati metro area. Because industry clusters do not respect state boundaries, it is necessary to broaden the focus outside of Kentucky to fully understand emerging industrial trends and opportunities.

The study's spatial analysis indicates that the degree of geographic concentration in Kentucky's motor vehicle cluster is compara-

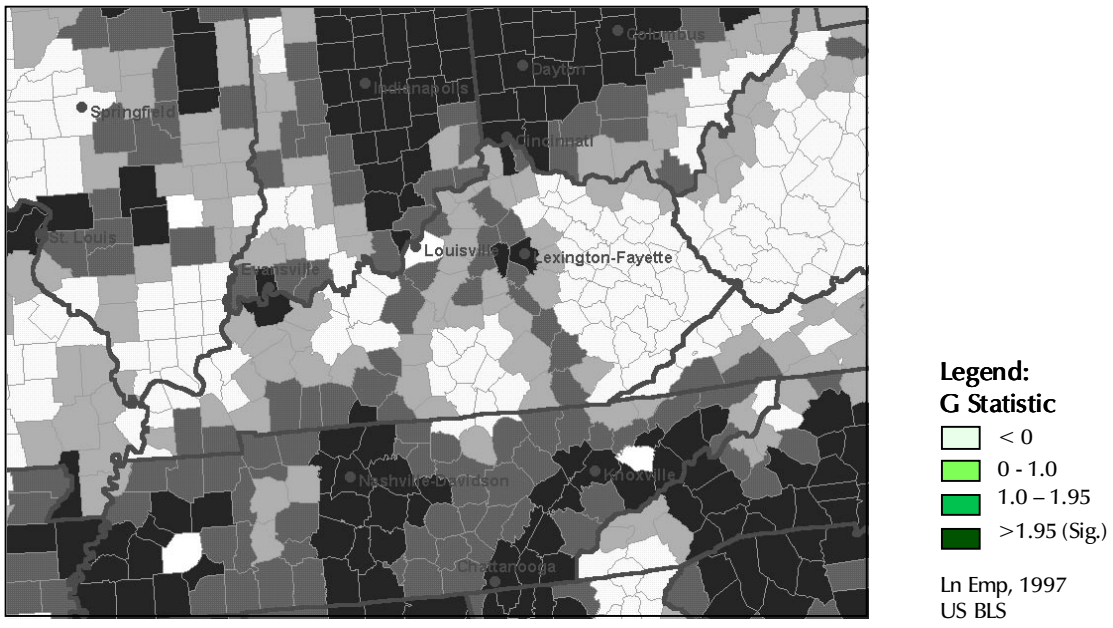

Figure 2
Regional clusters, motor vehicle manufacturing

tively modest, though northern Kentucky, greater Lexington, Henderson, Owensboro, and Bowling Green constitute localized vehicle manufacturing complexes. Generally, the automotive industry has had a fairly broad geographic impact on the state. While the center of the state (along Interstates 75, 65 and 64) enjoys the bulk of motor vehicles-related employment, the cluster also has a notable presence in western Kentucky. The generally dispersed pattern is consistent with an automotive industry that is still dominated by comparatively few large plants located in peripheral locations where land and labor costs are modest. As Kentucky's automotive industry develops and the presence of suppliers continues to grow, more spatial clustering will likely be observed.

Two value-chain clusters that are highly concentrated in the state are transportation, shipping, and logistics and boat building. Transportation, shipping and logistics has its strongest presence in the Louisville, northern Kentucky/ Cincinnati, and Evansville, Indiana areas. Boat building (namely houseboats), while a fairly small cluster, is an example of a strong rural cluster with important linkages to similar clusters in Tennessee. Kentucky's boat building cluster is concentrated around Lake Cumberland west of Interstate 75. The cluster benefits from proximity to similar production, as well as demand, in eastern Tennessee. Other concentrations of boat building activity are in Cincinnati/northern Kentucky and southern Indiana.

Case Studies. The study examined in detail one existing cluster (motor vehicles), one potential cluster (information technology), and one cluster not captured by the benchmark methodology (biotechnology). The three clusters are critical to Kentucky's future for different reasons.

Motor vehicles is one of the state's core competitive advantages as well as one of its largest contributors to gross state product, employment, and payroll. The emergence of vehicle production in Kentucky has meant the location of top flight international companies and their technical and management personnel (in both assembly and supplier sectors), additional resources and investments in college and university education and training, and an image of the state as a major player in a core global industry. Kentucky's capitalization on the general southern shift of U.S. vehicle production has resulted in the strong growth of higher-wage, comparably skilled jobs for workers displaced from the declining textiles, apparel, and tobacco industries. Kentucky can make a credible claim to a significant motor vehicles industry cluster, one that is large and diverse in terms of its component sectors and firms, has a strong technology complement, has a significant rural-urban distribution, and is still expanding at a rapid clip. Challenges to the long-term prosperity of Kentucky's motor vehicles cluster include the dominance of satellite-oriented branch plant production and a relative a lack of Kentucky-based R&D and innovation activities.

In contrast to motor vehicles, the information technology cluster in Kentucky is neither large nor diverse. In fact, it is dominated by comparatively few companies and lower technology IT activities (back office processing and call centers). At present, its importance to the state derives primarily from its central role in regional and state economies everywhere: not only is IT one of the fastest growing areas of the U.S. economy, especially in software and computer services, but it is also commonly viewed as an "enabling" industry, that is, a supplier of critical infrastructure and services for nearly every industry. While the IT "cluster" in Kentucky is under-represented compared to national trends, it is growing fast and will likely represent a source of strong job growth for years to come.

The biotechnology industry has very clear linkages to university research activities. Therefore, it is a natural candidate for efforts to pursue knowledge-based or innovation-oriented economic development. Because commercial bio-

technology activity is only now emerging in Kentucky, its future as a competitive advantage in the state remains uncertain. While the study identified some 40 biotech enterprises in the state, many of those are extremely small and lack significant resources. Findings from a survey of biotech companies, undertaken as part of this study, indicate that inadequate venture capital, insufficient public sector support, an absence of opportunities for interfirm collaboration, and a lack of specialized suppliers are key concerns among these companies.

Policy Considerations and Action Guides

Like many states, Kentucky must find ways to aid its economy's gradual transition from a cost-sensitive, labor-intensive industrial orientation to more knowledge-based, higher-technology production and services. The state has a considerable complement of higher-technology heavy manufacturing on which to build (namely its motor vehicle cluster, but also related sectors/clusters that are benefiting from the growth of vehicle manufacturing in the state). To begin to capture the full benefits of its manufacturing industry, as well as to spur entrepreneurial activity and innovation in knowledge-based manufacturing and non-manufacturing industries, the state must focus more on generating growth from within. That requires support for university R&D, technology transfer, incubators, networking initiatives, technical training programs, and other initiatives that fall under the general rubric of technology-related economic development. Technology-related economic development is the object of the Kentucky Innovation Act.

This study is designed to provide both findings and tools useful for helping to guide the implementation of the Kentucky Innovation Act and related initiatives aimed at building Kentucky's innovation economy. Offered next are policy considerations and potential action steps for using the data and results provided in this report.

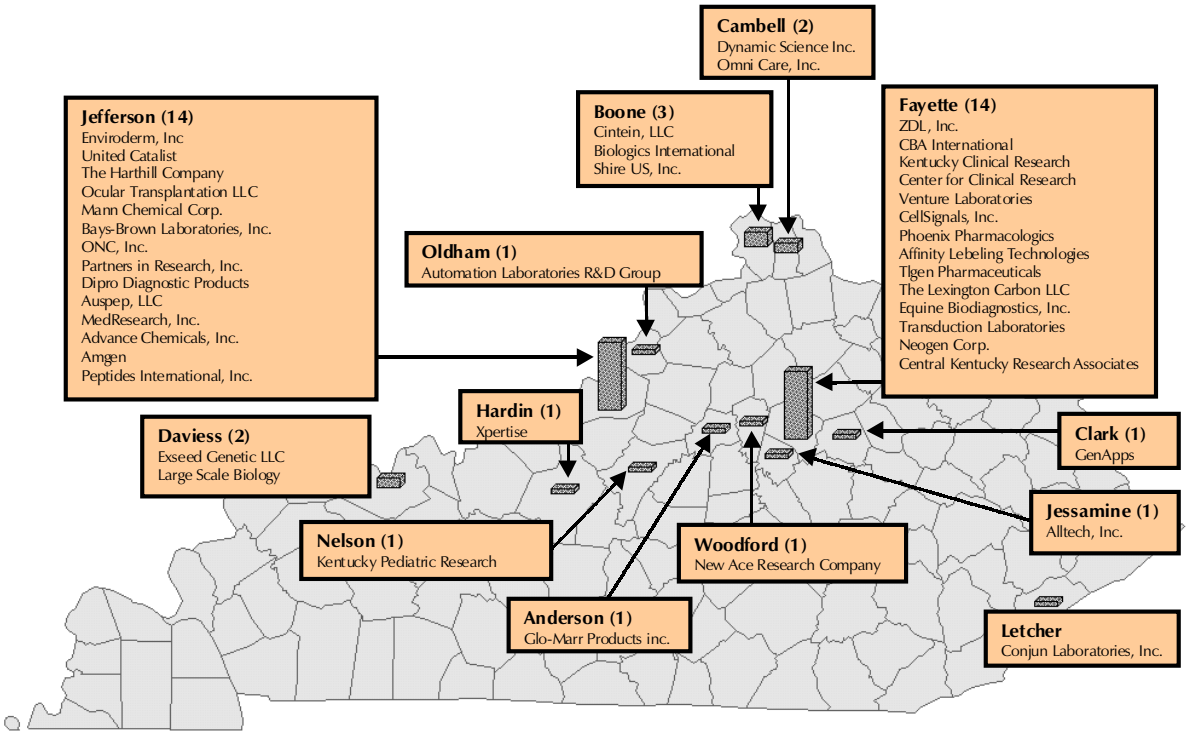

Figure 3
Identified Kentucky biotechnology companies

- The past is a poor barometer of future success, particularly in the area of innovation. So, targeted development based on existing strengths is only part of the picture. Indeed, this report identifies a number of key Kentucky clusters that can serve as focus areas of the state's development strategy, such as motor vehicles, industrial machinery, the rapidly growing transportation and shipping cluster, and even the state's growing potential in the information technology arena. Yet broad-based initiatives are also needed. While the state would do well to identify and invest in key technology growth areas (perhaps by building R&D capacity and infrastructure in promising disciplines in the universities), some technology and entrepreneurship strategies must also be designed to encourage and nurture start-ups and growth regardless of sector.

- The findings from the report illustrate how successful Kentucky's focus on attracting external investment has been. Key high tech clusters are all in heavier industry (appliances, vehicles, industrial machinery). The motor vehicle manufacturing cluster, in particular, is large, diverse, and continues to expand. It has been a

Table 3
Kentucky Clusters: Industrial Interdependence and Economic Competitiveness
Summary of Study Findings

Clusters *(Logic of Inter-Dependence)*	**Value-Chain Industry Clusters** *Membership in Extended Buyer-Supplier Chains*	**High-Tech Value-Chain Clusters** *Membership in Extended High-Tech Buyer-Supplier Chains*	**Labor-Based Industry Clusters** *Shared Labor Skill Requirements*
EXISTING *Critical mass: Absolute size, relative size, depth, diversity*	Tobacco manufacturing ☂ ⬇ Textiles ☂ ⬇ Motor vehicles ✈ ➡ Aluminum ⚑ ⬇ Metalworking, machinery ✈ ➡ Transportation, shipping ✈⚑ ⬆	Appliances ☂ ⬇ Motor vehicles ✈ ➡ Industrial machinery ✈ ➡ *Heavier industry main high-tech specialization*	Low skill, non-durable mfg ☂ ⬇ Food and tobacco ⬇ Packaged foods offering replacement jobs for tobacco Standardized heavy industry ✈ ➡ Health services ✈ ⬆
EMERGING *Growing with signs of critical mass*	Hospitals, labs, spec. services ✈ ⬆ Construction materials ✈ ➡ Chemicals & plastics ⬆ Packaged food products ✈ ➡ Wood products & furniture ✈ ➡ Boat building ✈⚑ ⬇ Mainly houseboats	*No emerging high-tech value-chain clusters*	Distribution, freight handling ⬆ Building products manufacturing ✈ ➡ Specialized labor intensive ➡ Such as mobile homes, furniture, fabricated metals, and tires
POTENTIAL *Small, no critical mass but growing fast*	Information technology ✈⚑ ⬆ Mainly instruments, back office processing, call centers, peripheral devices	Information tech, instruments ✈ ⬆ Communications svcs, software ✈ ⬆ *Growth essentially following national trend*	
OTHERS	Biotechnology: Not well-captured by existing data sources but showing evidence of start-up activity and growth.		

NOTE: ☂ Declining cluster in KY; ✈strong growth cluster in KY; ⚑ high degree of spatial localization (concentration identifiable KY regions; evaluated only for general value-chain clusters). Emerging and potential clusters are identified on the basis of growth trends over 1989–1999 period and do not constitute projections. ⬆ high growth cluster at U.S. level (based on employment and/or wage trends, 1989–1999); ➡ slow growth or little change at national level; ⬇ decline at national level.

major source of higher wage jobs for workers displaced from the declining textiles, mining, and tobacco industries.

Historically, economic development strategies focused on business recruitment have proven most successful when they have helped build the resources and infrastructure necessary to nurture locally-based start-ups and spin-offs in higher technology industries. Kentucky's challenge is to find ways to leverage its sizable branch-oriented manufacturing economy along these lines.

- Do not focus on what is successful within the narrow confines of Kentucky, but rather Kentucky's competitive position *vis-à-vis* the national economy. Unlike many cluster studies, the present report focuses on Kentucky's industrial strengths relative to U.S. averages and trends. Thus the identified existing clusters are those that are not simply large in the state, but those that represent real specializations in the context of the national economy.

- Create industry associations that can lead cluster strategies. A successful strategy in other states has been the creation of industry associations designed to establish a common identity among cluster firms and to provide a venue for shared information and joint problem-solving. Findings from this report suggest who the members of such associations might be (in terms of specific sub-industries).

- Utilize expertise from the private sector. No one but businesses themselves can provide better information on inter-industry linkages and current practices regarding supplier contracting, technical locational requirements, modernization and training needs, and potential growth markets. Advisory groups of local business leaders can provide help in interpreting specific findings in this study as well as any subsequent findings generated from data reported here.

- In designing specific strategies, evaluate local technological and market constraints to the expansion of each cluster, perhaps through additional case study work along the lines of the biotechnology case in the report. The Biotechnology survey instrument created for this study can be easily modified for additional industries and administered via mail or Internet.

- Identify university research strengths by discipline. Such an analysis would serve as a valuable complement to the cluster findings. Clusters of university strengths could then be compared to industry clusters identified here to isolate specific areas of joint academic/industrial competitive advantages that may warrant further investments in innovation and R&D.

- Do not just read, but also use, this report. The benchmark cluster analysis is as much an analytical tool as it is a means of deriving a single set of findings. Employed on an ongoing basis, industry cluster analysis can help community colleges develop and target better training programs and local industrial extension offices design and target services. Buyer/supplier conferences can be organized to connect local buyers with suppliers in the state (an import replacement strategy). Entrepreneurship strategies (e.g., incubators, venture capital efforts) can be directed to industries that might serve as suppliers to or customers of major regional companies. The data provided here can help support such efforts.

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CHAPTER ONE

Introduction

Interdependence is a critical feature of the modern knowledge economy. Businesses are part of extended product value chains comprising their primary and secondary suppliers, producer services providers, and sources of capital equipment and external R&D. They share innovations and ideas with other businesses, some of whom are direct competitors, and hire personnel who gained valuable training and experience while working in other firms and industries. They face joint challenges in the form of increasing globalization and foreign competition, increasing complexity in workforce and environmental regulation, and the growing scarcity of technically trained workers. They share the benefits of publicly-financed infrastructure, quality primary and secondary schools, and well-planned communities that can attract and hold skilled personnel and their families. The notion of solitary businesses competing in isolation is a myth. Businesses do indeed compete. Nevertheless, their competitiveness is jointly determined with that of many other enterprises and organizations.

This study had its genesis in the view that the private sector, state and local government, educational institutions, and other organizations involved in assisting and supporting firms in Kentucky can design and implement more effective and efficient programs by better understanding the link between interdependence and competitiveness. *Kentucky Clusters* characterizes economic interdependence in Kentucky through an industry cluster analysis. Industry cluster analysis helps reveal unique areas of strength and weakness in the state's economy along with potential points of intervention for technology, entrepreneurship, or other development programs. Ultimately, state agencies, local development organizations, and educational institutions must work collectively in an integrated fashion if they are to broaden and expand existing clusters, as well as nurture those that are emerging or potential in the state.

Background

The recent Kentucky Innovation Act seeks to broaden and diversify Kentucky's economy so that more knowledge- and technology-based industries grow and reach critical mass. The precursor to the Act, Kentucky's Science and Technology Strategy, noted: "Using clusters as one means to help build economic ca-

pacity in Kentucky does not imply a traditional means of assessing strengths. Analyzing the strength or potential strength of a cluster means evaluating its real assets—not necessarily its current or historical products—but its knowledge base or technology, both of which could lead to multiple future economic scenarios." More to the point, the Act emphasizes the need to better understand the potential of the Kentucky economy and envision scenarios of broad-based strengths when it states that:

> The General Assembly finds that the general welfare and material well-being of the citizens of the Commonwealth depend on immediate action to develop a strong, entrepreneurial economy, characterized by knowledge, innovation, and speed and that it is in the best interests of the Commonwealth to promote research, innovation and high-technology enterprises that utilize the higher-order skills of an educated workforce (Kentucky Innovation Act, 2000).

In support of searching out these new economic scenarios, *Kentucky Clusters* was commissioned by the Kentucky Science and Technology Corporation (KSTC) in conjunction with its project partners. Those partners, which include the Kentucky Chamber of Commerce, Kentucky Council on Postsecondary Education, Kentucky Cabinet for Economic Development, Kentucky EPSCoR (Experimental Program to Stimulate Competitive Research), and Kentucky Technology Service, are now lead players in implementing the interrelated programs under the Kentucky Innovation Act. *Kentucky Clusters* is offered as a timely resource to help inform the priority setting for targeted funding.

The report provides a detailed profile of Kentucky's major manufacturing and non-manufacturing industry clusters. At the core of the analysis is a quantitative methodology (termed *benchmark cluster analysis*) that has been used to investigate inter-industry relationships and trends in other regions and states in the U.S. and Europe. Here, the original methodology is extended to include a systematic look at the geographic location of key clusters in Kentucky and neighboring border counties in Ohio, Indiana, Illinois, Tennessee, Virginia and West Virginia. Also included are brief case studies of three technology-oriented industries of vital importance for Kentucky's economic future: motor vehicle manufacturing, information technology, and biotechnology. The report focuses principally on trends in the industrial sector.

Approaches to Industry Cluster Analysis

An industry cluster may be defined very generally as a group of firms in which each member's competitive success depends on one, some, or all other members of the group. Also often included in clusters are related governmental and non-profit organizations (e.g. industry associations, training providers, educational institutions, development and technical assistance agencies). The principal features of an industry cluster are interdependence and shared benefits: businesses in large, well-developed industry clusters enjoy ready access to supplies and equipment, skilled labor, specialized infrastructure, and top-quality technical and scientific personnel. Evidence suggests that businesses in clusters benefit from working jointly to solve collective problems while also engaging in direct competition.

In principle, industry clusters can help state and regional economic development professionals design strategies that capitalize more effectively on unique economic advantages. In practice, identifying industry clusters is notoriously difficult. First, state- and regional-level data on linkages and relationships between firms and other organizations are sparse to non-existent. Second, the often underappreciated complexity of the cluster concept itself, as well as the significant variation in the policies and strategies that clusters might inform, dictate that no single methodology is appropriate for all policy needs.

In the end, industry cluster analysis is simply a means of making sense—in a way that accounts for important industrial interdependencies—of a state's or region's existing and emerging economic assets. Contrary to received wisdom in economic development practice and the

academic literature, one can and should approach industry cluster analysis in very different ways depending on its intended policy uses. Since the types of interdependencies between firms vary, so should the ways in which clusters are defined, identified, and characterized.

With that in mind, this report adopts a dual approach to cluster analysis that focuses on two critical types of business interdependence. The first is value-chain linkage. Value-chain clusters consist of groups of industries that make up extended product chains (end-market producers and first-, second,- and third-tier suppliers). A well-known example in Kentucky is the automotive manufacturing industry, with its major assemblers (Toyota, Ford, and GM) and many core suppliers (e.g. Hitachi, Dana Spicer). Value chains are the conduits through which many ideas, technologies, and innovations flow, in addition to goods and services. Firms in value-chain clusters face many of the same broad economic concerns related to technological change, workforce development, and regulatory and tax issues.

Value-chain clusters can be a useful analytical tool. They are detailed enough to support efforts to shift the industrial base to meet objectives such as expanding high-technology industries, increasing wages, and reducing dependence on manufacturing. By investigating the relative presence of given value chains in Kentucky, one can identify gaps in supply chains that might be filled through recruiting or entrepreneurship ("home-grown") business development strategies. Using data on occupational labor demands it is also possible to identify the skill needs of specified target industries. Such information permits the isolation of industries that represent a good "fit" for the state given its present industrial and human capital structure.

The second type of interdependence is shared labor skill requirements. Labor skill clusters consist of groups of industries that draw from the same basic labor pools. Since they combine sectors from different value chains, they reveal a slightly different and unique picture of a state's economic strengths and weaknesses. The value of viewing industrial interdependence in terms of shared human capital needs is become more and more evident as the economies of states and regions across the U.S. transition from a fo-

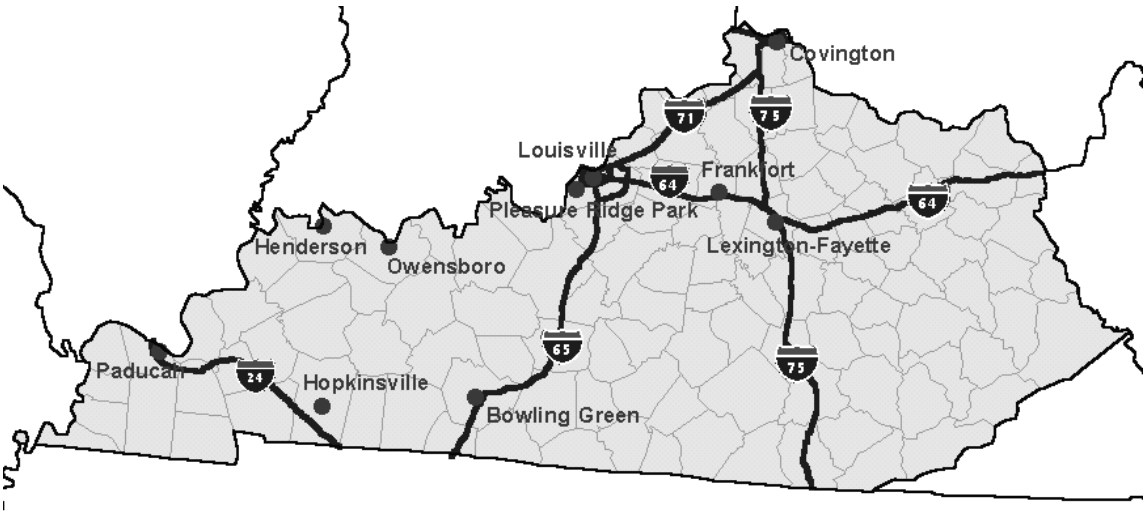

Figure 1.1
Kentucky cities and highways

cus on low-cost, efficient production to flexible, knowledge-intensive activities where continued innovation is paramount.

Organization of the Document

Findings of the report are summarized in six chapters, with detailed data tables and extensive supplementary material provided in two appendices.

Chapter 2 sets the stage by briefly summarizing recent basic trends in population, employment, and income for the economy as a whole and for selected two- and three-digit Standard Industrial Classification (SIC) sectors.

Chapter 3 describes the benchmark approach to industry cluster analysis.

Chapter 4 identifies Kentucky's major existing, emerging, and potential value-chain and labor skill clusters on the basis of employment and payroll trends over the 1989 to 1999 period. It also discusses specializations and gaps in selected value chains, and identifies growth sectors in Kentucky that share the same basic labor-skill requirements as the major declining industries.

Chapter 5 investigates the spatial distribution of key value-chain clusters by county in Kentucky along with surrounding counties in the neighboring states of Ohio, Indiana, Illinois, Tennessee, Virginia and West Virginia. A short section examines cluster trends in the Cincinnati metropolitan area and discusses linkages to Northern Kentucky.

Chapter 6 reports the results of case studies of three clusters: one existing (vehicle manufacturing), one potential (information technology), and one that is of vital policy interest but cannot be captured with typical data sources (biotechnology).

The appendices contain cluster definitions, detailed and supplementary data tables, maps of cluster employment by county, a copy of the Kentucky Biotechnology Company Survey instrument, and a copy of the case study interview protocol.

CHAPTER TWO

Kentucky's Changing Economy

Like many other states, particularly those in the southeast, Kentucky's economy is shifting from a heavy dependence on cost-sensitive, traditional manufacturing to one in which various technology industries and producer and consumer services assume a larger role. Kentucky has enjoyed moderate economic growth over the last ten years, despite facing significant layoffs in its textile, apparel, tobacco, and mining industries. The gap between average per capita income in the U.S. and Kentucky is narrowing and average real wages in the state are on the rise. Yet contractions in many core sectors continue, and the recent slowing of demand for cars and light trucks has significant implications for Kentucky, where a sizable vehicle manufacturing industry has emerged as a major economic engine. The state thus faces several challenges: find immediate new high-wage job opportunities for displaced workers in declining industries, weather any slowdown in automotive manufacturing, and sustain investments in science and technology infrastructure. The third challenge is imperative for maintaining the competitive position of Kentucky in a U.S. economy that is increasingly driven by technology-based industries and knowledge-intensive advanced services.

Population, Income and Unemployment

With a population of 4.04 million in 2000, Kentucky is the 25th largest state. Population growth over the 1990 to 2000 period was a solid but modest 9.7 percent (compared to 17.3 percent in the South and 13.2 percent nationwide). Year by year estimates show that the state has gradually grown slower than the U.S. as a whole and the broader southeast since the 1992 recession. Kentucky was the 28th fastest growing state in terms of population over the last decade, outpacing only Louisiana and West Virginia in the U.S. South.

Job and output growth have been comparatively stronger. Full- and part-time jobs expanded by 20 percent between 1989 and 1998, compared to 16.7 percent in the U.S. as a whole. Kentucky's annual real expansion in gross domestic product has also significantly outpaced the nation's since the 1992 recession (4.3 versus 3.5 percent).

At the time of this writing, unemployment in Kentucky stood at 3.9 percent, slightly below the nation's 4.0 percent. Per capita income was $22,183 in

1998, roughly 81 percent of U.S. average per capita income (at $27,203). That is an important relative improvement since 1989, when the Kentucky per capita income was 78 percent of the U.S. average. Since Kentucky's cost of living is reasonably close to the U.S. average, much of the difference in per capita incomes can be attributed to the state's current relative concentration of activity in low-wage industries.

The Shifting Industrial Mix and Key Industries

Like much of the rest of the U.S., Kentucky's economy is evolving away, albeit slowly, from a predominance of manufacturing activity toward more producer and consumer services (see Figure 2.1). Manufacturing accounted for about 26 percent of the state's earnings payments in 1998, down from 29 percent in 1989. Compare that to the national economy where manufacturing earnings were just 20 percent of the total in 1998 and services accounted for a full 34 percent.

Table 2.1 reports basic trends in selected industries in the state (excluding primarily local-serving industries such as retail trade, government, and personal services). Among the state's largest industries are hospitals and labs (79,245 employees in 1999), motor vehicle manufacturing (39,195 employees), financial institutions (38,176 employees), and industrial machinery and equipment (37,199 workers). Large industries with net job losses in excess of 5,000 workers between 1989 and 1999 include mining, apparel, electronics, and textiles. Tobacco manufacturing employment fell by roughly half over the period and now accounts for slightly under 3,000 Kentucky jobs.

In relative terms, leading employment growth sectors over the 1989 to 1999 period were transportation services, real estate offices, computer and data processing services, motor vehicle production, and air courier services. Comparing the size of various Kentucky industries to the U.S. industrial mix using 1998 employment location

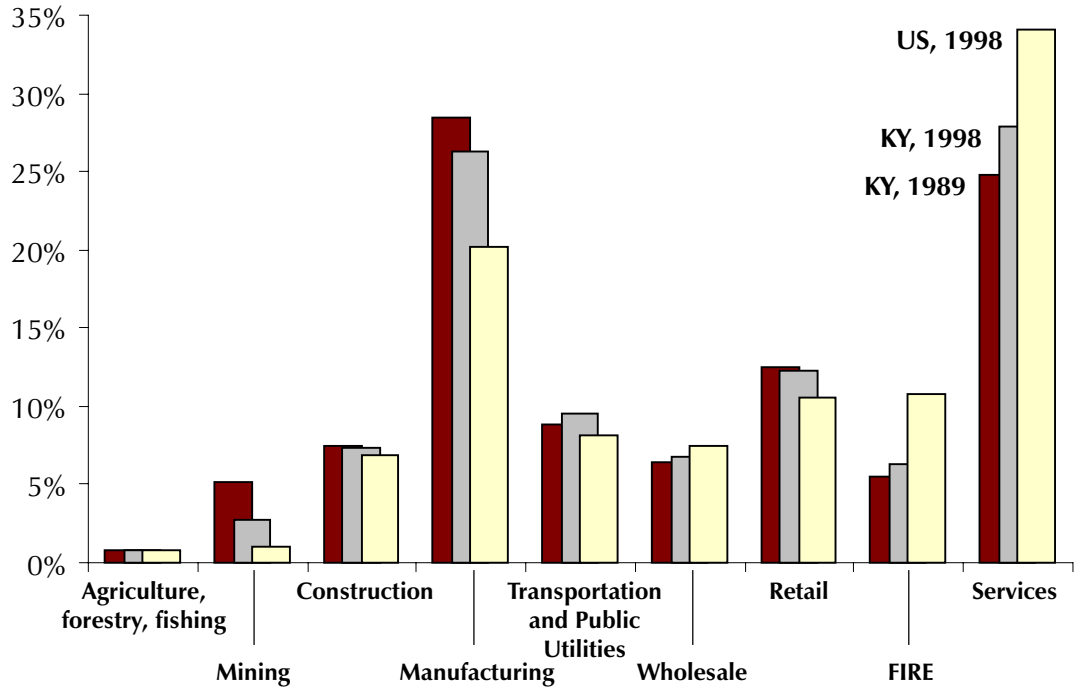

Figure 2.1
Industrial transition in Kentucky
Share of total earnings by sector (government not shown) *Source: BEA*

quotients, it is clear that growing and emerging specializations in motor vehicles, primary metals, rubber and plastics, hospitals and labs, and even boat building (namely houseboats) are replacing long-term specializations in tobacco manufacturing, mining, petroleum and coal, and apparel.

The following chapters investigate economic trends after re-sorting industries into value-chain and labor skill clusters.

Table 2.1
Summary Data, Basic Industry Trends, Kentucky

Sector	Establishments, '99	Employment, '99	Payroll (millions), '99	LQ, '98	Chng LQ, '89-98	Emp. Chng., '89-'99	CAGR, emp, '89-99	Average wage, '99	CAGR, real wage	CAGR, US emp, '89-'98	CAGR, US real wage	SIC
Mining	706	21,026	958	2.38	(1.51)	(13,257)	(4.77)	45,586	.48	(1.75)	1.13	10-14
Food and kindred products	248	27,421	933	0.99	.09	8,538	3.80	34,009	.32	.31	.47	20
Tobacco products	19	2,968	182	5.96	(2.63)	(2,692)	(6.25)	61,317	2.08	(2.76)	.85	21
Textile mill products	62	4,032	111	0.43	(.62)	(5,633)	(8.37)	27,443	2.22	(2.12)	.83	22
Apparel and other textile products	172	19,878	481	1.81	(.38)	(10,275)	(4.08)	24,205	3.69	(3.80)	1.21	23
Lumber and wood products	710	16,302	422	1.18	(.00)	4,899	3.64	25,859	2.78	.86	.48	24
Furniture and fixtures	92	6,190	188	0.65	(.02)	1,679	3.21	30,423	2.71	.17	1.03	25
Paper and allied products	122	13,023	497	1.10	.04	3,620	3.31	38,164	.64	(.29)	.39	26
Printing and publishing	668	22,375	713	0.88	(.11)	2,817	1.35	31,884	.85	(.02)	1.15	27
Chemicals and allied products	201	15,015	802	0.90	(.10)	1,346	.94	53,421	1.35	(.35)	1.93	28
Petroleum and coal products	62	2,162	140	1.14	(.97)	(2,080)	(6.52)	64,762	2.89	(1.40)	2.09	29
Rubber and misc. plastics products	214	20,151	629	1.25	(.24)	3,266	1.78	31,228	.17	1.47	.68	30
Leather and leather products	10	1,017	30	0.81	(.46)	(1,220)	(7.58)	29,805	9.69	(5.29)	1.84	31
Stone, clay and glass products	296	11,495	426	1.29	(.05)	1,907	1.83	37,058	1.64	(.04)	.47	32
Primary metal industries	121	18,789	841	1.58	(.18)	1,407	.78	44,765	.35	(.91)	.17	33
Fabricated metal products	463	27,501	1,014	1.05	.07	9,288	4.21	36,855	1.73	.48	.31	34
Industrial machinery and equipment	732	37,799	1,532	1.07	(.14)	5,222	1.50	40,520	.69	.42	1.07	35
Electronic and other electric equipmer	168	24,224	1,051	0.90	(.47)	(6,183)	(2.25)	43,371	1.71	(.26)	2.02	36
Motor vehicles and equipment	122	39,195	2,408	2.22	.63	22,050	8.62	61,436	2.87	1.83	.57	371
Boat building and repairing	34	1,251	27	1.18	.14	356	3.41	21,612	(.91)	(1.36)	.51	3732
Other transportation equipment	33	3,483	144	0.27	.13	1,476	5.67	41,381	1.39	(3.22)	.68	372-9 (exc. 3732)
Instruments and related products	62	4,361	158	0.30	(.00)	367	.88	36,234	2.74	(1.84)	1.70	38
Miscellaneous manufacturing industrie	153	4,473	126	0.74	(.29)	(564)	(1.18)	28,151	1.12	.27	.95	39
Trucking and warehousing	2,506	29,873	965	1.02	(.20)	5,146	1.91	32,314	.67	.97	(.02)	42
Water transportation	128	3,490	121	1.06	(.26)	560	1.76	34,594	.83	.63	.12	44
Air courier services	61	11,555	926	1.41	(3.18)	6,078	7.75	80,163	14.33	20.31	(.54)	4513
Other transportation by air	70	9,065	434	0.90	.21	4,640	7.43	47,913	1.21	1.50	(.33)	45 (exc. 4513)
Pipelines, except natural gas	7	56	3	0.26	(.21)	(54)	(6.53)	53,719	8.86	(3.12)	1.25	46
Transportation services	201	4,258	162	0.95	.44	3,321	16.34	38,123	1.31	5.46	.00	47
Communications	436	7,961	333	0.46	(.22)	25	.03	41,767	(.66)	1.53	1.41	48
Financial institutions	2,870	38,176	1,467	0.68	(.13)	6,712	1.95	38,430	3.41	.95	4.22	60-62
Insurance carriers and agents	302	5,820	240	0.41	(.29)	(1,537)	(2.32)	41,305	2.53	.99	2.37	63-64
Real estate and holding offices	1,326	6,116	172	0.51	.20	3,881	10.59	28,101	2.91	2.69	.61	65-67
Advertising	199	2,443	102	0.52	.02	972	5.20	41,676	2.51	1.45	1.62	731
Computer, data processing services	1,001	15,750	658	0.50	(.22)	9,068	8.95	41,749	5.75	9.08	3.70	737
Health offices, clinics	1,052	12,243	373	1.03	(.28)	5,514	6.17	30,499	2.83	6.32	1.43	801-5, 808-9
Hospitals and labs	330	79,245	2,673	1.21	.02	25,743	4.01	33,728	2.49	1.71	1.00	806-7
Legal services	1,991	9,953	429	0.62	(.06)	2,172	2.49	43,140	4.09	.95	.87	81
Engineering and management services	1,070	13,414	582	0.58	.04	5,471	5.38	43,417	3.23	1.93	1.03	87

Data source: Kentucky Department for Employment Services and adjusted U.S. Bureau of Labor Statistics ES-202 files (from Minnesota IMPLAN Group, Inc.). n.a. = not applicable. Government not included.

CHAPTER THREE

Benchmark Industry Cluster Analysis

The most common approach to industry cluster analysis involves three steps.[1] First, measures of size, concentration, and growth are used to identify large and/or high-performing sectors. Second, those sectors are grouped into clusters based on judgment or secondary information about their local interdependence.[2] Third, related and supporting organizations and institutions that may have some bearing on the performance of the enterprises in the cluster are identified (e.g., universities, training agencies, industry associations, etc.). The result is a set of key industry clusters as they exist at the time of the study.

In many states and regions, such an approach has severe limitations. First, it often reveals little about key industries of interest (e.g., information technology, health sciences, high-tech manufacturing, etc.) simply because such sectors are not yet as large—in relative or absolute terms—as other industries. Second, it ignores the fact that in many industries local ties are not a significant determinant of competitiveness. The branch plant manufacturer producing a standardized good is an example. Its principal linkages are with its headquarters, suppliers, and equipment vendors, all of which may be located in another region or state. Finding clusters is relatively straightforward in places like Silicon Valley, New York City, or Los Angeles. However, cluster analysis that generates real policy implications for more traditional economies with comparatively little technology-related activity is more difficult.

The Current Study

In a restructuring economy—one in which traditional industries remain dominant and knowledge-intensive sectors dependent on strong local linkages are only beginning to attain critical mass—a *benchmarking* approach to industry cluster analysis can contribute insights the typical approach cannot. The benchmarking method begins by identifying major industry clusters—groups of interdependent and related sectors—for the U.S. economy as a whole using detailed secondary data on inter-industry linkages or relationships. Then, the distribution, composition, and performance of such clusters are examined in the state or region in question.[3]

Defining Industry Clusters

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

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

Emerging clusters are clusters that will likely attain critical mass if current trends continue. An example in Kentucky is transportation and shipping, a key industry in Louisville that has a limited presence in the rest of the state. *Potential clusters* are more speculative than emerging clusters. In a potential cluster, few related industries may be present or the cluster may be dominated by just a few large firms. In a potential cluster, there is opportunity but conditions favorable to the actual emergence of the cluster are uncertain. An example is information technology, a potential Kentucky cluster that, although small in relative terms, has an important anchor in Lexmark and has been growing steadily over the last ten years.

It is important to realize that the designation of a cluster as "emerging" or "potential" is based on an analysis of past trends and does not constitute an endorsement of "winners" or future specializations in the state that necessarily deserve policy attention. In many cases, it may make sense for states and regions to focus effort on arresting decline in traditional clusters rather than spurring growth in new ones. In other cases, emerging clusters may constitute future competitive advantages that would benefit from public investments in traditional or technology infrastructure, workforce development programs, technical assistance, and the like. Either way, the decision about where to target scarce development resources must be based on an assessment of trade-offs and opportunity costs associated with different actions and a degree of caution with respect to future economic trends.

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

Some cluster studies focus on identifying strictly localized clusters, employing the implicit assumption that local ties are more crucial to the competitiveness of area businesses than non-local ties. Others, the present one included, use a market logic to identify interdependent businesses irrespective of location and then search for geographical concentrations of such businesses.

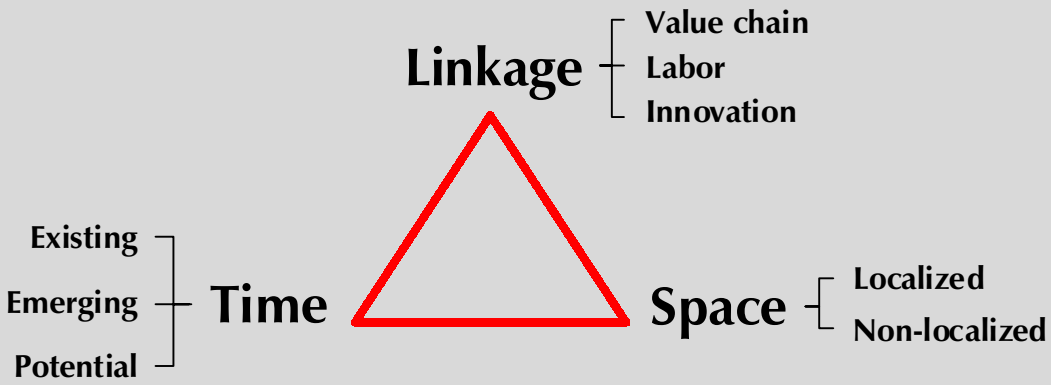

Figure 3.1
Identifying industry clusters: 3 dimensions

While the usual analytical approach focuses mainly on what a state or region *does have* at the current time, the benchmarking method identifies what is emerging and what an economy *could have*, perhaps with properly focused development policy. For example, it is well known that tobacco, textiles, and apparel are key clusters in Kentucky. The more important question is whether higher-technology and higher-wage industry segments can be developed within those clusters. To find the answer, one has to know what those segments are. They simply cannot be found by looking in a place where they have not yet developed.

Two Sets of Clusters

Two major types of benchmark clusters are used here: value-chain clusters and labor skill clusters. The clusters were derived from statistical analyses of three sets of data: the *Benchmark Input-Output Accounts of the United States*, the *U.S. Staffing Patterns Matrix*, and detailed occupational characteristics data maintained by the U.S. Department of Labor. The benchmark clusters are essentially alternative industry classification schemes to which secondary data on employment, wages, etc. may be applied. In the report, most attention is focused on the value-chain clusters; trends based on the labor cluster definitions are used primarily as a supplement to gain additional insight into the competitive strengths and weaknesses of the Kentucky economy.

Benchmark Value-Chain Clusters

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

Value-chain clusters are therefore groups of industries that fall into the same broad product chain (final market producers and their first-, second-, and third-tier supplier sectors) or, for industries that do not trade significantly in physical goods, that draw from the same broad labor pool. The latter include legal services, banking and advertising, and transportation services and logistics. See Appendix Table 1 for the sectors comprising each cluster.

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

Technology Value-Chain Clusters. To recognize the full range of strengths in the economy while also focusing on high-technology businesses, we developed two sets of benchmark

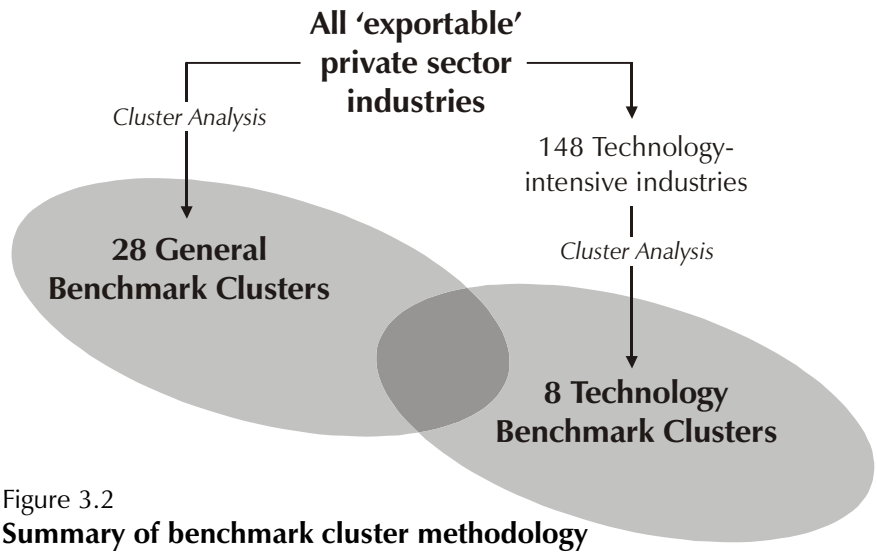

Figure 3.2
Summary of benchmark cluster methodology

value-chain clusters. We derived the first from a statistical analysis of interdependence among *all* potential export sectors in the U.S. economy.[4] That analysis revealed 28 clusters, ranging from metalworking and industrial machinery to pharmaceuticals. Many of the 28 benchmark clusters comprise both high-tech and low-tech sectors while some sectors are members of multiple clusters. For example, the software industry is a member of both the information technology/instruments and hospitals/labs/specialized medical services clusters. Appendix Table 2 reports the detailed makeup of each technology cluster.

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

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

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

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

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

- The set of revealed clusters is influenced by limitations in the federal government's industry classification system. Some fast-growing technology industries—such as biotechnology and specialized information technology—are not easily detected in the analysis since many such sectors did not exist when the last revision of the SIC system was released. Such industries are captured in the pharmaceuticals and hospitals/medical technologies clusters, as well as chemicals and plastics (due to the presence of agricultural chemicals). This problem, in part, motivated the conduct of the biotechnology case study reported in Chapter 6.

- The statistical procedures used to develop the benchmark clusters include factor analysis and hierarchical cluster analysis. A supplementary appendix describing methodological issues in more detail is available.[5] An important feature of the clusters is that they are based on a systematic rather than arbitrary analysis of observed ties between industries.

The Value-Chain Clusters in Detail. Table 3.1 lists the 28 general U.S. benchmark clusters along with basic payroll, wage, and employment information. The largest cluster in the U.S. in terms of employment is printing and publishing. Nearly 9.3 million Americans work in the various industries that make up the cluster. Its large size can be explained in part by the inclusion of the hospitals and software industries. Hospitals are a major consumer of paper products, from printed forms, gowns, and sheets, to sanitary products, packaging, bags, and cleaning supplies. The demands of hospitals and medical services providers have driven the development of some higher-value paper goods. The software and computer services industry is a major supplier to the publishing industry but is also closely tied to hospitals and medical services (including via the emerging field of bioinformatics). Thus, the printing and publishing cluster runs the gamut from resource extraction and physical commodity production to information technology.

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

Table 3.1
U.S. Benchmark Value-Chain Clusters

	Employment				Payroll			
Clusters	1998 (000's)	% private sector 1998	CAGR '89-'98	Establishments '98 (000s)	1998 (Mil)	% private sector 1998	CAGR '89-'98	Average Wage 1998
Metalworking and industrial machinery	5,256.1	5.00	0.6	125.6	203,290.0	6.10	4.2	38,677
Packaged food products	1,640.7	1.56	0.3	21.4	52,327.9	1.57	3.8	31,894
Construction materials	3,343.2	3.18	0.7	140.6	130,229.8	3.91	4.7	38,954
Printing and publishing	9,293.9	8.85	2.2	280.1	393,958.9	11.82	7.4	42,389
Information technology and instruments	4,177.2	3.98	1.6	168.0	240,460.4	7.22	7.7	57,565
Chemicals and plastics	2,856.5	2.72	1.9	120.5	114,116.5	3.42	5.7	39,950
Apparel	1,206.7	1.15	-3.7	24.3	30,365.4	0.91	0.5	25,164
Motor vehicle manufacturing	2,919.4	2.78	1.1	38.8	119,598.6	3.59	4.9	40,966
Fabricated textiles	1,255.0	1.19	-2.9	32.0	32,141.1	0.96	1.6	25,610
Stone and clay products	304.1	0.29	-0.9	4.3	15,782.0	0.47	3.3	51,902
Wood products	1,023.9	0.97	0.5	38.9	32,702.0	0.98	3.8	31,940
Primary nonferrous metals	593.9	0.57	1.2	28.2	21,443.3	0.64	4.6	36,107
Leather goods	74.8	0.07	-5.7	1.7	1,905.8	0.06	-1.0	25,495
Tobacco products	40.2	0.04	-2.8	0.2	2,254.2	0.07	1.1	56,035
Canned and bottled beverages	197.8	0.19	-1.3	4.2	9,616.4	0.29	3.5	48,613
Food oil mills	31.4	0.03	-0.1	0.6	1,262.7	0.04	4.0	40,156
Aerospace	816.0	0.78	-4.8	4.4	44,975.3	1.35	-0.6	55,120
Petroleum products	142.0	0.14	-1.3	2.5	9,113.5	0.27	3.8	64,194
Jewelry	68.4	0.07	-2.2	3.7	2,238.4	0.07	1.6	32,722
Boat building	202.8	0.19	-1.5	5.6	8,477.5	0.25	2.2	41,801
Aluminum	195.6	0.19	-1.8	1.9	9,737.9	0.29	1.4	49,779
Hospitals, labs, specialized medical servi	6,955.6	6.62	3.5	257.4	283,854.7	8.52	9.3	40,809
Platemaking and typesetting	88.1	0.08	-1.9	4.2	4,073.5	0.12	2.3	46,235
Securities and insurance	1,765.7	1.68	2.1	178.4	81,634.6	2.45	7.8	46,234
Banking and advertising	3,460.3	3.29	0.8	193.9	187,555.7	5.63	7.8	54,202
Legal services	973.7	0.93	0.9	164.4	51,990.6	1.56	5.0	53,394
Transportation, Shipping & Logistics	3,241.1	3.09	2.8	182.3	110,870.0	3.33	5.7	34,208
Pharmaceuticals	277.7	0.26	2.1	2.3	18,992.4	0.57	8.3	68,401
Covered Private Sector Employment	105,051.3	100.00	1.8	7,379.4	3,332,422.5	100.00	5.8	31,722
Covered Exportable Employment	37,073.6	35.29	0.9	1,496.2	1,566,933.9	47.02	5.6	42,265

Note: Raw data are from Minnesota IMPLAN Group, Inc. Clusters are not mutually exclusive. n/a: Not applicable. Data are only for businesses "covered" under unemployment insurance law. CAGR: Compound annual growth rate. Note "exportable" sectors do not include mining and agriculture, as well as locally-traded retail, wholesale, and services.

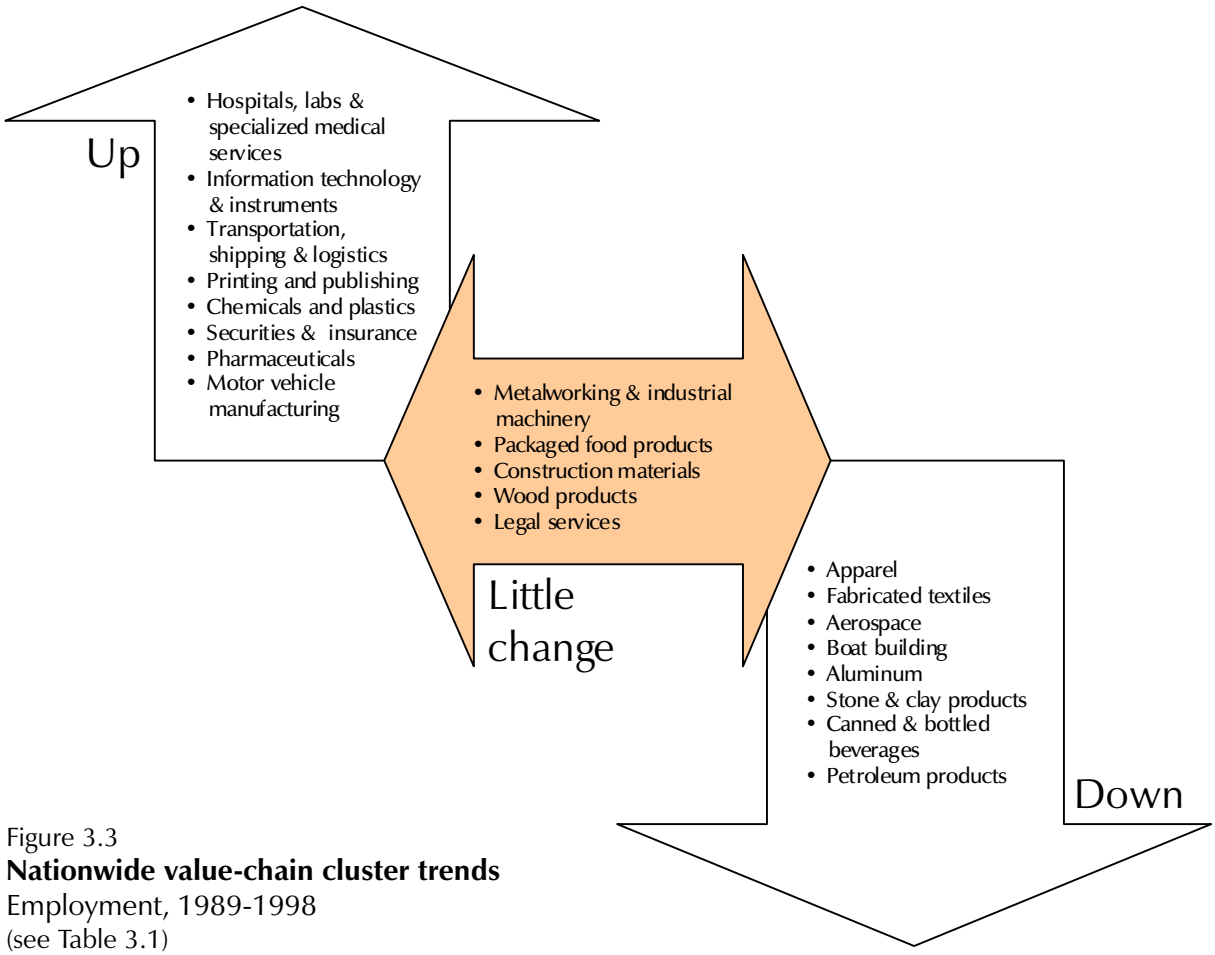

Figure 3.3
Nationwide value-chain cluster trends
Employment, 1989-1998
(see Table 3.1)

Table 3.2
U.S. Benchmark Technology Clusters

	Employment			Establish-	Payroll			
	1998	% private sector	CAGR	ments	1998	% private sector	CAGR	Average Wage
Clusters	(000's)	1998	'89-'98	'98 (000s)	(Mil)	1998	'89-'98	1998
Chemicals and plastics	1,338.0	1.27	1.1	44.9	59,935.8	1.80	5.2	44,796
Information technology and instruments	3,592.1	3.42	2.2	150.9	211,869.0	6.36	8.7	58,981
Industrial machinery	563.8	0.54	0.2	11.9	23,632.2	0.71	4.3	41,912
Motor vehicle manufacturing	1,510.2	1.44	1.0	14.5	72,815.4	2.19	4.8	48,217
Aerospace	842.8	0.80	-3.0	14.6	42,885.0	1.29	0.7	50,882
Household appliances	91.2	0.09	-0.5	0.4	3,287.9	0.10	3.1	36,036
Communications services and software	2,906.9	2.77	5.2	229.6	170,007.6	5.10	11.3	58,483
Pharmaceuticals and medical technologi	979.1	0.93	1.7	28.8	52,407.1	1.57	7.2	53,529
Covered Private Sector Employment	105,051.3	100.00	1.8	7,379.4	3,332,422.5	100.00	5.8	31,722
Covered Exportable Employment	37,073.6	35.29	0.9	1,496.2	1,566,933.9	47.02	5.6	42,265

Note: Raw data are from Minnesota IMPLAN Group, Inc. Clusters are not mutually exclusive. n/a: Not applicable. Data are only for businesses "covered" under unemployment insurance law. CAGR: Compound annual growth rate. Note "exportable" sectors do not include mining and agriculture, as well as locally-traded retail, wholesale, and services.

Figure 3.3 summarizes broad employment and wage trends in the clusters over the 1989 to 1998 period. During the 1990s, knowledge-intensive and/or technology-intensive clusters such as hospitals and labs, information technology, printing and publishing, securities and insurance, and pharmaceuticals have been expanding while lower-technology, traditional clusters are growing slowly or declining. An important exception is aerospace, a technology-intensive cluster that posted significant job losses over the period because of reductions in federal defense spending.

Table 3.2 lists the eight benchmark technology clusters. Among the largest high-technology clusters in the country are information technology and instruments, communications services and software, motor vehicle manufacturing, and chemicals and plastics. Note that when linkages between all industries—high-tech and low-tech—are examined, communications services and software does not fall out as a distinct cluster (rather, as enabling technologies, many communications services and software sectors fall into multiple general industry clusters; see Table 3.1 and the cluster definitions in Appendix 1). The cluster stands alone only when the focus is restricted to technology-intensive sectors. Likewise, medical technologies (which includes surgical instruments and equipment) is with pharmaceuticals and testing laboratories when the analysis is limited to high-tech sectors.

Among the fastest-growing technology clusters in the country are communications services and software and information technology and instruments. Both are among the highest-wage tech clusters in the U.S. (see Figure 3.4). Other clusters posting strong employment gains between 1989 and 1998 are pharmaceuticals and medical technologies, chemicals and plastics, and vehicle manufacturing (its technology-intensive segments in engines, electronics, and assembly). Employment in aerospace and household appliances declined over the period.

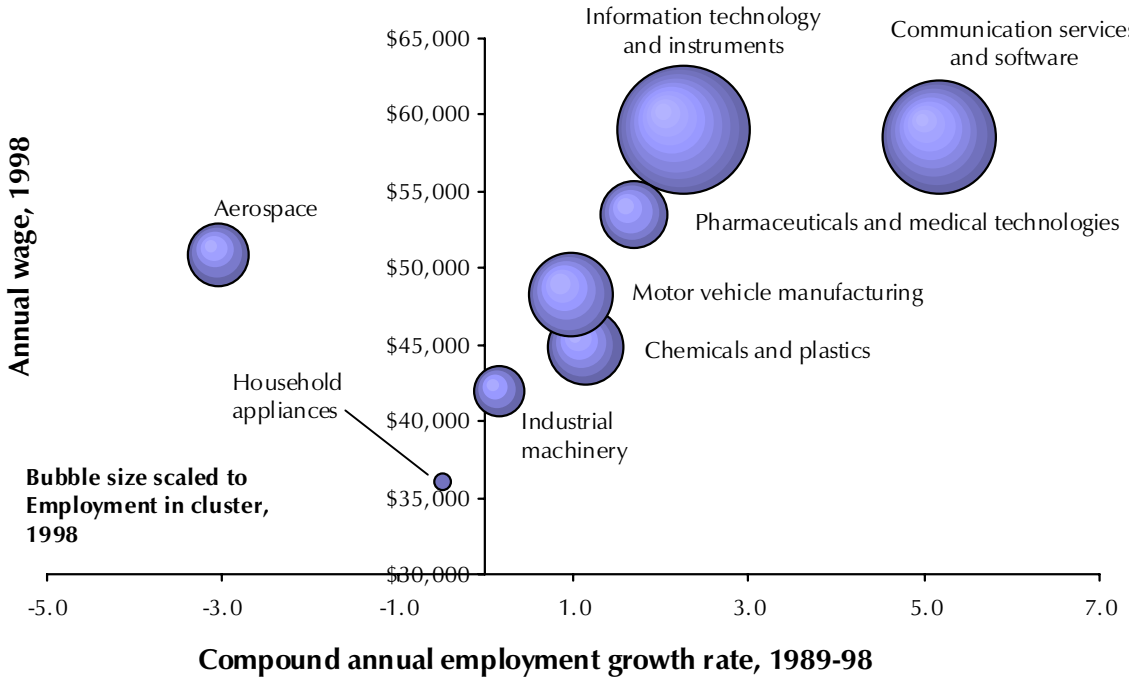

Figure 3.4
Nationwide technology value-chain cluster trends
(see Table 3.2)

Labor Skill Clusters

Under the Standard Industrial Classification system, detailed four-digit industries are grouped into three-, two-, and one-digit sectors according to similarity of product. Thus, the transportation equipment sector comprises mainly industries that produce end-market transportation equipment (cars, trucks, busses, boats, and ships). The benchmark clusters described above may be viewed as simply a "re-sorting" of the four-digit SIC system such that sectors are grouped according to presence in common value chains. The motor vehicles cluster includes not only vehicle manufacturers, but also textile goods, paints, rubber and plastic hoses, glass, stampings, springs, etc. The dimension of industrial interdependence defining the cluster (see Figure 3.1) is a value-chain linkage.

Value-chain clusters can help reveal supplier or buyer networks that can serve the needs of new or expanding enterprises. However, for many businesses, access to skilled labor is at least as important as proximity to suppliers or customers. Unfortunately, the businesses that fall into the same value chain do not necessarily draw from the same labor pool. Likewise, businesses that demand similar workforce skills are not necessarily members of the same value chain. A set of industry clusters based on buyer-supplier linkages may look very different from a set based on labor needs.

What we require is a similar "re-sorting" of the SIC system that is based on industry utilization of similar workforce skills. The result, a set of *labor skill clusters*, would help reveal important human capital characteristics and strengths in a region.[6] From a business development standpoint, a start-up or relocating business may be attracted to a place where a substantial cluster of enterprises use similar types of labor. In the

Table 3.3
U.S. Benchmark Labor Clusters

	Employment				Payroll			
Clusters	1998 (000's)	% private sector 1998	CAGR '89-'98	Establishments '98 (000s)	1998 (Mil)	% private sector 1998	CAGR '89-'98	Average Wage 1998
Low skill, non-durable manufacturing	3,393.3	3.23	-1.0	68.3	106,455.5	3.19	3.3	31,373
Information processing	3,404.7	3.24	4.7	312.3	176,396.8	5.29	11.5	51,809
Low skill miscellaneous manufacturing	1,562.8	1.49	0.2	34.4	47,276.7	1.42	4.0	30,251
Standardized heavy industry	3,523.6	3.35	0.4	43.7	157,651.9	4.73	4.1	44,742
High end information/business services	2,031.6	1.93	0.6	215.7	96,368.8	2.89	5.1	47,435
Distribution, freight handling	3,115.0	2.97	2.5	174.1	104,380.0	3.13	5.5	33,509
Electronics, measuring devices	2,356.5	2.24	-0.7	29.2	120,006.6	3.60	4.6	50,926
Chemicals, pharmaceuticals	675.5	0.64	0.1	9.1	41,880.7	1.26	5.4	61,999
Telecomm and banking	3,709.8	3.53	0.6	172.7	165,285.0	4.96	6.2	44,554
Science intensive	1,664.5	1.58	-0.2	104.6	86,108.7	2.58	3.9	51,732
High tech machinery, instruments	1,480.1	1.41	-0.7	49.6	65,958.0	1.98	2.9	44,563
Petroleum	108.9	0.10	-2.5	1.8	7,798.0	0.23	3.1	71,586
Health services	4,800.1	4.57	2.3	96.7	152,404.5	4.57	6.5	31,750
Specialized labor intensive	2,355.5	2.24	0.3	60.7	78,760.2	2.36	4.0	33,436
Food and tobacco manufacturing	856.9	0.82	-0.4	14.7	34,317.1	1.03	3.3	40,046
Securities	644.1	0.61	4.5	44.8	79,128.4	2.37	12.9	122,856
Building products manufacturing	1,206.0	1.15	0.7	54.7	39,767.5	1.19	4.2	32,975
Covered Private Sector Employment	105,051.3	100.00	1.8	7,379.4	3,332,422.5	100.00	5.8	31,722
Covered Exportable Employment	37,073.6	35.29	0.9	1,496.2	1,566,933.9	47.02	5.6	42,265

Note: Raw data are from Minnesota IMPLAN Group, Inc. Clusters are not mutually exclusive. n/a: Not applicable. Data are only for businesses "covered" under unemployment insurance law. CAGR: Compound annual growth rate. Note "exportable" sectors do not include mining and agriculture, as well as locally-traded retail, wholesale, and services.

short term, the region is more likely to attract or grow industries that are consistent with the current skill mix. In the long term, in order to attract or grow knowledge- or technology-intensive businesses, the skill mix must be altered through education, training, and targeted development of higher-skill-demanding businesses.

To develop a preliminary set of labor skill clusters, we first used data on the skill characteristics of over 1,100 occupations to identify a reduced set of skill groups, or sets of occupations that require similar basic skills.[7] We then used information from the latest U.S. *Staffing Patterns Matrix*, which reports industry employment by occupation, to cluster industries according to similarities in their demand for labor skills.[8] (Note that the *Staffing Patterns Matrix* reports industry employment data at the three-digit SIC level, whereas U.S. input-output data are reported at a combination of the three- and four-digit levels.) Figure 3.5 summarizes the clustering methodology; the resulting labor skill clusters are reported in Table 3.3.[9]

The largest labor skill clusters in the U.S. are health services, telecom and banking, standardized heavy industry, information processing, low-skill nondurable manufacturing, and distribution and freight handling. Note that the clusters are made up of industries that draw from similar labor pools. Therefore, the low-skill nondurable-manufacturing cluster includes sectors such as textiles, apparel, miscellaneous plastics, and paints and allied products. All component sectors depend on lower-skill production workers and few scientific, management, or administrative personnel. Health services include health practitioners, hospitals, and labs but not pharmaceuticals. The latter is clustered with chemicals because of high joint demand for scientists and chemists.

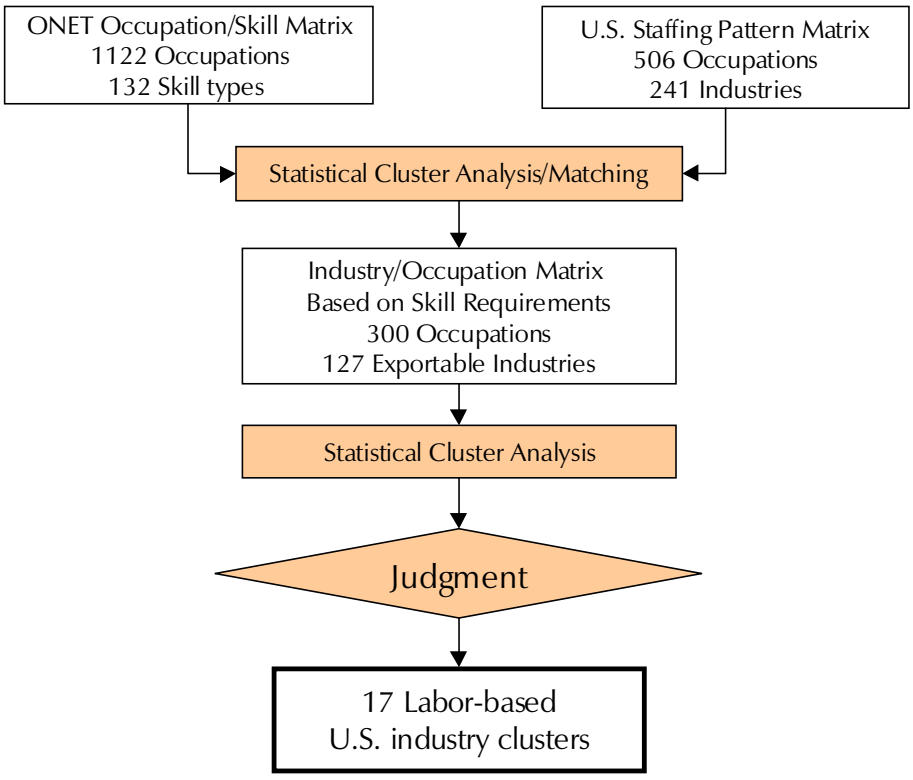

Figure 2.5
Summary of labor skill cluster methodology

Recent trends across U.S. labor skill clusters are summarized in Figure 3.6. Top growth clusters include information processing, securities, distribution and freight handling, health services, and telecom and banking. Major declining clusters include petroleum, low-skill nondurables, food and tobacco manufacturing, and high-tech machinery and instruments (the latter reflecting employment contraction in the hardware segments of the information technology sector).

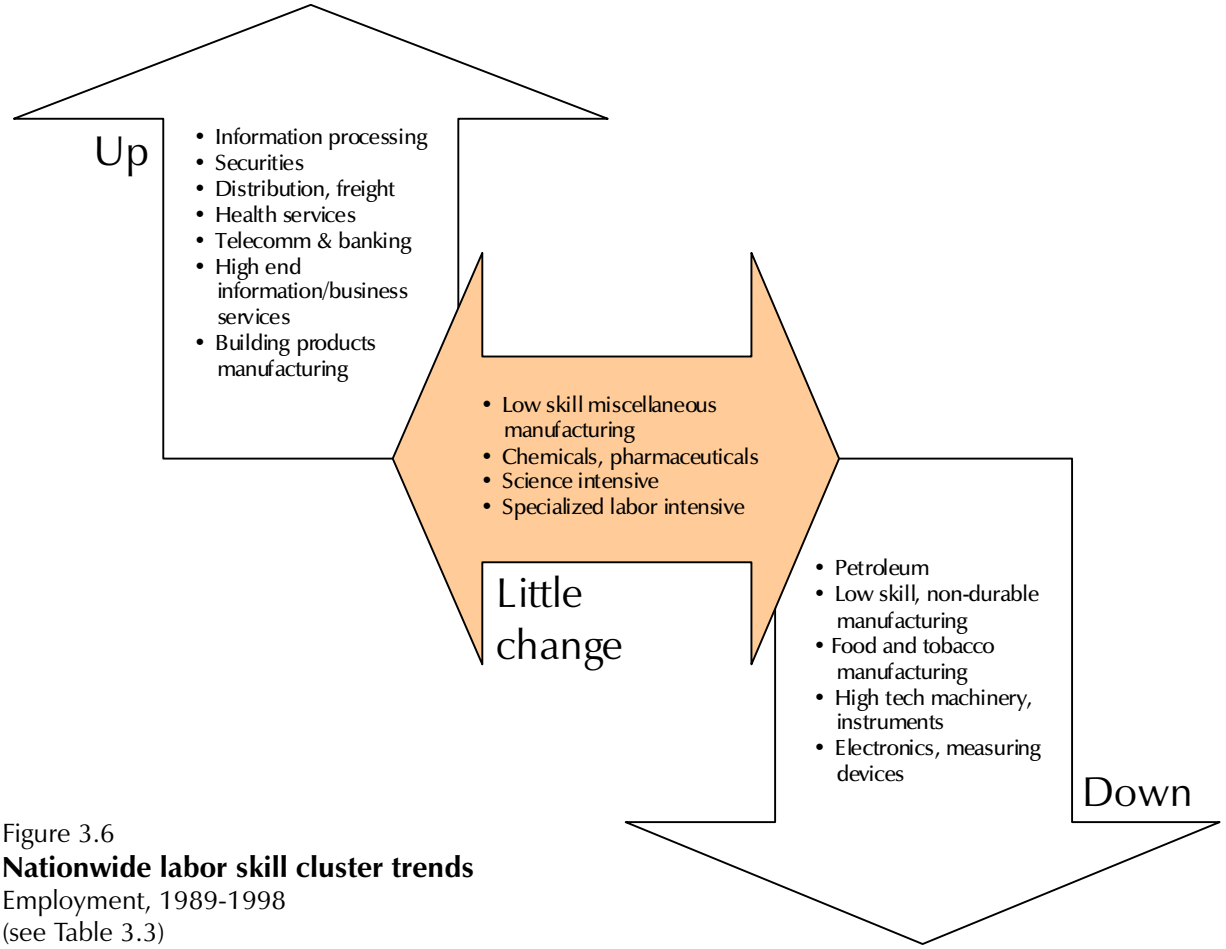

Figure 3.6
Nationwide labor skill cluster trends
Employment, 1989-1998
(see Table 3.3)

CHAPTER FOUR

Industry Clusters in Kentucky

Using selected criteria (absolute size, relative size, and depth) to evaluate detailed wage and employment data assembled for the benchmark cluster definitions outlined in the previous chapter reveals a diverse set of value-chain and labor skill clusters in Kentucky. The basic findings of this chapter are summarized in Table 4.1, which lists existing, emerging and potential value-chain and labor skill clusters in the state. The picture that Table 4.1 paints is of a state with growing strengths in comparatively heavy industry (metals, machinery, motor vehicles, chemicals and plastics) even as its core low-skill, nondurable manufacturing activity (tobacco, textiles) declines. Major U.S. information technology clusters have only a modest presence in the state, though their high rate of growth in Kentucky (due partly to their small size) warrants their consideration as potential clusters. Conspicuously absent from the list are key knowledge- and science-intensive labor skill clusters, which reflects Kentucky's comparatively modest, though growing, high-tech base.

Several industrial strengths stand out across cluster definitions. The motor vehicle manufacturing and industrial machinery industries are diverse and well developed across both high-tech and low-tech segments of their respective value chains. Transportation and shipping activity in the state, led by the UPS hub in Louisville, is a growing strength that appears under both labor skill and value-chain cluster definitions. Construction materials and food manufacturing are also growing clusters that are likely employing many semi-skilled workers displaced from the declining tobacco, textiles, and apparel industries. The following sections outline these findings in detail.

Major Value-Chain Clusters in Kentucky

Based on 1999 employment and payroll data, printing and publishing; hospitals, labs, specialized medical services; metalworking and industrial machinery; motor vehicle manufacturing; transportation, shipping, and logistics; and construction materials are the six largest clusters in Kentucky (see Table 4.2). Employment in all six clusters grew faster than the national average between 1989 and 1999. In addition, motor vehicle manufacturing; hospitals, labs, and specialized medical equipment; and transportation, shipping, and logistics are among the fastest-growing clusters in the state.

Absolute size and growth trends do not necessarily reveal competitive economic strengths, however. The importance of a cluster that is small in absolute terms but large relative to other places can be obscured if the only criterion used is size. Similarly, the depth of given clusters may be overstated by size measures; one or a few industries may easily dominate a cluster even if its aggregate size is substantial. A smaller but more diverse cluster may have higher sustained growth potential than a larger cluster dominated by a single industry.

A number of employment and wage indicators for all benchmark value-chain clusters are reported in Table 4.2. We used three criteria—absolute size, relative size, and depth (a diversity of underlying sectors)—to identify six specific clusters as existing or current industrial strengths in Kentucky: tobacco manufacturing, aluminum production, fabricated textiles, motor vehicle manufacturing, metalworking and industrial machinery, and transportation, shipping, and logistics. Among the six, aluminum and fabricated textiles employ the fewest workers, roughly 8,000 and 3,000, respectively. Growth in the aluminum cluster over the 1990s has been very modest while net employment in tobacco and textiles has declined precipitously. Nevertheless, tobacco and textile manufacturing remain significant concentrations of activity in the state and comprise many efficient, competitive businesses. The clusters as a whole, however, are likely to continue to contract as many producers seek lower-cost locations in Latin America and overseas.

Table 4.1
Profile of Kentucky Clusters

	Value Chain Clusters	**Trend**
Existing	Tobacco manufacturing	Decline
	Fabricated textiles	Decline
	Motor vehicle manufacturing	Growth
	Aluminum	Growth
	Metalworking and industrial machinery	Growth
	Transportation, shipping and logistics	Growth
Emerging	Hospitals, labs, specialized medical	Growth
	Construction materials	Growth
	Chemicals and plastics	Growth
	Packaged food products	Growth
	Wood products and furniture	Growth
	Boat building	Growth
Potential	Information processing and instruments	Growth
	Technology-intensive Value Chain Clusters	
Existing	Household appliances	Growth
	Motor vehicle manufacturing	Growth
	Industrial machinery	Growth
Potential	Communications services and software	Growth
	Information technology and instruments	Growth
	Labor Skill Clusters	
Existing	Health services	Growth
	Standardized heavy industry	Growth
	Low skill, non-durable manufacturing	Decline
	Food and tobacco manufacturing	Growth
Emerging	Distribution and freight handling	Growth
	Building products manufacturing	Growth
	Specialized labor intensive	Growth

Note: Clusters are not mutually exclusive.

Motor vehicle manufacturing. The motor vehicle manufacturing cluster in Kentucky comprises 557 establishments employing over 85,000 workers and paying out an annual $4.04 billion in payroll. The cluster pays an average annual wage of $47,226, 154 percent of the average private sector wage in the state ($30,724) and 115 percent of the average wage in the U.S. motor vehicles cluster. Employment in the Kentucky cluster expanded by 5.7 percent annually between 1989 and 1998; the most recent data indicate a slight slowing of employment growth to 4.8 percent over the 1998-1999 period. By contrast, employment in the U.S. motor vehicles cluster grew by only 1.1 percent annually over the 1989-1998 period.

At the core of Kentucky's motor vehicles industry is its major assemblers (Toyota, Ford, GM) and their key suppliers. Because Chapter 6 presents a detailed case study of the cluster, we delay further discussion of it until then.

Aluminum. The benchmark aluminum cluster comprises eight sectors. At the national level, employment in the cluster has declined by about 1.8 percent annually since 1989. In Kentucky, six of the sectors are represented, employing a total of just under 8,000 workers. The cluster experienced meager employment growth between

1989 and 1998, expanding by only 0.8 percent annually. Between 1998 and 1999, employment in the cluster declined by 1.1 percent statewide.

Despite dismal performance (in terms of job creation) during the 1990s, the aluminum industry remains strategically important to the state for two reasons. First, it pays among the highest average wages of any cluster (at $53,610). Industrial inorganic chemicals, n.e.c.[10] (SIC 2819), primary aluminum (SIC 3334), aluminum sheet/plates/foil (SIC 3353), and aluminum rolling and drawing (SIC 3355) all pay an average wage in excess of $50,000, and those sectors claim about 94 percent of the cluster's total employment. Second, such high-wage sectors are overrepresented in the state, suggesting that Kentucky has a competitive lead in the industry *vis-a-vis* other states. Location quotients for each of those sectors are 2.9, 3.2, 8.0, and 3.1 respectively. Major aluminum manufacturers such as Commonwealth Aluminum and Reynolds Metals have their headquarters in the Louisville area. While employment in primary aluminum and aluminum sheet/plates/foil has been shrinking both nationally and locally, the cluster's employment in Kentucky has been sustained mostly by large employment gains in the industrial inorganic chemicals and aluminum rolling and drawing industries.

Metalworking and industrial machinery. Metalworking and industrial machinery is the third largest cluster in Kentucky, with 103,072 employees as of 1999. Employment in the cluster has grown 2.1 percent annually since 1989, compared to a national annual growth rate of just 0.6 percent. Due to its strong employment

Table 4.2
Summary data, benchmark value-chain clusters, Kentucky

	Employment								Establishments			Payroll	
			% private	CAGR			Location Quotient						
		Per estab	sector	KY	KY	US		Change		Change	Share		Average
Clusters	1999	lishment	1999	'89-'98	'98-'99	89-'98	1998	'89-'98	1999	'98-'99	Single	1999	wage
Metalworking and industrial machinery	103,072	60.0	6.43	2.1	2.2	0.6	1.29	-0.03	1,717	52	0.90	4,058.7	39,377
Packaged food products	27,445	133.2	1.71	3.8	1.5	0.3	1.10	0.14	206	-1	0.75	938.6	34,200
Construction materials	52,739	25.6	3.29	2.1	2.7	0.7	1.03	-0.03	2,062	121	0.88	1,943.3	36,848
Printing and publishing	139,777	44.7	8.72	3.7	2.0	2.2	0.99	-0.02	3,127	301	0.80	4,878.4	34,902
Information technology and instruments	34,553	24.1	2.16	3.4	10.8	1.6	0.54	0.04	1,432	245	0.94	1,404.8	40,656
Chemicals and plastics	45,010	25.1	2.81	2.1	1.6	1.9	1.03	-0.16	1,795	113	0.71	1,664.8	36,988
Apparel	17,621	96.3	1.10	-6.4	-15.4	-3.7	0.96	-0.79	183	-3	0.68	424.5	24,090
Motor vehicle manufacturing	85,499	153.5	5.34	5.7	4.8	1.1	1.92	0.44	557	50	0.80	4,037.8	47,226
Fabricated textiles	25,201	99.2	1.57	-2.4	-10.2	-2.9	1.32	-0.35	254	8	0.70	653.7	25,938
Stone and clay products	5,143	68.6	0.32	-5.8	-5.8	-0.9	1.11	-1.12	75	-1	0.55	244.9	47,613
Wood products	15,490	25.1	0.97	3.4	10.5	0.5	0.99	0.16	617	51	0.93	448.7	28,965
Primary nonferrous metals	8,298	28.7	0.52	5.2	7.0	1.2	0.92	0.19	289	8	0.99	298.1	35,928
Leather goods	*s*	*s*	*s*	*s*	*s*	-5.7	*s*	*s*	14	-2	*s*	*s*	*s*
Tobacco products	2,968	156.2	0.19	-4.1	-23.6	-2.8	4.84	-3.75	19	1	0.58	182.0	61,317
Canned and bottled beverages	1,909	26.2	0.12	6.5	5.8	-1.3	0.63	0.27	73	6	0.66	85.7	44,873
Food oil mills	634	70.4	0.04	2.1	-2.6	-0.1	1.32	-0.01	9	0	0.44	28.5	44,990
Aerospace	1,891	145.5	0.12	9.1	-22.9	-4.8	0.15	0.08	13	-1	0.92	89.1	47,141
Petroleum products	2,286	33.1	0.14	-5.2	-13.2	-1.3	1.06	-1.02	69	-1	0.22	143.7	62,853
Jewelry	*s*	*s*	*s*	*s*	*s*	-2.2	*s*	*s*	9	1	*s*	*s*	*s*
Boat Building	3,120	49.5	0.19	2.5	-3.1	-1.5	1.01	0.14	63	3	0.92	102.7	32,904
Aluminum	7,991	266.4	0.50	0.8	-1.1	-1.8	2.68	0.11	30	2	0.53	428.4	53,610
Hospitals, labs, specialized medical serv	111,727	36.3	6.97	5.2	2.2	3.5	1.05	-0.01	3,077	336	0.81	3,839.0	34,361
Platemaking and typesetting	1,245	27.1	0.08	-0.2	1.6	-1.9	0.93	-0.01	46	1	0.96	55.3	44,382
Securities and insurance	12,424	6.2	0.78	2.7	0.3	2.1	0.46	-0.06	2,019	51	0.86	456.3	36,728
Banking and advertising	40,131	12.3	2.50	1.8	4.2	0.8	0.76	-0.04	3,251	320	0.42	1,526.9	38,047
Legal services	9,953	4.5	0.62	2.6	2.0	0.9	0.67	-0.01	2,194	56	0.97	429.6	43,167
Transportation, Shipping & Logistics	58,297	16.1	3.64	4.1	5.4	2.8	1.18	-0.02	3,616	245	0.93	2,614.2	44,842
Pharmaceuticals	*s*	*s*	*s*	*s*	*s*	2.1	*s*	*s*	12	1	*s*	*s*	*s*
Covered Private Sector Employment	1,602,202	15.5	100.0	3.8	2.7	1.8	n/a	n/a	103,057	4,843	0.83	49,226.8	30,724
Covered Exportable Employment	562,540	27.0	35.1	2.4	1.8	0.9	n/a	n/a	20,819	1,269	0.79	22,503.4	40,003

Note: KY figures for 1998/99 are based on confidential 4th quarter data from the KY Department for Employment Services. s indicates data suppressed to meet confidentiality guidelines. Data for 1989 (based on annual figures) are from Minnesota IMPLAN Group, Inc. Clusters are not mutually exclusive. n/a: Not applicable. Data are only for businesses "covered" under unemployment insurance law. CAGR: Compound annual growth rate. Note "exportable" sectors do not include mining and agriculture, as well as locally-traded retail, wholesale, and services.

growth over the last decade, metalworking and industrial machinery is now slightly over-represented in Kentucky (an employment location quotient of 1.29). Core sectors in the cluster are motor vehicle parts and accessories (SIC 3714, location quotient 1.84) and automotive stampings (SIC 3465, location quotient 2.19). The former, which accounts for over 16 percent of the cluster's employment, expanded by 141 percent from 1989 to 1999. Employment growth in automotive stampings has been even more explosive (roughly 340 percent). It is worth noting that these two sectors are also included in the motor vehicle manufacturing cluster, perhaps the most strategically important industry cluster in the state. There are clearly close linkages between motor vehicle manufacturing and metalworking/ industrial machinery. Other key metalworking sectors include motors and generators (SIC 3621), fabricated metal products, n.e.c. (SIC 3499), and household appliance manufacturing (SIC 3631, 3632, 3633, 3635, 3639).

Although the household appliances industry has been declining both locally and nationally, it remains a leading specialization in the state and an important part of the metalworking and industrial machinery cluster. General Electric operates two plants in Lexington and maintains other offices in Louisville. Matsushita Electronics has its home appliance division headquarters in Danville. The most important source of the state's competitiveness in household appliances is a well-developed supplier chain. Major first-tier supplier sectors for household appliance manufacturing are well represented in the state. Blast furnaces and steel mills (SIC 3312), aluminum die-castings (SIC 3363), motors and generators (SIC 3621), plastics materials and resins (SIC 2821), and miscellaneous plastic products, n.e.c. (SIC 3081-3089) are cases in point.

Jobs in metalworking and industry machinery cluster tend to be relatively high-wage. About 24 percent of workers in the cluster earn more than $40,000 a year. Although the private sector wage in Kentucky is substantially lower than the national average, many industries in the metal-

Interpreting Specializations and Gaps

Although an examination of total employment by cluster can help to uncover the existence or nonexistence of the state's relative strengths, an inspection of the distribution of employment within the clusters reveals more about the real development of each cluster. Aggregate differences between the distribution of activity in Kentucky and in the U.S. can often be explained by variations in the detailed sectoral mix of the clusters. When used as a benchmark, the distribution of U.S. sector employment across and within each cluster provides a guide for detecting whether certain industries (i.e., pieces of an extended supplier chain) are under- or over-represented in the state.

It is important to note that particular industries may be relatively over- or under-represented in a state as a result of basic factor conditions firms require (the unique mix of natural resources, land, skilled labor, capital availability, modern transportation and communication infrastructure, and educational institutions), demand conditions, or simple history and luck. It is also important to note that simply identifying under- and over-represented industries in Kentucky's clusters relative to the U.S. average is *not enough* to identify sectors for development focus. Market trends and basic location requirements for each under-represented sector must be investigated in depth before prospects for developing the sector in the state can be fully determined.

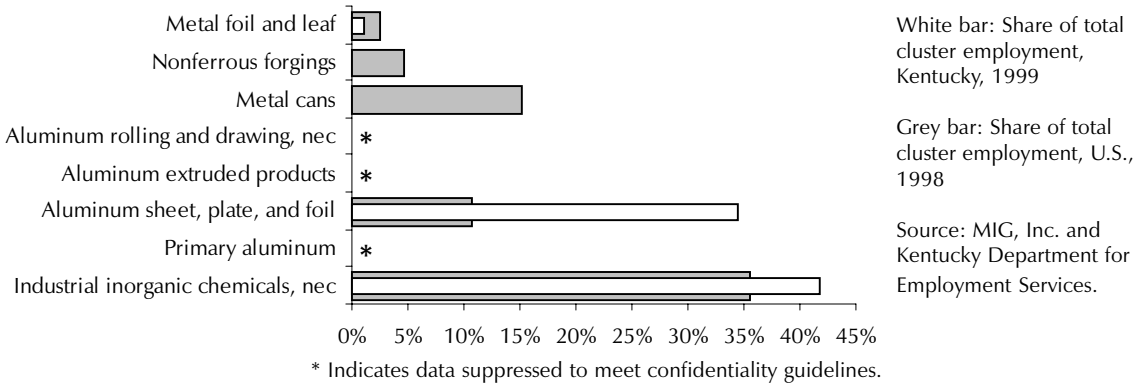

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Figure 4.1
Industry mix, aluminum cluster

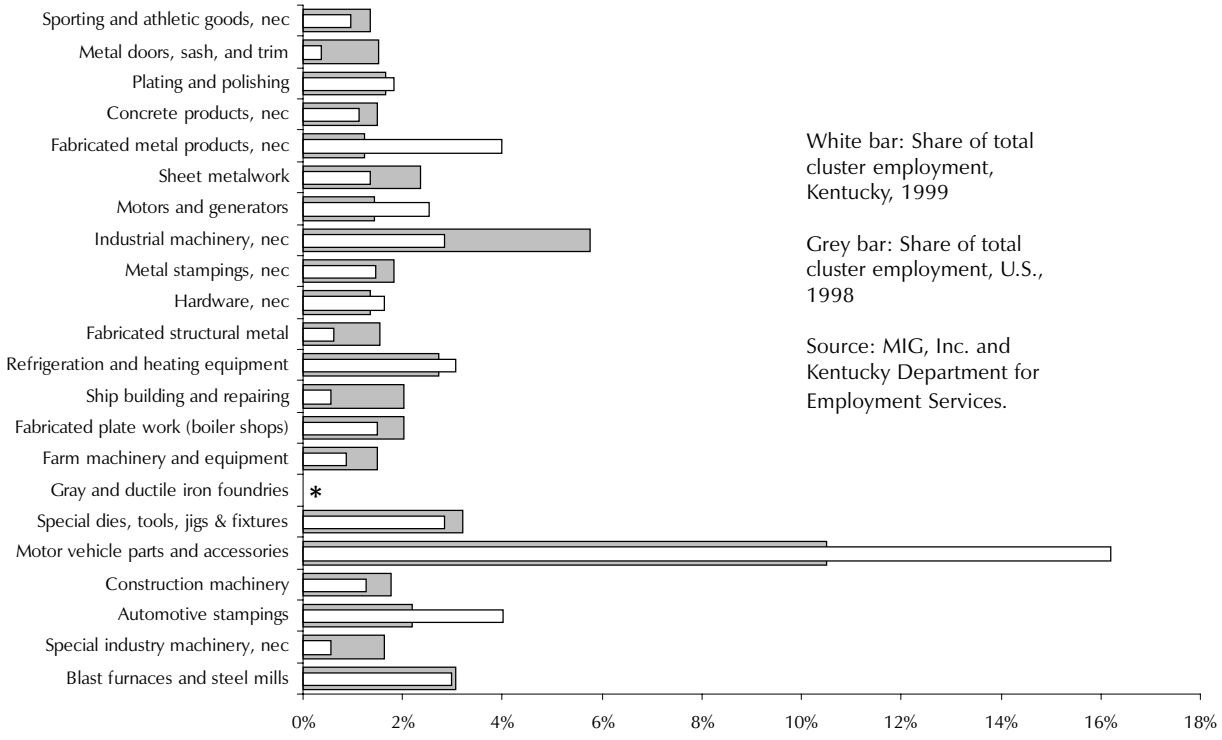

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Figure 4.2
Industry mix, Metalworking and industrial machinery

working cluster match or exceed national wage rates. The high wages are in part due to the development of higher-technology sectors such as automotive stampings, motor vehicle parts and accessories, and special dies/jigs/fixtures (SIC 3544).

Transportation, shipping and logistics. Transportation, shipping and logistics is an important and growing cluster in Kentucky. As of 1999, it employed 58,297 people, or 3.6 percent of all private sector workers in the state. The cluster enjoyed 4.1 and 2.8 percent annual employment growth in Kentucky and the U.S., respectively, between 1989 and 1998. Kentucky's location is ideal for shipping and logistics businesses given its position at the center of the Northeast, Midwest, and South, where almost 80 percent of the U.S. population resides. United Parcel Service's hub and automated sorting facility in Louisville anchors the cluster and has attracted several time-sensitive shippers.

Employment in transportation, shipping and logistics, both in the U.S. and Kentucky, is dominated by three industries: scheduled air transportation (SIC 4512), air courier services (SIC 4513), and non-air trucking and courier services (SIC 421). In Kentucky, those sectors account for 14.7 percent, 19.8 percent, and 44.9 percent of the total cluster employment, respectively. Freight transportation arrangement (SIC 4731) and transportation services, n.e.c. (SIC 4789) have also posted strong employment growth in the state during the 1990s.

Emerging Value-Chain Clusters

We define emerging clusters as those that are of significant absolute and relative size (as measured by a location quotient) and are posting strong growth relative to national trends. Note that the designation is based on past trends—they are the clusters that have emerged over the 1989 and 1999 period—and is not necessarily a prediction that the clusters will continue to expand in the future. There is no guarantee that past trends will continue.

Based on these criteria, emerging clusters in the state include hospitals, labs and specialized medical services; construction materials; chemicals and plastics; wood products; and boat

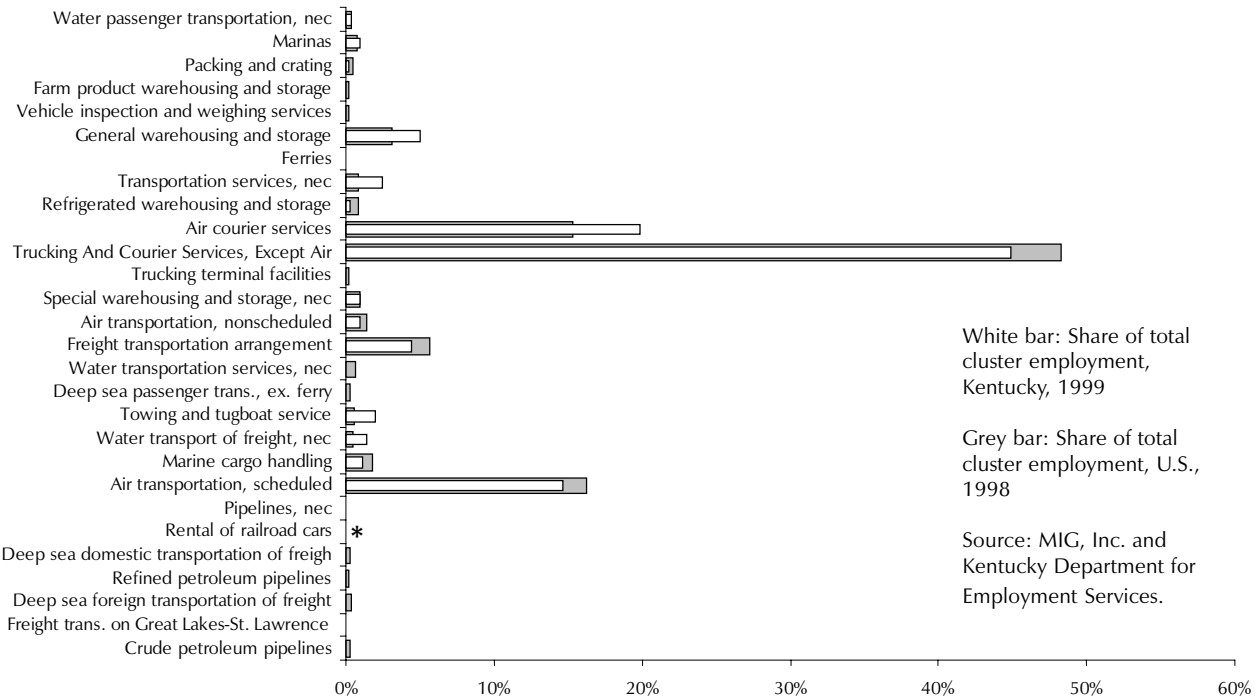

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Figure 4.3
Industry mix, transportation, shipping and logistics

building. All six emerging clusters expanded significantly faster than the national average over the 1989 to 1998 period and posted location quotients near or above 1.0.

Hospitals, labs and specialized medical services. One of the state's largest clusters—hospitals, labs, and specialized medical services—is an emerging strength. The cluster consists of 3,077 establishments and employs nearly 112,000 workers, paying out an average annual wage of $34,361 that is 112 percent of the private sector average. Employment in the cluster is expanding at a rate considerably above the national average (5.2 percent annually versus 3.5 percent U.S. over the 1989-1998 period). The cluster's location quotient (1.05) indicates that it is primarily serving a local market, but its rapid rate of growth suggests that it may be developing exportable specializations.

Hospitals, labs, and specialized medical services is the largest cluster in the U.S., representing 6.8 percent of total U.S. private sector employment. It is also technology-intensive, providing 36.1 percent of total cluster employment in high-tech sectors nationally. In Kentucky, general medical and surgical hospitals (SIC 8062) account for the bulk of employment in the cluster (64.2 percent). The national sectoral distribution is not much different, although the relative importance of the hospital sector is lower, repre-

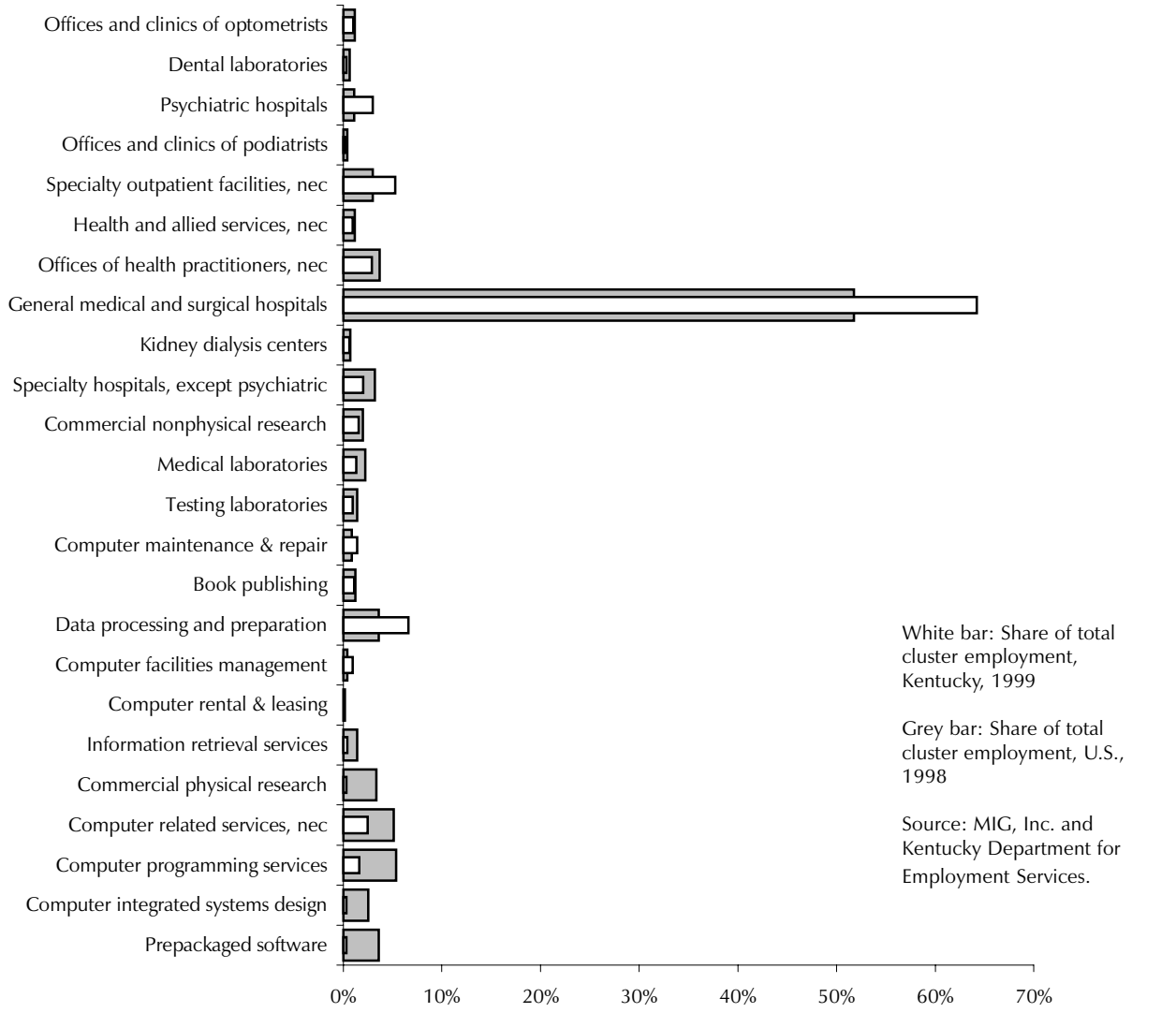

Figure 4.4
Industry mix, hospitals, labs, & specialized medical services

senting about 52 percent of this cluster's total employment. In addition, compared to the U.S. benchmark, Kentucky is under-represented in almost all information technology and computer-related sectoral components of the cluster (SIC 7371, 7372, 7373, 7375, 7379). For example, the computer programming services (SIC 7371) industry claims just 1.6 percent of the cluster's employment in Kentucky, while it represents 5.4 percent of the total cluster employment nationwide.

Employment in the state over the past decade has increased in every sector in the cluster. However, most of the employment growth has occurred in relatively low-wage sectors such as psychiatric hospitals (SIC 8063), specialty outpatient facilities, n.e.c. (SIC 8093), offices of specialized health practitioners, n.e.c. (SIC 8049), and general medical and surgical hospitals.

Construction materials. The U.S. construction materials cluster has grown 0.7 percent annually since 1989 and is dominated by one sector, engineering service (SIC 8711). Engineering services is a high-wage, knowledge-intensive sector, claiming 21 percent of the cluster's employment nationwide.

In Kentucky, the construction materials cluster has expanded faster than the national average and now accounts for 3.3 percent of the total private sector employment. At 14.7 percent, engineering services account for a smaller share of the cluster's employment (the location quotient for the engineering services industry is only 0.68). Kentucky's construction materials cluster is relatively specialized in miscellaneous metal work (SIC 3449), saw blades and handsaws (SIC 3425), converted paper products, n.e.c. (SIC 2679), heating equipment, except electric (SIC 3433), and household appliances, n.e.c. (SIC 3639). Major employment gains during the 1990s occurred in structural wood members, n.e.c. (SIC 2439), wood kitchen cabinets (SIC 2432), wood partitions and fixtures (SIC 2541), sheet metal work (SIC 3444), heating equipment, n.e.c., and miscellaneous metalwork.

Chemicals and plastics. The U.S. chemicals and plastics cluster has wide linkages to a vari-

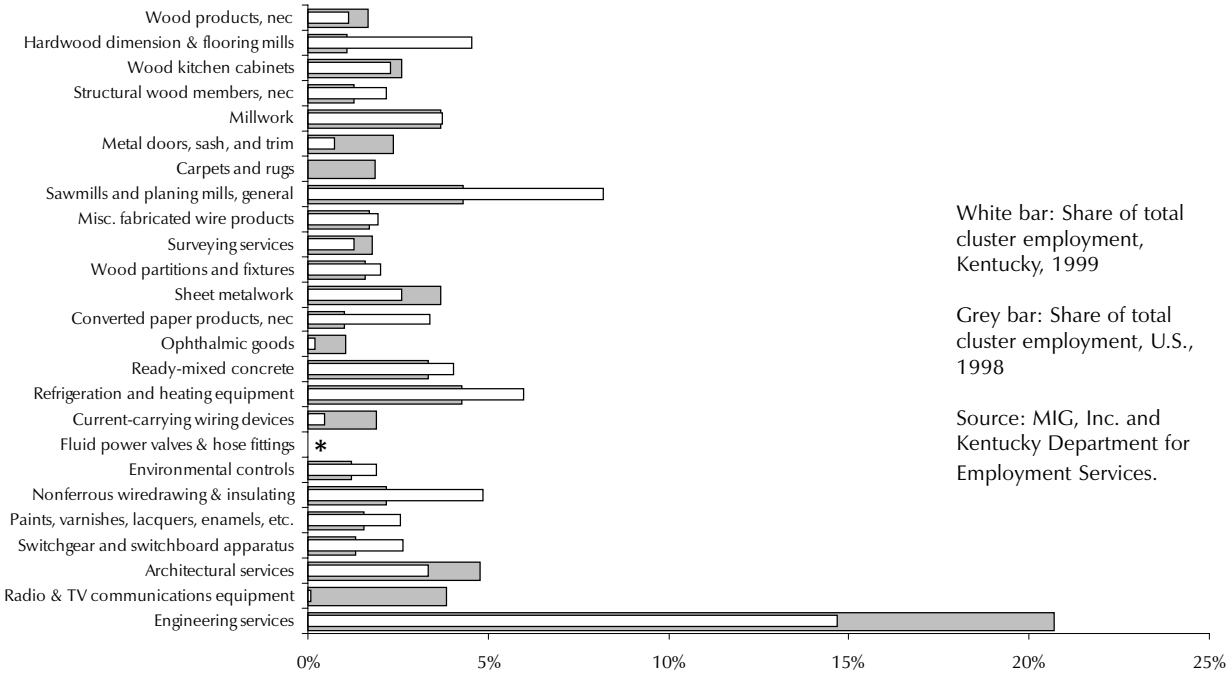

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Figure 4.5
Industry mix, construction materials cluster

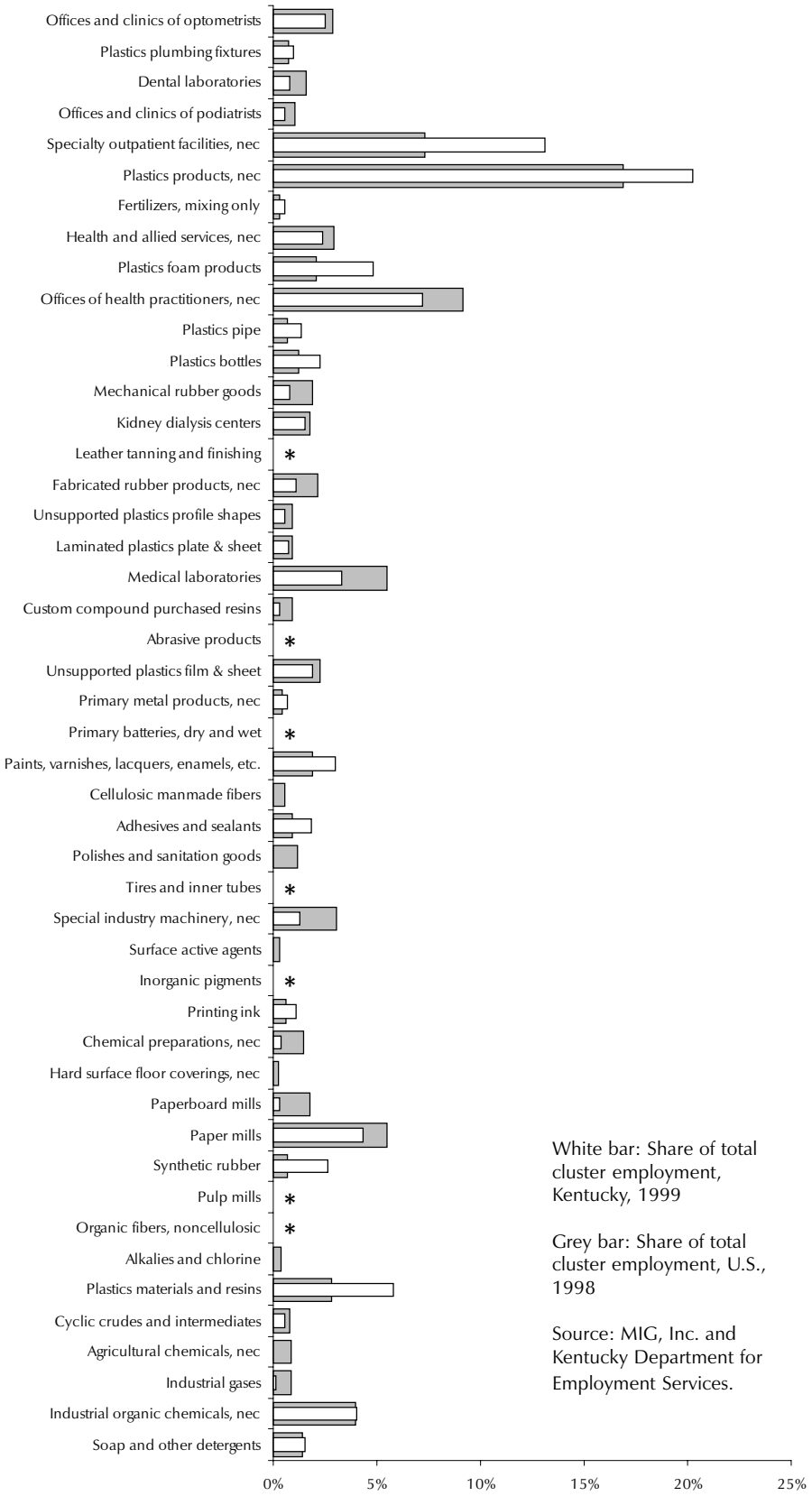

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Figure 4.6
Industry mix, chemicals and plastics

ety of other clusters, a significant number of high-technology sectors, and relatively high wages. A number of key chemicals industries are major suppliers to other core U.S. sectors. Of the 48 industries that compose the cluster, 25 are considered technology-intensive. In addition, 26 industries within the cluster pay among the top wages of all four-digit SIC private sector industries.

Kentucky's chemicals and plastics cluster consists of 113 establishments and slightly over 45,000 workers. The cluster is specialized in specialty outpatient facilities (SIC 8093, a component of the hospitals and labs cluster), plastic materials and resins (SIC 2821), synthetic rubber (SIC 2822), plastic foam products (SIC 3086), and plastic products, n.e.c. (SIC 3089). In Kentucky, the cluster is dominated by two low-wage sectors, miscellaneous plastic products and specialty outpatient facilities, which together account for 33.4 percent of total cluster employment. In general, the chemicals and plastics cluster in Kentucky is not well developed. While there are many under-represented sectors, especially among high-tech and high-wage segments, the cluster has good potential for future growth given its rich linkages to other clusters. Organic and inorganic chemicals (SIC 2812, 2813, 2816, 2865, 2869), a leading industry in the state, is a leading component of the aluminum cluster. It is also tied to the synthetic rubber industry, which is itself a key supplier to the transportation equipment industry.

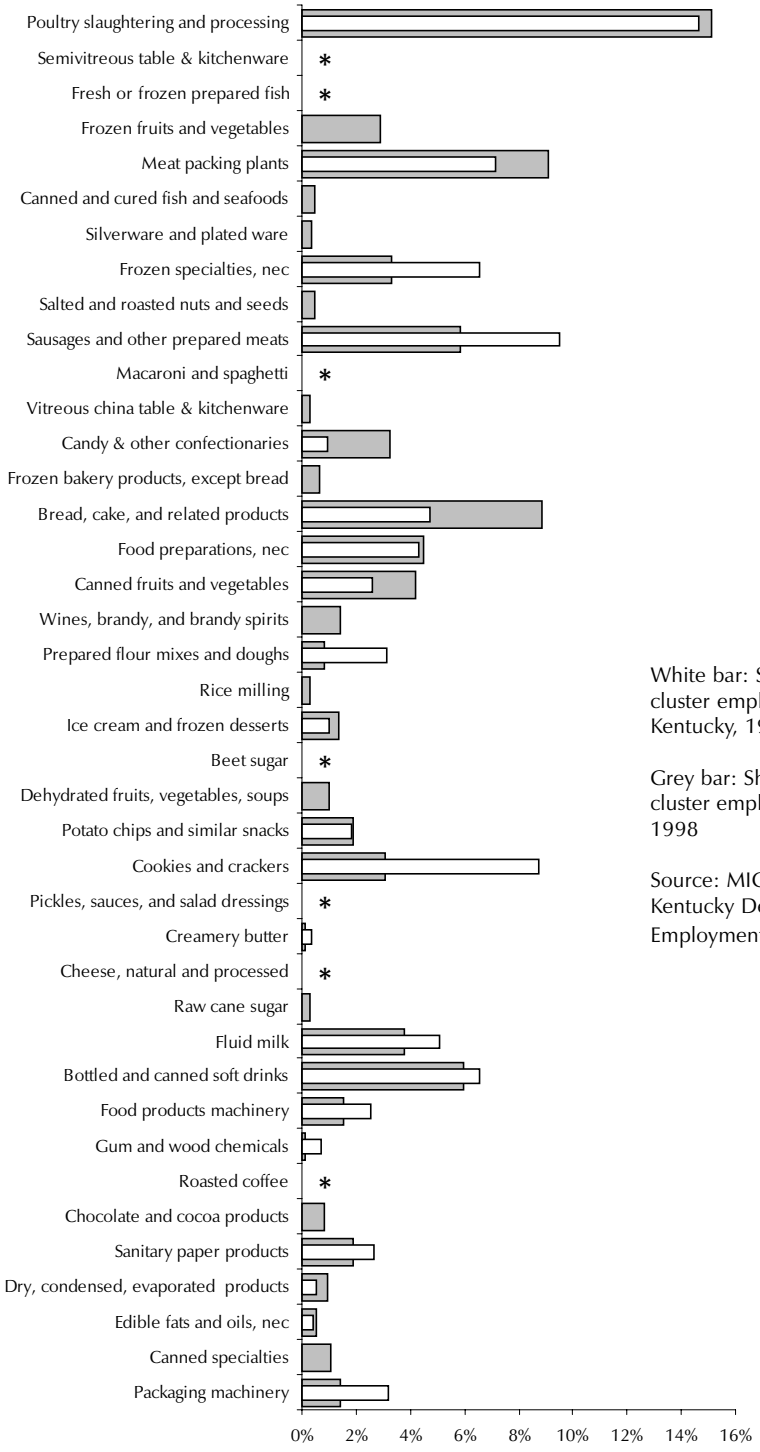
Packaged food products. Employment in the U.S. packaged food products cluster has been relatively stagnant over the last decade. It has seen a meager 0.3 percent annual growth during the 1990s, and many sectors in the cluster have contracted significantly (e.g., malt beverages, fluid milk, and canned fruits and vegetables). However, the packaged food products cluster has experienced strong growth in Kentucky. Employment in the cluster expanded 3.8 percent annually between 1989 and 1998. Over 200 enterprises in the cluster employed 27,445 workers in 1999.

Job gains have not occurred uniformly across all segments of the cluster. Declining industries include meat packing plants (SIC 2011), potato chips and similar snacks (SIC 2096), bread/cake/related products (SIC 2051), while gainers are poultry slaughtering and processing (SIC 2015), sanitary paper products (SIC 2676), frozen specialties, n.e.c. (SIC 2038), and sausages and other prepared meats (SIC 2013). Poultry slaughtering and processing has grown rapidly and now accounts for 14.6 percent of total cluster employment. Another top growth sector is frozen specialties. The state is also a leading producer of packaging machinery (SIC 3565, location quotient 2.28) and products machinery (SIC 3556, location quotient 1.66), both comparatively high-wage sectors.

Wood products and furniture. The U.S. wood products and furniture cluster experienced only very modest employment gains during the 1990s. The cluster is dominated mostly by low-technology, low-wage industries. There is no high-tech sectoral component in the cluster.

Kentucky's wood products cluster is made up of 617 establishments and 15,490 employees. The cluster pays out $448.7 million in wages annually. The cluster experienced strong employment growth during the 1990s (3.4 percent annually between 1989 and 1998 and over 10 percent between 1998 and 1999). Kentucky's wood products cluster is relatively specialized in gum and wood chemicals (SIC 2816), hardwood dimension and flooring mills (SIC 2426), wood containers, n.e.c. (SIC 2449), and wood pallets and skids (SIC 2448). The state has seen large employment gains in paper mills (SIC 2621), mill work (SIC 2431), structural wood members (SIC 2439), wood kitchen cabinets (SIC 2434), and hardwood dimension and flooring mills.

Boat building. While the boat building cluster is small in Kentucky in absolute terms (just over 3,000 workers and 63 establishments), it represents a relatively large concentration of such activity. Employment in the Kentucky cluster grew at a solid 2.5 percent annually between 1989 and 1998, even as it declined by 1.5 percent annually nationwide over the same period. One-third of the cluster's jobs are in the boat building and repairing sector, which itself is concen-



White bar: Share of total cluster employment, Kentucky, 1999

Grey bar: Share of total cluster employment, U.S., 1998

Source: MIG, Inc. and Kentucky Department for Employment Services.

* Indicates data suppressed to meet confidentiality guidelines.

Figure 4.7
Industry mix, packaged food products

trated in south central Kentucky near Lake Cumberland. The industry's real strength is in houseboats and is dominated by smaller, locally-established firms. High-tech segments of the cluster such as turbines and turbine generator sets (SIC 3511), internal combustion engines, n.e.c. (SIC 3519), and machine tools/metal cutting types (SIC 3541) are represented in the state, but they are relatively small. Only internal combustion engines n.e.c. has seen significant employment growth over the last decade.

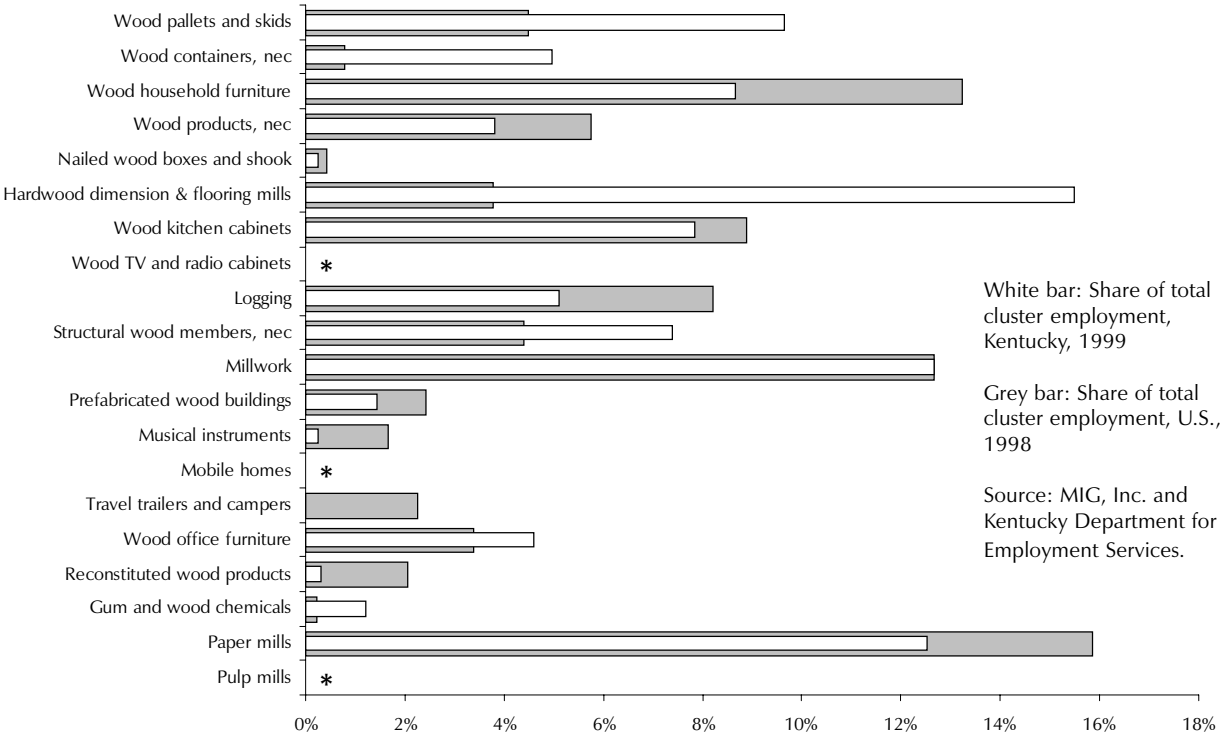
Potential Value-Chain Clusters

Potential value-chain clusters are those that remain comparatively small in size but have exhibited a particularly rapid rate of growth in recent years. The information technology and instruments cluster has not achieved a critical mass in Kentucky in comparison to the rest of the U.S. (its location quotient is 0.54), but it is nevertheless a sizable cluster with a strong rate of growth during the 1990s. In 1999, 245 information technology establishments employed 34,500 workers and paid out $1.4 billion in wages. Employment in the cluster expanded by 3.4 percent between 1989 and 1998, increasing to nearly 11 percent between 1998 and 1999. These rates are considerably above the 1.6 percent annual employment growth for the U.S. information technology cluster.

Given the importance of the information technology cluster in the U.S. economy and its rapid rate of growth in Kentucky, we examine it in detail in Chapter 6.

High-Tech Value-Chain Clusters

By focusing on interdependencies between strictly high-technology industries, the benchmark high-tech clusters provide additional insight into technology trends in the Kentucky economy. What the benchmark clusters show is that Kentucky's technology base is concentrated primarily in heavy industry (motor vehicles, industrial machinery), while high-growth clusters nationwide—communications services and software and pharmaceuticals and medical technolo-



* Indicates data suppressed to meet confidentiality guidelines.

Figure 4.8
Industry mix, wood products and furniture

gies—remain significantly under-represented in the state. These findings are summarized in Figure 4.10, which compares each cluster's degree of specialization against growth trends and size.

Table 4.3 supplies basic statistics on the eight benchmark high-tech clusters. The three largest high-tech clusters in the state are motor vehicle manufacturing, information technology and instruments, and communications services and software. However, information technology/instruments and communications services/software account for a comparatively small share of private sector employment in Kentucky (1.8 and 1.6 percent, respectively, compared to 3.4 and 2.8 percent at the national level). Kentucky's communications services and software cluster posted slightly higher annual employment growth over the 1989-98 period than the U.S. as a whole, but information technology and instruments failed to match U.S. growth rates.

In terms of relative concentration, Kentucky's strongest technology clusters are motor vehicle manufacturing, industrial machinery, and household appliances. Some 260 technology-intensive plants in the motor vehicles value chain employ nearly 52,000 workers and pay out nearly $3 billion in wages annually. The cluster's 1998 location quotient is 2.2, indicating a strong relative specialization for the state. Employment in the cluster also expanded by 6.5 percent annually between 1989 and 1998, compared to just 1.0 percent nationwide. At $56,097, motor vehicles pays the highest annual wage of any technology cluster.

At 13,384 workers, the high-tech industrial machinery cluster is considerably smaller than the motor vehicles cluster. Nonetheless, it represents a large concentration of activity in Kentucky relative to U.S. averages, and it has posted strong growth during the 1990s (though employment did contract by 2.0 percent between 1998 and 1999). The household appliances cluster is dominated by comparatively few small plants (33 in total, employing just under 8,000 workers). The cluster makes up about 0.5 percent of private sector employment in the state, well above the U.S. average of 0.1 percent. But the household appliances cluster has declined sharply during the 1990s: 4.0 percent annually between 1989 and 1998 (compared to a 0.5 percent decline nationwide) and 8.2 percent between 1998 and 1999.

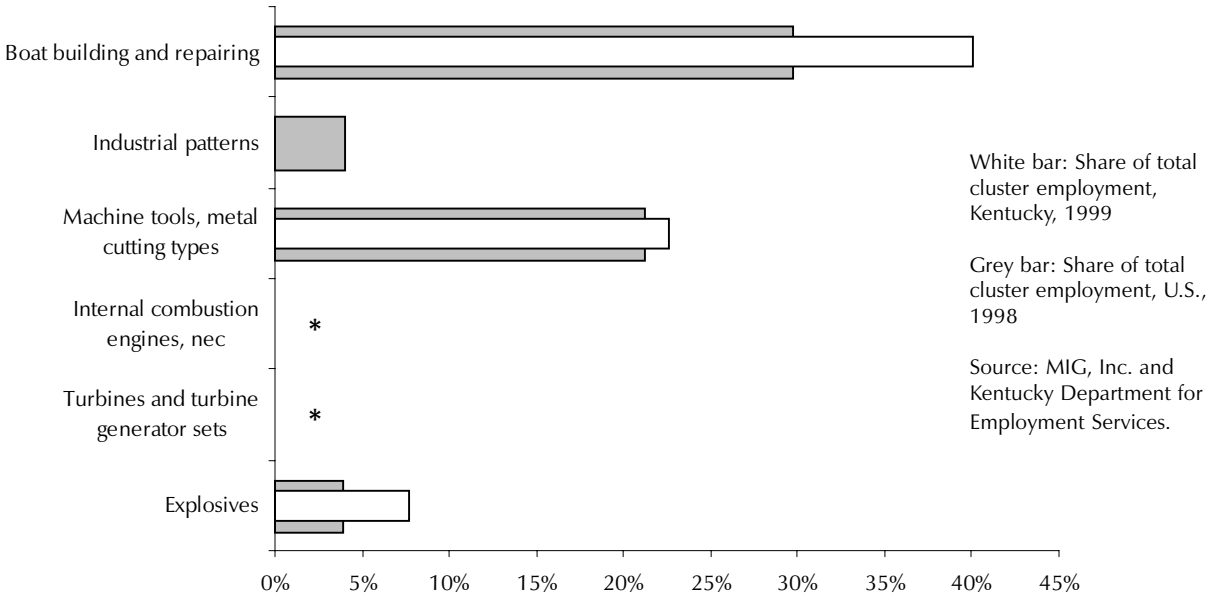


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Figure 4.9
Industry mix, boat building

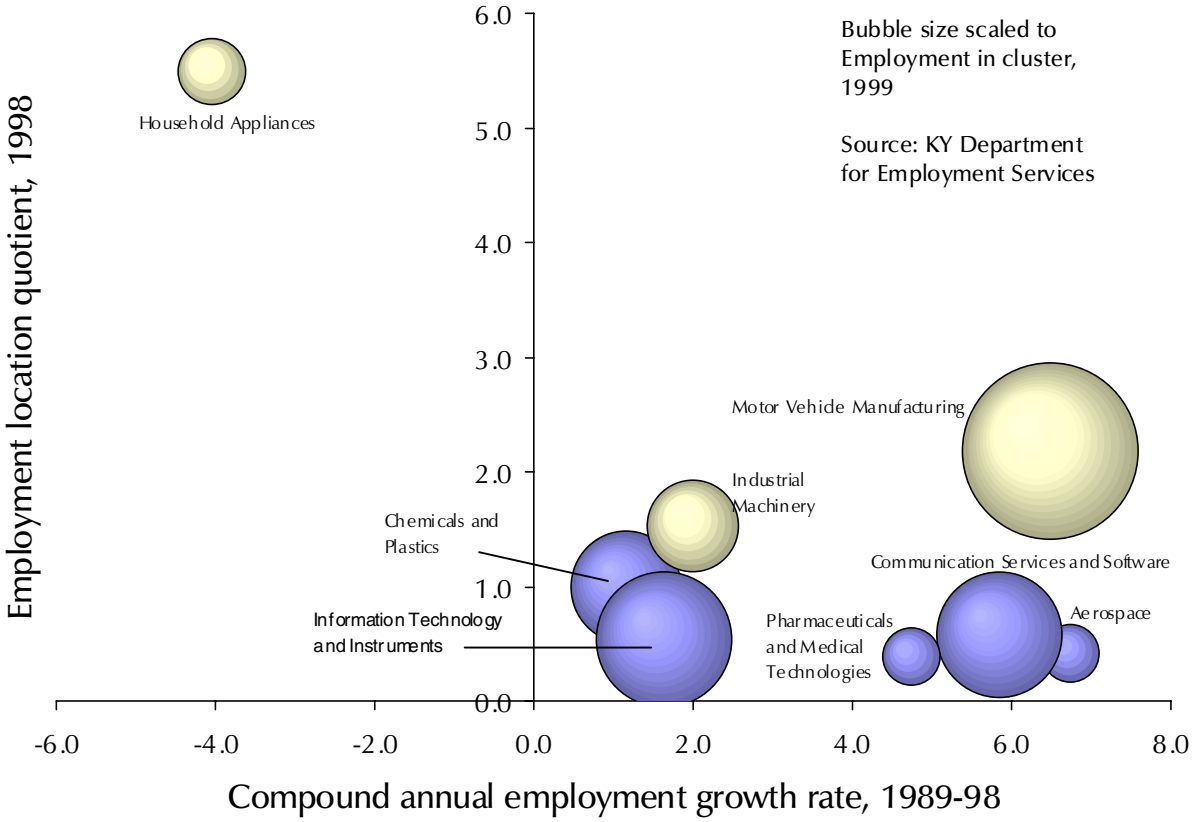

Figure 4.10
Kentucky Technology Value Chain Cluster Trends
(see Table 4.3)

Table 4.3
Summary data, technology clusters, Kentucky

	Employment						Location Quotient		Establishments		Payroll	
		Per establ	% private sector	CAGR KY	CAGR KY	CAGR US		Change		Change		Average
Clusters	1999	ishment	1999	'89-'98	'98-'99	'89-'98	1998	'89-'98	1999	'98-'99	1999	wage
Chemicals and plastics	20,699	26.0	1.26	1.1	4.4	1.1	0.99	-0.17	795	77	869.1	41,987
Information technology and instruments	29,736	23.7	1.81	1.6	7.7	2.2	0.53	-0.11	1,256	234	1,229.0	41,330
Industrial machinery	13,484	68.1	0.82	2.0	-2.4	0.2	1.53	-0.11	198	4	561.3	41,627
Motor vehicle manufacturing	51,640	198.6	3.14	6.5	8.3	1.0	2.18	0.65	260	33	2,896.9	56,097
Aerospace	5,433	28.4	0.33	6.8	-2.9	-3.0	0.41	0.19	191	2	216.7	39,892
Household appliances	7,863	238.3	0.48	-4.0	-8.2	-0.5	5.50	-4.71	33	-6	440.7	56,046
Communications services and software	26,484	11.0	1.61	5.9	11.6	5.2	0.58	-0.02	2,414	308	1,104.2	41,695
Pharmaceuticals and medical technologies	5,824	19.5	0.35	4.8	1.4	1.7	0.38	0.03	298	18	206.0	35,368
Covered Private Sector Employment	1,645,077	16.0	100.0	3.8	2.7	1.8	n/a	n/a	103,057	4,843	49,226.8	29,924
Covered Exportable Employment	572,523	27.5	34.8	2.4	1.8	0.9	n/a	n/a	20,819	1,269	22,503.4	39,306

Note: KY figures for 1998/99 are based on confidential 4th quarter data from the KY Department for Employment Services. Data for 1989 (based on annual figures) are from Minnesota IMPLAN Group, Inc. Clusters are not mutually exclusive. n/a: Not applicable. Data are only for businesses "covered" under unemployment insurance law. CAGR: Compound annual growth rate. Note "exportable" sectors do not include mining and agriculture, as well as locally-traded retail, wholesale, and services.

Labor Skill Clusters

The benchmark labor skill clusters essentially constitute a re-sorting of detailed SIC sectors into groups of industries with similar workforce skill utilization patterns. That is, members of a given benchmark cluster may be viewed as drawing from the same broad labor pool. In some cases, the clusters resemble value-chain clusters, in others they are wholly unique combinations of industries.

Labor skill cluster trends in Kentucky reinforce the findings from the value chain analysis. Major existing skill clusters are standardized heavy industry (driven by growth in industrial machinery and vehicles), low-skill nondurable manufacturing (in decline with contraction of textiles and apparel), health services (growing well above national rates as employment in hospitals and labs, as well as basic medical services, continues to expand), and food and tobacco manufacturing (with evidence that expansion of food production industries draws displaced workers from contracting tobacco). Basic statistics for each labor skill cluster are reported in Table 4.4.

Two of the state's emerging labor skill clusters pay comparatively low wages: building products manufacturing and specialized labor intensive (mobile homes, furniture, fabricated metals, tires). The third, distribution and freight handling, pays among the highest wages and closely parallels growth in the transportation and shipping value chain.

Under-represented in Kentucky are clusters with higher skill demands such as information processing (life insurance, computer and data processing, accounting), high-end information/business services (publishing, advertising, legal services), electronics and measuring devices, chemicals and pharmaceuticals, telecommunications and banking, securities, and science-intensive (aerospace, communications services, engineering services, and R&D labs). However, three of those clusters—securities, science-intensive, and information processing, grew rapidly during the 1990s. Employment in the securities clus-

Table 4.4
Summary data, benchmark labor clusters, Kentucky

	Employment								Establishments		Payroll	
			% private	CAGR			Location Quotient					
		Per estab	sector	KY	KY	US		Change		Change		Average
Clusters	1999	lishment	1999	'89-'98	'98-'99	89-'98	1998	'89-'99	1999	'98-'99	1998	wage
Low skill, non-durable manufactur	69,679	88.7	4.24	-1.7	-5.2	-1.0	1.31	-0.51	786	33	2,444.4	35,081
Information processing	30,287	9.1	1.84	5.5	12.0	4.7	0.57	-0.01	3,330	277	1,169.5	38,613
Low skill miscellaneous manufactu	27,659	41.8	1.68	4.1	-0.7	0.2	1.13	0.14	661	7	804.1	29,072
Standardized heavy industry	91,069	146.4	5.54	5.0	4.7	0.4	1.65	0.35	622	19	4,509.5	49,518
High end information/business ser	21,430	7.8	1.30	2.2	2.6	0.6	0.67	-0.02	2,747	107	800.2	37,341
Distribution, freight handling	55,266	15.0	3.36	-3.6	100.3	2.5	1.13	-0.08	3,673	2,924	2,488.8	45,034
Electronics, measuring devices	24,629	135.3	1.50	-0.5	2.1	-0.7	0.67	-0.12	182	3	981.5	39,850
Chemicals, pharmaceuticals	8,857	71.4	0.54	2.6	-1.0	0.1	0.84	0.00	124	9	470.6	53,129
Telecomm and banking	40,052	12.7	2.43	0.5	1.3	0.6	0.69	-0.16	3,150	251	1,377.9	34,404
Science intensive	13,453	10.5	0.82	5.9	1.3	-0.2	0.52	0.15	1,276	77	584.2	43,424
High tech machinery, instruments	13,303	24.1	0.81	3.6	-1.5	-0.7	0.57	0.08	552	15	520.3	39,114
Petroleum	1,893	49.8	0.12	-6.5	-13.4	-2.5	1.11	-1.19	38	-4	129.0	68,132
Health services	91,488	59.7	5.56	4.8	-0.7	2.3	1.22	0.01	1,532	79	3,046.3	33,298
Specialized labor intensive	34,985	49.7	2.13	1.0	8.0	0.3	0.95	-0.07	704	38	1,205.7	34,464
Food and tobacco manufacturing	16,207	84.4	0.99	0.4	-2.1	-0.4	1.21	-0.20	192	1	711.7	43,912
Securities	6,046	13.2	0.37	14.1	23.5	4.5	0.60	0.33	457	79	421.4	69,694
Building products manufacturing	21,474	34.3	1.31	2.6	2.0	0.7	1.14	-0.02	626	12	676.5	31,503
Covered Private Sector Employme	1,645,077	16.0	100.0	3.8	2.7	1.8	n/a	n/a	103,057	4,843	49,226.8	29,924
Covered Exportable Employment	572,523	27.5	34.8	2.4	1.8	0.9	n/a	n/a	20,819	1,269	22,503.4	39,306

Note: KY figures for 1998/99 are based on confidential 4th quarter data from the KY Department for Employment Services. Data for 1989 (based on annual figures) are from Minnesota IMPLAN Group, Inc. Clusters are not mutually exclusive. n/a: Not applicable. Data are only for businesses "covered" under unemployment insurance law. CAGR: Compound annual growth rate. Note "exportable" sectors do not include mining and agriculture, as well as locally-traded retail, wholesale, and services.

ter expanded by over 14 percent annually between 1989 and 1998, while the science-intensive and information processing clusters each grew by nearly 6 percent annually.

Identifying Potential Replacement Industries. The labor skill clusters are useful for identifying growing industries with the same basic skill requirements as those currently in decline. Thus it is possible to get a sense of in what industries (and at what wages) displaced workers stand good chances of being re-employed given their average skill set. In addition, information from the labor clusters can be used to identify industries with a limited presence in the state but that are high-performing nationwide. Such industries may represent potential development targets depending on market conditions and their unique location requirements.

Twenty industries that posted significant net job losses in Kentucky between 1989 and 1999 are listed in Table 4.5. Over 12,000 jobs were lost in two industries alone: miscellaneous office machines (SIC 3579) and knit underwear mills (SIC 2254). Nine of the twenty sectors are in textiles and apparel (SICs 22 and 23) while two are in electronics (SIC 36). Employment in the cigarette manufacturing industry fell by some 2,000 over the period. While several of the declining industries pay high wages relative to the state private sector average (cigarette manufacturing, household refrigerators and freezers, blast furnaces and steel mills, non-radio telephone communications), many pay below average wages. The average wage across all twenty declining industries is $34,299, 112 percent of the $30,724 private sector average.

Workers displaced from declining industries may eventually be re-employed in the state's major growth industries. Those include motor vehicles (both assembly and automotive stampings), computer peripheral equipment, air courier services, schedule air transportation, securities, engineering services, and computer services (see Table 4.6). The good news for Kentucky is that declines in comparatively low-wage industries are being offset by job gains in comparatively high-wage industries. The twenty sectors with the largest net increases in employment between 1989 and 1999 pay an overall average wage of $47,847, 156 percent of the private sector average and 139 percent of the average among the top declining sectors.

The problem is that workers from some declining sectors may not have the skills neces-

Table 4.5
Major Declining Sectors in Kentucky, 1989-99

		One Year Performance				Ten Year Performance				
		Establishments		Employment		.ocation Quotien		Emp Change		Avg Wage
SIC		1998	1999	1998	1999	1989	1999	Net	CAGR	1999
3579	Office machines, nec	s	s	s	s	s	s	s	s	s
2254	Knit underwear mills	s	s	s	s	s	s	s	s	s
3632	Household refrigerators & freezers	32	27	3,831	3,596	18.05	8.38	-3,248	-6.9	65,771
2322	Men's & boys' underwear, nightwear	7	8	2,265	2,205	16.10	11.25	-2,615	-8.3	37,095
3312	Blast furnaces & steel mills	11	12	3,380	3,077	2.02	1.23	-2,378	-6.2	53,056
6311	life insurance	171	155	2,323	1,885	0.70	0.32	-2,364	-8.6	34,148
2321	Men's & boys' shirts	7	5	878	506	3.02	0.87	-2,183	-16.9	19,296
2111	Cigarettes	4	5	2,467	1,712	7.61	4.09	-2,016	-8.3	82,313
2311	Men's & boys' suits, coats	7	6	1,321	1,210	4.60	2.90	-2,014	-10.3	19,301
2325	Men's & boys' trousers & slacks	20	17	3,944	3,146	4.51	3.40	-1,837	-5.0	20,793
3011	Tires & inner tubes	s	s	s	s	s	s	s	s	s
6035	Savings institutions, Federally chartered	93	97	1,065	1,130	0.83	0.49	-1,474	-8.9	29,891
2339	Women's & misses' outerwear, nec	11	10	1,356	1,022	0.95	0.41	-1,264	-8.6	20,675
2337	Women's & misses' suits & coats	s	s	s	s	s	s	s	s	s
4813	Telephone communications, exc. radio	317	336	6,608	6,733	0.72	0.51	-979	-1.5	43,162
2326	Men's & boys' work clothing	22	22	4,346	3,614	7.39	7.93	-755	-2.1	19,828
2361	Girls' & children's dresses, blouses	n/a	3	n/a	514	4.38	3.44	-749	-9.5	19,897
3625	Relays & industrial controls	10	10	949	905	1.88	0.99	-739	-6.4	41,611
3443	Fabricated plate work (boiler shops)	40	42	1,510	1,543	1.54	0.93	-588	-3.5	45,820
3691	Storage batteries	s	s	s	s	s	s	s	s	s

Source: Kentucky Department for Employment Services. *s* indicates data suppressed to meet confidentiality guidelines.

sary to obtain employment in the state's growth industries. Using the labor skill clusters as a guide, Table 4.7 indicates the most immediate re-employment options for declining industry workers. Table 4.7 was created by identifying growing industries within the same labor skill cluster as each declining industry. Thus, the growing food manufacturing industry in the state presents good employment opportunities for displaced tobacco workers, though likely at lower wages. The plastics and appliances industries may constitute higher-wage employment options for displaced apparel workers. Table 4.7 focuses on the sectors that have suffered the most precipitous declines over the 1990s, but any industry (growing or declining) can be subjected to the same analysis using the labor skill clusters as a guide.

Table 4.6
High Performance Sectors in Kentucky, 1989-99

		One Year Performance				Ten Year Performance				
		Establishments		Employment		Location Quotient		Emp Change		Avg Wage
SIC		1998	1999	1998	1999	1989	1999	Net	CAGR	1999
3714	Motor vehicle parts & accessories	89	99	16,032	16,693	1.33	1.93	9,754	10.2	38,641
3577	Computer peripheral equipment, nec	*s*	*s*	*s*	*s*	*s*	*s*	*s*	*s*	*s*
4513	Air courier services	69	68	11,281	11,555	4.59	1.49	6,078	8.6	80,163
4512	Air transportation, scheduled	33	38	7,983	8,541	0.69	1.03	4,326	8.2	48,853
6211	Security brokers, dealers, & flotation	266	323	4,470	5,547	0.31	0.74	4,241	17.4	67,984
3465	Automotive stampings	19	19	3,615	4,146	0.60	2.31	3,316	19.6	41,749
8711	Engineering services	593	638	7,348	7,737	0.59	0.71	3,220	6.2	48,666
7379	Computer related services, nec	482	625	2,059	2,751	0.31	0.49	2,435	27.2	55,303
4731	Freight transportation arrangement	163	167	2,135	2,601	0.25	0.90	2,206	23.3	37,499
8111	Legal services	2,138	2,194	9,761	9,953	0.68	0.65	2,172	2.8	43,167
3363	Aluminum die-castings	10	9	2,852	3,299	3.21	5.36	2,131	12.2	35,939
3231	Glass products, made of purchased glass	29	27	3,026	2,695	1.19	2.66	1,814	13.2	37,551
7371	Computer programming services	238	278	1,649	1,784	0.09	0.30	1,626	30.9	58,532
3713	Truck & bus bodies	9	12	327	1,669	0.72	2.52	1,286	17.8	36,384
6162	Mortgage bankers & loan correspondent	311	376	2,609	2,273	0.59	0.54	1,280	9.6	37,285
2531	Public building & related furniture	8	8	1,235	1,355	0.24	1.87	1,250	32.9	42,260
4789	Transportation services, nec	33	30	1,279	1,458	1.74	3.34	1,232	23.0	38,881
8069	Specialty hospitals, except psychiatric	12	10	2,409	2,283	0.55	0.66	1,140	8.0	39,921
7376	Computer facilities management	13	17	1,069	1,102	0.04	2.44	1,088	62.4	74,138
3462	Iron & steel forgings	8	10	918	1,055	0.95	2.03	655	11.4	40,300

Source: Kentucky Department for Employment Services. *s* indicates data suppressed to meet confidentiality guidelines.

Table 4.7
Possible Replacement Sectors to Declining Industries

Declining Sectors	Labor Clusters	Alternative Sectors	Average Wage
Tobacco products	Food/tobacco manuf	Food manufacturing products	$48,174
SIC 2011		SIC 204, 208, 295	
Men's and women's apparel and mills	Low skill, nondurable mfg	Plastics/rubber products and household appliances	$50,385
SIC 2254, 231, 232, 233, 236, 3632		SIC 282, 308, 353, 363	
Tires/inner tubes/fabricated plate	Specialized labor intensive	Furniture and metalworking	$38,125
SIC 3011, 3443		SIC 253, 339, 344, 347, 399	
Blast furnaces and steel mills	Standardized heavy industry	Aluminum products and motor vehicle manufacturing	$40,637
SIC 3312, 3443		SIC 335, 336, 356, 371	
Low-tech machinery and electronic equip.	Electronics/measuring devices	Computer and communication equipment	$51,993
SIC 3579, 3625, 3691		SIC 357, 366	
Telecomm and savings institutions	Telecomm and banking	Loan/credit institutions	$41,000
SIC 4813, 6035		SIC 614, 616	
Insurance	Information processing	Computer services	$55,112
SIC 6311		SIC 737	

Source: Authors' calculations and Minnesota IMPLAN Group's ES-202 files.

CHAPTER FIVE

Spatial Clusters and Cross-Border Linkages

Knowledge of Kentucky's unique industry clusters is important for designing economic development strategies that capitalize on existing and emerging economic strengths. However, Kentucky's economy should be understood in the context of a broader region that encompasses parts of neighboring states. The economies of the northern Kentucky counties of Boone, Campbell, Gallatin, Grant, Kenton, and Pendleton have close ties to southern Ohio and the Cincinnati metro area as well as southeastern Indiana. Likewise, the economies of southern and southwestern Indiana (particularly in the Louisville and Evansville areas) and northern Tennessee (north of Nashville) are linked, though to a more limited extent than in the case of the Cincinnati metro area, to nearby Kentucky cities and counties. Because industrial clusters do not respect state boundaries, it is necessary to broaden the focus beyond Kentucky to fully understand emerging industrial trends and opportunities.

In addition, the most well-developed clusters tend to concentrate in particular regions. Indeed, spatial patterns in cluster firm locations and employment can provide additional clues as to the significance of a given industry cluster in a state. Knowledge of where particular clusters are concentrated permits better targeting of economic development strategies and programs as well as prediction of the likely regional impact of growth and decline in various industries. For example, Kentucky's contracting textile and apparel clusters are especially concentrated in the south along the border with Tennessee, while key growth clusters (transportation and shipping, information technology, and motor vehicles) are concentrated in the central and northern parts of the state.

This chapter does two things. First, it examines cluster trends in Cincinnati and northern Kentucky. Second, it maps the location of selected clusters with significant regional concentrations in Kentucky and neighboring counties in Illinois, Indiana, Ohio, West Virginia, Virginia, and Tennessee. Detailed maps of all existing, emerging, and potential value-chain clusters identified in Chapter 4, as well as several other clusters with significant spatial concentrations, are provided in the Appendix.

Cluster Trends in the Cincinnati Metro Area

By comparing cluster trends in the Cincinnati metro area as a whole with trends in northern Kentucky alone, it is possible to identify areas of industrial strength in the southwestern tip of Ohio and southeastern corner of Indiana that are already affecting growth and development in Kentucky, and vice versa. Tables 5.1 and 5.2 profile major value-chain and labor clusters in the two areas. Note that the Cincinnati profile is based on trends in *all* counties in the metro area, including those of northern Kentucky. The northern Kentucky profile is based on an analysis of industry trends in the following Kentucky counties: Boone, Campbell, Gallatin, Grant, Kenton, and Pendleton. Appendix Tables 4-9 contain the detailed data from which Tables 5.1 and 5.2 were derived.

Key value-chain clusters in Cincinnati include the growing transportation and shipping, aluminum, and chemicals and plastics clusters and the declining (in terms of employment) metalworking and industrial machinery, boat building, and aerospace clusters. Emerging clusters include banking and advertising, motor vehicle manufacturing, primary nonferrous metals, and packaged food products. Technology-intensive value chains like information technology, pharmaceuticals, and hospitals and labs are comparatively under-represented in the region, though fast growth relative to the nation classifies information technology and legal services as potential clusters. Cincinnati's workforce favors continued development of light and heavy industry: high-skill labor clusters are relatively small, though there is some growth in the science-intensive, high-end information/business services, and telecommunications and banking labor clusters.

What characterizes northern Kentucky is the even heavier dependence on traditional manufacturing (metalworking and industrial machinery, motor vehicles, packaged food products) than the metro area as a whole and even greater under-representation of information technology. The chemicals and plastics cluster (both the broader cluster and its high-tech segments) is emerging as a strength in northern Kentucky, and is already an important specialization for the region as a whole. Two key technology value chains—information technology/instruments and communications services/software—account for just 0.6 and 1.0 percent, respectively, of private sector employment in northern Kentucky, compared to 1.8 and 2.3 percent in Cincinnati as a whole and 3.4 and 2.8

Table 5.1
Profile of Cincinnati Clusters

	Value-Chain Clusters	**Trend**
Existing	Transportation, shipping & logistics	Growth
	Aluminum	Growth
	Chemicals and plastics	Growth
	Metalworking and industrial machinery	Decline
	Boat Building	Decline
	Aerospace	Decline
Emerging	Banking and advertising	Growth
	Motor vehicle manufacturing	Growth
	Primary nonferrous metals	Growth
	Packaged food products	Growth
Potential	Information technology and instruments	Growth
	Legal services	Growth
	Technology-intensive Value Chain Clusters	
Existing	Chemicals and plastics	Growth
	Industrial machinery	Decline
	Aerospace	Decline
Emerging	Motor vehicle manufacturing	Growth
Potential	Information technology and instruments	Growth
	Labor Skill Clusters	
Existing	Standardized heavy industry	Growth
	Low skill miscellaneous manufacturing	Decline
	High tech machinery, instruments	Decline
	Chemicals, pharmaceuticals	Growth
	Food and tobacco manufacturing	Growth
Emerging	Securities	Growth
	Distribution, freight handling	Growth
	High end information/business services	Growth
Potential	Science intensive	Growth
	Telecomm and banking	Growth

Note: Clusters are not mutually exclusive. For counties in Indiana (Dearborn, Ohio), Kentucky (Boone, Campbell, Gallatin, Grant, Kenton, Pendleton), and Ohio (Brown, Clermont, Hamilton, Warren).

percent in the U.S. Northern Kentucky's strongest cluster may be transportation, shipping and logistics. Employment in the cluster (now at near 14,000) has expanded by over 9 percent annually since 1989.

Regional Clusters in Kentucky and Neighboring States

We used two approaches to identify sub-state concentrations of various clusters. First, we used employment by county in Kentucky and neighboring states to calculate a statistical measure of spatial association that helps pinpoint groups of counties where given clusters are of significant size. High values of the measure, which is called a local *G* statistic, indicate that the given county is proximate to other counties with similarly high levels of cluster employment. Thus the *G* statistic is essentially an *inter-county* spatial concentration measure; an isolated county with a lot of employment in a given cluster but surrounded by counties with very little cluster activity would not be identified. The use of the *G* in the present context implies that localized industry clusters are significant only once they encompass a broader region than a single county.[11]

Our second approach acknowledges that a high concentration of activity in a single county, even if neighboring counties have a completely different industrial base, may be of policy interest. Specifically, we calculated employment location quotients by county for selected clusters (including all identified existing, emerging, and potential clusters). Maps of the *G* statistics and location quotients thus provide complementary pictures of the regional distribution of cluster activity in Kentucky as well as important localized clusters in neighboring states. Note that employment data for this analysis are from 1997, the latest year (at the time of this writing) for which consistent county-level employment data were available for all states. The 1997 data mean that some recently-developed clusters (e.g. transportation, shipping and logistics) are not effectively captured in this analysis.

To illustrate, Figures 5.1 and 5.2 map the county *G* statistics and location quotients for the motor vehicle manufacturing cluster. Figure 5.1 reveals extensive geographic concentrations of vehicle manufacturing in Ohio, Indiana, and Tennessee (darker shades on the map indicate higher values of *G*, with the darkest shade indicating statistical significance). The degree of spatial concentration in Kentucky is much more modest, though northern Kentucky, greater Lexington, Henderson, Owensboro, and Bowling Green are part of localized complexes of vehicle manufacturing activity. The distribution of vehicle manufacturing employment along Interstates 75 and 65 is very clearly illustrated. Certainly, the state is at the center of extensive southern U.S. vehicle manufacturing production.

Figure 5.2 provides some indication of why the *G* analysis found comparatively few localized clusters of vehicle manufacturing activity in Kentucky. Counties with significant

Table 5.2
Profile of Northern Kentucky Clusters

	Value Chain Clusters	**Trend**
Existing	Transportation, shipping & logistics	Growth
	Metalworking and industrial machinery	Growth
	Motor vehicle manufacturing	Growth
	Packaged food products	Growth
Emerging	Banking and advertising	Growth
	Chemicals and plastics	Growth
	Technology-Intensive Value Chain Clusters	
Existing	Industrial machinery	Growth
Emerging	Chemicals and plastics	Growth
Potential	Motor vehicle manufacturing	Growth
	Labor Skill Clusters	
Existing	Distribution, freight handling	Growth
Emerging	Standardized heavy industry	Growth
	Low skill, non-durable manufacturing	Growth
	Low skill miscellaneous manufacturing	Growth
	Securities	Growth
	Building products manufacturing	Growth
Potential	Telecomm and banking	Growth
	High end information/business services	Growth

Note: Clusters are not mutually exclusive. For Boone, Campbell, Gallatin, Grant, Kenton, and Pendleton counties.

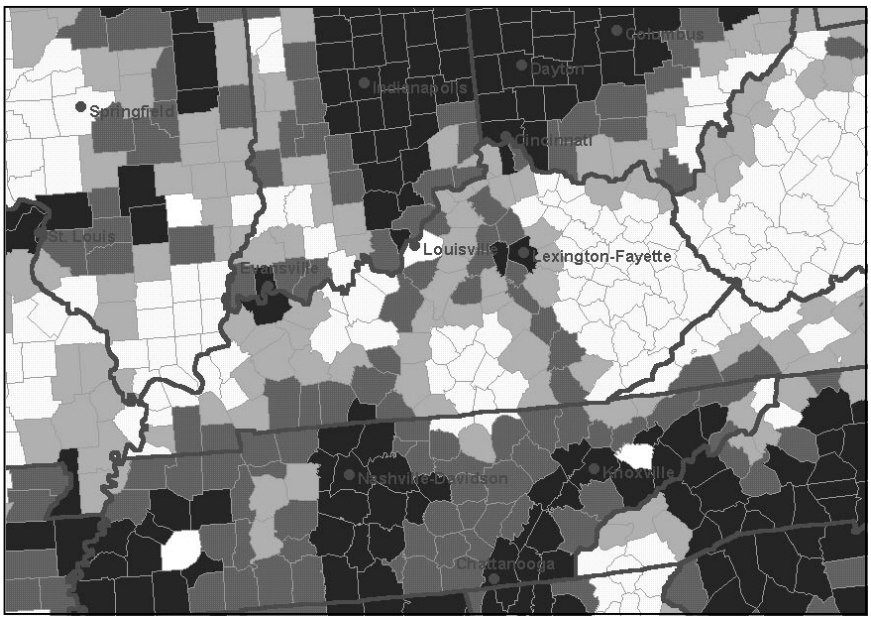

Figure 5.1
Regional clusters, motor vehicle manufacturing

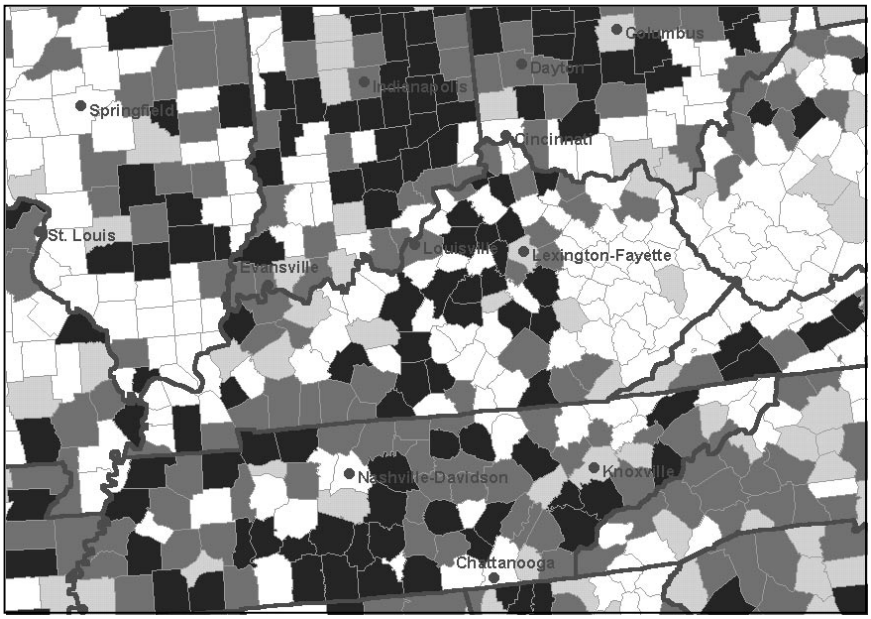

Figure 5.2
County specializations, motor vehicles

vehicle production tend to be more isolated from one another than in Tennessee, Ohio, and Indiana. This pattern would be consistent with a Kentucky automotive industry that is still dominated by comparatively few large plants located in peripheral locations where land and labor costs are modest. As Kentucky's automotive industry develops and the presence of suppliers continues to grow, increased spatial clustering will likely be observed. It also should be noted that the current pattern indicates that the automotive industry's rise in Kentucky has had a fairly extensive spatial impact on the state; though the center of the state enjoys the bulk of the employment, the industry also has a strong presence in western Kentucky.

Two value-chain clusters that are highly concentrated in the state are transportation, shipping, and logistics and boat building. Transportation, shipping and logistics has its strongest presence in the Louisville, northern Kentucky/ Cincinnati, and Evansville, Indiana areas. According to Figure 5.3, the cluster's presence in the greater Louisville area actually appears modest. But this impression is primarily a function of the underlying data (1997 employment) that fail to capture very recent substantial growth associated with the UPS hub.

Boat building (namely houseboats), while a fairly small cluster, is an example of a strong rural cluster with important linkages to similar clusters in Tennessee. Kentucky's boat building cluster is concentrated around Lake Cumberland west of Interstate 75 (see Figure 5.4). The cluster benefits from proximity to similar production, as well as demand, in eastern Tennessee. Less well-known are concentrations of boat building activity in Cincinnati and northern Kentucky and southern Indiana.[12]

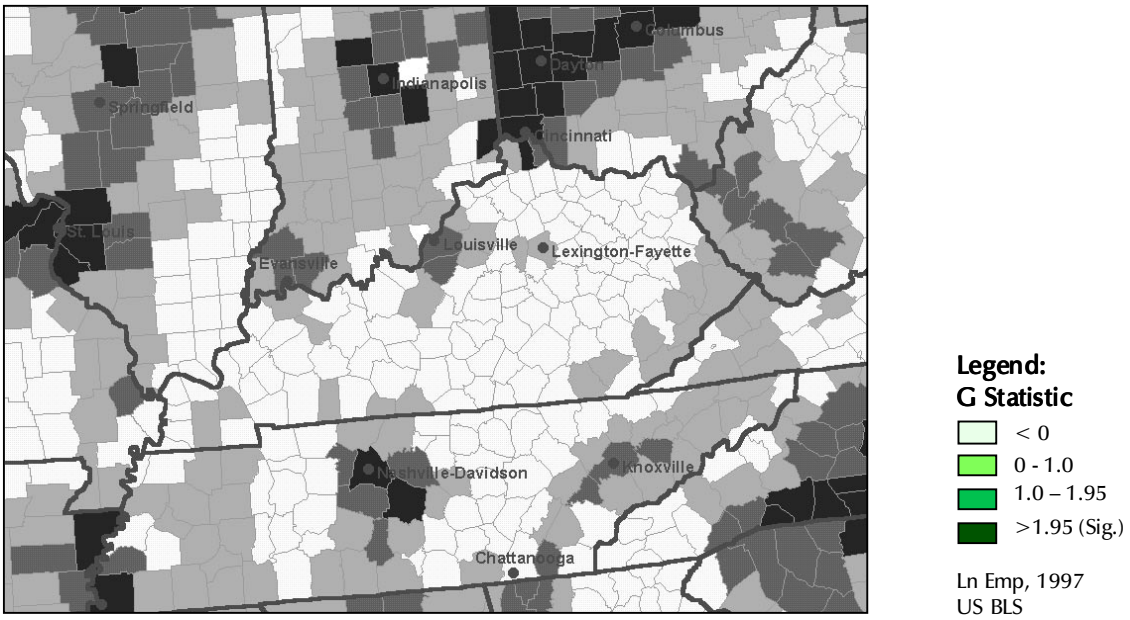

Figure 5.3
Regional clusters, transport, shipping, logistics

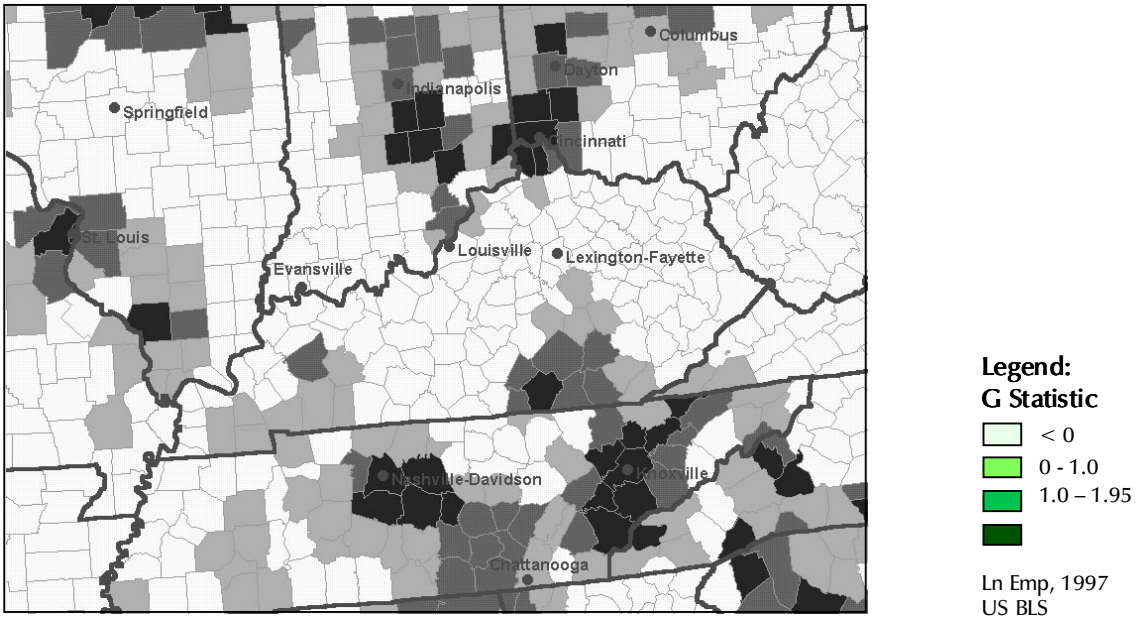

Figure 5.4
Regional clusters, boat building

CHAPTER SIX

Case Studies

This chapter explores trends in three clusters: one existing (vehicle manufacturing), one potential (information technology), and one that is of particular policy importance given the state's university research strengths and concern with nurturing small, technology-intensive entrepreneurial companies (biotechnology).

The motor vehicles and information technology clusters are critical to Kentucky's future for different reasons. Motor vehicles is one of the state's core competitive advantages as well as one of its largest contributors to gross state product, employment, and payroll. The emergence of vehicle production in Kentucky has meant the location of top flight international companies and their technical and management personnel (in both assembly and supplier sectors), additional resources and investments in college and university education and training, and an image of the state as a major player in a core global industry. Kentucky's capitalization on the general southern shift of U.S. vehicle production has resulted in the strong growth of higher-wage, comparably-skilled jobs for workers displaced from the declining textiles, apparel, and tobacco industries. Kentucky can make a credible claim to a significant motor vehicles industry cluster, one that is both large and diverse in terms of its component sectors and firms.

By contrast, information technology in Kentucky is neither large nor diverse. In fact, it is dominated by comparatively few companies and lower-technology IT activities (back office processing and call centers). At present, its importance to the state derives primarily from its central role in regional and state economies everywhere: not only is IT one of the fastest-growing areas of the U.S. economy, especially in software and computer services, but it is also commonly viewed as an "enabling" industry, i.e. a supplier of critical infrastructure and services for nearly every industry. While the IT "cluster" in Kentucky is under-represented compared to national trends, it is growing fast and will likely remain a source of strong job growth for years to come.

A third cluster of some policy interest is biotechnology. As a cluster, biotechnology is not easily captured through analyses based on standard industry categories (even when those industries are classified at the highly detailed four-digit level). Thus, biotechnology is not identified among any of the bench-

mark definitions. However, few states in the U.S. are not implementing at least some initiatives to develop this potential high-growth cluster. Private sector biotechnology enterprises often have very clear linkages to university research activities. Therefore, biotechnology is a natural candidate for efforts to pursue knowledge-based or innovation-oriented economic development. Because commercial biotechnology activity is only now emerging in Kentucky, its future as a competitive advantage in the state remains very uncertain. Findings from a survey of biotech companies in Kentucky conducted as part of this study indicate that inadequate venture capital, insufficient public sector support, an absence of opportunities for inter-firm collaboration, and unavailability of specialized suppliers are key concerns of this nascent cluster.

Motor Vehicle Manufacturing: An Existing Cluster

Motor vehicle manufacturing is a particularly important cluster in the U.S. economy due to its size, technological intensity, diverse linkages to other industries, and high-wage jobs. Nationwide, 44 percent of the cluster's employment is in sectors designated as "technology-intensive" under commonly accepted definitions. That rate is among the highest of the 28 benchmark clusters. Motor vehicle manufacturing touches nearly every other manufacturing industry to some degree, as well as a great many producer services sectors.[13]

A long-time focus of Kentucky's economic development strategy, the motor vehicle industry accounted for a substantial part of the state's strong employment and wage growth in the 1980s and 1990s. Kentucky has been very proactive in recruiting and retaining vehicle manufacturers and their core suppliers. Active worker training programs through the Kentucky university and community college system, attractive business incentives, and technical assistance through the University of Kentucky (e.g. its Center for Robotics and Manufacturing Systems), and strong leadership from the governor's office have all been praised by motor vehicle producers in the state. Growth in the cluster has helped smooth Kentucky's transition from an economy reliant on natural resource-based activities and low-wage, labor-intensive manufacturing, to one built on heavier, more technology-intensive industry. Real wages have risen as a result.

The challenge for Kentucky is how to fully capture and leverage the spectacular growth of vehicle production in the state to the benefit of other emerging industries. What limited data are available, as well as a large volume of anecdotal evidence, suggests there is comparatively little "home-grown" activity in the cluster, in either assembly or the extended supply chain.[14] Major assemblers and their suppliers are branch facilities of larger corporations that are themselves anchored outside the state. That means that critical decisions about the future of the industry are made outside Kentucky. Kentucky is primarily a site of production, not innovation, research, or development; activities that offer even higher wages and help build the technology infrastructure necessary to develop other technology competencies. Entrepreneurial opportunities in the vehicle cluster in Kentucky may be limited given the dominance of large branch plants with established supply chains.

The pursuit of the motor vehicle industry in Kentucky is, in essence, an export-led economic development strategy. The state has sought to grow by attracting major plants from outside that would export goods to the rest of the nation and world. Local multiplier effects are driven by strong external demand for the cars and trucks built in Kentucky. But in the long run, export-led strategies work best when the growth that is realized leads to the development of the technology infrastructure, human capital, and entrepreneurial conditions necessary to foster locally-based, innovative industries both inside and outside of the vehicle cluster. The success of the pursuit of vehicle production as a competitive advantage in Kentucky will ultimately be judged on whether it helped bring the infrastructure and conditions into place for the development of homegrown firms and industries.

Characteristics and Trends. Kentucky's motor vehicle manufacturing cluster is anchored by

Toyota (in Erlanger and Georgetown), Ford (in Louisville), and General Motors (in Bowling Green). The cluster is diverse, with at least some activity and employment in 37 of 39 component sectors as of 1999. In 1998, the cluster accounted for roughly 5.1 percent of total private sector employment and 14.5 percent of total exportable industry employment statewide, compared to 2.8 and 7.8 percent, respectively, nationwide. Motor vehicle cluster employment in the state expanded by 5.7 percent annually during the 1990s, five times the rate of growth for the U.S. as a whole.

A striking feature of the state's motor vehicle cluster is its solid share of technology-intensive employment and its comparatively high average wage. Conventional wisdom holds that large automobile manufacturers are located in southern states such as Kentucky, South Carolina, and Alabama to take advantage of relatively inexpensive labor. It is also commonly believed that the supply chain for motor vehicle manufacturing in those states is mostly dominated by less sophisticated labor-intensive industries.

But those assumptions do not hold in the Kentucky case. Fifty-six percent of motor vehicle cluster workers in Kentucky are employed in technology-intensive industries, compared to 44 percent nationwide. In addition, the average wage in Kentucky's motor vehicle cluster in in 1998 was $44,025, about $3,000 higher than the national average. In fact, workers at Toyota's Georgetown plant are paid at rates comparable to those offered by Detroit-based manufacturers. Characterizing Kentucky automotive plants' location in Kentucky as simply a matter of the pursuit of a workforce willing to accept lower wages is too simplistic; indeed, industry experts interviewed for this study argued the state competes favorably with traditional automotive states such as Michigan and Ohio on a number of dimensions (infrastructure, business climate, production workforce skill).

Detailed Industry Mix. The motor vehicle manufacturing cluster, both in Kentucky and nationwide, is dominated by three sectors: motor vehicles and car bodies (SIC 3711), motor vehicle parts and accessories (SIC 3714), and miscellaneous plastic products (SIC 3089). Together, these three industries account for 54 percent of total cluster employment in Kentucky and 47 percent in the U.S. Motor vehicles/car bodies and motor vehicle parts/accessories are particularly important because of their relatively high degree of technology intensity and comparatively high wages. Over the last decade, the top employment growth sectors within the cluster were motor vehicle parts and accessories (114 percent growth between 1989 and 1999), motor vehicle parts and accessories (141 percent), automotive stampings (400 percent), and truck and bus bodies (336 percent).

In general, Kentucky's motor vehicle cluster is highly diverse and well developed (see Figure 6.1). Nineteen of the top 20 sectors in terms of employment size (which together account for 91 percent of total cluster employment) constitute specializations in the state; that is, Kentucky's private sector share of employment in the nineteen sectors is well above the comparable share for the U.S. as a whole (the employment location quotients for the nineteen industries vary from 1.1 to 7.0). Motor vehicles and car bodies (location quotient of 3.6), motor vehicle parts and accessories (1.8), automotive stampings (2.2), and engine electrical equipment (3.0) are examples. It is also worth noting that most of the state's specializations are among the more technology-intensive, high-wage segments of the cluster. Several labor-intensive, low-technology, lower-wage segments are under-represented (e.g., motor homes, fabricated rubber products, mechanical rubber goods, and automotive trimmings).

Considerable insight into the cluster can be gained by studying the relative presence or absence of key supplier sectors to its core industry segments. For example, key suppliers to motor vehicle parts and car bodies include motor vehicle parts/accessories, automotive stampings, miscellaneous plastic products, automotive and apparel trimmings, and refrigeration and heating equipment. Together, those five sectors employ over 6,600 people in Kentucky and post an employment location quotient of 1.6. Even though we lack information on the direct trad-

ing patterns of Kentucky companies, that is nevertheless at least modest evidence of the strength of the supply base for major assemblers in the state. Table 6.1 identifies the top five supplier sectors for ten core vehicle cluster industries. Other core cluster industries with a strong supply base in Kentucky include motor vehicle parts and accessories, miscellaneous plastics, refrigeration and heating equipment, and internal combustion engines n.e.c.

Kentucky's principal weakness is in the computer, electronics, and information technology segments of the cluster. While the engine electrical equipment industry is well-represented in the state (over 3,100 workers and a location quotient of 3.0), its own high-tech supplier industries such as semiconductors and electronic components have only a minimal presence (in semiconductors, no presence at all). Indeed, the engine electrical equipment sector is dominated by a single Hitachi branch plant located in Harrodsburg. In interviews, industry experts attributed the lack of related electronics and computers activity to a dearth of skilled technicians and engineers, with several arguing that graduates from the state's colleges and universities are too few in number and sometimes inadequately prepared.

The problem can be illustrated vividly with an analysis of Kentucky's occupational mix. Spe-

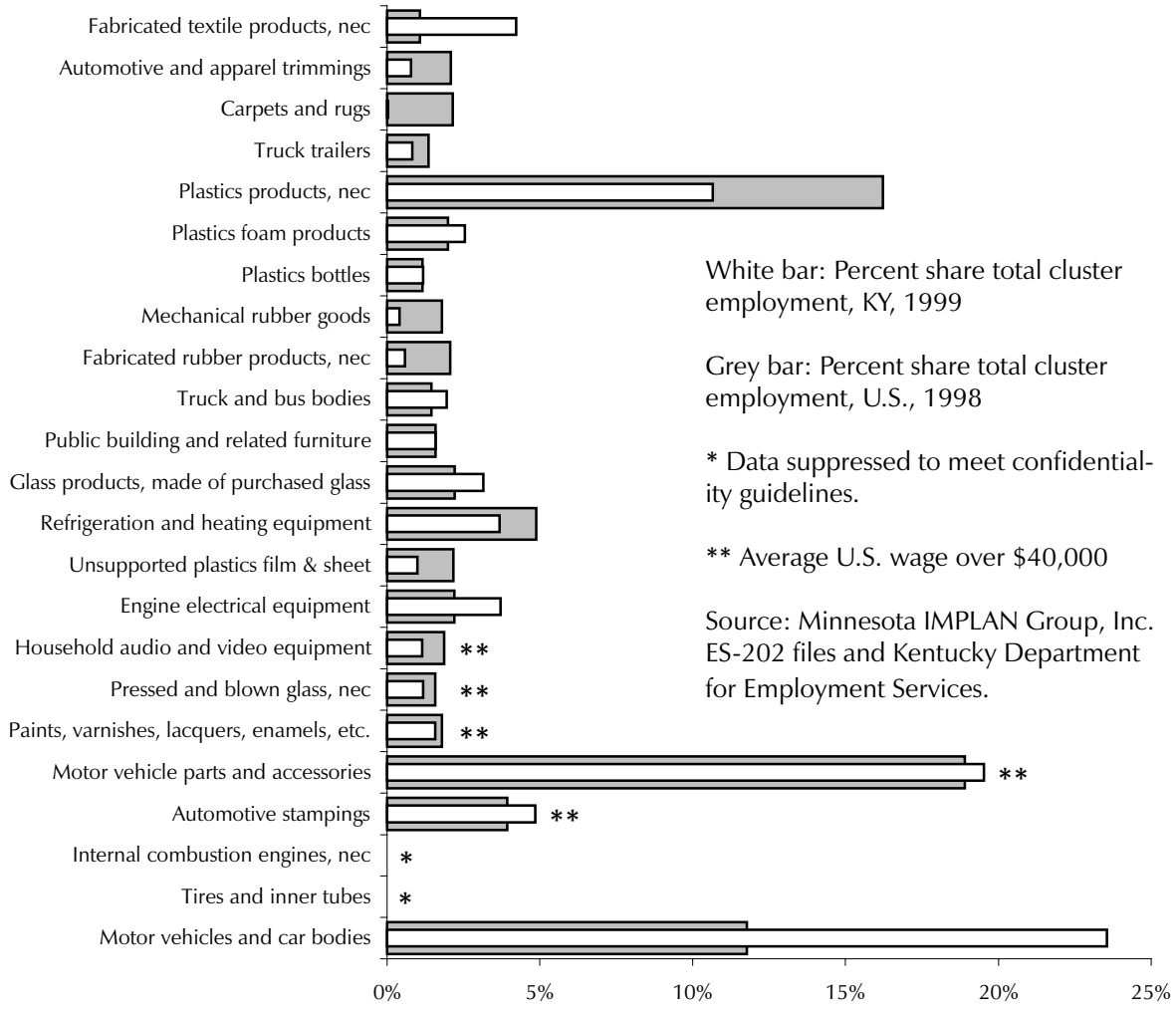

Figure 6.1
Industry mix, motor vehicle manufacturing cluster

Table 6.1

Top five suppliers to each major motor vehicle manufacturing sector

	Sector	KY Employment 1999	KY Annual Employment Change (%) 1989-1999	US Annual Employment Change (%) 1989-1998	KY Average Wage 1999	US Average Wage 1998	LQ
Motor vehicle parts and accessories		**16,693**	**9.18**	**3.36**	**38,641**	**44,566**	**1.84**
	Motor vehicle parts and accessories	16,693	9.18	3.36	38,641	44,566	1.84
Supplier Group	Blast furnaces and steel mills	3,077	-5.56	-3.05	53,056	53,289	1.17
Employment 27,309	Industrial machinery, nec	2,927	2.99	2.71	33,386	34,346	0.59
LQ 1.38	Automotive stampings	4,146	17.45	0.71	41,749	45,774	2.19
	Iron and steel foundries	466	2.20	-0.53	30,723	38,443	0.23
Automotive stampings		**4,146**	**17.45**	**0.71**	**41,749**	**45,774**	**2.19**
	Blast furnaces and steel mills	3,077	-5.56	-3.05	53,056	53,289	1.17
Supplier Group	Cold finishing of steel shapes	526	54.02	-0.83	48,737	43,320	1.81
Employment 10,579	Steel pipe and tubes	498	-1.80	1.18	40,521	39,960	1.07
LQ 0.92	Industrial machinery, nec	2,927	2.99	2.71	33,386	34,346	0.59
	Special dies and tools and machine tool accessori	3,551	5.96	0.88	35,956	40,955	1.01
Miscellaneous plastics products		**14,927**	**2.52**	**2.00**	**30,755**	**31,525**	**1.28**
	Plastics materials and resins	2,607	-1.81	-1.31	59,782	58,452	2.03
Supplier Group	Industrial inorganic and organic chemicals	272	-10.50	0.60	50,581	58,954	0.38
Employment 22,115	Miscellaneous plastics products	14,927	2.52	2.00	30,755	31,525	1.28
LQ 1.25	Paperboard containers and boxes	4,261	2.54	0.48	37,848	37,417	1.24
	Organic fibers, noncellulosic	48	10.31	-4.30	19,765	55,917	0.07
Automotive and apparel trimmings		**667**	**27.89**	**2.91**	**26,379**	**26,219**	**0.66**
	Broadwoven fabric mills and fabric finishing plant	144	-4.41	-3.59	16,902	28,127	0.06
Supplier Group	Leather tanning and finishing	*s*	-25.06	-1.60	*s*	*s*	*s*
Employment 15,616	Nonwoven fabrics	545	13.18	4.73	32,691	41,960	2.39
LQ 1.07	Finishing plants, nec	*s*	-3.97	1.42	*s*	*s*	*s*
	Miscellaneous plastics products	14,927	2.52	2.00	30,755	31,525	1.28
Refrigeration and heating equipment		**3,144**	**-1.78**	**0.80**	**36,273**	**36,700**	**1.34**
	Refrigeration and heating equipment	3,144	-1.78	0.80	36,273	36,700	1.34
Supplier Group	Motors and generators	2,595	0.08	-1.70	30,728	33,820	2.08
Employment 10,801	Blast furnaces and steel mills	3,077	-5.56	-3.05	53,056	53,289	1.17
LQ 1.39	Copper rolling and drawing	470	5.94	-0.41	47,528	40,444	1.24
	Metal stampings, nec	1,515	2.89	1.85	29,862	34,419	0.95
Semiconductors and related devices		**0**	**n/a**	**1.45**	**n/a**	**64,431**	**0.00**
	Semiconductors and related devices	0	**n/a**	1.45	n/a	64,431	0.00
Supplier Group	Industrial inorganic and organic chemicals	272	-10.50	0.60	50,581	58,954	0.38
Employment 19,739	Plating and polishing	1,882	7.48	1.38	24,378	30,097	1.30
LQ 0.56	Other electronic components	1,835	4.11	-0.63	27,470	35,472	0.55
	Computer and data processing services	15,750	8.95	9.08	41,870	65,210	0.63
Engine electrical equipment		**3,175**	**6.91**	**-1.18**	**38,372**	**39,763**	**2.99**
	Other electronic components	1,835	4.11	-0.63	27,470	35,472	0.55
Supplier Group	Semiconductors and related devices	0	**n/a**	1.45	n/a	64,431	0.00
Employment 10,647	Engine electrical equipment	3,175	6.91	-1.18	38,372	39,763	2.99
LQ 0.85	Nonferrous wiredrawing & insulating	2,560	1.55	-0.34	43,266	41,585	2.12
	Blast furnaces and steel mills	3,077	-5.56	-3.05	53,056	53,289	1.17
Motor vehicles and car bodies		**20,132**	**7.89**	**-0.05**	**83,322**	**68,273**	**3.55**
	Motor vehicle parts and accessories	16,693	9.18	3.36	38,641	44,566	1.84
Supplier Group	Automotive stampings	4,146	17.45	0.71	41,749	45,774	2.19
Employment 39,577	Miscellaneous plastics products	14,927	2.52	2.00	30,755	31,525	1.28
LQ 1.56	Automotive and apparel trimmings	667	27.89	2.91	26,379	26,219	0.66
	Refrigeration and heating equipment	3,144	-1.78	0.80	36,273	36,700	1.34
Internal combustion engines, nec		***s***	**4.76**	**-1.26**	***s***	***s***	***s***
	Internal combustion engines, nec	*s*	4.76	-1.26	*s*	*s*	*s*
Supplier Group	Iron and steel foundries	466	2.20	-0.53	30,723	38,443	0.23
Employment 5,729	Iron and steel forgings	1,055	10.18	0.08	40,300	40,936	1.93
LQ 1.28	Carburetors, pistons, rings, valves	909	-3.90	-0.50	34,445	41,410	2.35
	Aluminum die-castings	3,299	10.94	3.61	35,939	34,011	5.09
Tires and inner tubes		***s***	**-7.34**	**-0.79**	***s***	***s***	***s***
	Tire cord and fabrics	0	**n/a**	0.49	**n/a**	29,789	0.00
Supplier Group	Synthetic rubber	1,183	1.14	1.98	62,095	55,149	3.93
Employment 2,424	Industrial inorganic and organic chemicals	272	-10.50	0.60	50,581	58,954	0.38
LQ 0.83	Carbon black	124	n/a	1.22	29,575	68,212	2.46
	Fabricated rubber products, nec	845	2.74	0.30	28,568	32,496	0.48

Source: Kentucky Department for Employment Services and authors' calculations. *s* indicates data suppression to satisfy confidentiality restrictions.

cifically, we identified a set of occupations predominant in the electronics and information technology industries, and then expanded the list to include additional occupations that require similar skills but fall mainly into other industries. Identifying all workers in this expanded "skill group" offers a rough indication of the extent of the Kentucky labor pool in electronics and information technology (see Table 6.2).

As it turns out, roughly the same share of Kentuckians are employed in occupations that are critical to the electronics, computers, and information technology industries as the national average (the employment location quotient is essentially 1.0). However, Kentucky's distribution is significantly skewed toward the lower-skilled occupations in the group. Kentucky's pool of high-skill professional workers such as electronic engineers, computer engineers, computer programmers, and system analysts is small and, in relative terms, is well below the national average (with a location quotient of just 0.6). At the same time, the state's pool of lower-skill electronics and IT workers is slightly over-represented (location quotient of 1.1).

The relative mix of high- and low-skill IT/electronics workers is consistent with the mix of activity in the information technology cluster, as we demonstrate below. The statistics also confirm the concerns of many of our interviewees. Several of the experts we interviewed argued that the state may lose its edge in motor vehicles in the 21st century because firms in the region are not involved in significant innovation and R&D like their competitors in Ohio and Michigan. While the state's production labor force is abundant and efficient, it lacks a sufficient pool of highly skilled and technical labor that can at-

Table 6.2
Electronics, IT labor pool

Major Occupations for Computer/Electronics/IT	Expanded Major Occupations for Computer/Electronics/IT		
Electrical and electronic assemblers	Electrical and electronic assemblers		
	Packaging and filling machine operators and tenders		
Electronic semiconductor processors	Electronic semiconductor processors		
	NC machine tool operators and tenders, metal,plastic		
Electrical, electronic equipment assemblers, precision	Electrical and electronic equipment assemblers, precision		
	Electricians		
Inspectors, testers, and graders, precision	Inspectors, testers, and graders, precision		
Electrical and electronics engineers	Electrical and electronics engineers		
Assemblers, fabricators, and hand workers	Assemblers, fabricators, and hand workers		
Electrical and electronic technicians and technologists	Electrical and electronic technicians and technologists		
Blue collar worker supervisors	Blue collar worker supervisors		
Engineering technicians and technologists	Engineering technicians and technologists		
Engineers	Engineers		
Computer engineers	Computer engineers		
Computer programmers	Computer programmers		
Systems analysts	Systems analysts		
Sales and related workers	Sales and related workers		
General managers and top executives	General managers and top executives		
Data entry keyers, except composing	Data entry keyers, except composing		
	File clerks		
Secretaries, except legal and medical	Secretaries, except legal and medical		
Computer operators, except peripheral equipment	Computer operators, except peripheral equipment		
Engineering, science, and computer systems managers	Engineering, science, and computer systems managers		
Data processing equipment repairers	Data processing equipment repairers		
Professional workers	Professional workers		
Database administrators, computer support specialists, other	Database administrators, computer specialists, other		
Employment and location quotient	**All occupations:**	302,990	0.99
	High skill occupations:	25,770	0.59
	Low skill occupations:	277,220	1.06

Source: Bureau of Labor Statistics, Occupational Employment Survey and authors' analysis of the U.S. Staffing Pattern Matrix.

tract and retain highly technologically sophisticated and R&D-intensive facilities. Moreover, as we noted above, such facilities, and the related technology infrastructure they engender, are a critical foundation for high-technology growth. The contrast between the occupational mix of electronics, computers and IT can clearly be seen in Table 6.3, which reports key occupations in motor vehicle manufacturing (SIC 373). Key occupations in the latter are mostly moderately skilled precision production workers. Those are certainly good jobs compared to many in the state's nondurable manufacturing industries, but a larger base of innovation-oriented jobs and activities are important for the state's longer-term growth.

Vehicle Production across the State. Chapter 5 found that the motor vehicle cluster is concentrated primarily along the I-64 and I-75 corridors. What was clear was that the cluster as a whole is not as geographically concentrated in Kentucky as it is in neighboring states. Indeed, vehicle cluster firms in Kentucky are located in a large number of counties. That is good in the sense that both urban and rural communities in the state are enjoying the benefits of the cluster's

Table 6.3
Motor vehicles labor pool

Major Occupations for Computer/Electronics/IT	Expanded Major Occupations for Computer/Electronics/IT
Assemblers, fabricators, and hand workers	Assemblers, fabricators, and hand workers
Engineers	Engineers
Machine operators, tenders, setters, etc.	Machine operators, tenders, setters, and set-up operators
Blue collar worker supervisors	Blue collar worker supervisors
Inspectors, testers, and graders, precision	Inspectors, testers, and graders, precision
Metal and plastic machine setters, operators	Metal and plastic machine setters, operators, and related
Welders and cutters	Welders and cutters
	Automotive body and related repairers
	Sewing machine operators, non-garment
	Pressing machine operators/tenders, textile, garment
Machine tool cutting operators/tenders, metal, plastic	Machine tool cutting operators and tenders, metal and plastic
	Musical instrument repairers and tuners
	Punching machine setters and set-up operators, metal and plastic
	Typesetting and composing machine operators and tenders
	Sewing machine operators, garment
	Solderers and brazers
Electricians	Electricians
	Electrical and electronic equipment assemblers, precision
Helpers, laborers, and material movers, hand	Helpers, laborers, and material movers, hand
Industrial truck and tractor operators	Industrial truck and tractor operators
	Paving, surfacing, and tamping equipment operators
	Grader, bulldozer, and scraper operators
Professional workers	Professional workers
Engineering technicians and technologists	Engineering technicians and technologists
Industrial machinery mechanics	Industrial machinery mechanics
Tool and die makers	Tool and die makers
	Optical goods workers, precision
	Drilling, boring machine tool setters, set-up operators, metal/plastic
	Grinding machine setters and set-up operators, metal and plastic
Welding machine setters, operators, and tenders	Welding machine setters, operators, and tenders
	Heat treating machine operators and tenders, metal and plastic
	Furnace operators and tenders
	Textile bleaching and dyeing machine operators and tenders
	Photographic processing machine operators and tenders
	Dairy processing equipment operators, including setters

Source: Bureau of Labor Statistics, Occupational Employment Survey and authors' analysis of the U.S. Staffing Pattern Matrix.

growth. However, it also likely reflects the satellite-oriented production in Kentucky, that is, the predominance of branch plants that have stronger linkages to home corporations in other states or overseas than with neighboring firms. Thus geographic proximity, and the innovation-inducing spatial externalities and localized spillovers that come with it, may not be as characteristic of Kentucky's motor vehicles cluster as some others in the U.S. (e.g. in Detroit).

Even with relatively even distribution (at least compared to other states), there are still several dominant areas of vehicle cluster activity in Kentucky. Figures 6.2 and 6.3 plot the locations of firms and employees in core industries in the cluster and identify major companies and their locations.[15] Establishments are concentrated in Lexington, Louisville and northern Kentucky. Other areas of the state, for example Bowling Green and Elizabethtown, are major employment centers given the presence of few large plants. Some 81 percent of workers in the core automotive industries are employed in branch plants although branch plants account for only 14 percent of all core enterprises.

It is important to emphasize that we cannot know for sure how many transactions are occurring among motor vehicle and equipment manufacturing firms within Kentucky. However, there is anecdotal evidence that internal supply chains and associated inter-firm networks are developing. Toyota provides an example of developing interactions among firms linked through buyer-supplier chains within the state. The company-initiated association of its suppliers, the Blue Grass Auto Manufacturers Association, is a useful mechanism for the exchange of ideas and joint problem-solving. Toyota support centers send engineers to work closely with supplier firms to help them meet company specifications and improve quality. In addition, Toyota supports and works with the University of Kentucky's Center for Robotics and Manufacturing Systems to transfer lean manufacturing concepts and technologies to other firms both inside and outside of the automotive industry. Ford Motor Company also uses similar mechanisms in dealing with its suppliers.

Unfortunately, at the industry level, there have been few attempts to promote interaction

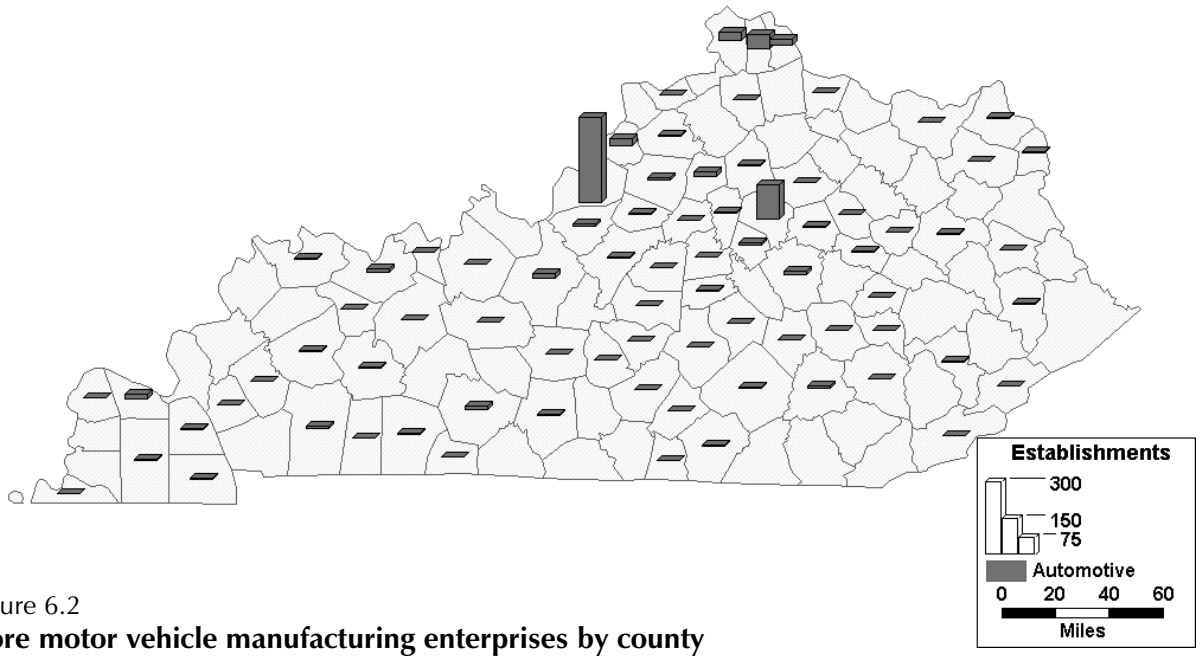

Figure 6.2
Core motor vehicle manufacturing enterprises by county
Source: Kentucky Department for Employment Services

and establish venues for joint problem-solving and innovation among motor vehicle cluster firms. The Kentucky Auto-Truck Industry Council, the only industry level organization representing motor vehicle firms in Kentucky, has not been involved in any active role to promote interactions or form a broader alliance within the industry.

Information Technology: A Potential Cluster

The U.S. information technology (IT) value-chain cluster is made up of 50 four-digit SIC industries, including electronics and computers, electrical equipment and appliances, navigation and space equipment, scientific instruments, and computer programming services and software. In 1998, the cluster employed 4.2 million workers in 168,000 enterprises and generated the third largest payroll among the 28 value-chain clusters (roughly $240.5 billion). Nationwide, IT cluster workers earn $57,565 annually, 181 percent of the average private sector wage. Between 1989 and 1998, employment in IT expanded by 1.6 percent annually, slightly lower than the employment growth rate for the private sector as a whole (at 1.8 percent annual growth). That rate, however, masks significant growth in selected components of the cluster (namely software and information services). During the 1990s, employment in the hardware segments of the IT cluster expanded little or suffered declines as firms exploited productivity gains and relocated plants to Mexico and overseas. At the same time, employment in software and programming services grew significantly.

Those trends become clear if we break the cluster into its major components, where the latter are defined as major industry groups that make up the value chain. The 50 sectors fall into roughly six segments: computers and office machines, electrical equipment, semiconductors and electronics, aerospace and navigation equipment, scientific instruments, and computer services and software (see Table 6.4). While computers/office machines and computer services and software arguably form the core of the IT cluster, semiconductors and electronics, electrical equipment, and scientific instruments are all key suppliers in the chain as well as, in some

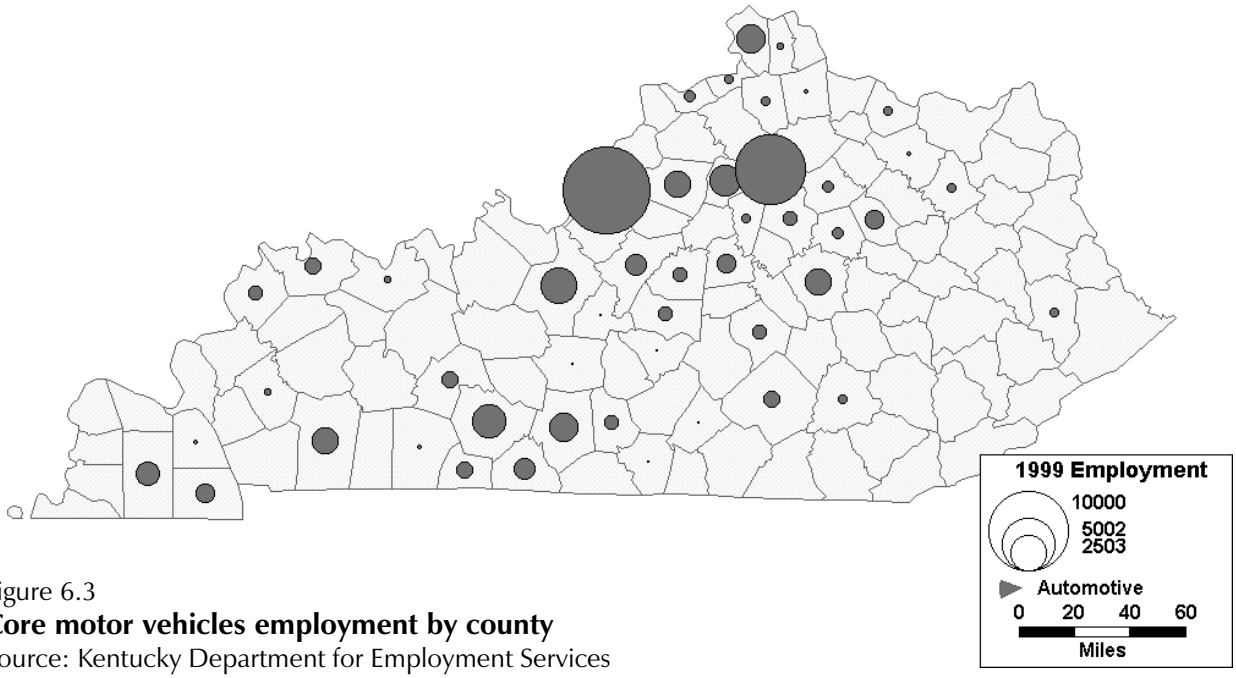

Figure 6.3
Core motor vehicles employment by county
Source: Kentucky Department for Employment Services

cases, purchasers of computers and computer services. Aerospace and navigation equipment falls into the chain because of their heavy use of information technology.

Nationwide, 38 percent of IT cluster workers are in the computer services and software industry (see Table 6.4). Semiconductors/electronics and scientific instruments employ another 15 percent each while electrical equipment employs 13 percent. During the 1990s, the strongest employment growth occurred in computer services and software (9.1 percent growth annually), followed by semiconductors and electronics (at 1.1 percent annually). Employment fell in four of six major cluster components, most precipitously in aerospace and navigation equipment.

Kentucky's IT Cluster. If a cluster is defined as a large, critical mass of activity in a given set of related industries, Kentucky cannot claim an information technology cluster. Kentucky's IT cluster consists of roughly 1,400 establishments, 34,500 workers, and $1.4 billion in annual payroll.[16] Forty-six percent of Kentucky's employment in the cluster is in computer services and software, followed by computers and office machines (20 percent), electrical equipment (16 percent), and scientific instruments (12 percent). On the whole, the cluster is under-represented in the state. Nationwide, IT activity accounts for roughly 4 percent of total private sector employment. In Kentucky, that share is only just over 2 percent.

Though IT activity is modest in Kentucky, it has been growing rapidly. Between 1989 and 1999, employment expanded by 4.1 percent annually, well above the U.S. average 1.6 percent. The state also posted at least nominal growth in all six of the cluster's major segments, with computer services and software, scientific instruments, and electrical equipment recording the biggest relative gains (see Table 6.4). (Note that the exponential growth of the aerospace and navigation equipment segment was due primarily to its small size in 1989; it still consists of fewer than five establishments and less than 200 workers.)

With the exception of one cluster segment—the small aerospace and navigation equipment industry—Kentucky's IT cluster firms pay well

Table 6.4
Major segments, information technology value chain

Segment	Establish-ments	Employment				Payroll (Mil $)	Average Wage
		Total	Pct Share	Location Quotien	CAGR '89-'99		
U.S. *(Establishments and employment in 000s)*							
Computers and office machines	2.9	380.0	9.1	n/a	-2.0	27,026.1	71,123
Electrical equipment, including communications	7.0	553.9	13.3	n/a	-0.2	28,201.0	50,917
Semiconductors and electronic components	7.1	640.0	15.3	n/a	1.1	30,668.2	47,916
Aerospace, navigation equipment	3.0	386.4	9.3	n/a	-5.4	21,414.5	55,418
Scientific instruments	13.2	615.2	14.7	n/a	-0.5	28,707.5	46,661
Computer services and software	134.7	1,601.6	38.3	n/a	9.1	104,443.2	65,210
All segments	168.0	4,177.2	100.0	n/a	1.6	240,460.4	57,565
Kentucky							
Computers and office machines	11.0	6,913.0	20.0	1.19	0.2	86.1	49,810
Electrical equipment, including communications	47	5,525	16.0	0.65	1.9	54.0	39,064
Semiconductors and electronic components	25	1,946	5.6	0.20	0.5	13.3	27,380
Aerospace, navigation equipment	3	132	0.4	0.02	36.2	2.1	63,058
Scientific instruments	78	4,287	12.4	0.46	3.0	30.9	28,824
Computer services and software	1,268	15,750	45.6	0.64	9.0	164.9	41,870
All segments	1,432	34,553	100.0	0.54	4.1	351.2	40,656

Source: Kentucky Department for Employment Services and authors' calculations.

below national average wages. For example, the U.S. average wage in computer and office machines is slightly over $71,000, compared to just under $50,000 in Kentucky. Similarly, large differences are found in electrical equipment, semiconductors and electronics, scientific instruments, and computer services and software. Overall, the IT cluster in Kentucky paid an average wage of $40,656 in 1999, 71 percent of the U.S. average for IT in 1998. Accounting for inflation, Kentucky's wage is about 69 percent of the national average. A very modest part of the wage gap can be traced to cost of living differences, although Kentucky's cost of living, particularly in its urban centers where IT is predominantly concentrated, would not be expected to be significantly lower than the national average. Most of the gap is probably explained by the concentration of activity in lower-technology, standardized or cost-sensitive segments within IT (e.g., peripheral equipment in the computer and office machines segment, back office information processing in the software and computer services segment, engines/electrical equipment and relays/controls in the electrical equipment segment, and plating/polishing and environmental controls in the scientific instruments segment).

Core Industries and Firms. Our data allow us to be even more specific about the mix and growth in Kentucky's IT cluster. Table 6.5 reports basic trends for eleven core industries, that is, those four-digit SIC sectors that make up the computers and software/services segments, excluding three computer services management sectors (computer rental/leasing, maintenance and repair, and miscellaneous services). It is clear from the table that Kentucky's existing relative strengths are in computer peripheral equipment and data processing/preparation; both are significantly over-represented in the state relative to the national average. Computer peripheral equipment, however, is driven almost exclusively by Lexmark International in Lexington, a leading manufacturer of desktop and office printers. Indeed, Lexmark is the largest IT enterprise in the state, with over 5,000 workers according to company officials. While Lexmark itself was essentially "spun-out" of IBM's printer manufacturing business, the company has not yet been responsible for any related IT equipment spin-offs.

In Kentucky, the data processing and preparation industry consists mainly of contract back office operations and call centers, thus accounting for the comparatively low wage in the sector

Table 6.5
Core IT cluster industries (computers & software/services)

			Employment				
		Establish-	Total	Location	CAGR		
		ments	1999	Quotient	KY	US	Payroll
3571	Electronic computers	*s*	*s*	*s*	New	-3.9	*s*
3572	Computer storage devices	0	0	n/a	n/a	2.0	0.0
3575	Computer terminals	0	0	n/a	n/a	0.4	0.0
3577	Computer peripheral equipment, nec	*s*	*s*	*s*	92.2	2.5	*s*
3674	Semiconductors and related devices	0	0	n/a	n/a	1.5	0.0
7371	Computer programming services	278	1,784	0.30	27.4	11.6	104.4
7372	Prepackaged software	24	346	0.09	3.8	11.1	16.9
7373	Computer integrated systems design	41	322	0.12	6.3	6.8	16.8
7374	Data processing and preparation	125	7,383	1.89	3.5	2.4	213.1
7375	Information retrieval services	51	451	0.29	15.2	9.1	17.0
7379	Computer related services, nec	625	2,751	0.49	24.2	17.9	152.1
	All core sectors	1,154	19,298	0.58	11.9	5.5	520.3

Source: Kentucky Department for Employment Services and authors' calculations. *s* indicates data suppression to satisfy confidentiality restrictions.

(at $28,864). Major employers are National Processing Company, Sykes Incorporated, Automatic Data Processing, Banc One Services Corporation, and First Tennessee Bank. Together, the data processing industry and Lexmark account for 37 percent of all core IT cluster employment. There is limited evidence of an emerging base of IT solutions providers, as well as a growing number of software and Internet start-ups. Among the larger of the solutions providers are Keane Incorporated and Image Entry Incorporated (image entry and data conversion services).

The vast majority of software and computer services firms are extremely small. Cross-listing our database with available directories and online sources, we found that only 142 out of slightly over 1,000 software and computer services companies operating in the state employ 10 or more workers. Over half (56 percent) of those firms are located in Louisville while another 18 percent are located in Lexington. Some 800 software/services companies employ 3 or fewer workers. Figures 6.4 and 6.5 plot the distribution of core cluster establishments (those in the industries reported in Table 6.5) and employment. While IT establishments are relatively evenly distributed throughout the state, employment is highly concentrated in Louisville and Lexington.

Biotechnology: Trends and Prospects

Relatively little is known about the extent and growth of the biotechnology industry in the U.S. There is considerable disagreement about appropriate definitions of biotech activity, and most current government sources of employment, wage, income, and output data inadequately capture the industry due to its highly specialized nature. One recent Ernst & Young study estimates total biotech-related jobs in the U.S. at 437,400 in 1999, biotech revenues at $47 billion, and R&D spending at $11 billion. The study included both biotech companies and related suppliers and service providers. It also noted that the industry as a whole has not yet reached a state of profitability since marketable products are still some years away for many companies.[17] Ultimately, the industry is expected to generate considerable profits once research shifts to development and commercialization.

Not surprisingly, biotechnology is in a nascent state of development in Kentucky. There is no critical mass of biotechnology firms, and accordingly, specialized suppliers and service providers are few. Using ES-202 data, existing directories, Internet searches, interviews, and an email-based inquiry of experts, we identified some 40 biotech firms in the state, most of them extremely small and recently formed. A survey targeted to those firms netted only 15 responses, despite repeated telephone follow-ups, so our knowledge of the industry remains limited. However, what responses were received emphasized the key role of the state government and Kentucky universities in supporting biotechnology-related growth and development. Most biotechnology firms in Kentucky are homegrown, and many of them were spun off from university labs. Respondents indicated that there is a strong need for public-sector strategies to nurture these firms.

Defining Biotechnology. Biotechnology as an "industry" rather than science is relatively new and consists of firms in sectors ranging from pharmaceuticals to information technology (so-called bioinformatics). Only in the last decade has the biotech industry seen dramatic growth. It is no surprise, then, that various existing studies use slightly different definitions of biotechnology to define the sector. For example, the Biotechnology Industry Organization (BIO) defines biotechnology as "the use of the cellular and molecular processes to solve problems or make products," while the recent Ernst & Young report defined biotechnology as "companies that are *primarily* engaged in biotechnology activities" as laid out by BIO. Excluded from Ernst & Young's definition are pharmaceuticals without distinct biotech divisions, contract research organizations (e.g. Quintiles), and equipment manufacturers.

For this study, we defined biotechnology firms very generally as companies that use living organisms, cells, and biological molecules to make useful products. Such companies use improved understanding of biological processes and new technologies to engineer better health,

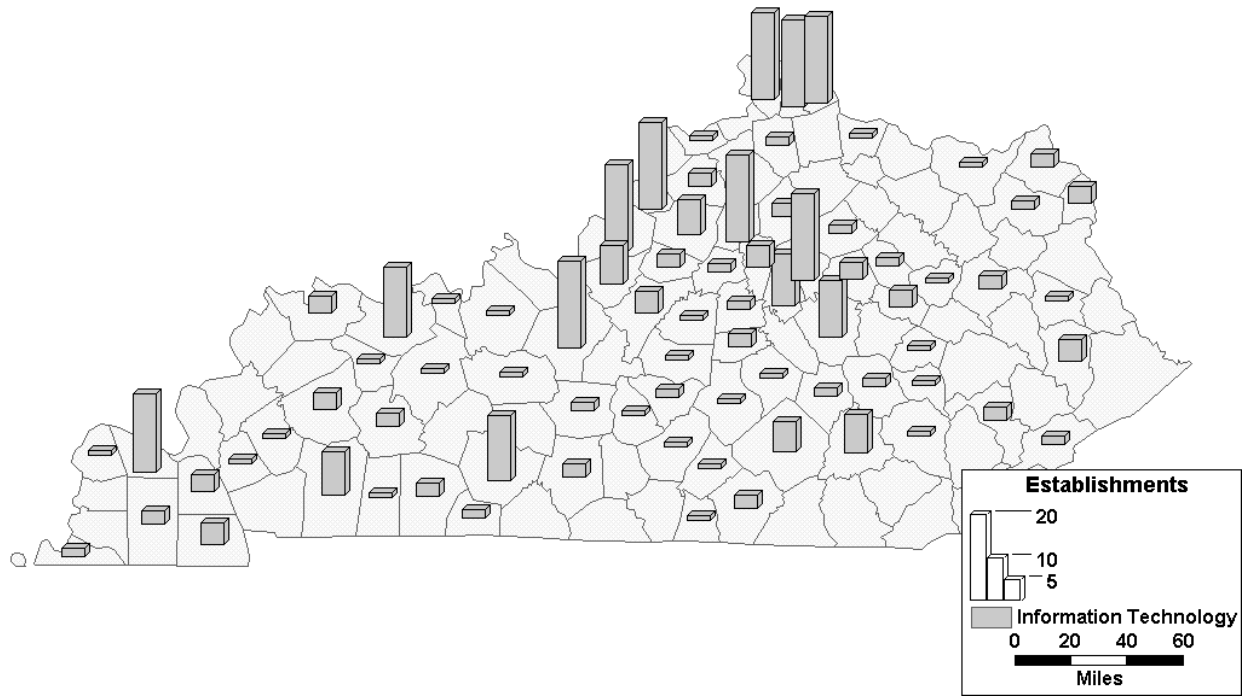

Figure 6.4
Core information technology enterprises by county
Source: Kentucky Department for Employment Services

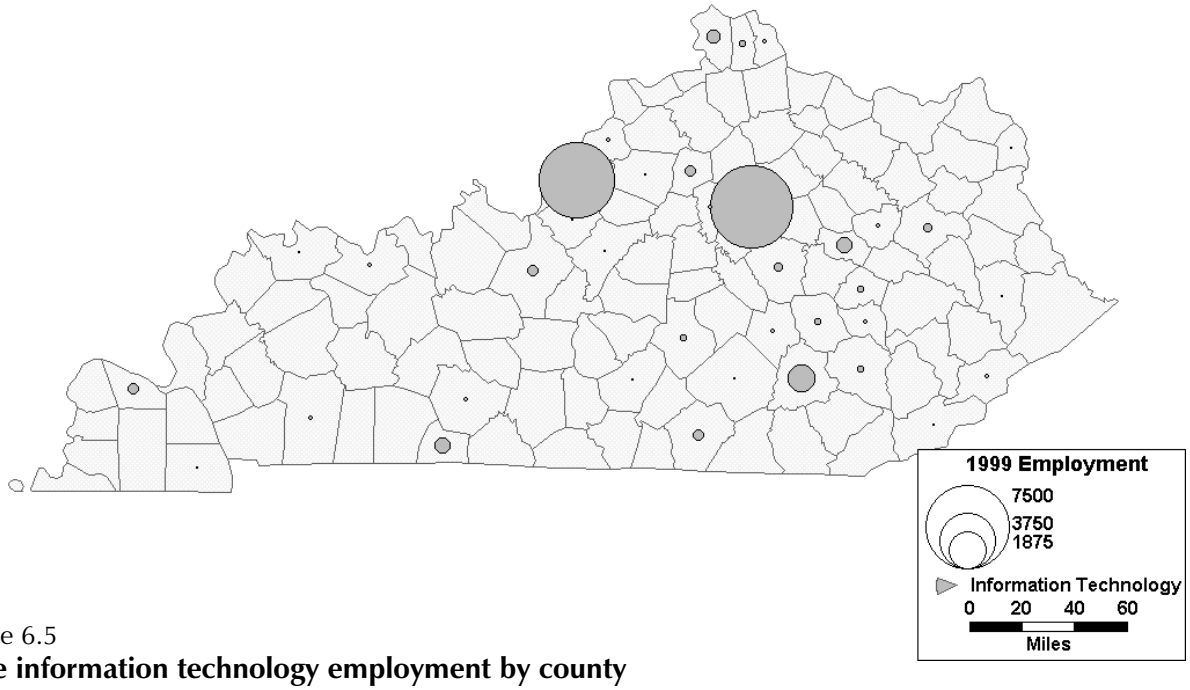

Figure 6.5
Core information technology employment by county
Source: Kentucky Department for Employment Services

environmental, food, and industrial products and services. The definition includes some firms often classified as diagnostic, reagent/assay, or pharmaceutical; general service organizations (e.g., research labs); and firms engaged in neuroscience, genome initiatives, and genetic data management and mining (bioinformatics). Enterprises categorized as medicinal chemicals and botanicals (SIC 2833), pharmaceutical preparations (SIC 2834), diagnostic substances (SIC 2835), biological products (SIC 2836), and commercial physical research (SIC 8731) were initially included and later parsed out after collecting additional information. Of course, some legitimate biotechnology firms are buried in more traditional industry classifications well outside the health sciences.

Identifying Biotechnology Companies in Kentucky. Based on our definition, we first identified firms using ES-202 microdata supplied for research purposes by the Kentucky Department for Employment Services, Labor Market Information Division. We initially included enterprises categorized as medicinals and botanicals, pharmaceutical preparations, diagnostic substances, biological products, and commercial physical research. We then used databases developed by researchers in Kentucky, proprietary databases (e.g. IBInternet), and directories freely available on the Web to further refine the list and add additional firms. We also sent an email message to fifteen industry experts and public officials in the state knowledgeable about the industry, providing them with a list of our firms and asking them to verify those we had listed and to identify any missing companies. That process yielded 68 firms. We then attempted to call each of the 68 enterprises to determine which of them are still operating in Kentucky. In the end, we were able to confirm the existence of 42 biotechnology establishments; they are listed in Table 6.6.

Kentucky's Biotechnology Industry. As the number of biotechnology firms identified indicates, activities in biotechnology-related industries in Kentucky are very limited. In the traditional sense, Kentucky does not have a biotechnology cluster. The 42 companies are concentrated in the Lexington and Louisville areas (see Figure 6.6), where connections to universities, skilled labor, and advanced infrastructure (e.g., scheduled air service) are available.

Table 6.6
Identified Kentucky biotech companies

Company	Location
Advance Chemtech, Inc.	Louisville
Affinity Labeling Technologies	Lexington
Alltech, Inc.	Nicholasville
Amgen	Louisville
Auspep, LLC	Louisville
Automation Laboratories, Inc.	Crestwood
Bays-Brown Laboratories, Inc.	Louisville
Biologics International, Inc.	Florence
CBA International	Lexington
CellSignals, Inc.	Lexington
Center for Clinical Research, LLC	Lexington
Central Kentucky Research Associates	Lexington
Cintein, LLC	Union
Conjun Laboratories, Inc.	Isom
Dipro Diagnostic Products	Louisville
Dynamic Science, Inc.	Covington
Enviroderm, Inc.	Louisville
Equine Biodiagnostics, Inc. EBI	Lexington
Exseed Genetics, LLC	Owensboro
GenApps	Winchester
Glo-Marr Products, Inc.	Lawrenceburg
Kentucky Clinical Research, Inc.	Lexington
Kentucky Pediatric Research, Inc.	Bradstown
Large Scale Biology	Owensboro
Mann Chemical Corp.	Louisville
MedResearch, Inc.	Louisville
Neogen Corp.	Lexington
New Ace Research Company, Inc	Versailles
Ocular Transplantation LLC	Louisville
Omni Care, Inc.	Covington
Partners in Research, Inc.	Louisville
Peptides International, Inc.	Louisville
Phoenix Pharmacologics	Lexington
Shire US, Inc.	Florence
The Harthill Company	Louisville
The Lexington Carbon Company, LLC	Lexington
Tlgen Pharmaceuticals	Lexington
Transduction Laboratories (previously Glentech)	Lexington
United Catalist	Louisville
Venture Laboratories, Inc.	Lexington
Xpertise	Elizabethtown
ZDL, Inc.	Lexington

Identified from Kentucky Department for Employment Services files, published and unpublished directories, email inquiries, and the Internet. Note that, in compliance with Kentucky Department for Employment Services rules and assurances provided respondents on the Kentucky Biotechnoloyg Survey, no data for any individual company are reported in this study.

Although there is no critical mass of biotechnology firms within the state, there are some firms with potential, especially in the pharmaceutical and animal-product areas. For example, industry experts we interviewed singled out Altech, Transduction Laboratory, Advanced Chemtech, and Peptides International as especially promising companies. Pharmaceuticals and animal products-related biotech account for more than half of all biotechnology firms identified.

The lack of a serious critical mass of commercial biotechnology activity in Kentucky is a hindrance to the industry's continued development. We found, for example, anecdotal evidence that a number of firms that initially started up in Kentucky subsequently moved to other states where with larger complements of biotechnology research and associated venture capital (e.g. California, Pennsylvania, and Massachusetts). It is worth noting that many of the 42 biotechnology firms are homegrown and affiliated with universities, especially the University of Kentucky. While there is no question that the continued strengthening of the University of Kentucky's research capacity is critical for the further development of the biotechnology industry, what is unclear is whether the state can retain promising biotechnology start-ups out of the University of Kentucky and other universities.

Biotechnology Survey. To obtain a better picture of the biotechnology industry in Kentucky and to characterize (however possible) its current relative competitiveness, we sent out a detailed mail questionnaire to the 42 identified biotechnology firms. The survey instrument was designed to solicit company views about the competitiveness of the biotech industry in Kentucky. Forty-one questions investigated four major issues: the regional business environment, regulatory conditions and policy, industry organization and strategy, and the state of the environment for innovation in Kentucky.[18] Several companies explicitly refused to complete the

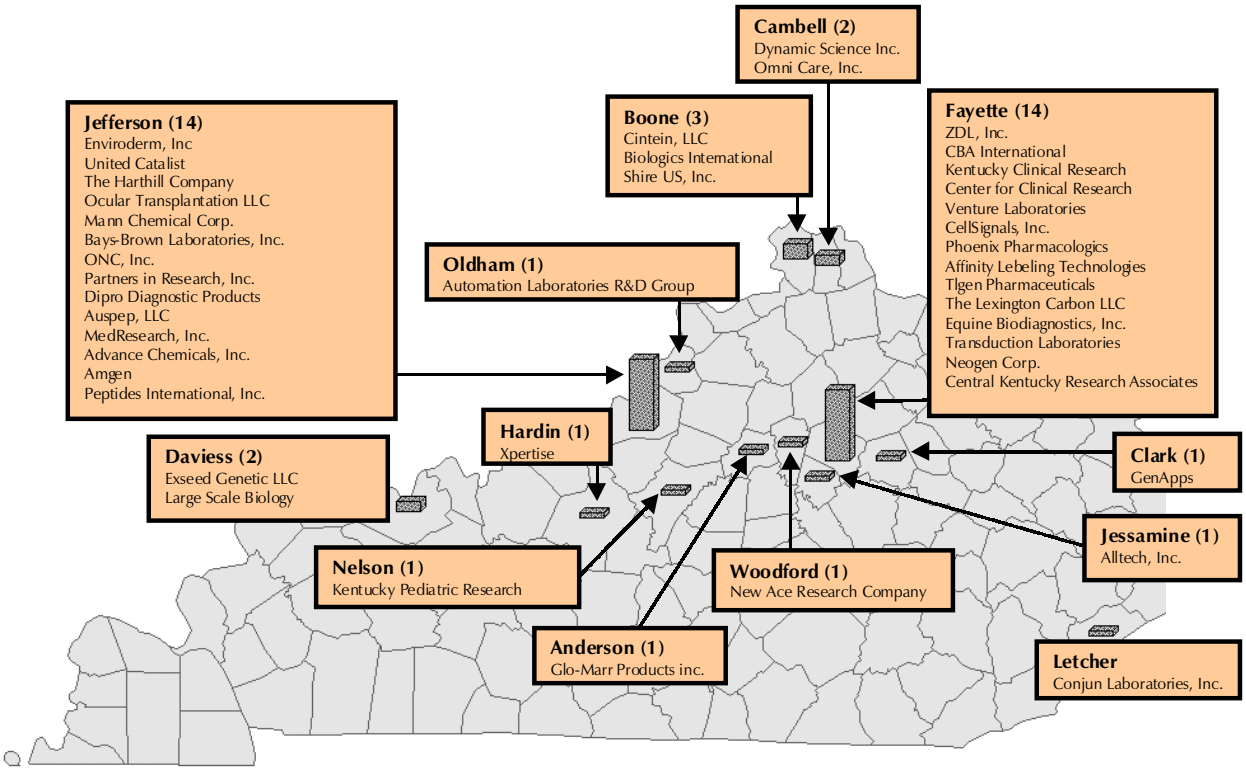

Figure 6.6
Identified Kentucky biotechnology companies

survey, citing confidentiality concerns and company policies against responding.[19] Telephone follow-ups and two rounds of instrument mailings yielded fifteen usable responses.[20] The following sections broadly summarize the principal findings from the survey.

Regional Business Environment. Several questions inquired about business climate and infrastructure issues in the firm's immediate region and Kentucky as a whole (see Table 6.7). In general, respondents praised the state's research facilities, communication infrastructure, labor pools (especially scientists and engineers), generally low cost of doing business, and low cost of living. Respondents also indicated that the quality of life in Kentucky eases recruitment and retention of key employees. **However, over two out of three of them mentioned that access to venture capital is very difficult.** About one-third indicated that quality of transportation is poor and that knowledge transfer from research institutions to the industry rarely happens. According to one of our interviewees, it is not only the lack of overall venture capital in Kentucky that is the problem, but that most investors and possible sources of venture capital in the state lack familiarity with the biotechnology industry. Thus, innovation-oriented industries like information technology may have more success attracting venture capital since that industry is better understood.

Regulatory Conditions and Policy. A series of questions sought firms' views of the current regulatory and policy environment in the state (see Table 6.8). With two exceptions, responses were neutral. Two thirds of the firms said state government's support for investment in R&D (e.g. funding business incubators, cost-sharing incentives, organizing partnerships or creating consortia) is not sufficient, while about half believe the state's overall responsiveness and ability to work with the needs of business is low.

Industry Organization and Strategy. Eleven questions queried firms about their customers, competitors, access to key supplies and services, the nature of competition in their region and Kentucky, and industry associations and organizations (see Table 6.9). Responses indicated that there are currently too few opportunities for inter-firm collaboration and cooperation in Kentucky. Four-fifths of respondents indicated that specialized suppliers of their businesses are not available inside Kentucky, while those that are available appear to be of low quality. In addition, more than half of respondents said firms and organizations in the biotechnology industry rarely exchange ideas with each other and rarely participate in industry- or cluster-wide initiatives or programs. While there are general business forums in the state's urban centers, where networking and collaboration might occur, none are tailored to the biotechnology sector.

Table 6.7
Biotech survey findings, regional business environment

Percentage of respondents reporting

Question		Scale 1	2	3	4	5	6	
Cost of doing business is	High	0	8	25	50	17	0	Low
Quality of transportation infrastructure is:	Poor	0	33	17	17	33	0	Good
Research facilities are:	Few and ineffective	8	0	23	31	31	8	Many and effective
Knowledge transfer from institutions in immediate region is:	Rare	31	0	23	23	15	8	Frequent
Communication infrastructure is	Unsatisfactory	8	15	8	31	31	8	Satisfactory
Scientiests and engineers are:	Scarce	8	8	31	8	31	16	Sufficient
Pool of skilled technical workers is:	Small or inflexible	8	15	31	39	0	8	Large and flexible
Import of trained workers is:	Unnessasary	8	23	31	8	15	15	Necessary
Workers trained at advanced education programs in region are:	Low quality	8	0	31	46	15	0	High quality
Access to risk capital is:	Difficult	31	39	23	0	8	0	Easy
Quality of life is:	Low	0	8	0	31	62	0	High
Cost of living is:	High	15	0	15	23	39	8	Low

Source: Kentucky Biotechnology Survey 2001.

Kentucky's Environment for Innovation. Twelve questions solicited views regarding the environment for innovation in Kentucky. We asked about the importance of firms' relationships with various organizations in Kentucky (universities, community colleges, research institutions, consumers, other biotechnology firms, suppliers, venture capital firms, industry associations, and business assistance centers) for generating new ideas and developing and commercializing new products. Few of those organizations were cited as important to the product development and commercialization process (see Table 6.10). However, 42 percent of firms responded that universities in Kentucky provide frequent input for generating new ideas, which confirms the importance of universities and university-industry partnerships for the biotechnology industry's future development.

Only one firm indicated that local organizations are helpful for developing business contacts and getting business advice. That would seem to indicate that state and local business assistance programs are not in high demand among biotech firms. However, several of our interviewees identified a need not only for qualified engineers and scientists, but also for quality business graduates capable of preparing and guiding the implementation of business plans. Without sufficient business management talent, university researchers are inclined to sell new products and innovations to established corporations (often out of state), rather than bring a start-up into operation.

Table 6.8
Biotech survey findings, regulatory conditions and policy

Percentage of respondents reporting

Question		Scale 1	2	3	4	5	6	
State regulations	Inappropriate	0	8	39	39	8	8	Appropriate
Federal regulations	Inappropriate	8	0	46	15	31	0	Appropriate
Enforcement of environmental standards, safety regulations	Too lax	0	8	31	54	8	0	Too strict
Private investment in R&D	Not encouraged	31	39	31	0	0	0	Encouraged
State support for R&D investment	Insufficient	39	31	23	8	0	0	Sufficient
State governement's responsiveness	Low	23	23	31	15	8	0	High

Source: Kentucky Biotechnology Survey 2001.

Table 6.9
Biotech survey findings, industry organization and strategy

Percentage of respondents reporting

Question		Scale 1	2	3	4	5	6	
Special needs from regional customers	Low	23	15	0	15	31	15	High
Feedback from regional customers	Infrequent	8	25	17	50	0	0	Frequent
Number of Kentucky competitors	Low	42	8	17	25	8	0	High
Specialized suppliers	Not available in KY	46	31	0	15	8	0	Available in KY
Quality of specialized suppliers in KY	Low	31	8	31	8	15	8	High
Information sharing among businesses	Uncommon	8	17	25	42	8	0	Common
Relationships between biotechnology firms & organization in KY	Not helpful to	39	15	23	8	15	0	Helpful to
Representative organizations for the industry in Kentucky	Do not exist	31	46	15	0	8	0	Exist and
Geographic location of business partners	Indifferent	15	23	46	8	8	0	Prefer proximity
Knowledge gain from other organizations	Infrequent	25	25	33	8	8	0	Frequent
Participation in industry- and cluster-wide programs	Rare	15	46	31	8	0	0	Frequent

Source: Kentucky Biotechnology Survey 2001.

In terms of potential state and local government policies to improve innovation and the general competitiveness of the biotechnology industry, respondents emphasized building partnerships with industry and universities (83 percent), improving primary and secondary education (67 percent), supporting the specific needs of start-ups (67 percent), and increasing funding for university research (67 percent). In addition, 58 percent of respondents identified the lack of tax incentives and other inducements appropriate for small technology start-ups (as opposed to large manufacturers) as a significant barrier for business expansion in Kentucky.

Most biotechnology firms are located in Kentucky for one or both of two reasons: first, Kentucky is the chief executive's residence, and second, the firm was spun-off from a Kentucky university (see Table 6.11). The University of Kentucky, including the Coldstream Research Park, is perhaps the most critical asset for the biotechnology industry in Kentucky (although several of our interviewees indicated that there is strong demand for research/lab space closer to UK than Coldstream).[21] Forty-two percent of respondents indicated "luck" as the reason for their location in Kentucky, while 25 percent cited the state's quality of life.

Table 6.10
Biotech survey findings, innovation environment

Mean value of 1-6 scale, where 1 is 'never' and 6 is 'frequently'

	Innovation Activities		
Regional Assets	Idea generation	Product development	Product commercialization
KY universities	3.5	2.8	1.3
KY community colleges	1.1	1.1	1.1
KY public or private research houses	1.7	1.4	1.2
KY-based customers	2.4	1.7	1.8
Other KY biotech firms	1.6	1.4	1.3
KY-based suppliers	1.8	1.5	1.5
Venture capital firms	1.5	1.5	1.5
Industry associations	2.3	1.3	1.6
Business assistance centers	1.8	1.2	1.6

Source: Kentucky Biotechnology Survey 2001.

Table 6.11
Biotech survey findings, reasons for location in Kentucky

Percent respondents indicating item as a reason

Reason	%
Spun off from other KY business	25
Spun out of KY university	67
Proximity to KY suppliers to industry	0
Happenstance (chance or luck)	42
Quality of life for employees	25
Access to skilled workers	0
Proximity to KY research and development centers	17
Business friendly environment	17
Low cost of labor	0
Proximity to competing firms in same line of business	8
Low cost of living for employees	0
Chief executive's principal residence	83

Source: Kentucky Biotechnology Survey 2001.

Endnotes

[1] Feser, E. J., and K. Koo, *High-Tech Clusters in North Carolina* (Raleigh, NC, North Carolina Board of Science and Technology, 2001).

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

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

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

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

[6] Note that we used occupational utilization data to help identify four clusters listed in Table 3.1: securities and insurance, banking and advertising, legal services, and transportation, shipping, and logistics. These are essentially hybrid labor skill/value-chain clusters. Table 3.3 reports a grouping of industries based purely on labor skill demands.

[7] Skill data for each occupation were derived from the Occupational Information Network (ONET), U.S. Department of Labor, Employment and Training Administration. ONET, a replacement to the Dictionary of Occupational Titles, catalogs attributes of detailed occupations in the U.S. economy.

[8] As in the case of the value-chain cluster, data reduction methods (statistical cluster analysis and factor analysis) were used to group industries. A detailed discussion of the methodology is available upon request.

[9] The underlying industrial composition of the labor skill clusters is reported in Appendix Table 3.

[10] n.e.c. = not elsewhere classified.

[11] An extensive discussion of the local *G* can be found in Ord, J. K., and A. Getis, "Local spatial autocorrelation statistics: Distributional issues and an application," *Geographical Analysis*, vol. 27, pp. 286-306, 1995. The skewed urban size distribution tends to limit the effectiveness of the G statistic when very large counties are compared to very small ones. Therefore, we use the natural log of employment in calculating the local G to dampen the size distribution effect.

[12] Kentucky's houseboat cluster is reviewed in detail in *Clusters in Rural Areas: Auto Supply Chains in Tennessee and Houseboat Manufacturers in Kentucky*, by S. Rosenfeld, C. Liston, M. Kingslow, and E. Forman (Chapel Hill, NC, Regional Technology Strategies, 2000).

[13] From Henry Ford's introduction of cost-minimizing, mass production techniques to produce the revolutionary Model T, the motor vehicle industry has been a major source of product and process innovations that have shaped large-scale manufacturing worldwide.

[14] There is some information in the state's ES-202 files regarding the branch plant status of individual vehicle cluster establishments. However, the ES-202 statistics do not closely parallel Harris InfoSource data maintained by the Kentucky Cabinet for Economic Development and Kentucky Chamber of Commerce. The ES-202 figures suggest that the number of branch establishments in the state is more modest than commonly believed while the Harris information suggests the opposite. In the end, the Harris data collected by Kentucky Cabinet for Economic Development probably provide a more accurate sense of branch plant dominance in Kentucky vehicle manufacturing since they are restricted to narrowly defined auto manufacturing sectors, whereas the ES-202 data are assembled for a broader vehicle manufacturing cluster that includes secondary and tertiary supplier industries that may also supply non-vehicle producers.

[15] Note that the map lists major companies strictly to identify the cluster's core firms; the underlying employment figures are for all companies in the selected core segments of the cluster.

[16] It is important to note that Kentucky data used in this study are from 1999. Given the rapid growth of information technology in the state and nationwide, it is likely that the report fails to capture the presence of some IT companies that started up or located in the state in the last 1-2 years.

[17] *The Economic Contributions of the Biotechnology Industry to the U.S. Economy*, Ernst & Young Economics Consulting and Quantitative Analysis (prepared for the Biotechnology Industry Association), May 2000.

[18] A copy of the instrument is provided in the Appendix.

[19] Two companies that refused claimed they were in the pharmaceutical rather than biotechnology business. Because we explicitly included pharmaceuticals in our biotechnology definition, we retained the firms in our list of 42 enterprises.

[20] Business surveys often yield response rates from 15-20 percent. In relative terms, the biotech survey was successful (i.e. roughly 35 percent response). However, subsequent survey efforts may have to employ even more aggressive follow-up in order to obtain a larger sample of responses.

[21] One interviewee noted that empty tobacco warehouses nearby the UK campus could be adapted for use as biotechnology business incubators, permitting closer interaction between campus researchers and firms. The absence of suitable lab space for biotechnology companies is a problem in many states, and adaptive reuse of older properties is a common solution.