Using NAICS to Identify National Industry Cluster Templates for Applied Regional Analysis

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Abstract

Whereas FESER and BERGMAN, 2000, developed the concept of national-level cluster templates and introduced a systematic methodology to identify such clusters, their technique and results were based on the now-outdated Standard Industrial Classification (SIC) system for categorizing industries. We update their results using the 1997 Benchmark Input-Output Accounts for the United States, which are based on the North American Industry Classification System (NAICS). Since the treatment of services is much more comprehensive under NAICS, we are able to expand on the Feser and Bergman manufacturing templates to identify more comprehensive mixed-sector templates. The cluster templates we determine can provide a foundation for regional economic development strategies.

Industry Clusters & Linkages; Regional Development Policy

JEL Classification: R10, R11, R58

INTRODUCTION

In the last decade, many states and communities have adopted cluster analysis as a policy-making tool in economic development. Target-cluster identification permits state and local governments to allocate scarce resources to the expansion and retention of a small group of key industries. The cluster approach to development has intellectual roots both in industrial organization economics and regional geography. While industrial economists stress inter-industry and inter-organization linkages as well as intra-industry competition (see, for example, AUDRETSCH and FELDMAN, 1996; PORTER, 1990, 1998; and YAMAWAKI, 2002), economic geographers and regional economists focus on the importance of agglomeration economies in industrial location and spatial concentration (DOERINGER and TERKLA, 1995; MARKUSEN, 1996).

PORTER, 1998, defines clusters as follows.

> Clusters are geographic concentrations of inter-connected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition. They include, for example, suppliers of specialized inputs such as components, machinery, and services, and providers of specialized infrastructure. Clusters also often extend downstream to channels and customers and laterally to manufacturers of complementary products and to companies in industries related by skills, technologies or common inputs. Finally, many clusters include governmental and other institutions --- such as universities, standard-setting agencies, think tanks, vocational training providers, and trade

associations --- that provide specialized training, education, information, research, and technical support. (p. 78)

PORTER, 1998, explains that clusters represent a new spatial form of organization, significantly different from the traditional, hierarchal vertical integration of companies and markets. The fact that companies are clustered together in one region, and that the ongoing exchanges among them foster communication and trust, produces "advantages in efficiency, effectiveness, and flexibility." (pp. 79-80)

Indeed, economic development practitioners recognize the following advantages of industrial clusters: economic efficiencies that reduce costs (of information, of specialized inputs and infrastructure, and of skilled labor) for firms in the cluster; increased technological change and innovation encouraged by the cluster; reduced risk to investment in start-up companies in the cluster; and the generation of visibility and identity for a region. For the Greater Cincinnati region alone (a fifteen-county area, including counties in Ohio, Kentucky, and Indiana), over the last several years, no fewer than *six* separate studies have been undertaken to identify and describe important inter-industry linkages.[1]

It is relatively straightforward, using publicly available data, to measure regional industrial strength by way of shift-share analysis, location quotients, regional employment and establishment count, regional impact multipliers, and regional growth relative to national growth. Many of these methods are described in McCANN, 2001. In fact, it is tempting to identify clusters directly from the regional strengths of industries that may seem to be related to each

other. However, except for regions with well-established clusters (e.g., the biotechnology clusters in the San Diego and Raleigh-Durham-Chapel Hill areas), this method of cluster identification gives little guidance to regional planners regarding development strategies.

FESER and BERGMAN, 2000, developed the idea of national cluster "templates" that include industries that are linked together, taking into account as many of PORTER's, 1998, inter-industry relationships as possible. The templates provide a type of road-map for development planners to follow, as they seek to build upon a region's existing strengths, by indicating what new industries they might attract that could readily interact with existing firms. Feser and Bergman also developed a statistical technique, based on factor analysis, to identify national-level clusters. (Although we refer to them as "clusters" throughout this paper, they are clusters without a regional context, and are better termed "cluster templates" as the titles of this paper and the Feser and Bergman paper suggest.) The Feser and Bergman technique reveals latent opportunities in a regional economy that would otherwise not become evident by merely examining current local trading patterns and employment statistics.[2] The technique is capable of identifying clusters that include vertically-linked as well as horizontally-linked industries. Moreover, it has the potential for uncovering government and university linkages as well. Unfortunately, the timing of the Feser and Bergman paper was unlucky. Their technique and results were based on the 1987 Benchmark Input-Output Accounts, which, in turn, were based on the Standard Industrial Classification (SIC) system for categorizing industries. Since current employment and establishment data for cluster analyses are collected on the new North American Industry Classification System (NAICS), the Feser and Bergman results are now difficult to apply.

In this paper, we update FESER and BERGMAN, 2000, using the 1997 input-output tables, which are based on NAICS industries. In so doing, we are making a practical contribution to the literature on cluster analysis. It turns out that the Feser and Bergman technique is remarkably robust when applied to the NAICS industries and allows us to identify sixty-one national cluster templates. Whereas some of the cluster templates we identify are primarily for either manufacturing clusters or service clusters (or agricultural or mining clusters, for that matter), others include a mix of industries from different aggregate sectors. This result is an improvement over the Feser-Bergman set of SIC-based cluster templates, which are in the manufacturing sector only. It is also an improvement over the FESER and KOO, 2001, mixed-sector cluster templates, some of which are not economically reasonable, and, indeed, needed to be revised by Feser and Koo using additional, occupation-based data.[3]

SIC TO NAICS

The 1997 Benchmark Input-Output Accounts from the U.S. Department of Commerce Bureau of Economic Analysis are based on NAICS. As opposed to the SIC system which classifies establishments that have similar products, NAICS groups together establishments with similar production processes. According to LAWSON, *et al.*, 2002, NAICS-based classifications are more in line with the principle underlying the input-output classifications of the Bureau of Economic Analysis. In addition, the NAICS-based classifications introduce considerable detail in the service sector, as opposed to the SIC system, and a completely new sector, "Information," has been added under NAICS. As a result of the NAICS changes, nearly US$200 billion has

been shifted from the goods-producing sectors to the service-providing sectors of the economy (LAWSON, *et al.*, 2002).

The 1997 Benchmark Input-Output Accounts present inter-industry transactions at three different levels of industry aggregation: the sector level, the summary industry level, and the detailed industry level. As did FESER and BERGMAN, 2000, we work with detailed industry level data. However, unlike Feser and Bergman, we include industries in the transportation, agricultural, construction, utilities, and service sectors of the economy. In total, we consider 483 Industries.[4]

METHODOLOGY

We follow the factor-analysis technique described in FESER and BERGMAN, 2000. For two industries A and B to be considered part of the same cluster, they must be linked in one of the following four ways:

1. A buys directly or indirectly from B;
2. A sells directly or indirectly to B;
3. A and B have similar purchase patterns from other industries; or
4. A and B have similar sales patterns to other industries.

Let x_i (i = A,B) be the vector of purchase shares for each industry i. (That is, the 483 elements of x_A indicate the fraction of purchases made by industry A that come from each of the 483 industries we consider.) Similarly, let y_j (j = A,B) be the vector of sales shares for each industry j. Then, we construct four correlation coefficients to characterize the similarities in

input-output structure between each pair of industries A and B. The specific correlation coefficients we estimate are as follows:

$r(x_A,y_B)$ measures the degree to which the buying pattern of industry A is similar to the selling pattern of industry B, i.e., the degree to which industry A purchases inputs from industries that B sells to;

$r(y_A,x_B)$ measures the degree to which the buying pattern of industry B is similar to the selling pattern of industry A, i.e., the degree to which industry B purchases inputs from industries that A sells to;

$r(x_A,x_B)$ measures the degree to which industries A and B have similar input purchasing patterns; and

$r(y_A,y_B)$ measures the degree to which A and B possess similar sales patterns, i.e., the degree to which they sell goods to a similar mix of buyers.

We then choose the largest of the four correlation coefficients as the best indication of the strength of the connection between the two industries. Repeating this process for all possible industry pairs yields a 483 x 483 symmetric matrix of "maximum correlation coefficients."

Principal components factor analysis with promax rotation leads to 103 factors with eigenvalues greater than one.[5] However, nearly 100 percent of the variance is explained by the top 61 factors; hence, applying the proportion criterion (conservatively) leaves us with 61 industrial clusters to interpret. Industries with factor loadings that exceed a minimum value (the "cutoff factor loading") are considered part of the industrial cluster that factor represents. Whereas FESER and BERGMAN, 2000, used a fixed cutoff value of 0.35, we do not. The

specific cutoff factor loadings we use vary by factor and are listed in Appendix A. We selected low values generally in order to offer development planners maximum flexibility in target-industry selection for their clusters of interest. Moreover, with expertise in several of the clusters, including biotechnology, we could determine cutoffs that made economic sense. Nevertheless, other values could be chosen. The complete list of factor loadings is posted on the author's website (http://irving.vassar.edu/faculty/rr/research.htm) so anyone wishing to use the NAICS-based templates can apply his or her own desired cutoff values.

NATIONAL INDUSTRY CLUSTER TEMPLATES

Appendix A lists the 61 factors in descending order of percentage variance explained. Our interpretations (that is, cluster names) appear in the second column. Two of the factors contain such a diversity of industries as to have inconclusive interpretations, and are so identified in the table. Among the top ten industrial clusters, eight are primarily, though by no means exclusively, manufacturing clusters, one is a service-oriented cluster, made up of industries that provide services for households, while one is inconclusive. In a comparison with the top ten loadings in FESER and BERGMAN, 2000, four clusters are interpreted similarly: Metalworking, Vehicle Manufacturing, Processed Foods & Beverages (Packaged Food Products in Feser and Bergman), and Chemical Products (Chemicals and Rubber in Feser and Bergman).

The industrial clusters are not mutually exclusive. Indeed, with 61 factors and fairly low cutoff factor loadings, our approach favors larger clusters with significant overlap (although only one cluster, Fats & Oils, Factor 59, is a proper subset of another, Feed Products, Factor 37). For example, along with Processed Foods & Beverages, we also find separate Dairy Products, Soft

Drinks, Fats & Oils, and Confectionery Products clusters. We identify a total of four clusters that feature textile, apparel, and textile-support industries. There is considerable overlap as well between Medical Supplies & Services and Biotechnology. The overlapping nature of the clusters gives economic development planners significant flexibility when applying the national cluster results to specific geographic regions. Table 1 shows that each of the 483 industries belongs to at least one of the 61 clusters. The modal number of clusters for each industry is two; 196 industries belong to exactly two clusters. There are seven very "popular" industries, each belonging to more than four clusters. Belonging to five clusters each are the following industries: Grain Farming (NAICS 11113, 11114, 11115, 11116, & 11119), Other Animal Food Manufacturing (NAICS 311119), Carpet and Rug Mills (NAICS 31411), Transit and Ground Passenger Transportation (NAICS 485), Architectural, Engineering, and Related Services (NAICS 5413), and Specialized Design Services (NAICS 5414). Architectural, Engineering, and Related Services (NAICS 5413) is a member, quite reasonably, of the following five clusters: Nonmetallic Construction Components (Factor 23), Construction (Factor 12), Consumer Services (Factor 2), IT Support Services (Factor 42), and Construction Materials (Factor 4). Two of these clusters are primarily manufacturing clusters. Hence, we capture the importance of engineering services to consumers, to businesses, and also to heavy industries. Other Animal Food Manufacturing shows up, as might be expected, in Fats & Oils (Factor 59), Grain Products (Factor 17), Feed Products (Factor 37), and Dairy Products (Factor 25), as well as in Biotechnology (Factor 52) as a purchaser of pharmaceuticals.

[Insert Table 1 here]

One industry, Scientific Research and Development Services (NAICS 5417), belongs to six clusters, including Consumer Services (Factor 2), Biotechnology (Factor 52), Vehicle Manufacturing (Factor 8), Advanced Electronic Systems & Components (Factor 58), Glass Products (Factor 38), and Information Technology Support Services (Factor 42). These loadings are *prima facie* reasonable since, according to the Census Bureau's NAICS definition in OFFICE OF MANAGEMENT AND BUDGET, 1998, Scientific Research and Development Services comprises establishments "engaged in conducting original investigation undertaken on a systematic basis to gain new knowledge (research) and/or the application of research findings or other scientific knowledge for the creation of new or significantly improved products or processes (experimental development)." Certainly the high-technology clusters listed above would utilize such services, as would Glass Products (which includes fiber optics and optical devices) and Vehicle Manufacturing (for vehicle design).

While there are a few industrial clusters with industries from a single industrial sector, the vast majority of clusters have broader sectoral representation. Table 2 lists the industrial sectors represented in each cluster and shows that the following 13 clusters are comprised of only manufacturing industries (i.e., those in NAICS sectors 31, 32, and 33): Chemical Products, Plastics, Industrial Machinery & Equipment, Aluminum, Container Manufacturing, Fabricated Metal Products, Concrete & Cement, Industrial Textiles, Soft Drinks, Mobile Homes & Motor Homes, Aircraft Components, Small Metal Products & Parts, and Leather & Rubber Products. Vehicle Manufacturing (Factor 8), which was only a manufacturing cluster in FESER and BERGMAN, 2000, and FESER and KOO, 2001, here includes mining, manufacturing, transportation, rental & leasing, professional & technical service, and other service industries.

The Radios, Movies, & TV cluster (Factor 36) includes manufacturing, information, and professional & technical service industries along with industries in the arts, entertainment, and recreation sector of the economy. In Appendix B, available on the author's website (http://irving.vassar.edu/faculty/rr/research.htm), we give the precise industrial composition of each cluster template. Industries are listed in descending order of their factor loadings. In addition, Appendix B lists the 483 different industries and each of the clusters to which they belong.

[Insert Table 2 here]

As measured by receipts, there were seven trillion-dollar national clusters in 2002. At US$5.3 trillion (almost half of U.S. gross domestic product), the Consumer Services cluster is by far the largest, followed by Business Support Services at US$2.2 trillion. The next five high-receipts clusters are Medical Supplies & Equipment (US$1.4 trillion), Entertainment & Performing Arts (US$1.0 trillion), Insurance (US$1.3 trillion), IT Support Services (US$1.1 trillion), and Biotechnology (US$1.3 trillion). Vehicle Manufacturing, the largest cluster in FESER and BERGMAN, 2000, ranks tenth with approximately US$860 billion in receipts. Table 3 gives economic statistics for each cluster, including the number of firms and establishments, employment, employment growth, annual payroll, receipts, and annual salary.[6]

[Insert Table 3 here]

The last column (Annual Salary) in Table 3 is particularly interesting from an economic development perspective since high-income jobs are quite valuable to the community. At US$73,473, the Information Processing Equipment cluster pays the highest average annual salary. Fossil Fuels at US$64,996 and Mining Equipment at US$60,181 rank second and third respectively. The clusters with average annual salaries between US$50,000 and US$60,000 include Electrical Equipment; Telecommunications; Entertainment & Performing Arts; Radio, Movies, & TV; Glass Products; Container Manufacturing; Insurance; Tobacco Products; Aircraft Components; and Advanced Electronic Systems & Components.

The fifth column of Table 3 shows the percentage change in employment each cluster experienced between 1998 (the first time employment was reported using NAICS) and 2002. The national trend from primary and secondary activities to tertiary employment is clearly indicated. Textile Products, Knitted Products, Copper, Industrial Textiles, Tobacco Products, Leather & Rubber Products, and Textile Support all experienced employment declines of more than 20 percent over the four years leading up to 2002. Large employment decreases are also observed in Metalworking, Electrical Equipment, Industrial Machinery & Equipment, Nonferrous Metals Processing, and a number of other generally manufacturing-oriented clusters. At the same time, employment in Consumer Services and Business Support Services grew by 9.11 percent and 11.36 percent, respectively, and employment in IT Support Services grew by 16.15 percent. Employment in the three healthcare-oriented clusters, Medical Supplies & Services, Biotechnology, and Medical Laboratories, grew by 8.45 percent, 5.51 percent, and 6.76 percent, respectively. The Entertainment & Performing Arts cluster as well as Radio, Movies, &

TV also experienced employment growth during this time period, despite the March 2001 – November 2001 recession.

THE BIOTECHNOLOGY CLUSTER

Encouraging biotechnology cluster development has become a priority of many state and local economic developers over the last five to ten years. Biotechnology industries tend to be attractive targets for economic development because of their relatively high wages (our Biotechnology cluster has an average annual salary of US$48,580 --- well above the average U.S. 2002 industrial salary of US$35,081) and because of the potential for export outside the region by some of its component industries. Employment in the Biotechnology cluster grew 5.51 percent between 1998 and 2002. Moreover, employment and output growth forecasts for the next decade, provided by the Bureau of Labor Statistics, are optimistic, implying continued additional opportunities in biotechnology for entrepreneurs, established firms, employees, and geographic regions.[7]

The factor analysis technique leads to an obvious Biotechnology cluster candidate: Factor 52. Its 14 industries, listed in Table 4, include both Pharmaceutical and Medicine Manufacturing (NAICS 3254) and Scientific Research and Development Services (NAICS 5417), which, according to an October 2003 U.S. Department of Commerce report, *A Survey of the Use of Biotechnology in U.S. Industry*, account for approximately 70 percent of the surveyed firms' primary NAICS codes. In other words, most of the biotechnology work being accomplished, at least in the private sector, is done by firms in 3254 and 5417.[8] Although the average cluster wage is US$48,450, according to Table 3, average salaries are considerably higher in the two

core industries: US$66,742 in Pharmaceutical and Medicine Manufacturing (NAICS 3254) and US$64,357 in R & D (NAICS 5417). Also included are three medical device manufacturing industries, which makes sense since many new medical devices must go through an approval process with the Food and Drug Administration (FDA) similar to that required for new pharmaceutical products. The medical equipment industries in the cluster are Surgical Appliance and Supplies Manufacturing (NAICS 339113), Surgical and Medical Instrument Manufacturing (NAICS 339112), and Electromedical and Electrotherapeutic Apparatus Manufacturing (NAICS 334510). Five end users of biomedical services also load onto Factor 52, that is, form part of the biotechnology cluster. Other Animal Food Manufacturing (NAICS 31119), Dental Laboratories (NAICS 339116), and Veterinary Services (NAICS 541940) purchase a significant amount of pharmaceutical products, while Other Ambulatory Health Care Services (NAICS 6214, 6215, and 6219) and Hospitals (NAICS 622) purchase both pharmaceuticals and surgical devices. Linked as vendors to these latter two industries are Paperboard Container Manufacturing (NAICS 322210), Industrial Gas Manufacturing (NAICS 325120), and Sanitary Paper Product Manufacturing (NAICS 322291). Finally, eight of the industries in the cluster are heavy users of Management of Companies and Enterprises (NAICS 55), an industry with average annual salary of US$70,287 in 2002. Smaller firms in these eight industries tend to outsource managerial functions, including strategic and organizational planning.

[Insert Table 4 here]

The Biotechnology cluster template we identify includes industries across broad sectors of the economy, including manufacturing, healthcare, and services. It could not have been

uncovered through identification of manufacturing clusters alone, nor with the SIC system at all as FESER and KOO, 2001, showed. Indeed, according to DUN AND BRADSTREET, 2006, three top private-sector biotechnology employers in the Cincinnati region --- P & G Pharmaceuticals, Endo-Ethicon, and Kendle International --- have primary NAICS codes of 3254, 339113, and 5417, respectively. Interestingly, Cincinnati Children's Hospital, very active in biotechnology in the regional economy, has 5417 as its primary NAICS code (rather than Hospitals, NAICS 622).

Table 5 shows dollar linkages between industries in the biotechnology cluster; these values are taken from the Input-Output Accounts. The pharmaceutical industry (NAICS 3254) is shown to sell US$1.4 billion to the Veterinary Services industry (NAICS 541940), while purchasing US$1.6 billion from Scientific Research and Development Services (NAICS 5417). Other purchasers of pharmaceuticals include ambulatory health care, dental laboratories, animal food manufacturing, and hospitals. Meanwhile, pharmaceutical industries purchase management services, scientific R & D services, paperboard containers, industrial gases, and a small amount of animal food. Significant linkages, representing at least four percent of the sales of the selling industry *or* at least four percent of the purchases of the buying industry, are depicted in Figure 1.

[Insert Table 5 here]

[Insert Figure 1 here]

The linkages shown in Figure 1 are for the entire U.S. economy. As such, they indicate potential, rather than actual, regional linkages; it is not necessarily the case that (for example) local scientific research firms sell to local pharmaceutical firms. However, in a series of thirty-two interviews with biotechnology executives in the greater Cincinnati area, most firms indicate they would prefer to sell more locally as well as buy more of their inputs locally, meaning that building up the pharmaceutical sector, for example, will help the scientific research industry and vice versa. Although too small to appear as an arrow in Figure 1, one interview revealed a connection between a firm classified in the scientific research industry and one producing surgical devices, in NAICS 339113.[9]

A 2004 Milken Institute report (DEVOL, *et al.*, 2004), develops an Overall Composite Biotech Index by evaluating metropolitan areas for their human capital, risk capital, inputs into research and development, and other regional features. According to this report, the following five metropolitan areas were ranked first through fifth, respectively, as having strong biotech presences: (1) San Diego, (2) Boston, (3) Raleigh-Durham-Chapel Hill, (4) San Jose, and (5) Seattle-Bellevue-Everett. For these five regions, as well as for the Cincinnati-Middletown region, which aspires to specialize in biotechnology, we computed location quotients for each of the cluster's 14 industries from Table 4. (A location quotient, or LQ, is the share of a region's employment in the cluster industry divided by the share of the nation's employment in that same industry. A value larger than one indicates that the region is specialized in that industry.) The results are given in Table 6. Interestingly, the one common industry specialization across all five regional centers is in NAICS 5417, Scientific Research and Development Services. San Diego is four times more specialized in this industry than the nation as a whole, while the Raleigh-

Durham-Chapel Hill area and San Jose are even more specialized in this activity. Boston has an LQ of 2.70 implying high industry concentration as well. The Seattle area's LQ is somewhat lower (1.47), but still indicates specialization in the industry. The Cincinnati-Middletown area's LQ of 1.60 gives the aspiring region some optimism regarding its future in biotech. However, where the Cincinnati-Middletown area lags behind the leading regions is in the core applications of biotechnology to pharmaceuticals and medical devices.

Each of the biotech centers, as identified in the Milken Institute report, is specialized in at least one of the following three industrial applications: Pharmaceutical and Medicine Manufacturing (NAICS 3254), Surgical and Medical Instrument Manufacturing (NAICS 339112), and Electromedical and Electrotherapeutic Apparatus Manufacturing (NAICS 334510). Indeed, San Diego is specialized in all three industries, with LQs of 1.81, 1.44, and 1.96, respectively. Boston, as well, is specialized in all three core applications, with LQs of 1.76, 2.17, and 5.71, respectively. In the Raleigh-Durham-Chapel Hill area, the main application is pharmaceuticals; the area has an LQ of 3.63 in Pharmaceutical and Medicine Manufacturing. This region is not particularly specialized in medical devices. The opposite situation exists in San Jose. Here the LQs for Surgical and Medical Instrument Manufacturing and Electromedical and Electrotherapeutic Apparatus Manufacturing are 5.99 and 7.25, respectively. Seattle, the fifth biotech center, is also specialized in the latter industry (NAICS 334510), with an LQ of 3.81. The Cincinnati region, as of 2004, is not specialized in either pharmaceuticals or medical devices. As for most of the other industries in the cluster template, Table 6 suggests that they need not be located within a region for it to be a successful biotech center. San Diego, for

example, imports most of its paperboard containers, sanitary paper products, and industrial gases from outside the area.

[Insert Table 6 here]

IMPLICATIONS FOR ECONOMIC DEVELOPMENT

The cluster approach has a number of clear advantages over other methods for economic development. First, it is a focused approach that directs scarce development resources, including the time necessary for strategic planning and economic analysis, toward those industries development planners feel will bring the most benefit. The approach does not mean that firms outside the targeted clusters will be ignored but may suggest they be given secondary priority. Second, the cluster approach forces regional developers to think about linkages between industries that many times play a role in their location decisions, and subsequent spatial patterns. Firms that require rail or water transportation, for instance, tend to locate near these transportation sources. Firms that support biotechnology activity in either pharmaceuticals or medical devices tend to locate near their biotechnology customers. Of course, spatial implications are not always present since there are hospitals, large consumers of pharmaceuticals, in every major metropolitan area regardless of the presence of large pharmaceutical companies. But, it is good to know that if a pharmaceutical company locates in a region, it has local hospitals, as well as hospitals outside the region, that it can sell to (and/or collaborate with). In addition to identifying vertical linkages between buyers and sellers, the cluster approach also picks up on horizontal relationships among industries. One of the clusters identified above, for example, consists primarily of industries that sell to automobile producers.

These industries neither buy from nor sell to each other. In these clusters, there is one key industry that brings a number of others to the region to support it. Third, the particular cluster approach described in this paper allows development planners to "think outside the box." Rather than concentrate simply on the industries that are currently strong in the region, they can start with national cluster templates to determine what might be possible in the region. Especially for the regions in the United States that depend critically on declining clusters (for example, textiles in southeastern regions of the United States), this approach shows that there may be potential to "remake themselves" based on national trends in inter-industry linkages.

After national clusters are identified, they should then be screened based on their strengths in the regional economy and their potential for leading to significant regional economic development. ECONOMICS CENTER FOR EDUCATION & RESEARCH, 2004, describes six screening criteria that are recommended in selecting target clusters. (1) The cluster should have high average salaries, impacting positively on local incomes. (2) The cluster should have a strong employment base (as measured by the percent of cluster employment in the region) in order to have a high enough chance to take root and succeed (except, of course, for those regions attempting a makeover). (3) The cluster should have industries that serve more than just the local economy; it should have an export base since new money from outside the region can help facilitate economic development by way of impact multipliers. (4) The cluster should have a reasonably high location quotient, signifying strong presence in the region relative to the national economy. (5) The cluster should exhibit strong national growth in employment. National trends may indicate where there are opportunities to "catch a wave" that can help boost the local economy. (6) The cluster should exhibit strong relative local growth (local growth minus

national growth). If a cluster shows a high value on this screening criterion, it means that either the region is able to succeed in the face of an adverse national trend or it can outperform the industry's already positive national growth rate.

Development planners must be aware of the limitations of the data that are currently available. First, the level of aggregation in the input-output table is a problem in some cases, especially in the service industries. Although NAICS is certainly an improvement over the SIC system in this regard, it is still the case that information for the manufacturing industries is much more detailed than the information available for the service industries. For example, numerous studies, including CORTRIGHT and MAYER, 2002, have mentioned the importance of venture capital to biotechnology start-ups. However, Miscellaneous Intermediation (including Venture Capital), or NAICS 523910, is not broken out in the detailed input-output table, and, hence, does not load onto the Biotechnology cluster (Factor 52). Furthermore, firms in NAICS industry 541380 (Testing Laboratories) contribute to medical device testing for FDA approval. Since 541380, however, is but a small part of Architectural, Engineering, and Related Services (NAICS 5413 in the input-output table), it fails to load as well onto the Biotechnology cluster. Second, in screening the clusters for a development portfolio, the most commonly used data are *County Business Pattern* data, which cover private, nonagricultural employment. In the case of Cincinnati, though, the data omit the area's largest employer, the University of Cincinnati, with approximately 15,000 employees --- an important omission for any cluster (like Biotechnology) that relies on university-based research. Indeed, the addition of the Genome Research Institute in 2002 as part of the University of Cincinnati will not be captured by *County Business Patterns*. Other problems, like data suppression, make it hard to obtain regional-specific employment

estimates for certain, usually smaller, industries. Finally, the national-cluster-template approach is still very new. It has yet to stand the test of numerous applications.

CONCLUSION

Regional policy makers involved in strategic economic development are often interested in identifying a small group of target industries that are critical to the future growth of the region and on which they can focus their expansion and retention efforts. While it is relatively straightforward to determine which industries are currently strong in an area, this information provides little guidance regarding other industries they might credibly seek to attract to the area in order to take advantage of potential synergies among industries. In this paper, we provide a list of sixty-one national industry cluster templates, identified using factor analysis and the most recent, detailed industrial input-output table. We anticipate that this list will provide the foundation for a wide range of regional analyses, particularly when coupled with other tools of economic development. This work improves on previous research by using the latest industrial classification system. It produces mixed-sector cluster templates that capture the various and rich relationships among primary, secondary, and tertiary industries in the U.S. economy.

NOTES

[1] The six studies are *Target Marketing Strategy*, by the WADLEY-DONOVAN GROUP, 1999; *Kentucky Clusters: Industrial Interdependence and Economic Competitiveness*, by FESER and KOO, 2001; *An Ohio Technology-Based Economic Development Strategy*, by BATTELLE MEMORIAL INSTITUTE, 2002; *Hamilton County's Comparative and Competitive Advantages*, by NOLAN, 2003; *Northern Kentucky New Economy Readiness Strategy*, by ANGELOU ECONOMICS, 2003; and *Identification of Industry Clusters for Guiding Economic Development Efforts in Cincinnati USA*, by the ECONOMICS CENTER FOR EDUCATION & RESEARCH, 2004. Although each of the studies includes a biotechnology cluster, each study defines this cluster differently. The study done by the Economics Center used the FESER and BERGMAN, 2000, technique applied to summary industries. The biotechnology cluster identified was less than satisfactory; working with detailed industries produces a much stronger result.

[2] It is worth noting that our method is not the only systematic, quantitative approach to cluster identification. For example, FESER, 2003, suggests a statistical methodology for identifying clusters of industries that have similar occupation patterns. Using both supply-chain and occupational approaches (based on national data) in tandem could provide an especially rich base for regional cluster analyses.

[3] Twenty-eight value-chain clusters are identified in FESER and KOO, 2001, pp. 63-69. Included in the Printing and Publishing cluster are General Medical and Surgical Hospitals (SIC 8062), Psychiatric Hospitals (SIC 8063), and Testing Laboratories (SIC 8734). Included in the Chemicals and Plastics Cluster are Offices and Clinics of Optometrists (SIC 8042), Kidney

Dialysis Centers (SIC 8092), and Specialty Outpatient Facilities (SIC 8093). Moreover, none of the 28 clusters provides a good approximation to biotechnology. Pharmaceuticals is identified as an independent cluster with only four industries: Medicinals and Botanicals (SIC 2833), Pharmaceutical Preparations (SIC 2834), Diagnostic Substances (SIC 2835), and Biological Products, Excluding Diagnostics (SIC 2836).

[4] Of the 490 detailed industries in the 1997 Benchmark Input-Output Accounts, only seven are omitted from the factor analysis. Wholesale Trade (NAICS 42) and Retail Trade (NAICS 44 and 45) are omitted due to their two-digit level of aggregation. In some initial work, these industries proved too aggregated to load meaningfully on factors. If there is greater detail in future benchmark tables produced by the Bureau of Economic Analysis, consideration should be given to working again with these sectors. Moreover, Private Households (NAICS 814), Federal Electric Utilities (S00101), State and Local Government Passenger Transit (S00201), State and Local Government Electric Utilities (S00202), and General Government Industry (S00500) are omitted as well from the analysis. These industries sell only to final purchasing sectors; they have no intermediate industrial sales. Moreover, they are excluded from both the *2002 Economic Census* and *County Business Patterns*. We do, however, maintain two final industries: Hospitals (NAICS 622) and Nursing and Residential Care Facilities (NAICS 623); hospitals, at least, are expected to load onto healthcare clusters identified.

[5] We use a promax rotation, rather than the varimax rotation in FESER and BERGMAN, 2000, since the promax rotation accounts for inter-factor correlations (which are present to some degree in our data). The results are generally robust to the rotation technique used.

[6] These statistics are taken from *Statistics of U.S. Businesses,* 2002 and 1998, U.S. DEPARTMENT OF COMMERCE Bureau of the Census, accessed, on June 4, 2006, at http://www.census.gov/csd/susb/usalli02.xls, http://www.census.gov/csd/susb/usalli98.xls, respectively. Note that FESER and BERGMAN, 2000, report value added for clusters identified. Since value added data are available only for manufacturing industries, we instead report total receipts, which are collected consistently across all sectors of the economy.

[7] The Bureau of Labor Statistics forecasts substantial growth in both employment and real output in Pharmaceutical and Medicine Manufacturing (NAICS 3254) and Scientific Research and Development Services (NAICS 5417). The 2004-2014 forecast for pharmaceuticals is a 2.3 percent annual average growth in employment and a 3.3 percent annual average growth in real output. The forecast for R & D is a 2.5 percent annual average growth in employment and an impressive 4.8 percent annual average growth in real output. See U.S. DEPARTMENT OF LABOR Bureau of Labor Statistics, *Employment and Output by Detailed Industry*, accessed on June 4, 2006, at http://www.bls.gov/emp/empinddetail.htm.

[8] See the 2003 U.S. Department of Commerce Report, *A Survey in the Use of Biotechnology in U.S. Industry*. Out of the 897 biotechnology users surveyed by the Department of Commerce that reported being in any industry at all, 333 were in Scientific R & D Services (NAICS 5417); 301 were in Pharmaceutical and Medicine Manufacturing (NAICS 3254); 36 were in Electromedical and Electrotherapeutic Apparatus Manufacturing (NAICS 334510); 20 were in Medical and Diagnostic Laboratories (NAICS 6215); 16 were in Food Manufacturing and

Beverage and Tobacco Product Manufacturing (NAICS 311 and 312, respectively); and 19 were in Basic Chemical Manufacturing (NAICS 3251). Most of these industries load onto the Biotechnology cluster as identified in this paper.

[9] Interviews were conducted in Spring 2006 in the context of a study commissioned by the Hamilton County Regional Planning Commission.

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Table 1

Number of Industries Belonging to Different Numbers of Clusters

	NUMBER OF CLUSTERS							
	0	1	2	3	4	5	6	> 6
NUMBER OF INDUSTRIES	0	111	196	130	39	6	1	0

Table 2

Sector Representation in Clusters

CLUSTER (NUMBER)	NAICS SECTORS REPRESENTED*
Metalworking (1)	21,23,32,33
Consumer Services (2)	11,22,23,48,49,52,53,54,56,61,62,71,72,81,OOD[a]
Processed Foods & Beverages (3)	11,31,32,33,71
Construction Materials (4)	21,31,32,33,54
Electrical Equipment (5)	33,81
Paper Products (6)	11,22,31,32,33,51
Inconclusive (7)	21,31,32,33,51,53,54,56
Vehicle Manufacturing (8)	21,31,32,33,48,53,54,81
Chemical Products (9)	31,32,33
Plastics (10)	31,32,33
Automotive Components (11)	31,32,33,54,61,81
Construction (12)	11,21,23,33,54,LG[b]
Textile Products (13)	11,31,32,33
Wood Products (14)	11,23,32,33
Industrial Machinery & Equipment (15)	33
Industrial Transportation (16)	21,23,32,33,48,61,71
Grain Products (17)	11,31,32,33
Furniture & Household Items (18)	11,31,32,33
Nonmetallic Mineral Products (19)	32,33,48,49,54
Petroleum Products (20)	21,22,32,48,49
Printing & Publishing (21)	31,32,33,51,56,81
Agriculture, Hunting, & Forestry (22)	11,31
Nonmetallic Construction Components (23)	32,33,54
Medical Supplies & Services (24)	31,32,33,48,49,53,54,56,61,72
Dairy Products (25)	11,31,32,33,54
Aluminum (26)	33
Knitted Products (27)	11,31,32,33
Business Support Services (28)	31,32,33,48,49,52,53,54,56,72,FG[c]
Telecommunications (29)	33,51,81
Fossil Fuels (30)	21,22,32,33,53,54
Copper (31)	21,33
Nonferrous Metals Processing (32)	21,33
Information Processing Equipment (33)	33,51
Entertainment & Performing Arts (34)	31,32,33,51,53,54,55,56,61,71,81
Residential Construction (35)	21,23,32
Radio, Movies, & TV (36)	33,51,54,71
Feed Products (37)	11,31,32
Glass Products (38)	32,33,54
Container Manufacturing (39)	32,33

CLUSTER (NUMBER)	NAICS SECTORS REPRESENTED*
Insurance (40)	52,OOD[a]
Fabricated Metal Products (41)	32,33
IT Support Services (42)	21,51,54,56,61,62,81
Concrete & Cement (43)	32,33
Mining Equipment (44)	21,22,32,33
Industrial Textiles (45)	31,32
Air Travel (46)	32,33,48,49,56,72
Tobacco Products (47)	11,31
Transportation Equipment (48)	33,48,81
Animal Products (49)	11,31,32,72
Inconclusive (50)	21,31,32,33,51,53,54,62,71,72
Soft Drinks (51)	31,32,33
Biotechnology (52)	31,32,33,54,55,62
Mobile Homes & Motor Homes (53)	32,33
Aircraft Components (54)	31,33
Small Metal Products & Parts (55)	33
Medical Laboratories (56)	32,33,51,62
Leather & Rubber Products (57)	31,32,33
Adv. Electronic Systems & Components (58)	33,54
Fats & Oils (59)	11,31
Textile Support (60)	31,33,56
Confectionery Products (61)	11,31,32

[a] OOD: Owner-Occupied Housing
[b] LG: State & Local Government Enterprises
[c] FG: Federal Government Enterprises

* NAICS Sector Titles

Sector 11	Agriculture, Forestry, Fishing and Hunting
Sector 21	Mining
Sector 22	Utilities
Sector 23	Construction
Sector 31-33	Manufacturing
Sector 48-49	Transportation and Warehousing
Sector 51	Information
Sector 52	Finance and Insurance
Sector 53	Real Estate and Rental and Leasing
Sector 54	Professional, Scientific, and Technical Services
Sector 55	Management of Companies and Enterprises
Sector 56	Administrative and Support and Waste Management and Remediation Services
Sector 61	Educational Services
Sector 62	Health Care and Social Assistance
Sector 71	Arts, Entertainment, and Recreation
Sector 72	Accommodation and Food Services
Sector 81	Other Services (Except Public Administration)

Table 3

Cluster Summary Statistics for 2002*

CLUSTER (NUMBER)	FIRMS	ESTAB-LISHMENTS	EMPLOY-MENT	% EMPL CHANGE 98-02	ANNUAL PAYROLL (US$1,000)	RECEIPTS (US$1,000)	ANNUAL SALARY **
Metalworking (1)	91,788	98,532	3,727,947	-15.68	147,385,748	772,856,141	39,535
Consumer Services (2)	2,896,275	3,547,975	53,852,456	9.11	1,590,226,236	5,298,555,468	29,529
Processed Foods & Beverages (3)	34,763	38,340	1,676,159	-0.34	51,417,747	472,892,643	30,676
Construction Materials (4)	154,357	176,994	3,644,725	-3.01	149,993,188	622,489,296	41,153
Electrical Equipment (5)	31,823	35,249	1,639,883	-19.75	86,726,901	433,252,024	52,886
Paper Products (6)	73,938	84,143	2,048,057	-11.03	80,367,050	425,732,035	39,241
Inconclusive (7)	172,480	222,957	6,960,007	4.44	225,269,153	559,976,708	32,366
Vehicle Manufacturing (8)	218,705	245,755	3,857,380	-6.43	152,618,106	860,609,619	39,565
Chemical Products (9)	11,032	13,463	714,795	-14.50	33,572,667	330,974,186	46,968
Plastics (10)	14,798	17,937	988,217	-12.04	36,934,296	257,466,568	37,375
Automotive Components (11)	188,513	204,649	3,678,971	-1.06	123,119,242	557,085,945	33,466
Construction (12)	380,424	397,584	3,864,199	7.11	180,464,910	893,254,511	46,702
Textile Products (13)	27,631	29,125	875,167	-33.88	23,195,698	128,142,752	26,504
Wood Products (14)	46,473	48,933	1,164,929	-6.92	38,253,870	214,770,944	32,838
Industrial Machinery & Eqpt (15)	39,494	41,619	1,304,291	-17.24	53,753,835	268,139,099	41,213
Industrial Transportation (16)	12,703	19,232	1,889,403	6.64	60,494,011	245,150,272	32,018
Grain Products (17)	13,768	15,215	266,744	-3.01	9,283,714	99,639,693	34,804
Furniture & Household Items (18)	32,500	34,129	965,530	-8.86	34,495,272	228,467,539	35,727
Nonmetallic Mineral Products (19)	125,650	145,700	1,898,816	2.71	69,538,236	268,234,039	36,622
Petroleum Products (20)	36,385	54,158	1,861,598	0.30	76,852,331	703,862,998	41,283
Printing & Publishing (21)	126,982	136,778	1,737,739	-1.35	58,296,245	265,872,312	33,547
Ag, Hunting, & Forestry (22)	3,780	3,982	63,505	-0.87	1,708,002	8,331,040	26,896
Nonmet Construction Cmpts (23)	110,876	123,941	1,752,637	2.27	85,422,165	253,631,127	48,739
Medical Supplies & Services (24)	778,026	971,371	18,368,987	8.45	428,742,874	1,418,025,689	23,341

CLUSTER (NUMBER)	FIRMS	ESTAB-LISHMENTS	EMPLOY-MENT	% EMPL CHANGE 98-02	ANNUAL PAYROLL (US$1,000)	RECEIPTS (US$1,000)	ANNUAL SALARY **
Dairy Products (25)	43,270	46,382	1,009,088	4.32	38,845,777	345,936,139	38,496
Aluminum (26)	1,835	2,066	149,630	-17.69	5,833,957	38,343,711	38,989
Knitted Products (27)	8,155	8,807	402,592	-26.49	11,488,873	70,848,350	28,537
Business Support Services (28)	553,670	779,942	10,818,466	11.36	510,508,994	2,224,794,897	47,189
Telecommunications (29)	50,703	86,501	1,563,791	2.85	80,430,439	425,124,615	51,433
Fossil Fuels (30)	61,654	77,984	1,459,055	-1.27	94,833,048	878,163,505	64,996
Copper (31)	1,361	1,618	121,155	-23.98	4,787,747	33,706,979	39,518
Nonferrous Metals Processing (32)	12,057	12,494	208,453	-15.93	7,807,153	37,801,050	37,453
Information Processing Eqpt (33)	21,983	26,322	860,991	-1.16	63,259,719	285,059,899	73,473
Enter & Performing Arts (34)	329,700	408,388	7,352,524	9.62	386,894,841	1,038,695,806	52,621
Residential Construction (35)	183,405	185,610	1,134,952	12.27	46,543,310	347,339,622	41,009
Radio, Movies, & TV (36)	81,242	97,839	1,419,541	8.99	73,098,538	305,897,236	51,494
Feed Products (37)	1,957	3,036	334,201	2.02	8,596,831	94,230,070	25,724
Glass Products (38)	17,009	20,144	620,002	10.11	33,810,498	103,988,474	54,533
Container Manufacturing (39)	968	1,457	218,920	-13.57	11,442,490	88,841,599	52,268
Insurance (40)	132,828	172,514	2,376,265	1.71	119,977,665	1,335,345,579	50,490
Fabricated Metal Products (41)	12,680	13,678	581,601	-13.70	21,704,387	120,250,829	37,318
IT Support Services (42)	544,045	613,309	7,934,919	16.15	379,925,334	1,060,094,559	47,880
Concrete & Cement (43)	11,329	15,876	444,113	-8.58	17,114,134	85,078,717	38,536
Mining Equipment (44)	6,606	16,395	770,382	-7.98	46,362,051	386,995,767	60,181
Industrial Textiles (45)	2,130	2,611	239,627	-26.17	7,273,594	50,114,350	30,354
Air Travel (46)	427,596	569,461	9,532,901	5.19	148,146,573	722,418,979	15,541
Tobacco Products (47)	114	133	24,031	-26.37	1,379,716	39,426,765	57,414
Transportation Equipment (48)	57,053	65,775	990,649	-0.30	36,788,353	157,801,177	37,136
Animal Products (49)	382,623	510,104	8,781,839	6.86	110,627,038	451,735,817	12,597
Inconclusive (50)	93,515	127,910	3,188,566	-4.02	78,410,299	437,435,687	24,591
Soft Drinks (51)	6,216	8,452	420,897	-8.97	15,763,640	130,550,263	37,452
Biotechnology (52)	107,586	157,524	10,422,719	5.51	506,332,479	1,284,108,813	48,580

CLUSTER (NUMBER)	FIRMS	ESTAB-LISHMENTS	EMPLOY-MENT	% EMPL CHANGE 98-02	ANNUAL PAYROLL (US$1,000)	RECEIPTS (US$1,000)	ANNUAL SALARY **
Mobile Homes & Motor Homes (53)	3,733	4,340	492,649	-9.86	22,293,074	283,473,893	45,251
Aircraft Components (54)	5,319	6,311	744,697	-18.48	39,921,099	201,845,130	53,607
Small Metal Products & Parts (55)	6,086	6,393	306,411	-16.45	12,285,787	60,351,933	40,096
Medical Laboratories (56)	37,689	57,502	1,318,575	6.76	52,258,110	182,253,708	39,632
Leather & Rubber Products (57)	8,652	9,658	430,074	-20.34	15,403,118	84,547,623	35,815
Advanced Electronic Systems & Components (58)	76,305	85,377	2,037,266	-3.75	117,708,837	404,928,219	57,778
Fats & Oils (59)	1,348	2,049	62,175	-8.17	2,373,154	49,666,486	38,169
Textile Support (60)	33,814	36,825	799,006	-29.74	21,360,101	99,339,730	26,733
Confectionery Products (61)	3,312	3,818	181,743	-4.52	6,066,337	57,757,141	33,379

Source: U.S. DEPARTMENT OF COMMERCE Bureau of the Census, *Statistics of U.S. Businesses***,** 2002 and 1998.

* Clusters are not mutually exclusive. The following industries were excluded from the calculations in Table 3: S00102, S00203, S00800, 111110, 111120, 111130, 111140, 111150, 111160, 111190, 111200, 111310, 111320, 111331, 111332, 111333, 111334, 111335, 111336, 111339, 111400, 111910, 111920, 111930, 111940, 111991, 111992, 111998, 112100, 112200, 112300, 112400, 112500, 112900, 230130, 230140, 230310, 230320, 230330, 230340, 482000, and 491000. Data for them were not available either from the *2002 Economic Census* or from *County Business Patterns*. Because of these exclusions, values for some of the clusters, such as Agriculture, Hunting, & Forestry, are severely understated.

** Average salary is calculated by dividing annual cluster payroll by cluster employment.

Table 4

Industries in the Biotechnology Cluster

NAICS	INDUSTRY	FACTOR LOADING
325400	Pharmaceutical and Medicine Manufacturing	0.8788
541940	Veterinary Services	0.7476
550000	Management of Companies and Enterprises	0.5178
541700	Scientific Research and Development Services	0.3942
621B00 *	Other Ambulatory Health Care Services	0.3691
322210	Paperboard Container Manufacturing	0.3454
325120	Industrial Gas Manufacturing	0.3213
339116	Dental Laboratories	0.3134
339113	Surgical Appliance and Supplies Manufacturing	0.3013
339112	Surgical and Medical Instrument Manufacturing	0.3006
322291	Sanitary Paper Product Manufacturing	0.2860
311119	Other Animal Food Manufacturing	0.2715
334510	Electromedical and Electrotherapeutic Apparatus Manufacturing	0.2550
622000	Hospitals	0.2340

* 621B00 = 6214 + 6215 + 6219.

Table 5
Input-Output Linkages in Biotechnology
(In Millions of 1997 U.S. Dollars)

NAICS SELLER	NAICS BUYER													
	325400	541940	550000	541700	621B00*	322210	325120	339116	339113	339112	322291	311119	334510	622000
325400	na	1440.5	0.0	0.0	2021.7	0.0	0.0	147.6	0.0	0.0	0.0	1122.7	0.0	7131.1
541940	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	161.5
550000	6619.0	0.0	na	173.3	808.7	2134.0	390.2	46.1	705.7	911.2	222.7	405.9	459.1	5450.1
541700	1615.5	11.0	0.0	na	40.1	99.2	95.1	4.5	124.6	161.8	15.1	39.8	82.9	739.7
621B00*	0.0	106.5	0.0	0.0	na	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	186.1
322210	928.5	12.5	16.8	32.7	45.7	na	4.9	9.4	172.7	198.0	212.2	17.0	45.0	287.3
325120	139.8	10.6	1.9	50.3	192.1	4.0	na	0.8	0.0	0.1	0.0	0.0	0.0	888.2
339116	0.0	0.0	0.0	0.0	0.0	0.0	0.0	na	35.0	0.0	0.0	0.0	0.0	0.0
339113	0.0	106.0	0.0	0.0	227.1	0.0	0.0	0.0	na	327.1	0.0	0.0	0.0	1678.9
339112	0.0	112.4	0.0	0.0	585.8	0.0	0.0	4.4	551.0	na	0.0	0.0	0.0	2440.6
322291	0.0	76.2	0.0	0.0	147.4	0.0	0.0	0.0	0.0	0.0	na	0.0	0.0	908.4
311119	3.2	98.4	0.0	29.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	na	0.0	0.0
334510	0.0	7.2	0.0	0.0	111.2	0.0	0.0	0.0	149.5	5.9	0.0	0.0	na	633.5
622000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	na

na*:* not applicable

* 621B00 = 6214 + 6215 + 6219.

Table 6

Location Quotients in U.S. Biotechnology Centers

NAICS	INDUSTRY	METROPOLITAN STATISTICAL AREA					
		San Diego[a]	Boston[b]	Raleigh-Durham[c]	San Jose[d]	Seattle[e]	Cincinnati[f]
325400	Pharmaceutical and Medicine Manufacturing	1.8090	1.7562	3.6278	0.2992	0.2907	0.8289
541940	Veterinary Services	1.0461	0.7279	1.5231	0.6815	1.0883	0.9939
550000	Management of Companies and Enterprises	0.6614	1.3225	1.1716	1.8431	1.3300	1.1680
541700	Scientific Research and Development Services	4.2729	2.7047	5.5601	5.8249	1.4713	1.6043
621B00*	Other Ambulatory Health Care Services	1.0546	1.3152	0.8314	0.6801	1.3971	0.8235
322210	Paperboard Container Manufacturing	0.2950	0.5146	0.8729	0.6380	0.5659	2.4243
325120	Industrial Gas Manufacturing	0.2067	0.3894	0.8108	0.5585	0.5155	1.4720
339116	Dental Laboratories	0.9474	0.8855	0.9168	2.2791	1.4911	0.6880
339113	Surgical Appliance and Supplies Manufacturing	1.7862	0.8564	1.2494	0.8006	0.4351	0.7149
339112	Surgical and Medical Instrument Manufacturing	1.4355	2.1657	0.6716	5.9884	0.3378	0.6442
322291	Sanitary Paper Product Manufacturing	0.0131	0.0000	0.2971	0.0000	0.0000	0.0000
311119	Other Animal Food Manufacturing	0.0449	0.0114	1.2020	0.0380	0.1274	0.7705
334510	Electromedical and Electrotherap. App. Manufac.	1.9559	5.7059	0.0000	7.2500	3.8093	0.3711
622000	Hospitals	0.7701	1.1975	1.3159	0.7794	0.7635	0.9631

* 621B00 = 6214 + 6215 + 6219.

[a] San Diego-Carlsbad-San Marcos, CA

[b] Boston-Cambridge-Quincy, MA-NH

[c] Raleigh-Cary, NC, and Durham, NC

[d] San Jose-Sunnyvale-Santa Clara, CA

[e] Seattle-Tacoma-Bellevue, WA

[f] Cincinnati-Middletown, OH-KY-IN

Source: *2004 County Business Patterns*. Location quotients are based on the most recent metropolitan area definitions provided by the U.S. Census Bureau. Those definitions may be found at http://www.census.gov/population/www/estimates/metrodef.html (accessed on 15 July 2006). For some regions, only a range of employees in an industry was reported in *2004 County Business Patterns*. For these regions, we used county-level data on the size distribution of establishments to narrow down the range. Then, the midpoint of this narrower range was taken as the point estimate. In all cases, we were able to narrow down the range considerably using this approach.

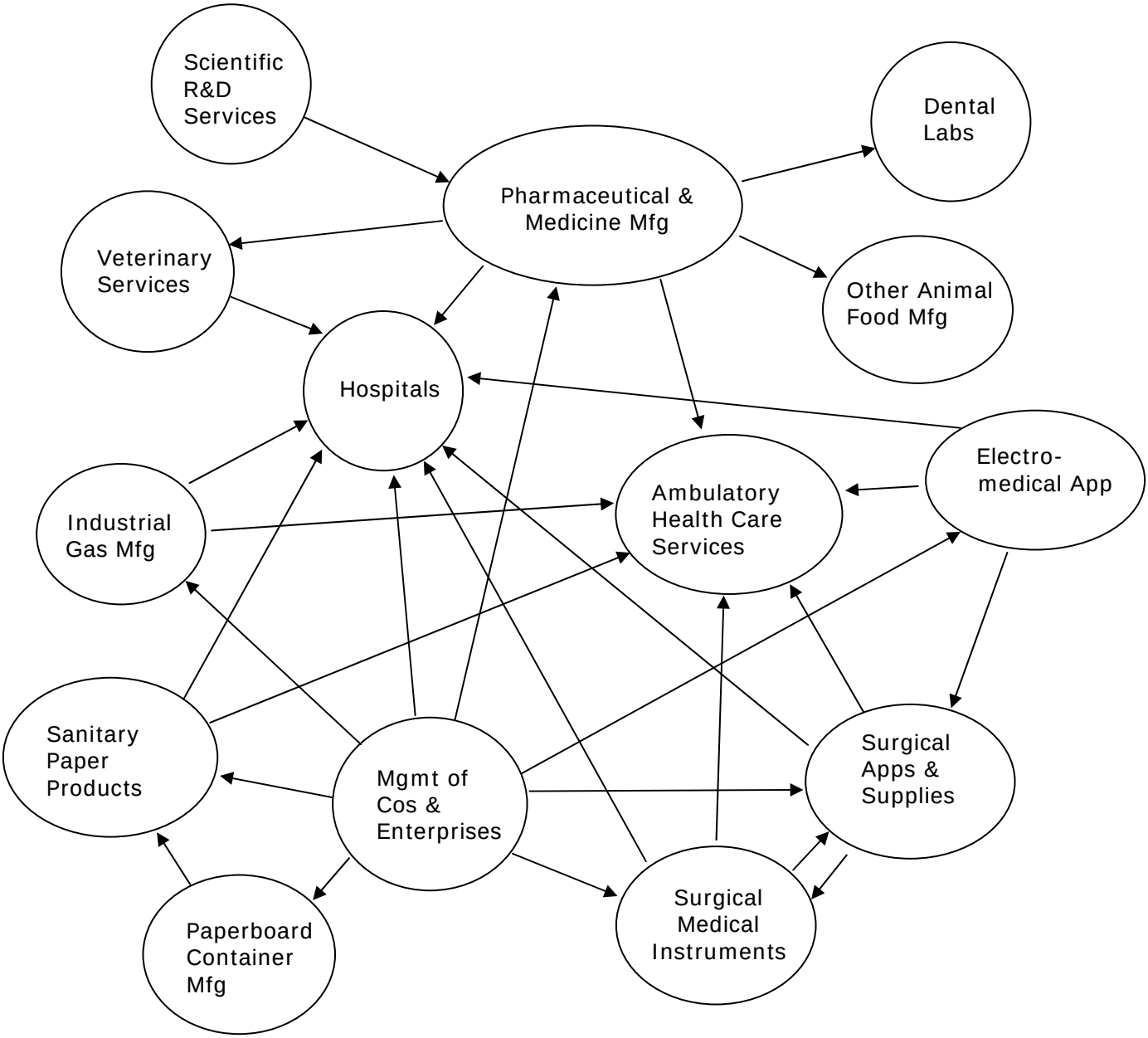

Figure 1: Biotechnology Cluster

Appendix A

Summary Results: Principal Components Factor Analysis

FACTOR	FACTOR INTERPRETATION	EIGENVALUE	PERCENT VARIANCE EXPLAINED	CUTOFF FACTOR LOADING	NUMBER OF INDUSTRIES
1	Metalworking	97.40	20.17	0.19	88
2	Consumer Services	40.44	8.37	0.31	65
3	Processed Foods & Beverages	27.85	5.77	0.40	37
4	Construction Materials	22.89	4.74	0.21	50
5	Electrical Equipment	20.73	4.29	0.24	31
6	Paper Products	15.54	3.22	0.17	28
7	Inconclusive	13.93	2.88	0.40	28
8	Vehicle Manufacturing	12.11	2.51	0.25	32
9	Chemical Products	11.68	2.42	0.29	22
10	Plastics	10.84	2.24	0.30	17
11	Automotive Components	9.83	2.03	0.27	20
12	Construction	9.56	1.98	0.30	18
13	Textile Products	9.42	1.95	0.30	18
14	Wood Products	7.89	1.63	0.18	26
15	Industrial Machinery & Equipment	7.66	1.59	0.20	40
16	Industrial Transportation	7.47	1.55	0.29	16
17	Grain Products	6.91	1.43	0.22	15
18	Furniture & Household Items	6.39	1.32	0.25	26
19	Nonmetallic Mineral Products	6.04	1.25	0.24	20
20	Petroleum Products	5.98	1.24	0.29	13
21	Printing & Publishing	5.59	1.16	0.30	11
22	Agriculture, Hunting, & Forestry	5.51	1.14	0.30	13
23	Nonmetallic Construction Components	5.25	1.09	0.30	17
24	Medical Supplies & Services	5.10	1.06	0.21	23

FACTOR	FACTOR INTERPRETATION	EIGENVALUE	PERCENT VARIANCE EXPLAINED	CUTOFF FACTOR LOADING	NUMBER OF INDUSTRIES
25	Dairy Products	4.86	1.01	0.15	18
26	Aluminum	4.68	0.97	0.30	8
27	Knitted Products	4.52	0.94	0.09	14
28	Business Support Services	4.43	0.92	0.23	17
29	Telecommunications	4.28	0.89	0.36	8
30	Fossil Fuels	4.16	0.86	0.22	12
31	Copper	3.92	0.81	0.30	8
32	Nonferrous Metals Processing	3.79	0.78	0.30	10
33	Information Processing Equipment	3.61	0.75	0.21	9
34	Entertainment & Performing Arts	3.54	0.73	0.22	25
35	Residential Construction	3.53	0.73	0.25	9
36	Radio, Movies, & TV	3.38	0.70	0.17	9
37	Feed Products	3.31	0.69	0.17	14
38	Glass Products	3.28	0.68	0.25	9
39	Container Manufacturing	3.16	0.65	0.41	5
40	Insurance	3.06	0.63	0.50	4
41	Fabricated Metal Products	3.03	0.63	0.21	19
42	Information Technology Support Services	2.97	0.62	0.23	20
43	Concrete & Cement	2.91	0.60	0.23	11
44	Mining Equipment	2.83	0.59	0.23	10
45	Industrial Textiles	2.71	0.56	0.40	7
46	Air Travel	2.66	0.55	0.23	9
47	Tobacco Products	2.62	0.54	0.30	4
48	Transportation Equipment	2.56	0.53	0.23	10
49	Animal Products	2.53	0.52	0.19	14
50	Inconclusive	2.43	0.50	0.24	14
51	Soft Drinks	2.41	0.50	0.20	9
52	Biotechnology	2.34	0.48	0.23	14
53	Mobile Homes & Motor Homes	2.32	0.48	0.22	10

FACTOR	FACTOR INTERPRETATION	EIGENVALUE	PERCENT VARIANCE EXPLAINED	CUTOFF FACTOR LOADING	NUMBER OF INDUSTRIES
54	Aircraft Components	2.25	0.47	0.21	10
55	Small Metal Products & Parts	2.22	0.46	0.23	10
56	Medical Laboratories	2.12	0.44	0.23	11
57	Leather & Rubber Products	2.12	0.44	0.19	13
58	Advanced Electronic Systems & Components	2.06	0.43	0.24	15
59	Fats & Oils	2.03	0.42	0.30	6
60	Textile Support	2.01	0.42	0.30	6
61	Confectionery Products	2.00	0.41	0.20	10