

# Regional Cluster Analysis with Interindustry Benchmarks

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## 1. Introduction

Industry cluster studies have become a very common type of applied regional economic analysis. Many involve detailed examination of the characteristics and competitive foundations of the local industrial base or investigation of formal and informal networks among local businesses. Others explore regional, national, and global linkages that manifest themselves through interindustry trade, management practices, and corporate governance of extended value chains. In practice, data limitations, differing views about the industry cluster concept and how it should be operationalized, and the sheer variety of planning and policy issues motivating applied studies have led to the development of multiple approaches to cluster analysis (Martin and Sunley, 2003). Studies in place- and policy-specific contexts—*applied* analyses, as opposed to formal academic research—account for the bulk of methodological innovations that have emerged. There is only a small formal academic literature on applied industry cluster analysis methodology, if one defines an academic literature as a sustained, interactive “conversation” among a group of scholars focused on a distinct and reasonably bounded problem (Hopkins, 2001). Most published academic work on cluster analysis does not investigate more general methodological issues but rather describes the results of specific regional applications.

Unfortunately, the implied or intended assumptions underlying applied studies are rarely carefully articulated, primarily because most are carried out by consultants who regard key parts of their work—especially the methodological details—as proprietary. Consultancies have a strong incentive to innovate in the area of methodology in order to establish a marketable advantage in a crowded field. Of course, innovation is good for advancing the state of the art. However, consulting houses also have incentives to refrain from carefully documenting their methods, which would effectively distribute their intellectual property freely

while also exposing inevitable weaknesses, as well as to claim their own individual approaches as superior to all others. The latter is problematic because it has created something of a red herring in economic development practice: the notion that there must be a single best way to understand and define industry clusters and, consequently, an optimal technique for identifying and documenting their development.

Unlike techniques such as cost-benefit analysis, which are based on a systematic body of formal theory and related economic principles, industry cluster analysis aims to measure a concept that derives from a loose amalgamation of quite diverse and largely informal theories, a body of inductive case study research of widely varying quality, and comparatively few rigorously conducted quasi-experimental empirical studies (Feser and Luger, 2003). In the absence of a formal and widely-accepted “theory of clusters,” there can be no optimal cluster analysis methodology. Instead, there is a variety of ways one might legitimately analyze industry clusters to inform development practice, provided one clarifies the specific planning or policy concerns at hand, narrows the operational definitions of industry clusters and clustering accordingly, uses measures and analytical techniques consistent with those definitions, and is forthright about what the given methodology is (and is not) capable of revealing about regional economic trends and opportunities.

In this chapter, we discuss a particular approach to regional industry cluster analysis—the use of *interindustry benchmarks*—and illustrate the use of *one* particular operationalization of that approach—the use of value chains derived from an analysis of observed national interindustry trading patterns. We demonstrate the principles and illustrate the techniques in a brief analysis of Maine’s economy. We do not claim that the use of interindustry benchmarks is the universal standard bearer in analysis, or even that it is always the least flawed among a set of partially flawed approaches. We *do* claim that it is a good approach for some kinds of applications and policy contexts, and that there are superior techniques in other policy contexts. Thus, our aim is to clarify how a benchmark-based approach relates to other possible ways one might undertake an analysis of clusters and clustering, discuss the specific kinds of insights benchmark techniques can reveal and potential pitfalls analysts may encounter, and offer some general guides for cities and states seeking to conduct an applied industry cluster study.

The organization of the chapter is straightforward. Section 2 discusses the benchmark approach in general, section 3 summarizes briefly how the national value chains we use are derived, section 4 applies the value chains as benchmarks to the Maine case, and section 5 concludes with a short discussion of the strengths and weaknesses of the benchmarking approach to applied industry cluster studies.

## **2. What are interindustry benchmarks?**

We define interindustry benchmarks as *classifications of interrelated industries* that have been developed from analyses of interindustry relationships undertaken for a region (or set of regions) other than the one under study. The concept of interindustry benchmarks is perhaps best grasped by way of example. One of the earliest applications in the present context was a study by Bergman, Feser et al. (1996), who used factor analysis techniques applied to 1987 national input-output data to identify U.S. manufacturing value chains, or groups of manufacturing industries trading directly and indirectly (see also Bergman and Feser, 1999 and Feser and Bergman, 2000). Initially, the purpose of the work was not industry cluster analysis as it is commonly understood today. It was to reveal empirically one set of pathways—trading linkages—through which manufacturing technology diffusion occurs. A state organization that wished to target scarce manufacturing technology assistance resources commissioned the project. The policy motivation was based on research that indicated that manufacturers upgrading their production technologies exert pressure on their upstream suppliers to do likewise, which implied that business assistance programs aimed at end-market producers might yield more upgrading activity overall than if programs are more or less untargeted.

Bergman and Feser's analysis does not classify detailed U.S. manufacturing industries into groups according to similarities in their product, as they are under the Standard Industrial Classification (SIC) system, but rather by their patterns of direct and indirect interindustry trade. For example, for U.S. motor vehicles production, auto assemblers are joined with tire, glass, electronics, plastics and other relevant industries in a vehicle value chain. The groups are non-mutually exclusive, since some value chains are highly interdependent, and the

methodology provides a quantitative measure of the strength of the linkage between industries and the overall value chain.

Although the initial study was motivated by the question of technology diffusion, it became clear that a value chain classification of this kind can be a useful tool for a variety of exploratory analyses of the industrial mix and competitive advantage of specific regions, including a version of applied industry cluster analysis. Indeed, Feser and Bergman (2000, p. 2) describe the value chains as “national industry cluster templates”:

When used in subsequent regional analyses, the national clusters serve as templates for developing a strategic view of a regional manufacturing economy in a manner that is wholly distinct from that revealed through typical studies and data analyses that rely upon broad SIC categories. By grouping those firms that are most likely to interact with each other, both directly and indirectly, the templates reveal relative specializations in the regional economy by exposing otherwise opaque extended product chains. They are thus a valuable analytic tool for the design of economic development strategies that seek to exploit or leverage direct and indirect interfirm linkages. Examples include buyer-supplier and import replacement strategies, as well as technology deployment, cross-firm networking, and industrial park initiatives.

Feser and Bergman use the terminology “national cluster” to describe the chains following a distinction long established in the field of regional science that describes “clusters” as groups of trading industries and “industrial complexes” as specific places where those clusters are co-located (Czamanski and Ablas, 1979; Feser and Sweeney, 2000; Feser, Sweeney et al., 2005).<sup>1</sup> In essence, the national value chains are one *benchmark* against which an analyst can measure a region’s economic mix and explore trends. Like any benchmarking standard, the chains have strengths and weaknesses and are useful for some kinds of applications and not others. Either varying the way industries are related (i.e., the type of industrial interdependence) or the geography which is used (e.g., the nation or the world) creates other benchmark classifications

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<sup>1</sup> There is extraordinary diversity in the disciplinary origins of scholars writing on the subject of clusters, and consequently the same terminology is often used to describe significantly different concepts, definitions, and assumptions. Economic geographers, business strategists, regional scientists, urban and regional planners, and economic sociologists have all made valuable contributions to the literature.

that are useful for different kinds of studies and development planning interventions. Trade flows are only one kind of interdependence; others are technology flows, informal networking, and shared labor pools. Also important are institutional and organizational forms of interdependence, or how relations between firms are governed, to use the terminology of the global value chains research paradigm (Gereffi, Humphrey et al., 2005).

### ***Linkages and Geography***

Bergman and Feser's use of national input-output data was purposeful and helps illustrate an important point about the different ways geography might be handled in the creation of interindustry benchmarks that are intended for use in cluster studies and other kinds of economic analyses. Bergman and Feser used national rather than state-level input-output data because they sought to identify local gaps in national value chains with some presence in North Carolina, gaps that could potentially inhibit the diffusion of new technologies. Imagine that a given North Carolina industry, such as truck manufacturing, is comprised solely of end-market assemblers and no suppliers. The state's truck producers cannot very well diffuse manufacturing technologies to in-state suppliers that do not exist. U.S. interindustry data help reveal national value chains, which are then present to varying degrees and in differing sub-industries in particular places. Reference to North Carolina input-output data would find that there is little trade between truck producers and other in-state manufacturing sectors, given the absence of trucking suppliers. However, without the *additional information on the structure of the broader value chain*, one would have no means of recognizing the lack of suppliers as meaning that North Carolina is capturing just one segment of the national truck manufacturing industry. In other words, one only knows one has a *gap* by reference to a relevant *whole*.

Note that the nation is not necessarily the ideal reference area. The fragmentation and internationalization of production means that the relevant whole is increasingly the *global* value chain, not the national one. Bergman and Feser defended the use of U.S. (as opposed to

international) input-output (IO) data on the grounds that U.S. input-output tables are the best systematic source of trading information for the full range of industries.<sup>2</sup>

An analysis of state or regional interindustry trading data could produce useful information, but it would be of a fundamentally different kind. For instance, we may suspect that some regional industries have value chains that are fundamentally unique. Indeed, industries may differ in their production technologies across regions simply because regions differ in the factor endowments and other locational characteristics that influence businesses' production technology options and choices (Moses, 1958). Thus, a widget produced wholly in Los Angeles may have a value chain that looks quite different from the value chain for a widget produced wholly in Chicago. Documenting value chains using regional input-output data might help reveal unique local technologies, especially if used in conjunction with value chains derived from national or international data. Alternatively, studies that seek to identify clusters as groups of related industries concentrated in a particular region might use regional input-output data to identify local interindustry linkages. However, such studies are not equivalent to approaches using benchmarks. Again, what distinguishes the benchmark approach is that it uses a classification of linked industries derived for an appropriate reference economy, usually the nation as a whole.

The most widely known interindustry benchmarks used in economic development practice are the "clusters" developed by Michael Porter (Porter, 2003, 2004). Porter began by segmenting 879 U.S. SIC industries into three types: 241 that serve primarily *local* markets (e.g., retail, personal services), 48 that are *resource-dependent* (e.g., mining, logging, agricultural goods, etc.), and 590 that *trade* across regions and/or countries. He then calculated Pearson correlation coefficients for each pair of traded industries using states as the unit of analysis and

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<sup>2</sup> According to Bergman and Feser (1999, section 3.3.3): "Using a 'global' [input-output] table, one could identify industrial interdependency among sectors regardless of location and then investigate—perhaps with the help of a regionalized table or primary data collection with surveys, interviews, and focus groups—possible linkages between and among those sectors in the region. Since there is no such thing as a global table, a national table (particularly in highly diverse economies such as the United States) constitutes a workable substitute."

employment as the measure of industry size in each state, arguing that a high correlation implies that the two industries in the given pair of industries are co-located:

We proceed...using the locational correlation of employment across traded industries to reveal externalities and define cluster boundaries. For example, if computer hardware employment is nearly always associated geographically with software employment, this provides a strong indication of locational linkages (Porter, 2004, p. 3).<sup>3</sup>

Porter used the correlations to combine industries more or less by hand, “beginning with small groups of obviously related industries and then tracing correlation patterns to others” (p. 4). He acknowledged a significant problem with this approach: that co-location among industries does not necessarily imply economic linkage—what can be called functional, as opposed to spatial, interdependence—among industries. Some industries are co-located for historical reasons, others by chance, others because they target similar large end-markets (e.g., major cities) or transportation infrastructure (e.g., ports), and still others because of their co-dependence on nearby natural resources. Porter addressed the problem by making adjustments in the composition of the groups using information from case studies of specific sectors and reference to national input-output data:

Where there was no logical externality [based on the case study investigation] *and* [italics in original] the I-O [input-output] data revealed no meaningful product flows, a correlation pair was excluded as spurious. Through this sequence of steps, we eliminated those pairs of correlated industries where there was no apparent basis for linkages (Porter, 2004, p. 5).

The result is 41 non-mutually exclusive groups of industries, or “traded clusters,” comprised of both manufacturing and non-manufacturing industries.

Porter’s classification is similar to Bergman and Feser’s in that it groups U.S. industries based on an analysis of interdependence. As in Bergman/Feser, that interdependence is also ultimately intended to be defined by functional economic linkage. In essence, Porter uses co-

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<sup>3</sup> The question of how to properly measure the spatial clustering of industries has itself spawned a large literature in geostatistics and regional science. Porter’s use of simple correlations on areal data, by no means an uncommon approach, is highly problematic for a number of reasons. Some of the most important challenges in measuring industry concentration and clustering are discussed in Arbia (2001).

location only as an *initial indicator* of such linkages, making adjustments in a more or less in an ad hoc fashion when the spatial results prove inappropriate or implausible. In Bergman and Feser's case, interindustry linkages are measured directly by analysis of trade between industries without any reference to the subnational distribution of economic activity. Interestingly, Porter's 41 groups of industries are very close in number to the 45 found in the most recent update of the Bergman and Feser approach (Feser 2005).<sup>4</sup> As might be expected, the two classifications differ given their underlying methodologies but the overall categories of industries are very similar. Like Bergman and Feser, Porter views his classification as a cluster benchmarking tool: "Clusters, then, represent a different way of dividing the economy than is embodied in conventional industrial classification systems which are based primarily on product type and similarities in production" (Porter, 2004, p. 6).

Subscribers to the Harvard Cluster Mapping Project website may access drop-down menus to investigate U.S. state and metropolitan trends for industries aggregated into [benchmark] clusters according to the Porter classification.<sup>5</sup> Or they may produce charts and graphs plotting employment by [benchmark] cluster for specific places. The implication is that if metropolitan area *A* has a high level of absolute and relative employment in, say, the industries Porter identifies as part of his automotive cluster, metropolitan area *A* *may* have a *regional* automotive cluster. Bergman and Feser's industry groupings are best understood as value chains but their use as benchmarks in applied cluster studies is similar. If metropolitan area *A* has significant activity in the various industries that make up the U.S. automotive value chain, Bergman and Feser argue that *A* *may* have a *regional* automotive cluster. The use of the term "may" in the two preceding sentences is quite intentional. Both industry classification schemes are derived using theories of economic interdependence. To the extent those theories are valid, they are useful tools. However, neither classification reveals anything about the

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<sup>4</sup> The original chains in Bergman, Feser et al. (1996) were updated in 2000 using the 1992 U.S. benchmark input-output accounts and to include both manufacturing and non-manufacturing sectors (see Feser and Koo, 2000). The 2005 update applies a slightly different methodology using the 1997 U.S. benchmark input-output accounts. All versions of the value chains have been publicly available online for download since their initial development.

<sup>5</sup> See <https://secure.hbs.edu/isc/login/login.do?http://data.isc.hbs.edu/isc/index.jsp>.

actual behavior of companies at the regional or local scales (including trade, informal network, shared technology, etc.). Interindustry benchmarks are insufficient by themselves if the goal is to identify regional clusters defined as “geographically proximate group[s] of interconnected companies and associated institutions in a particular field, including product producers, service providers, suppliers, universities, and trade associations.”<sup>6</sup> Interindustry benchmarks only suggest the *possible* presence of *actual* regional interconnections that are typically very difficult to measure:

In many cases, a lack of data on local and interregional industrial linkages, shared business institutions, channels of technology and knowledge transfer, and other dimensions of the cluster concept means that relatively simple measures (location quotients, industry size) are often used to initially detect clusters in subnational regions...we suggest a means of using available information on national interindustry linkages to identify potential clusters in subnational areas (Feser and Bergman 2000, p. 1).

The following example further illustrates the implications of the different ways Bergman/Feser and Porter handle geography in the derivation of their classification schemes. Imagine few makers of automotive wiring harnesses are co-located with automotive assemblers in the U.S. Indeed, a considerable share of the wiring harnesses used in cars, trucks and other vehicles manufactured in the United States are produced just across the U.S.-Mexico border in the *maquiladora* industry (Helper, 1995). The Porter classification, which is based on a methodology that considers the geographic distribution of industries jointly with economic linkages between them, would presumably exclude the wiring harness industry from the group of industries assigned to the automotive cluster.<sup>7</sup> In principle, Porter’s classification reveals

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<sup>6</sup> The quote is from the Data Glossary page of the Harvard Cluster Mapping Project website, under the entry “cluster.”

<sup>7</sup> This example exposes another wrinkle that we will ignore for now: the problem of international trade. In fact, *U.S.-based* wiring harness makers may often be co-located with *U.S.-based* assemblers, which would lead Porter to group the two industries in his classification given his analytical approach, since his analysis is based strictly on U.S. data. However, *most* wiring harnesses installed in the U.S. are manufactured outside the U.S. and, consequently, if Porter had information on the global location of industries and the trade between them, he would not group wiring harness makers and vehicle assemblers in his classification. This illustrates one important pitfall

industries that are both linked *and* have a tendency to co-locate. Therefore, it would show that wiring harness makers are not likely to be part of a localized agglomeration of automotive industry activity in the U.S. if current trends are a guide, knowledge that is valuable for economic developers interested in supporting the growth of the motor vehicles industry.

In contrast, the Bergman/Feser classification would identify the wiring harness industry as part of the automotive value chain. That might be misleading to economic developers seeking to build regional clusters if they imagine that local gaps in chains are, *ipso facto*, good development targets. At the same time, knowledge of the entire (non-local) value chain can also be valuable for development practice because of the insight it can offer regarding local competitive strengths and weaknesses. Armed with knowledge of the full extent of a given value chain, officials can ask why their region has developed some industries in a selected chain and not others. Sometimes the reasons are not subject to policy influence, such as when one segment of a chain must be nearby natural resources that a region does not possess. Frequently, however, the reasons are subject to public sector influence, such as when an industry's absence is a function of the region's inadequately trained labor force. Such exploratory work can be revealing. Feser and Bergman (2000) found, for example, that North Carolina specializes in labor-intensive, low wage segments of most national manufacturing value chains, regardless of those chains' overall technology intensity, suggesting structural challenges in North Carolina related to workforce preparation and advanced infrastructure that are very much subject to policy influence.

A general insight is that there are two important dimensions of the industry cluster concept—*economic interdependence* and *geography*—that are necessarily handled in some fashion in any cluster analysis methodology.<sup>8</sup> In the interindustry benchmarking context, different

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in the use of strictly U.S. data to derive cluster benchmarks. It is a problem for both the Porter and Bergman/Feser classifications in slightly different ways.

<sup>8</sup> One might describe economic linkages and geography as two kinds of industrial interdependence. However, spatial propinquity is not in itself behavioral, in the sense that it is always derivative of some other dynamic, such as economic linkage, the need for resources, chance, history, market access, and so forth. The idea that “geographic space” is less fundamental to economic growth and development than “economic space” traces at least as far back

information is created by considering functional interdependence and spatial clustering jointly, as in Porter's classification, and distinctly, as in Bergman and Feser's classification.

### ***Comprehensive versus Focused Benchmarks***

We define comprehensive interindustry benchmarks as those that are based on a systematic analysis of interrelationships among many, if not all, industries in the economy. They are contrasted with *focused* interindustry benchmarks, which are derived only for selected industries. To ensure valid comparisons, comprehensive benchmarks require standard measurements for all industries, thus the reliance on input-output, occupational employment, simulated interindustry patent flow, or regional employment data that may be assembled for the full industrial base. Because focused benchmarks are created for just one or a few industries, they may be based on a richer and more eclectic set of information. The development of focused benchmarks often relies heavily on primary data collection—a practical impossibility for comprehensive methodologies—as well as qualitative information about technologies, business management practices, and locational imperatives in specific industries.

Both the Bergman/Feser national value chain and Porter industry cluster classifications are comprehensive in their assessment of relationships among industries. The global value chains identified by Gereffi, Denniston et al. (2007) provide examples of focused benchmarks. Claiming that “most industries today are globally organized and geographically fragmented,” and that the “keys to economic development often depend on capturing or retaining the high-value activities in these industries,” they use a combination of qualitative and quantitative information to map out global value chains for selected industries. Gereffi, Denniston et al. then analyze a regional economy's position within those chains. For example, on a website titled *North Carolina in a Global Economy* maintained by Duke University's Center on Globalization, Governance and Competitiveness, users can examine establishment, employment and wage trends in NAICS industries identified as components of one of seven global value

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as Perroux (1950b; 1950a; 1988). The value of distinguishing between economic and geographic space in cluster studies is discussed more fully in Feser and Sweeney (2000), Feser, Sweeney et al. (2005) and Feser and Isserman (forthcoming).

chains; map industry activity by county; and produce tables listing the top employers in each industry.<sup>9</sup> The methodology uses *focused* benchmarks in that each value chain—banking, furniture, hog farming, textiles and apparel, biotechnology, information technology, and tobacco, all industries of well-known strength in North Carolina—is the subject of considerable industry- and firm-specific research. Both quantitative and qualitative kinds of information are brought to bear to first chart or “map” the global value chains, and then to identify the specific North Carolina companies in those chains.<sup>10</sup> Yet, like the Bergman/Feser and Porter approaches, the methodology is based fundamentally on a benchmarking logic: analysis of economic interdependence for a geographical baseline (in this case, worldwide production) beyond the locality in question (in this case, North Carolina) is used to gain insight into local economic trends, conditions and opportunities.<sup>11</sup>

A common type of applied industry cluster analysis is work on local networks and linkages among the businesses located in a specific region. Such intraregional analysis of selected industries draws heavily on the theory of Marshallian industrial districts, which postulates that the determinants of competitive advantage are primarily local (see Humphrey and Schmitz, 2002, for a discussion), such that linkages to companies, industries, and institutions outside the region may be de-emphasized or even ignored. The many case studies of industrial districts in Italy, Germany and elsewhere are examples in the sense that they are focused on documenting ties among businesses located in specific places. Intraregional approaches are sometimes perceived as the *only* kind of regional industry cluster analysis but,

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<sup>9</sup> See [http://www.soc.duke.edu/NC\\_GlobalEconomy/index.shtml](http://www.soc.duke.edu/NC_GlobalEconomy/index.shtml).

<sup>10</sup> “Cluster mapping” is a term used commonly in the burgeoning cluster consulting business to describe the process of diagramming the major business and institutional players in a given cluster using a value chain logic. Porter (1990) popularized the practice. Although many cluster mapping efforts focus on the players in a given region, Porter himself focused on the international competitive position of the clusters he investigated, similar to Gereffi, Denniston et al. (2007). Where the latter differ from Porter is in their emphasis on corporate governance issues influencing value chain formation and growth (see also Gereffi, 1994, 1999, 2001, 2005).

<sup>11</sup> The *national* value chain definitions developed by Bergman, Feser et al. (1996), Feser and Koo (2000), and Feser (2005) have similarly been used as classification schemes to track and map North Carolina state, regional and county industry trends.

as we have seen, that is an excessively narrow a view of how the industry cluster concept is being used to inform economic development practice. Table 1 distinguishes four common approaches to regional industry cluster analysis by whether they use *benchmark* or *intraregional* techniques and are *comprehensive* or *focused* in their treatment of industries.<sup>12</sup>

Table 1  
**Types of approaches to regional industry cluster analysis**

		Benchmark Analysis	Intraregional Analysis
Industry Coverage	Comprehensive	<ul style="list-style-type: none"> <li>• Study applies industry groupings derived for a <i>relevant reference area</i> (e.g., nation or world) to regional data to identify potential regional clusters or to document regional specializations within broader national or global industries</li> <li>• Groupings are developed from an analysis of interdependence among <i>all or most industries</i>, necessitating heavy reliance on secondary data sources (e.g., national input-output and other published economic series)</li> <li>• Example: McElroy, Olmedo et al. (2006)</li> </ul>	<ul style="list-style-type: none"> <li>• Study examines trends and linkages among firms and industries <i>within the study region</i> to identify local clusters (groups of related companies located in proximity)</li> <li>• <i>All or most industries</i> are included in the analysis, necessitating heavy reliance on secondary data sources (e.g., regional input-output and other published economic series)</li> <li>• Example: Hill and Brennan (2000)</li> </ul>
	Focused	<ul style="list-style-type: none"> <li>• Study applies industry groupings derived for a <i>relevant reference area</i> (e.g., nation or world) to regional data to identify potential clusters or to document regional specializations within national or global industries</li> <li>• Groupings are identified for only <i>selected industries</i>, often those perceived as particularly important to the region, permitting use of labor-intensive qualitative methods and primary data collection</li> <li>• Example: Gereffi, Denniston, et al. (2007)</li> </ul>	<ul style="list-style-type: none"> <li>• Study examines trends and linkages among firms and industries <i>within the study region</i> to identify local clusters (groups of related companies located in proximity)</li> <li>• Only <i>selected industries</i> are investigated, permitting use of labor-intensive qualitative methods and primary data collection techniques</li> <li>• Example: RTS (2003)</li> </ul>

### **Online Tools**

Interindustry benchmarks are increasingly being incorporated into user-friendly software and web applications for use in economic development practice. We have already mentioned the online applications of the Harvard Cluster Mapping Project and the Center on Globalization, Governance and Competitiveness at Duke University. The U.S. Employment and Training

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<sup>12</sup> Table 1 is designed to help clarify key concepts; the distinctions among study types are rarely tightly drawn in practice. It is very common for applied studies to use combinations of approaches. For example, cluster benchmarks might be used to scan the regional economy for an initial set of candidate industries for intraregional analysis of local company linkages.

Administration (ETA) is supporting the development and dissemination of a very basic economic information system and analysis tool that permits users to aggregate and display regional data for NAICS industries aggregated into groups labeled as “clusters.” The system, known as WITS (Workforce and Innovation Technical Solution), was created to support ETA’s Workforce Innovations for Regional Economic Development (WIRED) initiative. Another recent product is the web-based suite of tools developed by Economic Modeling Specialists, Incorporated (EMSI). Called Strategic Advantage, the tools include a “regional industry cluster report” that makes use of an interindustry classification created by a team of researchers led by Purdue University’s Center for Regional Development. The Purdue classification, which consists of 17 groups of NAICS industries, was developed as part of a study of rural industry clusters funded by the U.S. Economic Development Administration (EDA, 2007).<sup>13</sup>

### ***Summary***

Interindustry benchmarks are classifications of interrelated industries created from quantitative or qualitative analyses of interindustry relationships at a geographic scale regarded as a suitable referent for cluster studies and other analyses conducted for specific regions. The benchmarks may be comprehensive in their coverage of industries or focused on selected industries. The kinds of interrelationships among industries that the benchmarks seek to capture may include trading patterns (often measured using input-output data), simulated or real technology or knowledge flows (e.g., measured with patent data), labor force requirements (e.g., measured with occupational employment information), or organizational dynamics or management practices (the focus of the global value chains literature). The variety of the potential benchmarks reflects the malleability of the cluster concept and, more generally, the many different kinds of spillovers and externalities that influence business competitiveness. The variety also serves to emphasize that there is no single optimal set of benchmarks; different classifications are useful depending on the application at hand. In the next section, we briefly

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<sup>13</sup> We were unable to determine specifically how the WITS system and Purdue studies arrived at their interindustry classifications. Both make general reference to Porter’s approach and research but do not supply detailed documentation of their methods.

summarize the methodology behind a set of national value chains, and then follow with an application of the chains as interindustry benchmarks in an analysis of the Maine economy.

### 3. One Set of Interindustry Benchmarks: National Value Chains

We have argued that one way to operationalize the notion of a relationship between industries is through the concept of the industry value chain which, in turn, can be useful as a benchmark in applied cluster studies. Any industry's value chain consists of that industry itself together with its supplier (upstream) and customer (downstream) industries, irrespective of where those industries are located (locally, nationally, or internationally). Although theoretically there is a distinct value chain for each industry, the level of overlap between value chains for highly detailed industries is often so high that we can justify combining some of them. We demonstrate the use of the reduced set of value chains as interindustry benchmarks in Section 4. In this section, we very briefly summarize Feser's (2005) approach to using national input-output data to identify value chains, which sought to address several technical and practical deficiencies in Bergman, Feser et al.'s (1996) methodology.

The approach begins by calculating measures of trading linkage between pairs of industries using two ratios calculated from a national inter-industry transactions matrix,  $\mathbf{A}$ :

$$x_{ij} = \frac{a_{ij}}{a_{+j}} \quad (1)$$

$$y_{ij} = \frac{a_{ij}}{a_{i+}} \quad (2)$$

The value  $x_{ij}$  is the ratio of purchases of industry  $j$  from industry  $i$  to total intermediate purchases by industry  $j$ . A vector of values of  $x$ , written  $\mathbf{x}$ , is industry  $j$ 's intermediate input purchasing pattern. The value  $y_{ij}$  is the ratio of sales of industry  $i$  to industry  $j$  to total intermediate sales by industry  $i$ , so that a vector of  $y$  values, written  $\mathbf{y}$ , is  $i$ 's intermediate selling pattern. Given  $\mathbf{x}$  and  $\mathbf{y}$ , sets  $S_i$  and  $B_i$  can be defined, where  $S_i$  is the set of industries supplying goods and services to industry  $i$  and  $B_i$  is the set of industries purchasing goods or services from industry  $i$ . At the extreme,  $S$  and  $B$  would contain, for industry  $i$ , all industries  $j$  for which  $x_{ij}$  and  $y_{ij}$  are, respectively, greater than zero. In practice, we might set a threshold,  $\alpha$ , that  $x_{ij}$  and  $y_{ij}$

must exceed in order for sector  $j$  ( $i$ ) to be included in sector  $i$ 's ( $j$ 's) set of key suppliers (or buyers).

The next step is to use the union and intersection of sets  $S$  and  $B$  in the calculation of four simple measures of interindustry linkage:

$$\begin{aligned}
 I_{ij}^{SS} &= S_i \cap S_j, & U_{ij}^{SS} &= S_i \cup S_j \\
 I_{ij}^{BB} &= B_i \cap B_j, & U_{ij}^{BB} &= B_i \cup B_j \\
 I_{ij}^{SB} &= S_i \cap B_j, & U_{ij}^{SB} &= S_i \cup B_j \\
 I_{ij}^{BS} &= B_i \cap S_j, & U_{ij}^{BS} &= B_i \cup S_j
 \end{aligned} \tag{3}$$

$$R_{ij}^{SS} = \frac{I_{ij}^{SS}}{U_{ij}^{SS}}, \quad R_{ij}^{BB} = \frac{I_{ij}^{BB}}{U_{ij}^{BB}}, \quad R_{ij}^{SB} = \frac{I_{ij}^{SB}}{U_{ij}^{SB}}, \quad R_{ij}^{BS} = \frac{I_{ij}^{BS}}{U_{ij}^{BS}} \tag{4}$$

The ratios in (4) are simple and intuitive measures of four kinds of relationships between industries  $i$  and  $j$ . The value  $R^{SS}$  is the number of supplier sectors that industries  $i$  and  $j$  have in common over the total number (or universe) of supplier sectors to both  $i$  and  $j$ . The higher is  $R^{SS}$ , the stronger is the value chain linkage between industries  $i$  and  $j$  as indicated by joint sourcing from the same suppliers. Similarly,  $R^{BB}$  is the share of common buyer sectors.  $R^{SB}$  and  $R^{BS}$  are measures of second-tier relationships between each pair of industries; they increase as one industry's suppliers are also the other industry's buyers. Statistical data reduction techniques can be applied to the measures in (4) to identify a set of value chains.

There are several steps in the data reduction process. First, the 489 sector U.S. inter-industry transactions matrix is reduced to a 463 dimension matrix by eliminating 26 local services (e.g., retail) and government industries; the aim is to focus on industries with export potential. Second, the measures in (4) are calculated setting  $\alpha$  to a threshold level that is designed to capture the most important linkages since including all linkages—both strong and weak—will produce results that are too unwieldy to use in application. Third, a weight (<1.0) is applied to each of 55 producer services and transportation industries in the calculation of the  $R$  measures. The 55 industries may be viewed as “enabling industries” in the sense that they are linked to a very large number of other industries. Among them are banking, advertising, legal services, wholesaling, and warehousing and distribution. The weight discounts a linkage between industry  $i$  and a general enabling industry, which serves to emphasize linkages among

more specialized industries in the identification of the value chains. Finally, the maximum of the four  $R$  measures is selected to produce a 463-dimension linkage matrix ( $\mathbf{R}^{\text{MAX}}$ ) that is subsequently analyzed with statistical data reduction techniques.

Using the results of a Ward's hierarchical clustering algorithm applied to the matrix of linkages, Feser (2005) identified 45 mutually exclusive groups of related industries, or value chains. The concept of mutually exclusive value chains makes little sense, however, since most industries are linked to many different industries. In fact, value chains themselves are highly interrelated or "fuzzy." This inherent fuzziness among inter-industry linkages is acknowledged by viewing the initial mutually exclusive results as defining a set of *core* value chains, each made up of "primary" members. Additional industries, called "secondary" members, are then added to the core chains. A non-primary industry becomes a secondary member of a given value chain if the arithmetic average of its linkages with all primary members of the chain meets or exceeds a defined threshold.

We refer readers to Feser (2005) for additional details behind the selection of threshold values and weights and the Ward's clustering procedure. Here we wish to emphasize the interpretation of the results as interindustry benchmarks useful for applied regional cluster analyses. Appendix Table 1 reports the detailed makeup of several of the national chains, including primary and secondary members. The descriptor for each chain represents the predominant economic activity among the given group of industries, particularly those that are most tightly linked within the chain. Such summary descriptors should be interpreted carefully. None can adequately capture all of the relationships among industries in each chain. Again, the industries are grouped based on their economic interdependencies at the national scale, and therefore embed no information regarding sub-national industrial location. Together, the industries included in the benchmarks constitute a significant fraction of U.S. economic activity—roughly 65 percent of total U.S. employment in 2004. Not included among the national value chains, as noted above, are retail trade, government (including the U.S. Postal Service), primary and secondary schools, and consumer and personal services industries.

## 4. Example Application

The metrics and tools used to investigate clusters and clustering using interindustry benchmarks are typically no different than those used to analyze regional economies with other kinds of classification schemes and base referents. Among them are measures of absolute size, relative size, growth, regional specialization (such as location quotients), and industrial diversity, and techniques to measure absolute and relative change in a mix of industries (e.g., shift-share analysis). Although less commonly used in economic development practice, spatial analytical methods such as local indicators of spatial association (LISAs) offer additional powerful tools for applied analysis with interindustry benchmarks. To provide an overview of basic techniques, we briefly illustrate a version of cluster analysis for the State of Maine using the national value chains.<sup>14</sup>

Maine is a predominantly rural state with an industrial heritage rooted in natural resource extraction, agriculture, and manufacturing, particularly fishing, timber harvesting, and wood products manufacturing. Like other Northeastern states, Maine's economy slowed in the last decade of 20<sup>th</sup> century with job losses in its traditional industrial base. Although its health care and tourism sectors have flourished in recent years, the state has struggled to develop new manufacturing and advanced services industries that offer sustainable living wages. Driven by an overriding goal of expanding its economic base into growing higher wage sectors, Maine is seeking to concentrate its economic development resources on innovation-oriented industry clusters.

To develop an initial picture of potential interindustry relationships and potential clusters in Maine, we examine the presence of national value chains in the state using data for two periods, 2000 and 2005. To minimize the influence of national cyclical trends, it is preferable to choose base and terminal years representing roughly similar points in the U.S. business cycle. By this logic, an appropriate comparison base period for 2005 (the most recent year of data available to us at the time of this writing) falls in the mid 1990's. Unfortunately, the

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<sup>14</sup> Our primary source of information for the analysis is the *Quarterly Census of Employment and Wages* (QCEW) collected by Maine Labor Market Information Services.

universe of available base periods is limited by the shift from the SIC to the NAICS. The base year we use, 2000, is the earliest year for which NAICS-based employment data are available. It also represents a turning point from the economic expansion of the latter 1990's to the beginning of the macroeconomic slowdown of the early 2000s. The year 2005 is part of the modest recovery following the recession of 2000/2001. The intermediate period between 2000 and 2005 are mostly years of slow employment growth nationwide and in Maine. Matching 2005 to a down year would exaggerate recent growth. Furthermore, a time span of less than five years is generally too short reveal substantive trends. So, while perhaps not ideal, 2000 to 2005 offers a reasonable period over which to examine growth trends in the state.

The benchmarking approach is a kind of economic base analysis and, in that sense, is relatively straightforward to carry out.<sup>15</sup> Six-digit level NAICS industries are matched to the national value chain classification and aggregated into the value chain groups to document overall trends. Then, the industry mix within each chain is examined in detail. The classification of industries into value chains is repeated at the national level using publicly available national QCEW employment data from the U.S. Bureau of Labor Statistics.

We document the size, level of specialization (using location quotients), and growth of each value chain in Maine, the level and change in industrial diversity within each chain, and the industry mix or composition of selected chains. Diversity is measured by an index defined as the inverse of the sum of absolute differences in employment shares in each industry relative to its national share, or:

$$RDI_r = \frac{1}{\sum_i \left| \frac{E_{ir}}{E_r} - \frac{E_{in}}{E_n} \right|} \quad (5)$$

where  $E$  is employment,  $i$  indexes a specific industry within a given value chain,  $r$  indexes the region (the State of Maine in this case), and  $n$  indexes the reference area (the nation). The index RDI increases as the industry distribution of employment within the value chain in Maine more closely the mirrors the national distribution of employment across industries in the chain.

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<sup>15</sup> See <http://www.urban.uiuc.edu/faculty/feser/ESEBA/Index.html> for a discussion of cluster analysis as an exploratory economic base analysis technique.

### *Overall Value Chain Trends*

Table 2 reports employment, employment growth, specialization, and diversity for Maine for each of the 45 benchmark value chains. The largest value chain in the state is management, higher education and hospitals. It employs approximately 135,600 workers and accounts for 27.3 percent of the state's private sector workforce.<sup>16</sup> The next four largest chains—business services (17.0 percent), basic health services (15.8 percent), and hotels and transportation services (14.5 percent)—also represent a sizable portion of the state's private sector economy. Maine also has a relatively large component of its workforce employed in the financial services and insurance, arts and media, and information services chains. The remaining value chains are considerably smaller. After information services, which accounts for 8.6 percent of the state's 2005 employment, the next largest value chain is construction, which accounts for 2.5 percent of employment.

[Table 2 near here]

Despite their significant absolute size, none of the eight largest chains are Maine specializations when their share of state private sector employment is compared against the share for the U.S. economy as a whole. The share of Maine's employment in the management, higher education and hospitals value chain is nearly equal to the national share (2005 location quotient = 1.04), as is the share of employment in construction (location quotient = 1.01), but the remaining six of Maine's eight largest value chains are significantly under-represented when compared against the U.S. economy as a whole, with location quotients ranging from 0.88 to 0.76. That is not especially surprising given Maine's economic history, locational characteristics, and natural endowments, but it also highlights the continuing vulnerability of the state's economy given a general contraction in manufacturing and resource extraction industries nationwide.

Likewise, those benchmark value chains in which Maine specializes reflect the long-standing importance of natural resources in the state's economy. There are nine value chains in

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<sup>16</sup> Again, note that the value chains are not mutually exclusive and therefore the employment shares reported in Table 2 sum to a value greater than 100.

which Maine is specialized based on 2005 employment location quotients of 1.10 or higher, eight of which are the following (in descending order by total employment): wood processing, chemical-based products, plastics and rubber manufacturing, wood building products, wood products and furniture, paper, leather products, and dairy products. The ninth is aluminum and aluminum products, for which we cannot report the employment level or the exact location quotient because of confidentiality rules governing our use of Maine unsuppressed QCEW data. The four value chains with an especially pronounced relative presence in Maine—wood processing, chemical-based products, plastics and rubber manufacturing, and leather products—all declined in employment significantly nationwide between 2000 and 2005. In Maine, the rates of employment decline in those four chains were even higher.

Although the largest and most concentrated value chains in a given region often attract the bulk of policy attention as potential “clusters,” it is chains that show signs of emerging in the state that are often more appropriate targets for growth oriented development strategies. Detecting potential strengths and market opportunities in given industries is difficult using strictly historical data; the past is not necessarily a good barometer of what the future will bring. However, evidence of recent growth of related industries coupled with increasing regional specialization is one possible indicator of an emerging cluster. We define potential emerging value chain clusters in Maine as those posting employment growth of 3.0 percent or more over the 2000-2005 period, a 0.05 point increase in the chain’s location quotient between 2000 and 2005, and a 2005 location quotient of over 0.50 but below 1.0.

Application of those criteria singles out four chains: concrete and brick building products, breweries and distilleries, pharmaceuticals, and grain milling. The recent growth in the concrete and brick products chain is largely fueled by growing demand for residential building materials for new and second home construction. The possibility of an emergent pharmaceuticals cluster is clearly a promising sign for a state generally lagging in technology-related activity. Expansion of the industries in this value chain in Maine is not altogether surprising. The state has several anchor medicinal testing facilities such as Idexx and Jackson Laboratories, as well as a number of smaller testing facilities. The recent growth of the value chain can also be traced to the organic and botanicals niche market (e.g., Tom’s of Maine).

Growth in niche markets that play on Maine's image of an unspoiled environment and rugged individualism also explain the growth of the breweries and distilleries value chain in Maine. Out-of-state exports of Maine microbrews (e.g., by Shipyard Brewing Company, StoneCoast Brewing Company, and D.L Geary Brewing Company, among others) and bottled spring water companies (e.g., Poland Springs) have been very strong in recent years.

A common way of investigating industry trends is through the use of bubble charts, also an increasingly popular device for communicating key findings of cluster studies (see Figures 1 and 2). Bubble charts are a variation on the bivariate scatter plot. The horizontal and vertical axes typically represent regional and national employment growth, respectively, and each point on the scatter plot is proportionately scaled to represent the size of an industry or cluster (usually measured in terms of employment). A fourth indicator can be introduced by using shading to highlight industries with large relative size compared to the U.S. or other reference region (i.e., those posting location quotients at or above some pre-defined threshold). The upper right and lower left quadrants of the charts (which we label quadrants II and IV, respectively) are of particular interest. Value chains falling into quadrant II are those that are growing in both the U.S. and the study region, while chains falling into quadrant IV are those in decline in both the U.S. and region.

[Figures 1 and 2 near here]

Figures 1 and 2 show that most of the benchmark value chains in Maine are small, shrinking, or both, though in many cases Maine's weak employment growth is not out of line with national trends. Only four value chains are found in quadrant II (both U.S. and Maine growth). They are, in descending order of their 2000 to 2005 U.S. employment growth rate: mining (a tiny value chain cluster of just 48 establishments and 115 workers); basic health services; management, higher education and hospitals; and business services. Three of the four are under-represented in Maine; the management, higher education, and hospitals chain is the exception with a 2005 location quotient of 1.04. The state did slightly outpace national employment growth rates in the mining and management, higher education and hospitals chains over the 2000 to 2005 period. The majority of value chains fall into quadrant IV

(declining in nation and state), including all nine Maine specializations.<sup>17</sup> Nine of 28 chains falling into quadrant IV are declining more slowly in Maine than the nation while 19 are declining more rapidly.

Chains in quadrant I are growing at the national level but shrinking in Maine. Three value chains fall into this category: hotels and transportation services, construction, and financial services and insurance. Nine value chains fall into quadrant III, with employment gains in Maine and declines nationwide. Two of the nine—grain milling and steel milling—each employ fewer than 250 workers and are a negligible presence in the state. The other seven, in descending order of employment size, are: arts and media (with over 9,600 establishments and 44,950 workers); information services; concrete, brick and building products; appliances; motor vehicles; breweries and distilleries; and pharmaceuticals (with 58 establishments and 1,361 workers).

### ***Value Chain Composition: Diversity***

In smaller economies such as Maine's, many value chains may be dominated by just a few industries and, very often, by just a few large companies. In addition to scanning establishment and employment totals, the RDI index defined above provides a useful barometer of the overall diversity of a study region's value chains relative to the nation, as well as how that diversity is changing over time. The RDI index increases as a value chain's distribution of employment shares across industries in the study region approaches the nation's distribution. The RDI is of limited value in comparing the diversity of different chains within the same region because it depends on the number of industries, which differs across value chains. However, it is useful for comparing the diversity of the same value chain in different regions and it can also be used to determine whether that value chain is becoming more or less diverse, relative to the nation, in a given region over time.

From 2000 to 2005, the underlying industry mix of 20 of 45 value chains has become increasingly diverse in Maine as measured by the RDI index. For most value chains, the

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<sup>17</sup> Values for the aluminum/aluminum products and aerospace value chains are suppressed and therefore not shown in the figures.

difference between the level of diversity in 2000 and 2005 is negligible. Some value chains with an increasing RDI index stand out, however, including breweries and distilleries; concrete and brick building products; appliances; and motor vehicles. Increasing diversity tends to be associated with value chains that are emerging and/or growing in the state. Conversely, the most significant specializations in Maine—chemical based products, plastics and rubber, leather products, and wood processing—are becoming less diverse in their internal industry mix as they suffer employment declines. That makes sense, as growing industries create opportunities for growth in related industries while declining industries create negative ripple effects throughout a regional economy.

### ***Value Chain Composition: Industry Mix***

Overall value chain totals provide only an initial picture of potential clusters in a given study region. The greatest value of any benchmark cluster analysis approach as an exploratory economic base analysis technique comes in examining the underlying industry mix of each interindustry benchmark category. Since there is considerable overlap in the composition of the value chains, given the level of industrial interdependence in the U.S. economy, the same large industries and companies may be driving trends in multiple value chains. In addition, examining industry mix reveals the segments of national value chains that a given study region has been able to capture.<sup>18</sup> Two of Maine’s largest value chains—management, higher education and hospitals and arts and media—illustrate two important points about the benchmarks and their application.

First, as benchmarks, the U.S. value chains help identify connections among industries at the national level that also manifest themselves to varying degrees at the regional scale. Maine’s sizable hospitals (NAICS 622) and nursing and residential care facilities (NAICS 623) industries are well-known to state policy makers. Less well-known are the linkages of those industries to other industries that are not directly involved in the provision of health care services. Figure 3 displays the distribution of employment in the management, higher

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<sup>18</sup> Feser and Isserman (forthcoming) examine the urban-rural distribution of U.S. value chains, demonstrating that most national chains reach into counties of widely varying levels of development.

education, and hospitals value chain in Maine versus the U.S., in which several health care industries are members. Although many of the Maine businesses in this highly diverse chain are not in the health care industry *per se*, there may be important synergies—such as utilization of labor pools or direct and indirect trade—that link their competitive success to the state’s hospitals and nursing care industries and vice versa. The work of providing health care involves conducting testing and research, processing insurance claims, handling billing and accounting, and providing legal advice. Thus NAICS 622 and 623 are linked with NAICS 541 (professional, scientific and technical services, which accounts for 15 percent of the value chain’s overall employment in the state) and NAICS 561 (administrative and support services—accounting for 5 percent of the chain’s Maine employment). Health care facilities are also major institutional consumers of paper, plastics, medical devices and many other durable and non-durable goods, purchased through durable nondurable wholesalers (NAICS 423 and 424). Finally, many hospitals are centers for research and teaching, thus the linkages to educational services (NAICS 611).

[Figure 3 near here]

Second, the largest industries in a given value chain are not necessarily those that serve that chain’s primary end markets. For example, in terms of volume of employment at the national level, the largest components of the arts and media value chain cluster are durable and non-durable goods merchant wholesalers, followed by professional, scientific and technical services (see Figure 4). Amusement, gambling, recreation services, publishing, broadcasting, motion picture and sound recording, performing arts, telecommunications, Internet services, and data processing services are all much smaller industries in terms of employment. The durable goods wholesaling industry also accounts for a significant share of Maine’s employment in the arts and media chain. Given that wholesaling is linked to a variety of industries, that could mean Maine is not especially strong in arts and media. On the other hand, the state has above-average shares of its employment in the amusement, gambling and recreation industry and the publishing industry, and shares comparable to the national average in broadcasting, Internet broadcasting, and electronic wholesaling.

[Figure 4 near here]

The issue of industry composition begs the question of what we have we learned about the Maine economy by using interindustry benchmarks that is different than what we would have learned by simply examining trends by individual industry. What “value added” do the interindustry benchmarks in general, and national value chains in particular, give us? Table 3 reports basic trends for Maine and the U.S. for each three digit NAICS industry, excluding government, retail trade, the postal service, and personal services. To some extent, Table 3 tells a story very similar to that of Table 2. Indeed, some of the leading Maine industrial specializations revealed in Table 3 are forestry and logging, leather and allied products, wood products, and paper, all obviously part of value chains identified as specializations using the benchmarks. However, there are some important differences between Tables 2 and 3. Figure 5 lists those industries/chains from each table that are either indicated as Maine specializations (based on a location quotient of 1.10 or higher) or Maine growth industries (comparing Maine’s employment growth against the U.S. trend).<sup>19</sup> Figure 5 also indicates where each NAICS industry falls within each identified value chain cluster.<sup>20</sup>

[Table 3 and Figure 5 near here]

Some Maine industrial specializations identified in Table 3—examples are textile mills, textile product mills, hospitals, nursing and residential care facilities, and accommodation—are not indicated as Maine specializations when the broader value chains in which those industries are primary members are considered, though most identified specializations are at least secondary members of other value chains with a significant presence in the state.<sup>21</sup> For example, even though Maine has an above average share of employment in two textile-related industries, the broader textiles and apparel value chain is under-represented. That may be the result of

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<sup>19</sup> High performing industries are those with positive employment growth rates in Maine that exceed national growth rates. The very smallest industries and value chain clusters in Tables 2 and 3 are not included in Figure 5.

<sup>20</sup> Maine QCEW data suppression rules preclude us from reporting data for many six digit NAICS industries. Therefore, to create Figures 3-5 and illustrate basic principles, we have drawn a rough concordance between the three digit NAICS industries in Table 3 and the value chains in Table 2.

<sup>21</sup> For example, the textile mills and textile mill products industries are components of the leather products value chain.

perfectly logical locational dynamics in the U.S. textiles and apparel industry vis-à-vis Maine as a production location, downward trends in the industry overall, or saturated markets.

However, it may also hint at Maine strengths in selected textiles markets that might be the basis for economic advantage in industries with no presence in the state at present. One does not know without additional analysis, but finding out why Maine is over-represented in some component industries and yet under-represented in the overall value chains of which those industries are a part should reveal useful insights about the forces driving the state's growth.

Some of the value chains listed in Figure 5 are intriguing because they seem to have relatively few linkages to the NAICS industries that stand out in Table 3. Are such chains potential economic strengths for Maine that are not apparent in a scan of trends for isolated industries? In some cases, the answer is "no." Roughly 92 percent of employment in the chemical-based products value chain is accounted for by two industries in Maine, namely paper mills and newsprint mills. The same degree of internal concentration is true for the plastics and rubber manufacturing chain, which also has paper as a component. The aluminum and aluminum products value chain is dominated by ship building, principally one Department of Defense contractor—Bath Iron Works—and, in motor vehicles, boat building is the principal industry with few related supplier industries.

In other cases, the answer is a qualified "yes." The pharmaceuticals value chain in Maine is small but growing robustly in some areas, with a distribution of activity across a number of related industries, including pharmaceutical preparations, in-vitro diagnostic substances, medicinals and botanicals, and professional, technical and research services. The wood products industry accounts for a sizable share of the appliances value chain, but there is also significant activity in nonmetallic mineral products; electrical equipment, appliance and component manufacturing; petroleum and coal products; and furniture and related products (namely wood kitchen cabinets and countertops).

## **5. Discussion**

Interindustry benchmarks are groupings of industries—in essence, alternative industrial classifications to the standard SIC and NAICS systems—that are derived from analyses of

industrial interdependence for relevant reference or baseline regions, usually the nation as a whole. They provide two major types of information when used in industry cluster studies for specific regions. First, they offer an initial indication of *potential* relationships among industries in a region. Second, more fundamentally, they provide wholly different and conceptually useful frameworks for understanding and exploring regional competitive advantage. Porter's "clusters" are groups of industries that tend to co-locate as well as trade with one another. Applying them to an analysis of local industry mix may provide an indication of whether a region is home to specific complex of industries that have shown a national tendency to concentrate. Value chains reveal how different industries work in concert to produce goods and services for specific domestic and international markets. Applied to regional data, they help uncover the economic niches a region has or might capture in a broader economy which is increasingly functionally and geographically fragmented.

We noted above that there are many potential kinds of benchmarks that might be usefully developed, since there are many forms of industrial interdependence. For instance, industries might be grouped based on their utilization of workers with similar skill sets. Used as benchmarks, such an industry classification would help identify those industries among which workers can reasonably transfer their skills, perhaps with varying levels of re-training (Koo, 2005a). Although the need for better labor-based regional analysis was recognized two decades ago (Thompson and Thompson, 1985, 1987), there has been a dearth of research on labor-based industry classifications, in part because defining similarities in skill (as opposed to occupational) requirements among industries is a very demanding exercise. Data availability was limited until the recent advent of the U.S. Department of Labor's ONET database, the online replacement to the *Dictionary of Occupational Titles*. In principle, ONET's much richer and more accessible information on education, skill and ability differences among occupations can be combined with the Bureau of Labor Statistics' Staffing Patterns Matrix to yield a set of labor based benchmarks (Feser and Koo, 2001). However, there remain methodological and data hurdles to overcome.

Technology flows are another type of interdependence that could yield benchmarks of value for regional economic analysis. Technology flows can be captured with matrices derived

from patent citation records, which provide a means of tracing where new knowledge is created versus where it is applied (Koo, 2005b, 2006). Technology relationships between industries do not necessarily follow value chain linkages or mimic mutual labor requirements. Newly created knowledge or products developed in industry *A* can be an important source of new knowledge created or products developed in industry *B*, even when *B* is not trading with *A*. When the laser was first developed by Bell Labs, Bell researchers believed that it had little practical application to their industry. Yet lasers evolved into a critical new technology with a wide range of applications in industries ranging from medical instruments to telecommunications. Another well-known example is Henry Ford's revolutionary system of mass production. Ford's innovation was not invented in a lab, but was rather born when exchangeable parts produced by an increasingly sophisticated machine industry were combined with conveyor belt technology in the food industry. Such unpredictable connections between technologies and industries imply that a set of technology-based interindustry benchmarks is likely to look very different than spatial-based, value chain-based, or labor-based benchmarks.

In applying interindustry benchmarks in regional cluster studies, analysts must be careful to avoid a common mistake. It is to assume that interindustry benchmarks are principally an instrument for *finding* local or regional clusters defined as "geographically bounded agglomeration[s] of similar, related firms that together are able to achieve synergy" and, therefore, are "competitive" (Rosenfeld, 1995, p. 12). Interindustry benchmarks, depending on their origins, may provide guidance on where to look for regional clusters, but they provide no direct evidence of local interindustry ties (whether defined by trade, labor, technology, or otherwise).<sup>22</sup> They are far more valuable as a flexible tool for better understanding the region's economic niches within a larger national and global economy, or as

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<sup>22</sup> With respect to the specific application we demonstrate in section 4, although U.S. interindustry trade patterns are not identical to those in any U.S. region, national value chains supply information on probable regional interindustry ties when local data are scarce. And, indeed, local data on interindustry relationships are always scarce, because even regional input-output tables are simply estimates of local interindustry trade that are based ultimately on national production technology.

a starting point for more in-depth analysis of local linkages, than they are for identifying clusters as entities in a place.

Are we contradicting ourselves by advocating the use of interindustry benchmarks in regional cluster analysis but then cautioning against their use as a means of actually detecting competitive regional clusters? The answer is “no,” because the best regional “cluster studies” are, thankfully, no longer just exercises in “local cluster finding.” Indeed, as the cluster concept has penetrated economic development practice, it has heightened awareness of the importance of understanding critical interdependencies among industries and businesses even as the ultimate value of “targeting regional clusters” has come to be questioned. Increasingly, regional cluster studies are focused on revealing sources of interindustry synergies—within a region and externally—and finding ways to leverage those synergies through a variety of local economic development interventions, from marketing and recruitment to workforce development and technology transfer. Deciding whether a given group of companies is or is not a “cluster” is much less valuable for policy purposes than understanding the markets those companies serve and the factors that influence the companies’ individual and collective competitiveness. Interindustry benchmarks are a useful tool, among others, for helping analysts gain that understanding.

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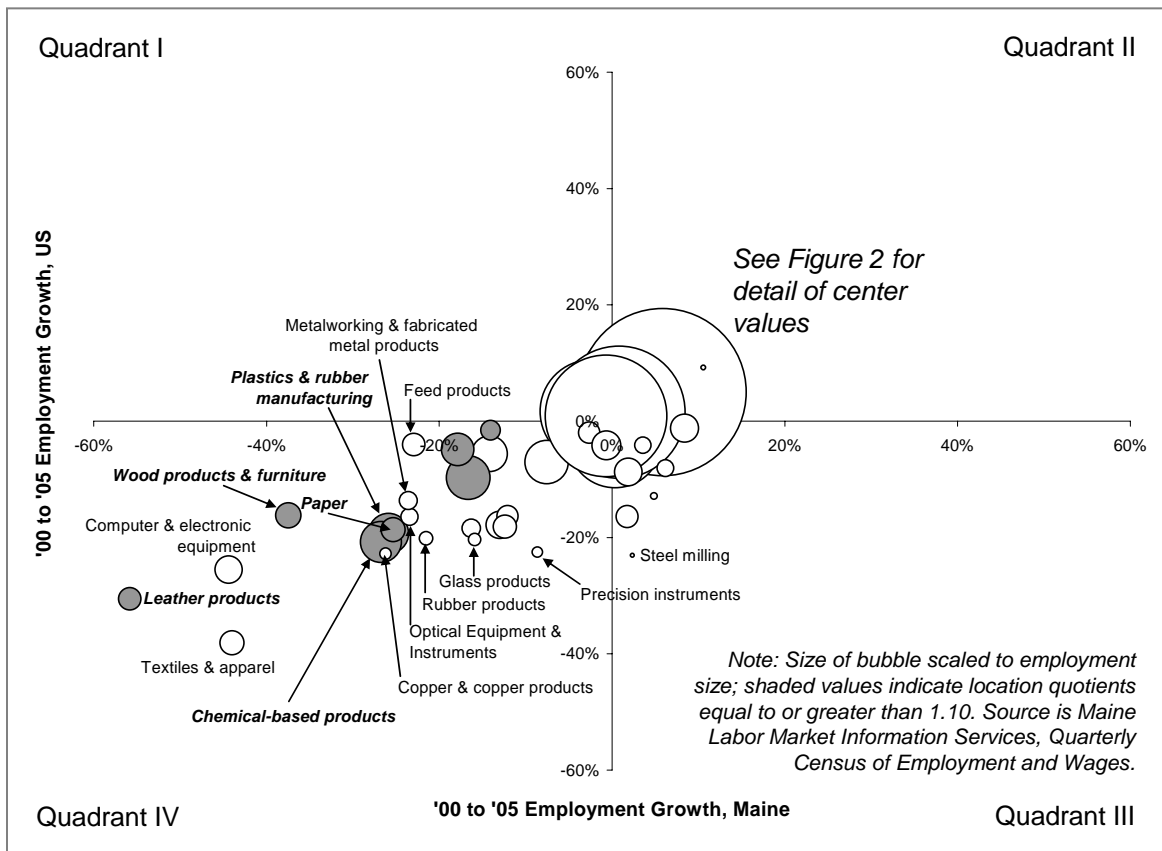


Figure 1  
**National value chains: Maine and U.S. trends**

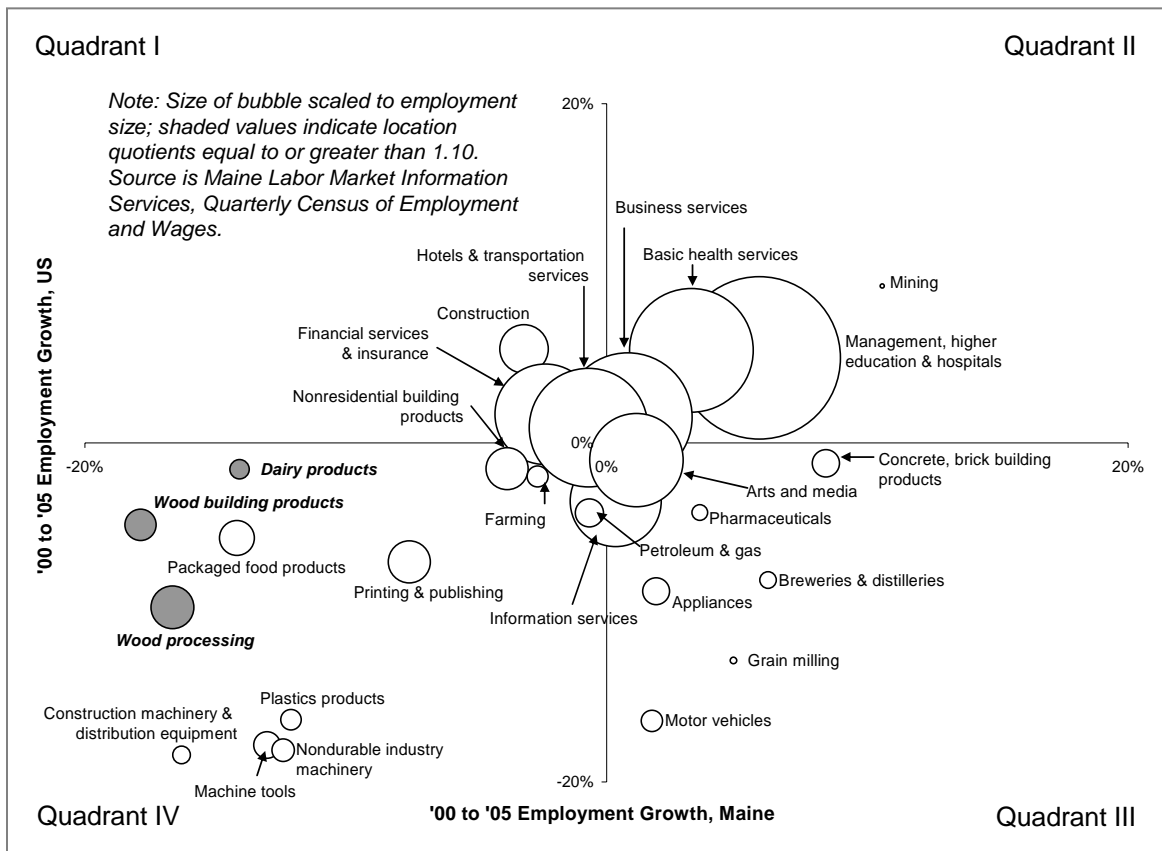


Figure 2  
**National value chains: Maine and U.S. trends (detail)**

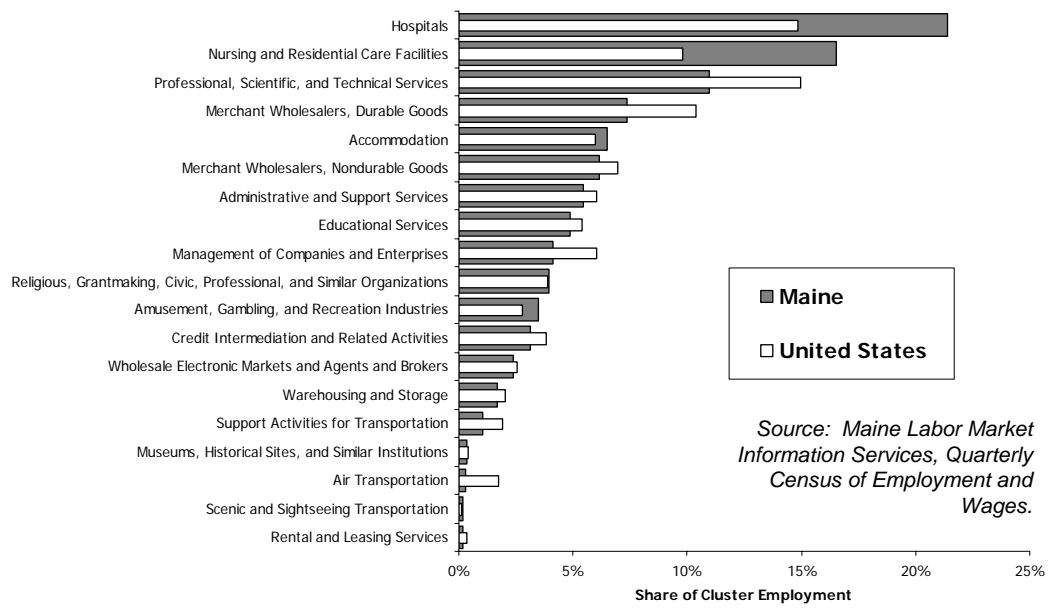


Figure 3  
**Value chain composition: Management, higher ed & hospitals**

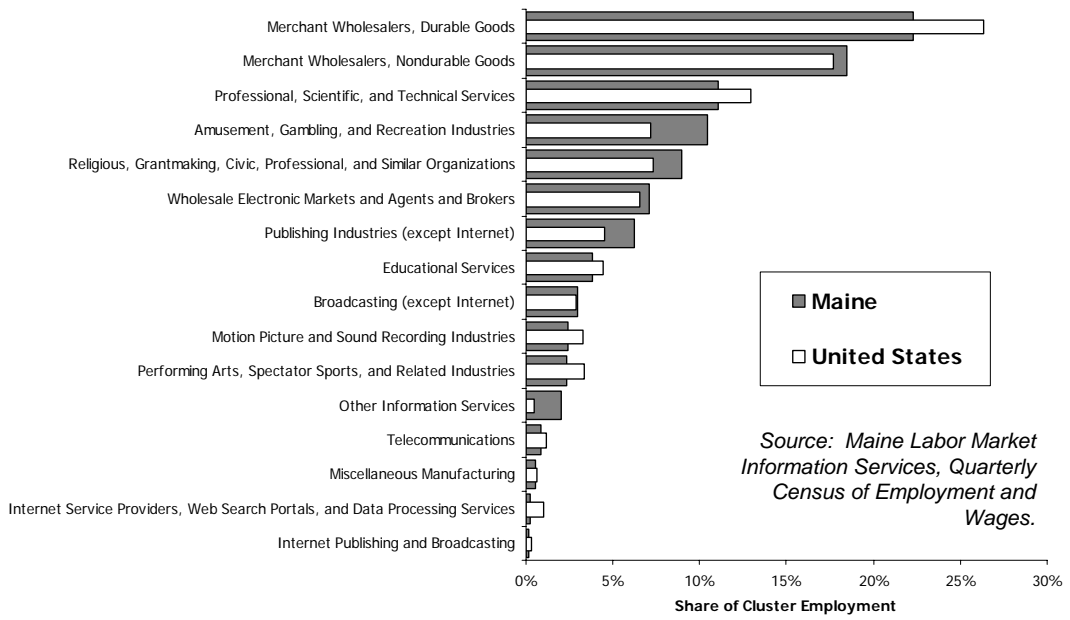


Figure 4  
**Value chain composition: Arts & media**

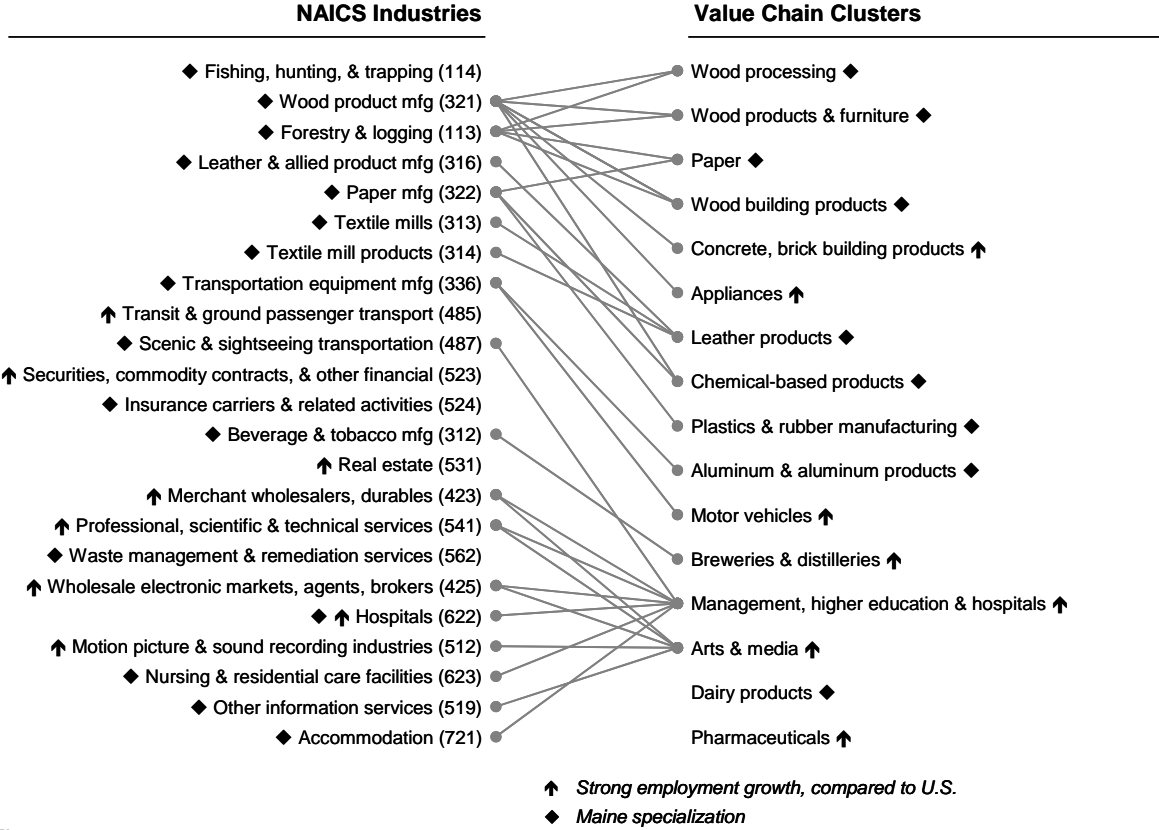


Figure 5  
**NAICS industry vs. national value chain trends: Maine**  
*(Connecting line indicates NAICS industry is a component of cluster)*

Table 2

**Maine's economic base by national value chain**

(Sorted in descending order by 2005 employment)

Cluster	Establs, 2005	Employment		Empl Growth, '00 to '05		Specialization		Intra-Cluster Diversity	
		2005	Share	Maine	U.S.	2005	Change '00-'05	2005	Change '00-'05
Management, higher education & hospitals	16,092	135,585	27.3%	5.9%	5.0%	1.04	0.02	100.47	0.00%
Business services	17,573	84,703	17.0%	0.8%	1.5%	0.77	0.00	100.35	0.00%
Basic health services	16,020	78,494	15.8%	3.3%	5.4%	0.79	-0.01	100.36	-0.01%
Hotels & transportation services	13,904	72,164	14.5%	-0.7%	0.9%	0.77	0.00	100.35	-0.01%
Financial services & insurance	8,870	51,973	10.5%	-2.3%	1.7%	0.75	-0.02	100.34	-0.01%
Arts and media	9,632	44,950	9.0%	1.1%	-1.0%	0.88	0.03	100.40	0.01%
Information services	10,670	42,545	8.6%	0.4%	-3.4%	0.76	0.04	100.34	0.01%
Construction	3,471	12,271	2.5%	-3.2%	5.5%	1.01	-0.08	100.45	-0.04%
Wood processing	1,363	9,500	1.9%	-16.6%	-9.7%	2.49	-0.18	101.13	-0.09%
Printing & publishing	2,044	9,211	1.9%	-7.6%	-7.0%	0.77	0.00	100.35	0.00%
Nonresidential building products	1,343	9,195	1.8%	-3.8%	-1.5%	0.88	-0.01	100.40	-0.01%
Chemical-based products	86	8,293	1.7%	-26.7%	-20.8%	4.07	-0.29	101.86	-0.15%
Plastics & rubber manufacturing	79	7,943	1.6%	-25.9%	-19.3%	2.84	-0.22	101.29	-0.11%
Packaged food products	383	6,307	1.3%	-14.2%	-5.6%	1.05	-0.09	100.47	-0.05%
Wood building products	415	5,177	1.0%	-17.9%	-4.8%	1.19	-0.18	100.54	-0.09%
Petroleum & gas	472	4,125	0.8%	-0.7%	-4.1%	0.67	0.03	100.30	0.01%
Concrete, brick building products	279	3,905	0.8%	8.4%	-1.2%	0.96	0.09	100.43	0.04%
Appliances	266	3,804	0.8%	1.9%	-8.8%	0.78	0.09	100.35	0.04%
Machine tools	299	3,711	0.7%	-13.0%	-17.8%	0.77	0.05	100.35	0.02%
Computer & electronic equipment	283	3,650	0.7%	-44.4%	-25.5%	0.59	-0.19	100.27	-0.09%
Wood products & furniture	391	3,191	0.6%	-37.5%	-16.2%	1.12	-0.37	100.51	-0.17%
Textiles & apparel	204	2,904	0.6%	-44.0%	-38.1%	0.80	-0.08	100.36	-0.04%
Paper	43	2,897	0.6%	-25.3%	-18.7%	1.19	-0.09	100.54	-0.05%
Nondurable industry machinery	332	2,693	0.5%	-12.4%	-18.1%	0.37	0.03	100.17	0.01%
Feed products	680	2,528	0.5%	-23.0%	-4.0%	0.66	-0.15	100.30	-0.07%
Leather products	102	2,506	0.5%	-55.8%	-30.6%	3.82	-2.13	101.75	-1.00%
Motor vehicles	165	2,389	0.5%	1.7%	-16.4%	0.43	0.08	100.19	0.03%
Farming	622	2,287	0.5%	-2.6%	-2.0%	0.74	0.00	100.34	0.00%
Plastics products	81	2,238	0.5%	-12.1%	-16.3%	0.63	0.04	100.28	0.01%
Dairy products	188	1,949	0.4%	-14.1%	-1.6%	1.16	-0.16	100.53	-0.08%
Construction machinery & distribution equip	53	1,691	0.3%	-16.3%	-18.4%	0.60	0.02	100.27	0.01%
Metalworking & fabricated metal products	119	1,657	0.3%	-23.6%	-13.7%	0.55	-0.07	100.25	-0.03%
Optical Equipment & Instruments	84	1,519	0.3%	-23.4%	-16.4%	0.77	-0.06	100.35	-0.03%
Breweries & distilleries	69	1,440	0.3%	6.2%	-8.1%	0.93	0.13	100.42	0.06%
Pharmaceuticals	58	1,361	0.3%	3.6%	-4.1%	0.57	0.05	100.26	0.02%
Rubber products	103	922	0.2%	-21.5%	-20.2%	0.40	0.00	100.18	0.00%
Glass products	100	767	0.2%	-15.9%	-20.4%	0.49	0.03	100.22	0.01%
Copper & copper products	78	687	0.1%	-26.2%	-22.8%	0.71	-0.03	100.32	-0.01%
Precision instruments	34	540	0.1%	-8.6%	-22.5%	0.30	0.05	100.14	0.02%
Grain milling	21	237	0.0%	4.9%	-12.8%	0.62	0.11	100.28	0.05%
Mining	48	115	0.0%	10.6%	9.2%	0.07	0.00	100.03	0.00%
Steel milling	5	87	0.0%	2.4%	-23.1%	0.10	0.03	100.05	0.01%
Aluminum & aluminum products	56	s	s	s	-20.4%	s	s	100.98	0.06%
Aerospace	10	s	s	s	-8.2%	s	s	100.27	0.02%

Source: Maine Labor Market Information Services, *Quarterly Census of Employment and Wages* (ES-202) series. The specialization rate is a location quotient: the share of Maine's total employment that is accounted for by cluster *i* to the share of total national employment accounted for by cluster *i*. Intra-cluster diversity is measured by a relative diversity index (RDI), which measures the inverse of the sum of absolute differences between Maine's employment shares in each six digit NAICS industry in the cluster and the nation's employment shares in each six digit industry. The index is rescaled by multiplying by 100. s indicates data suppressed to protect company confidentiality. Clusters are not mutually exclusive; share is share of total Maine private sector employment.

Table 3

## Maine's economic base by NAICS industry

Industry	NAICS	Empl, 2005	Empl Growth, '00 to '05		Specialization		Industry	NAICS	Empl, 2005	Empl Growth, '00 to '05		Specialization	
			Maine	U.S.	2005	Change '00 to '05				Maine	U.S.	2005	Change '00 to '05
Crop Production	111	1,518	-15.7%	-5.1%	0.62	-0.07	Truck Transportation	484	6,180	-3.7%	-1.7%	0.99	-0.01
Animal Production	112	624	-17.6%	7.8%	0.65	-0.19	Transit & Ground Passenger Transportation	485	1,453	6.7%	4.0%	0.84	0.03
Forestry & Logging	113	2,705	0.6%	-13.9%	8.45	1.29	Pipeline Transportation	486	74	2.8%	-16.2%	0.43	0.08
Fishing, Hunting & Trapping	114	379	45.2%	-19.1%	9.33	4.18	Scenic & Sightseeing Transportation	487	252	5.4%	-11.6%	2.03	0.34
Support Activities for Agriculture & Forestry	115	430	-31.4%	-1.0%	0.30	-0.13	Support Activities for Transportation	488	1,429	0.7%	3.2%	0.58	-0.01
Mining (except Oil & Gas)	212	115	11.7%	-5.3%	0.12	0.02	Couriers & Messengers	492	1,886	-9.5%	-8.6%	0.75	0.00
Support Activities for Mining	213	0	-100.0%	34.5%	0.00	0.00	Warehousing & Storage	493	2,318	-6.6%	13.3%	0.88	-0.18
Utilities	221	1,903	-6.6%	-8.4%	0.77	0.02	Publishing Industries (except Internet)	511	3,589	-4.5%	-12.2%	0.88	0.08
Construction of Buildings	236	8,087	7.3%	10.4%	1.05	-0.02	Motion Picture & Sound Recording Industries	512	1,078	39.3%	-2.4%	0.64	0.20
Heavy & Civil Engineering Construction	237	3,341	-26.3%	-0.3%	0.80	-0.27	Broadcasting (except Internet)	515	1,327	-19.4%	-3.8%	0.91	-0.17
Specialty Trade Contractors	238	19,430	10.1%	11.0%	0.93	0.00	Internet Publishing & Broadcasting	516	73	32.7%	-34.3%	0.52	0.26
Food Mfg	311	6,353	-11.9%	-5.2%	0.96	-0.06	Telecommunications	517	3,087	-13.8%	-21.8%	0.69	0.07
Beverage & Tobacco Product Mfg	312	1,040	-0.1%	-7.3%	1.20	0.10	ISPs, Web Search Portals, & Data Processing	518	1,112	-15.3%	-25.6%	0.65	0.08
Textile Mills	313	1,482	-40.8%	-42.7%	1.52	0.06	Other Information Services	519	926	-17.0%	10.6%	4.12	-1.32
Textile Product Mills	314	1,141	-34.5%	-22.5%	1.50	-0.26	Monetary Authorities - Central Bank	521	0		-8.2%	0.00	0.00
Apparel Mfg	315	265	-68.1%	-48.8%	0.23	-0.14	Credit Intermediation & Related Activities	522	13,430	0.5%	13.0%	1.04	-0.12
Leather & Allied Product Mfg	316	2,195	-57.3%	-43.3%	12.50	-3.95	Securities, Commodity Contracts & Other	523	1,508	1.9%	-2.0%	0.42	0.02
Wood Product Mfg	321	6,656	-18.1%	-9.0%	2.65	-0.27	Insurance Carriers & Related Activities	524	10,870	-2.6%	2.3%	1.13	-0.05
Paper Mfg	322	9,478	-26.2%	-20.1%	4.37	-0.31	Funds, Trusts, & Other Financial Vehicles	525	59	59.5%	3.4%	0.15	0.05
Printing & Related Support Activities	323	2,510	-14.4%	-20.2%	0.87	0.07	Real Estate	531	4,470	19.3%	10.4%	0.68	0.06
Petroleum & Coal Products Mfg	324	400	14.0%	-9.1%	0.79	0.17	Rental & Leasing Services	532	2,733	-5.4%	-4.9%	0.95	0.00
Chemical Mfg	325	1,555	-6.2%	-11.1%	0.40	0.02	Lessors of Nonfinancial Intangible Assets	533	5	-54.5%	-9.3%	0.04	-0.04
Plastics & Rubber Products Mfg	326	2,295	-13.8%	-16.4%	0.64	0.03	Professional, Scientific, & Technical Services	541	23,020	5.0%	3.7%	0.73	0.02
Nonmetallic Mineral Product Mfg	327	1,524	-16.4%	-9.6%	0.67	-0.05	Management of Companies & Enterprises	551	5,617	-13.8%	-2.3%	0.72	-0.09
Primary Metal Mfg	331	353	-18.5%	-25.4%	0.17	0.02	Administrative & Support Services	561	20,258	-5.3%	0.0%	0.58	-0.03
Fabricated Metal Product Mfg	332	4,683	-15.3%	-14.5%	0.69	0.00	Waste Management & Remediation Services	562	1,692	3.0%	7.8%	1.11	-0.04
Machinery Mfg	333	2,175	-24.3%	-20.5%	0.42	-0.02	Educational Services	611	9,217	11.0%	18.7%	0.96	-0.06
Computer & Electronic Product Mfg	334	3,482	-48.9%	-27.6%	0.59	-0.24	Ambulatory Health Care Services	621	24,368	8.5%	18.4%	1.06	-0.09
Electrical Equip, Appliance & Component Mfg	335	871	-30.9%	-26.8%	0.45	-0.02	Hospitals	622	29,037	19.0%	9.9%	1.50	0.13
Transportation Equipment Mfg	336	9,311	-4.7%	-13.9%	1.17	0.12	Nursing & Residential Care Facilities	623	22,392	6.2%	10.2%	1.75	-0.05
Furniture & Related Product Mfg	337	1,565	-29.9%	-17.6%	0.62	-0.10	Performing Arts, Spectator Sports & Related	711	1,035	8.5%	1.6%	0.61	0.04
Miscellaneous Mfg	339	2,117	-2.3%	-12.5%	0.73	0.08	Museums, Historical Sites, & Similar Institutions	712	437	18.1%	6.7%	0.82	0.09
Merchant Wholesalers, Durable Goods	423	10,023	1.8%	-4.5%	0.74	0.05	Amusement, Gambling, & Recreation Industries	713	6,566	5.2%	1.4%	1.07	0.05
Merchant Wholesalers, Nondurable Goods	424	8,312	-4.1%	0.4%	0.92	-0.03	Accommodation	721	11,261	4.3%	-3.0%	1.38	0.11
Wholesale Electronic Markets, Agents, Brokers	425	3,198	27.7%	23.9%	0.96	0.04	Food Services & Drinking Places	722	40,039	5.1%	11.0%	0.98	-0.05
Air Transportation	481	401	-31.8%	-18.0%	0.18	-0.03	Religious, Grantmaking, Civic, Prof & Similar	813	5,367	9.7%	4.5%	0.92	0.05
Water Transportation	483	130	-18.2%	8.9%	0.49	-0.16							

Source: Maine Labor Market Information Services, *Quarterly Census of Employment and Wages* (ES-202) series. The specialization rate is a location quotient: the share of Maine's total employment that is accounted for by cluster  $i$  to the share of total national employment accounted for by cluster  $i$ .

Appendix Table 1

**National value chains: Detail for selected chains**

<b>Value chain</b>	<b>NAICS</b>	<b>Industry</b>	<b>Category</b>
<b>Basic health services</b>	6216	Home health care services	Primary
	6211-3	Offices of physicians, dentists, and other health practitioners	Primary
	6214-5 6219	Other ambulatory health care services	Primary
	5611	Office administrative services	Primary
	5612	Facilities support services	Primary
	5613	Employment services	Primary
	3254	Pharmaceutical and medicine mfg	Secondary
	334510	Electromedical apparatus mfg	Secondary
	339112	Surgical and medical instrument mfg	Secondary
	339113	Surgical appliance and supplies mfg	Secondary
	42	Wholesale trade	Secondary
	5411	Legal services	Secondary
	5412	Accounting and bookkeeping services	Secondary
	5413	Architectural and engineering services	Secondary
	54161	Management consulting services	Secondary
	54162-9	Environmental and other technical consulting services	Secondary
	5614	Business support services	Secondary
	5617	Services to buildings and dwellings	Secondary
	<b>Financial services &amp; insurance</b>	523	Securities, commodity contracts, investments
5241		Insurance carriers	Primary
5242		Insurance agencies, brokerages, and related	Primary
525		Funds, trusts, and other financial vehicles	Primary
492		Couriers and messengers	Secondary
5222-3		Nondepository credit intermediation and related activities	Secondary
521 5221		Monetary authorities and depository credit intermediation	Secondary
5324		Machinery and equipment rental and leasing	Secondary
533		Lessors of nonfinancial intangible assets	Secondary
5411		Legal services	Secondary
5412		Accounting and bookkeeping services	Secondary
5413		Architectural and engineering services	Secondary
54161		Management consulting services	Secondary
5418		Advertising and related services	Secondary
5613		Employment services	Secondary
5614		Business support services	Secondary
<b>Wood products &amp; furniture</b>		33711	Wood kitchen cabinet and countertop mfg
	337122	Nonupholstered wood household furniture mfg	Primary
	337124	Metal household furniture mfg	Primary
	337127	Institutional furniture mfg	Primary
	337125 337129	Other household and institutional furniture	Primary
	337211	Wood office furniture mfg	Primary
	337212	Custom architectural woodwork and millwork	Primary
	337214	Office furniture, except wood, mfg	Primary
	337215	Showcases, partitions, shelving, and lockers	Primary
	321911	Wood windows and door mfg	Secondary
	321999	Miscellaneous wood product mfg	Secondary
	337121	Upholstered household furniture mfg	Secondary
	339992	Musical instrument mfg	Secondary

Source: Feser (2005).