Making Sense of Clusters: Regional Competitiveness and Economic Development

Metropolitan Policy Program
The Brookings Institution

MAKING SENSE OF CLUSTERS:
REGIONAL COMPETITIVENESS
AND
ECONOMIC DEVELOPMENT

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A Discussion Paper Prepared for the
The Brookings Institution Metropolitan Policy Program

March 2006

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ACKNOWLEDGMENTS

The author thanks Bruce Katz, Amy Liu, and Jennifer Vey of the Brookings Institution for challenging me to undertake this project. In the process of researching and writing this discussion paper, I benefited greatly from Howard Wial's thoughtful and thorough guidance and also from the valuable suggestions made by Bill Bishop, Sheila Martin, Terry Moore, Lee Munnich, Liz Redman, Mary Jo Waits, and Bob Weissbourd. Heike Mayer graciously agreed to read an early draft of this paper; any remaining errors are mine alone.

The Brookings Institution Metropolitan Policy Program thanks the Ford Foundation for its support of this paper, and the John D. and Catherine T. MacArthur Foundation for its general support of the Metro Economy Project, a multi-year initiative to promote understanding of the economic transformation underway in the nation's metropolitan areas and to provide practical advice that state and local leaders can use to maximize their communities' economic competitiveness.

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EXECUTIVE SUMMARY

In recent years, "cluster strategies" have become a popular economic development approach among state and local policymakers and economic development practitioners. An industry cluster is a group of firms, and related economic actors and institutions, that are located near one another and that draw productive advantage from their mutual proximity and connections. Cluster analysis can help diagnose a region's economic strengths and challenges and identify realistic ways to shape the region's economic future. Yet many policymakers and practitioners have only a limited understanding of what clusters are and how to build economic development strategies around them.

This discussion paper reviews the academic literature on industry clusters. It explains what clusters are, why they matter for regional economic development policy, and how to use cluster analysis as a guide to policy and practice. Overall, the review's most important findings for policymakers and practitioners are:

1. **Clusters are the key organizational unit for understanding and improving the performance of regional economies.** The foundation of a regional economy is a group of clusters, not a collection of unrelated firms. Firms cluster together within a region because each firm benefits from being located near other similar or related firms. The firms in a cluster have common competitive strengths and needs.
2. **Cluster thinking matters because it orients economic development policy and practice toward groups of firms and away from individual firms.** It is more important and fruitful to work with groups of firms on common problems (such as training or industrial modernization) than to work with individual firms. The cluster approach leads to little if any reliance on economic development subsidies and recruitment efforts aimed at individual firms; if these individual, firm-based policies are used at all, they should be focused on firms that fit within existing clusters.
3. **Cluster thinking offers important lessons for economic development policy and practice.** Cluster thinking teaches policymakers and practitioners to:
    - **Build on the unique strengths of their regions rather than try to be like other regions.** Different regions have different sets of economic development opportunities. Not every place can or should become another Silicon Valley.
    - **Go beyond analysis and engage in dialogue with cluster members.** Many policymakers and practitioners treat research on and analysis of clusters as the only elements of a cluster strategy. In fact, they are only a starting point for a cluster strategy. Identifying a cluster's competitive strengths and needs requires an ongoing dialogue with the firms and other economic actors in the cluster. Although the public sector cannot be the exclusive driver of cluster policy, it can play a central role in convening cluster members and working with private-sector cluster organizations.
    - **Develop different strategies for different clusters.** Clusters vary from industry to industry and from place to place and operate in many different dimensions. Different clusters have different needs. There is no one set of policies that will make all clusters successful. For example, a technology cluster may require help with

research or capital, while a metals industry cluster may require assistance with job training or technology deployment.

- **Foster an environment that helps new clusters emerge rather than creating a specific cluster from scratch.** It is difficult for public policy to create new clusters deliberately. Instead, policymakers and practitioners should promote and maintain the economic conditions that enable new clusters to emerge. Such an environment might, for example, support knowledge creation, entrepreneurship, new firm formation, and the availability of capital. Cluster policy is not about "picking winners" or excluding industries.

Much of the research on clusters has been preoccupied with debating the precise definition of a cluster, applying a single methodology, or examining whether clusters are good or bad for various measures of regional economic success. If research is to be more relevant to policy and practice, it should move beyond these concerns. Researchers should accept that clusters are an umbrella concept, not a precisely defined term, and that clusters vary from place to place and across industries. They should work toward a more widely shared, multidimensional approach for characterizing different types of clusters. They should combine quantitative and qualitative methods. Ultimately, cluster research should evolve to become a creative and informative mixture of art and science that helps academics, policymakers, and citizens better understand the varied workings of their regional economies.

Clusters: Lessons for Economic Development Policymakers and Practitioners

1. Cluster analysis can help diagnose a region's economic strengths and challenges and identify realistic ways to shape the region's economic future.
2. Different regions have different sets of economic development opportunities. Not every place can or should become another Silicon Valley.
3. The foundation of a regional economy is a group of clusters, not a collection of unrelated firms.
4. Successful development strategies are usually those that extend, refine, or recombine a region's existing strengths, not those that indiscriminately chase companies or industries.
5. Identifying a cluster's competitive strengths and needs requires an ongoing dialogue with the firms and other economic actors in the cluster.
6. It is more important and fruitful to work with groups of firms on common problems (such as training or industrial modernization) than to work with individual firms.
7. Economic development subsidies and recruitment efforts aimed at individual firms, if used at all, should be focused on firms that fit within existing clusters.
8. It is difficult for public policy to create new clusters deliberately. Instead, policymakers and practitioners should promote and maintain the economic conditions that enable new clusters to emerge. Such an environment, for example, might support knowledge creation, entrepreneurship, new firm formation, and the availability of capital.
9. Cluster policy and practice are not:
   - Just a public-sector activity
   - A program
   - A means of "picking winners"
   - A one-size-fits-all approach to economic development.

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MAKING SENSE OF CLUSTERS:
REGIONAL COMPETITIVENESS AND ECONOMIC DEVELOPMENT

I. INTRODUCTION

An industry cluster is a group of firms and related economic actors and institutions located near one another and that draw productive advantage from their mutual proximity and connections. In recent years, "cluster strategies" of economic development have become popular among state and local policymakers and economic development practitioners. As part of these strategies, state and local governments have conducted or commissioned studies of the industry clusters in their own regions. Yet many policymakers and practitioners have only a limited understanding of what clusters are and what to do with or for them. Too often, they treat cluster studies as ends in themselves, rather than as starting points for understanding and promoting regional development.

Given the popularity of the cluster approach, it is valuable to understand what clusters are, why they exist, how to identify them, how they matter for regional economic development, and how to use cluster analysis in policy and practice. This discussion paper translates a cross-section of the academic research on industry clusters into a series of policy-related conclusions that can help public officials, economic development practitioners, and other interested audiences make better use of this concept. One of the daunting aspects of this task is the sheer volume of recent research on the subject. By one count, the number of articles on agglomeration after 2000 was more than five times greater than the number published before 1980 (Maskell and Kebbir 2005).

Clusters represent a fundamental organizing framework for understanding regional economies and for developing economic strategies. Policymakers and practitioners can contribute to their regions' economic success by understanding the competitive strengths and challenges of their regions' industry clusters, building on the strengths, and addressing the challenges. To do so, they must go beyond simply conducting cluster studies. Rather, they should use quantitative and qualitative research as a starting point for an ongoing dialogue with the firms and other economic actors that make up their region's clusters. Such a dialogue can help craft appropriate economic development strategies. Before beginning this process, however, policymakers and practitioners must understand what clusters are and what they do, and likewise, what they are not and cannot do.

After considering the term "industry cluster," its various definitions and schools of thought in Section II, the paper proceeds in Section III by exploring the micro-foundations of industry clusters: the economic reasons why businesses in close proximity to one another might be more productive or successful. Section IV describes the quantitative and qualitative techniques that have been used to study industry clusters and outlines some of their strengths and limitations. Section V evaluates the evidence on the economic effects of industry clusters, including their pervasiveness, the relative impacts of specialization and diversification, and the impact of clustering on wages and poverty. It also discusses the difficulty of generalizing regional findings to larger segments of the economy. Section VI concludes with a discussion of the implications of cluster research for economic

development policy and practice and some thoughts about how to better connect research with action.

Cluster-oriented policy and practice are about realistically assessing regional economic strengths and challenges, building on existing regional strengths, working with groups of firms rather than individual firms, identifying competitive strengths and challenges through dialogue with cluster members, and creating economic conditions conducive to the continue success of existing clusters and the formation of new clusters.

II. DEFINING INDUSTRY CLUSTERS

"Industry cluster" is a broad concept rather than a precise term. A cluster consists of firms and related economic actors and institutions that draw productive advantage from their mutual proximity and connections. As explained later in this section, there are many different dimensions of clustering and, indeed, different types of clusters.

The past 15 years have seen an explosion of interest in industry clusters. Hundreds of cluster studies have been undertaken around the world (van der Linde 2002). A variety of academic disciplines have rediscovered an interest in the subject and at least one new field, "the new economic geography," has been spawned. This academic interest has been reflected in a wide range of policy innovation and experimentation, as practitioners have adopted the terminology and tried to make practical use of the concept.

Much ink has been spilled in a largely futile effort to define narrowly—and in some cases to brand—the term "industry cluster." Rather than trying to agree on a single definition, theorists and practitioners should focus on more carefully observing and understanding the different aspects of clustering and clusters. This section of the paper begins this task by exploring some, but by no means all, of the competing definitions of clusters. It then steps back to consider the range of concepts underlying this term. To explain the bases for the varying definitions and concepts, it briefly summarizes the wide-ranging academic literature that touches on the cluster concept. The section concludes with practical advice on how to make sense of the idea of clusters.

A. Competing Definitions: What Is an Industry Cluster?

The concept underlying industry clusters goes back many years and goes by many different names, including "industrial district," "agglomeration," and others. Today, however, the term "cluster" is in wide use. Harvard Business School professor Michael Porter (1990, p. 78), who is widely credited with popularizing the term "cluster," if not inventing it, defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field." Porter (1998) sees clusters as including:

- linked industries and other entities, such as suppliers of specialized inputs, machinery services, and specialized infrastructure
- distribution channels and customers, manufacturers of complementary products, and companies related by skills, technologies, or common inputs
- related institutions such as research organizations, universities, standard-setting organizations, training entities, and others.

Many others have offered their own variations. Martin and Sunley (2003) catalog 10 different ways of defining clusters. Typical of the alternatives is Rosenfeld (2002, p. 10), who defines a cluster as "a spatially limited critical mass (that is sufficient to attract specialized services, resources,

and suppliers) of companies that have some systemic relationships to one another based on complementarities or similarities."

In general, the definitions used are conceptual and descriptive rather than analytic and precise. Thus, although different authors seem to agree on at least the overall idea, they may disagree on its application to any particular region or industry.

This disagreement about what constitutes a cluster stems, in part, from the very disparate purposes for which the concept is being used. Clusters are being used to organize local economic development efforts, develop empirical analyses of local economies, and theorize about regional economic growth (Robinson 2002). Given these widely different uses, the range of authors using it, and the different intended audiences, confusion is unavoidable. The debates about what constitutes a cluster have been further complicated by a variety of authors each adding their own new terminology to the discussion.

It seems that after nearly two decades of study and debate, it is probably impossible to agree on a single, universal definition. It may be possible, however, to agree on the range of characteristics that describe and classify different kinds of clusters, which the remainder of this section outlines.

B. Dimensions of Clustering

One key to understanding clusters is to recognize that there are multiple dimensions to cluster relationships, including geography, social distance, technology, and production flows. Not all clusters operate in all dimensions. Clustering is about proximity; the underlying rationale is that businesses that are closer to one another have advantages that are unavailable to businesses that are farther away. Some firms that are close to one another perform differently from otherwise similar peers located elsewhere.

The most obvious dimension of a cluster is one of physical distance between firms, and virtually all the academic and practitioner literature about clusters is based on geographic proximity. However, other possible dimensions of distance include technological distance (how similar or dissimilar are the technologies that two businesses employ), skill or occupational distance (how similar are the workers employed by different businesses), market distance (whether different businesses have similar or connected sets of customers), and social distance (levels and kinds of interactions between the managers and workers in different businesses). Cluster studies may include one or more of these in addition to physical distance.

Feser (2004) considers three dimensions of clusters: life cycle (existing, emerging, and potential), linkages (buyer-supplier or labor pool), and geography (regional or statewide). Clustering can also be conceptualized as a spatially and industrially nested hierarchy. In some cases, a cluster may be thought of as a broad industry in a state or metropolitan area (e.g., apparel in North Carolina), and in other cases, it may be a narrow set of products in a specific neighborhood (hosiery

in Catawba, NC). Specializations and subspecializations are also evident in specific places. Portland, OR, is a major center for the U.S. electronics industry with a particularly concentrated set of firms that produce electronic display technology. This region might be described as having an electronics cluster and a display technology subcluster.

Characterizing the dimensions of clustering, as with defining clusters in the first place, is not an exact science. Different authors emphasize different dimensions, and the dimensions they emphasize do not necessarily correspond to the particular cluster definitions they use. The dimensions described above are perhaps the most useful, but others, such as in the following, are possible.

1. Industrial Connections: Buyer-Supplier Relationships and the Value Chain

Perhaps the most straightforward description of clusters derives from local buyer-supplier relationships. Most firms buy inputs (raw materials, services, components) from other firms. Many also sell their products or services to other businesses. Having a dense nearby network of suppliers and buyers is an advantage for firms in these locations. Porter's model of cluster interactions is drawn from the business strategy concept of the "value chain," that a firm's competitive advantages stem from how it manages activities, from product design and material procurement to logistics to sales and service. Because many of these activities necessarily involve interactions with other firms—suppliers, professional services firms, distributors, customers, and others—the firm's geographic location can be important to its value chain and its strategy (Porter 1990). The importance of these direct buyer-supplier relationships may have increased as firms have moved away from vertical integration (where a single firm performs each successive stage in a production process).

The value chain view also derives economist Alfred Marshall's (1842–1924) original idea that geographic concentrations of particular industries promote supplier specialization. In the widely studied industrial districts of northern Italy—clusters composed of many small firms in a particular neighborhood—each firm often specializes in a different step in the production process and coordinates its activities with those of other firms (Bianchi and Gualtieri 1987).

2. Interfirm Relationships and Industrial Organization

Industry clusters can be characterized by relationships between firms. Markusen (1996) described four types of clusters (or in her terms, industrial districts). "Marshallian" industrial districts are groups of roughly equal firms that compete with one another and engage in arm's-length transactions but do not intentionally cooperate. "Italianate" industrial districts (the type found in northern Italy) consist of firms that are roughly equal but that both compete and cooperate. For example, a firm that has more work than it can currently handle or more workers than it can currently employ may give the excess work or refer the excess workers to another firm in the district. "Hub and spoke" districts are dominated by a single large firm that creates a substantial market for local suppliers and generally sets the conditions for their relations (e.g., Toyota or Boeing). "Satellite

platform" districts are collections of branch plants, usually larger, autarkic, tapping low-cost labor, or getting closer to markets. "State-sponsored" districts are those that owe their existence to government spending, usually military spending or government research laboratories.

Gordon and McCann (2000) distinguish between three different types of clusters: (1) "pure agglomeration economies" (the Marshallian model) in which firms (and workers) are connected only by arm's-length transactions, (2) the "industrial complex model" (hub and spoke) in which a large central firm creates a production environment and social system, and (3) the "network model" (similar to the Italianate model) in which bonds of trust and associational links among relatively equal firms help drive economic activity.

3. Geographic Extent

The geographic extent of clusters varies widely from industry to industry. Most analyses identify clustering using a standard geographic unit of analysis, typically metropolitan areas or counties. For many industries this seems sensible. However, some industry clusters may be much smaller or more extensive than these units. The garment industry cluster in New York City is famously localized to just a few blocks in midtown Manhattan (Rantisi 2002). The automobile industry in the United States spans five states and two interstate highway corridors (Klier 1999).

Given the wide variety of industries and of different forces driving clustering, it should come as no surprise that different clusters exhibit different geographic scopes. This represents an important problem for statistical analysis that uses fixed geographic units to analyze employment concentrations. An obvious problem with using a single geographic unit to studying clustering across a wide range of industries is that it may be the right unit for detecting some clusters and the wrong unit for detecting others. In addition, globalization, outsourcing, and international flows of capital and labor mean that the appropriate context for analyzing clusters is international rather than national.

A parallel challenge faces those who study regional economies. Some clusters may be fully contained within a region (such as a metropolitan area), while others may run into adjacent areas or even other states. Critics of clusters regard the lack of neat geographic boundaries for defining clusters as a major problem: Martin and Sunley (2003) deplore what they regard as the cavalier use of geographic terminology and the lack of precision.

4. Cluster Life Cycle

There is general agreement that clusters exhibit a life cycle, which draws from "product life cycle" and "industry life cycle" Theories. Many studies describe clusters by their age and growth, often either as emerging (many new firms, rapid growth, frequent changes in firms and products), established or mature (fewer, larger firms, slower growth, fewer changes in products), or declining (stagnant or declining employment growth, more firm deaths than births, few or no changes in products). There are also potential, hoped for, or imaginary clusters. Often the product of economic

development efforts, these represent attempts to create an industry cluster where none currently exists. The cluster life cycle also includes the possibility that clusters may reinvent or redefine themselves as markets and technology change. Such reinvention or redefinition may reinvigorate a declining cluster.

Reviewing the Italian experience with industry clusters, Bianchi, Miller, and Bertini (1997) divide clusters into three broad groups: embryonic, consolidated, and mature. Because of continual changes in markets, competition, and technology, clusters tend to evolve continually, with some clusters ebbing or dying even as new ones form and grow.

As clusters evolve, the factors that drive their success change. The economic factors that give rise to a cluster can be very different from those that keep the cluster going. Once a cluster is established, positive feedback effects help drive cluster growth. However, the initial market or technological breakthroughs that cause a cluster to form are unpredictable (Bresnahan, Gambardella, and Saxenian 2001).

Different regions develop or attract clusters at different stages in the product life cycle. Audretsch and Feldman (1996) analyzed new product introductions by manufacturing firms in the 1980s and found significant differences in the geographic concentration of innovation by industry life cycle. Innovation tends to be focused in the early stages of an industry's formation and growth, becoming more dispersed as the industry matures. Duranton and Puga (2001) find that many industries emerge initially in larger metropolitan areas and later move to smaller, less diverse regions. Similarly, an analysis of patents shows that innovation occurs in large metropolitan areas in the early stages of an industry's life cycle and in smaller areas during its later stages (Orlando and Verba 2005).

5. Relationships among Cluster Participants

Another distinction of clusters is the relationships among participants in a cluster. A key question is whether cluster participants must be aware that they are members of a cluster for the cluster to exist. Some clusters may exhibit no awareness of other firms or actors. They may benefit from a pool of specially trained labor, for example, even when they are unaware of other firms that employ similar workers. In other cases, firms are aware of their colleagues and have developed informal or formal mechanisms for collaboration. They may buy and sell to one another, engage in partnerships on particular projects, or belong to a trade association. In some cases, clusters are groups of businesses that a state or local government recognizes or designates as such.

C. Schools of Thought: The Evolution of the Cluster Concept

This section summarizes some of the main schools of thought on clusters, from Alfred Marshall's original work to current and ongoing cluster development efforts. Most of the work identified here emerges from two broad traditions: the neoclassical economic tradition and the social and institutional tradition. Others, including business-strategy analyst Michael Porter and the many

economic development practitioners, have also drawn on a wealth of practical experience with clusters in addressing many of these same themes.

The observation that certain kinds of economic activity tend to be concentrated in certain locations is commonplace. Most explanations of clusters trace their roots to Alfred Marshall's studies of industrial districts in nineteenth century England, a subject he touched on in his wide-ranging treatise *Principles of Economics,* originally published in 1890. Academic interest in industry clusters waxed and waned, until two events in the 1980s and 1990s rekindled it. In the mid-1980s, several studies of networks of globally competitive small businesses in Italy revived Marshall's analysis of industrial district dynamics, and in 1990, Michael Porter published his *Competitive Advantage of Nations*, an 855-page study of the industrial structure of developed nations and the world's leading industries.

1. The Neoclassical Economic Tradition

The neoclassical economic tradition has been a major school of economic thought since the late nineteenth century. Since the mid-twentieth century it has been the principal school of thought among Anglo-American economists. Some aspects of neoclassical thinking have also influenced noneconomists who write on urban and regional issues, such as mid-twentieth century regional scientists and the iconoclastic contemporary urbanist, Jane Jacobs.

Neoclassical economics focuses on the behavior of individual consumers and firms. Consumers and firms interact in markets, which set the prices of goods and services. Taking into account their limited incomes and the prices set in the market, consumers buy the goods and services that maximize their well-being. Taking into account the prices set in the market, firms make decisions, including location decisions, that maximize their profits. Firms compete with one another, and this competition ensures that they will seek out and take advantage of profitable opportunities.

a. Alfred Marshall

The economist Alfred Marshall is widely credited with the first clear description of industry clusters (Marshall 1920). Marshall drew his insight from observations of the pattern of economic activity in the industrial districts of England. He identified three reasons why groups of firms in a particular trade located near one another would be more productive than they would be separately. These reasons form the Marshallian Trinity: labor market pooling, supplier specialization, and knowledge spillovers. Marshall observed that a concentration of similar firms would attract, develop, and benefit from a pool of labor with a common set of skills. Individual workers could minimize their economic risk by being located in a place with many possible employers of their specialized skills. Marshall also noted that a concentration of similar firms created a good market for suppliers and provided the scale needed for suppliers to refine and specialize their expertise. This, in turn, worked to the productive advantage of their customers. Finally, Marshall found that in industrial districts, ideas moved easily from firm to firm as if knowledge was “in the air.” Marshall's description of

industrial districts identified what economists today call "external economies," productive benefits that are not captured by the individual firms that create them.[1]

The Marshallian Trinity

- Labor Market Pooling
- Supplier Specialization
- Knowledge Spillovers

b. Regional Science

For nearly 50 years after Marshall's path-breaking work, economists paid little attention to space. Walter Isard (1956) and other scholars, however, helped organize the field of regional science in the 1950s, building on the work of German economists such as Lösch and Von Thünen. They applied the ideas and techniques of economics, including some from neoclassical economics, to the location of economic activity. Metropolitan-level studies of the distribution of economic activity and its change over time informed many of the insights of regional scientists.

Regional scientists refined Marshall's idea that firms benefit from being located near other firms. They distinguished between two kinds of external economies: localization economies (gains from proximity to similar firms, especially firms in the same industry) and urbanization economies (gains from proximity to dissimilar firms, especially firms in other industries). Urbanization economies are associated with large urban areas, which usually have a variety of industries, but the concept of urbanization economies is not the same as size. (Las Vegas is a large metropolitan area but it is not as industrially diverse as other metropolitan areas of similar size.)

In their book *The Location of Economic Activity,* Hoover and Giarratani (1948) describe external economies that arise from geographic agglomeration, identifying both localization and urbanization economies. In the early 1960s, Benjamin Chinitz (1961) noted the pervasive effects of different industrial specializations on the economic, and especially entrepreneurial, character of the New York and Pittsburgh metropolitan areas. In his view, Pittsburgh's lack of industrial diversity and its dependence on large firms inhibited entrepreneurship and economic growth in the region. Chinitz seemed to suggest that urbanization economies were more important than localization economies as drivers of regional growth.

Regional science helped reintroduce space into thinking about the economy, developed the distinction between localization and urbanization economies, and began an ongoing debate about the relative importance of the two types of external economies. Regional science, however, turned

[1] Interestingly, Marshall's concept of external economies is a refinement and extension of Adam Smith's famous "pin factory" observations about the connection between economies of scale and specialization. Smith applied the concept to nations; Marshall described its operation in particular neighborhoods.

out to be an eclectic, applied field with many useful analytical tools but no sweeping theoretical breakthroughs, and academic interest in the field waned after the 1960s (Krugman 1995).

c. Jane Jacobs

The iconoclastic urbanist Jane Jacobs has argued that cities play a decisive role in economic growth. Not an economist by training, but a shrewd observer of the urban environment with a grounding in history, Jacobs maintained that new knowledge created in cities drives human economies and progress (Jacobs 1969). In particular, the scale of cities and their diversity of inhabitants create the interactions that generate new ideas.

In Jacobs' view, the creation and development of new products and new technologies (or, in her terminology, "new work") are the source of economic development. The diversity and extensive interaction of economic actors within cities promote new work. Jacobs cites several examples throughout history of how, by being at the crossroads of trade, cities promoted the mixing of a wide range of people, ideas, and products, generating new work and triggering productivity and growth. By juxtaposing different industries, trades, and people, large and diverse cities create new ideas.

Although initially greeted with skepticism in the academic community, Jacobs' views have gained increasing credence. University of Chicago economist and Nobel laureate Robert Lucas (1988) broadly endorsed Jacobs' view of the role of cities in the creation of human capital. Jacobs continued the debate over the relative importance of localization and urbanization economies, weighing in strongly on the side of urbanization economies. She also broadened the concept of urbanization economies to include other types of diversity in addition to industrial diversity. Today, urbanization economies are alternatively referred to as "Jacobs externalities."

d. New Economic Geography

Prior to 1990, few researchers were applying formal, mathematical modeling to problems of economic geography. However, during the past 15 years, neoclassical economists have increasingly used sophisticated mathematical models to address Marshall's original concern about why firms locate in geographic agglomerations. These "new economic geography" models examine the location decisions of firms that face positive costs of transporting their products to market, increasing returns to scale (i.e., average costs that decline as the scale of production rises), and monopolistic competition (i.e., competition on the basis of product differentiation, not just on the basis of price (see, for example, Fujita, Krugman, and Venables 1999).[2]

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[2] Traditional neoclassical models of economic activity focused on cases of perfect competition, because economists had well-developed mathematical tools for dealing with equilibrium in a constant-returns-to-scale world (i.e., one in which average costs of production are independent of the scale of production, so that large firms have no cost advantage over smaller ones). The development of the Dixit-Stiglitz model of monopolistically competitive markets gave economists the means to model increasing returns mathematically. In the 1980s, economists applied this approach to make important advances in theorizing about international trade—the so-called New International Trade theory developed by Krugman and others. In his book

The models show that geographic clusters of firms are most likely to form when increasing returns to scale are strong; firms have power to set prices; transportation costs are low; and customers, suppliers, and workers are geographically mobile (Ottaviano 2003). An important implication of these models is that, unlike more traditional neoclassical economic models, they frequently have no single deterministic solution. Small, chance events can have enduring, long-term, and large-scale consequences. For the most part, this work remains highly abstract and only limited work has been done to test these models empirically.

e. Urban and Regional Economics

Separately from the new economic geographers, urban and regional economists have, since the 1970s, studied the spatial aspects of a variety of economic problems, including housing, transportation, labor, crime, and other issues. Since the early 1990s, the determinants of regional productivity and economic growth have been a particular concern of urban and regional economists. These economists have re-ignited the old debate about the relative importance of localization and urbanization economies. Using modern statistical techniques, they have studied the impacts of industry geographic concentrations, industrial diversity, and metropolitan size on regional growth. Among the more important contributions to this large research base are works by Henderson (1997) and Glaeser and colleagues (1992). These studies do not reach a consensus about whether industrial specialization or industrial diversity is more important to regional growth.

2. The Social and Institutional Tradition

Many geographers, urban and regional planners, sociologists, and political scientists, as well as some economists, approach the study of business location from a social and institutional perspective. Rather than focusing on the response of individual firms and consumers to economic incentives, these authors emphasize the effects of social forces and relationships that, in their view, cannot be fully reduced to the market decisions of individuals. Among the most important of these forces are customs, technological change, organizations, and social networks. These scholars do not assume that markets are the major organizing principle of economic life, but rather that the market itself is embedded in non-market social relationships.

a. Business Organization

One school of social and institutional thought explores clustering by analyzing the organization of production within and between firms. In this school of thought, the way in which production is organized—the types of technologies that firms use, how work is structured within and between firms, the relationships between employers and employees—shapes many other features of the economy, including the locations of firms.

Geography and Trade, Krugman (1991) proposed applying the same analytical approach to geography. During the next several years, Krugman and others developed a series of formal economic models of spatial processes.

During the first half of the twentieth century, the organization of production was dominated by "mass production" or "Fordist" production systems. Large firms could use economies of scale in production (standardizing products and production, dividing and simplifying work tasks) and in marketing to achieve lower costs and dominate markets. As the scale of economic activity increased to continental and global levels, it seemed that large firms would ultimately dominate the entire economy.

In several areas, however, including the Emilia-Romagna region near Bologna, Italy, groups of small firms flourished in highly specialized markets (Brusco 1982). In 1984, two American social scientists, Michael Piore and Charles Sabel, proclaimed a "second industrial divide," arguing that the saturation of mass markets for relatively standardized goods was giving way to consumer preference for greater variety and quality (Piore and Sabel 1984). This change in demand, coupled with technological change—flexible tools and computerization—made it possible for smaller, craft-oriented firms employing higher- skilled labor to out-compete larger, less flexible businesses.

Piore and Sabel's case studies of Italian industrial districts showed that networks of small, craft-oriented industrial firms were thriving in the international marketplace by producing distinctive, high-quality products in a diverse array of sectors, from ceramics to industrial machinery to furniture and textiles and apparel. Rather than being dominated by a single, large firm with overwhelming economies of scale, these industrial districts achieved their success through "flexible specialization"—their ability to rapidly discern and respond to changes in market demand and to fill market niches for customized, high-quality, and limited-quantity products. Larger firms, organized to make long runs of standardized products, could not fill these market niches or respond as quickly to changes in demand. Groups of firms in industrial districts were supported by a variety of institutions and a culture of cooperation that enabled them to mimic or offset many of the advantages of scale (group buying, technology-development, market research) that were previously only available to larger firms.

To Piore and Sabel, this model of small firms embedded in a community with a set of supporting institutions and culture, and with a fundamentally different relationship between labor and management, represented an important alternative to large-scale capitalism. If this way of organizing production were to become more widespread, clusters of small firms would become more common and these clusters would replace large firms as the engines of economic growth in advanced capitalist economies.

b. Geography and Urban and Regional Planning

Geographers and urban and regional planners have taken a keen interest in industrial districts and clusters and their role in city growth and development. Like Piore and Sabel, several geographers and planners have emphasized the nature of the relationships among firms in a region as a source of clustering.

Case studies of places such as Silicon Valley have provided considerable insight into the processes of industry clustering. Saxenian's (1994) comparative study of two competing high tech industry clusters—Route 128 near Boston, and Silicon Valley—attributes the latter's success to important differences in the organization of production (open, team-oriented rather than hierarchical), entrepreneurship, labor market flows, and a local culture that facilitated quick innovation that cut across firm boundaries. Scott (2004) and other analysts have studied a number of industry clusters in Southern California, including the entertainment and apparel industries. Storper (1997) has argued that proximate firms share what he calls "untraded interdependencies"—locally bounded resources that are available to firms that have a presence in a region and relationships with other firms.

Several authors have explored the changing roles of cities in the global economy, particularly the effect of the growth of the service sector and the changing scale and ownership of firms on the function of urban economies. Considerable debate has emerged about the agglomeration of high-end financial and producer services (legal, accounting, advertising, and other services provided primarily to businesses) and of corporate headquarters in major cities (Sassen 1999). Others have examined how global competition has altered the employment and pay levels in the low-skilled manufacturing jobs that have often provided economic opportunities in metropolitan areas (Pastor, Dreier, and Lopez-Garcia 2000).

The debate over the role of cities has much to do with the interactions between the global and the local. Some authors see local advantage—the knowledge creation process in industry clusters—as a key determinant of success in a global economy (Saxenian 1994; Storper 1997). Others see the economic power of international finance and transnational corporations as reshaping the industrial structure of cities, elevating a few to primacy and exacerbating inequality within larger urban areas (Sassen 1999).

3. Michael Porter and Business Strategy

In the early 1990s, Harvard Business School Professor Michael Porter emerged as an important management strategist with his two books on business strategy for market success, *The Competitive Advantage of Nations* (1990) and *The Competitive Advantage of Massachusetts* (1991).[3] Following these works, he undertook a global study of the world's most successful businesses and found that, with striking regularity, firms from one or two nations achieve disproportionate success in particular industries. From this, he developed a theory of industry clusters. His theory draws on ideas from the neoclassical and social and institutional traditions as well as from business strategy.

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[3] The definition of competitiveness is not always clear in Porter's writing. In case studies, he identifies firms that have the largest global market share or significant net exports. He frequently makes reference to productivity, innovation, "upgrading competitive advantage," and profitability, but seldom applies the consistent measures of these phenomena across industry clusters. Indeed, he concedes that many measures of sales and domestic profitability can be misleading, and concludes that "measuring the presence of true competitive advantage statistically is challenging" (Porter 1990, p. 25).

In *The Competitive Advantage of Nations,* Porter describes industry clusters as the product of four factors he calls the “diamond of competitive advantage”: factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry. Porter's work emphasizes the importance of place from the perspective of the firm: how a company's location affects its strategy and performance. The four elements of Porter's diamond are integral to understanding why industry clusters are more competitive than isolated firms.

Factor conditions: These include factors of production from which all firms in the cluster can draw, such as a skilled labor force, specialized infrastructure, and educational institutions. Porter (2000, p. 20) states that "to increase productivity, factor inputs must improve in efficiency, quality, and (ultimately) specialization to particular cluster areas.” Further, if specialized factor conditions are available only at one location, it is less likely that the same set of conditions will be available elsewhere. Thus, demand for services and products from firms in this specific cluster will rise because no other location provides the same set of services and products.

Demand conditions: The presence of sophisticated and demanding local customers will force industry cluster firms to continuously innovate and stay on the leading edge. Cluster firms must cooperate with their customers to meet their needs. In addition, meeting the demand of sophisticated local customers will help cluster firms to compete more successfully in global markets.

Related and supporting industries: Capable, locally based suppliers and competitive, related industries create a supportive web of providers for firms. Cooperation between firms and their suppliers leads to innovation because these firms must exchange information and knowledge about new processes and products.

Firm strategy, structure, and rivalry: If as a strategy cluster firms choose to upgrade and invest continuously, they will remain competitive. In addition, if these firms compete with others in the same industry cluster, they will be motivated to innovate to differentiate themselves from their rivals. Both firm strategy and rivalry contribute to regional competitiveness drawing on regional innovation dynamics.

Porter (2000, p. 21) concludes that "the cluster is the manifestation of the diamond at work. Proximity, arising from the co-location of companies, customers, suppliers, and other institutions, amplifies all of the pressures to innovate and upgrade."

4. Economic Development Practitioners

The exceptional economic performance of small European firms prompted international interest among economic development practitioners in the late 1980s. Many Americans and Europeans traveled to Emilia-Romagna and elsewhere in Northern Italy to examine the small firms firsthand and to meet with officials at trade associations, industry service centers, and local research organizations. A number of jurisdictions undertook efforts to replicate, in some fashion, the support for localized industry clusters they had seen in Italy. Denmark undertook a three-year, $25 million effort to organize "networks" of small manufacturing firms. Oregon established a state program to

support similar networks and officially designate statewide "key industries." Several other states experimented with a range of policies to study, organize, or support networking and clustering.

The experience of economic developers has produced a variety of literature on various aspects of clustering (although it can hardly be labeled a cohesive school of thought). Several development efforts have included commissioned research on industry clusters. In addition, several evaluations of programs designed to stimulate or promote clusters were undertaken. The firsthand study of industry clusters, coupled with observations of the effectiveness of efforts to develop these clusters further, has provided numerous practical insights into the nature of industry agglomerations (Rosenfeld 1997). The lessons from this experience are addressed more fully in the concluding section of this paper.

D. The Cluster Controversy

The surge of interest in industry clustering during the past decade coincides with an increasingly rancorous debate over what the term means. The term or at least the concept has been used by so many academics in so many different ways, and has been attached to so many economic development efforts around the world, that one scholar has plaintively asked whether it is one of those rare terms that has gone from obscurity to meaninglessness without any intervening period of coherence (Maskell and Kebir 2005).

Martin and Sunley (2003) make the strongest case against clusters. In their view, Michael Porter has gate-crashed the economic policy arena, largely overlooking the work of economic geographers and vastly overselling his own views on clusters through clever marketing and branding. The cluster literature is a patchy constellation of ideas and there is simply insufficient evidence to suggest that economic developers adopt a cluster mind-set. According to Martin and Sunley, they would be better advised to encourage greater productivity among all firms and improve the local business environment.

The multiplicity of interests in clustering, coupled with the widely varying perspectives different actors bring to its use, have created an ongoing debate about clusters: what are they, do they matter, and who “owns” them? Several academic disciplines claim part ownership of the concept and have overlapping but importantly different explanations of why and in what ways clusters "matter." These varied explanations of clusters and differing definitions are the source of much of the debate. The lack of precision is maddening to many academics and others; "the concept turns out to be so fuzzy that it is now commonly used in a variety of ways by a wide variety of academics, consultants, and policy-makers" (Desrochers and Sautet 2004, p. 233).

There are also important differences in the evidence used to discern the existence of clusters and to measure their effects. Academics tend to rely on secondary data. They frequently depend on the industrial, occupational, or knowledge taxonomies into which data are sorted to discern the proximity of one firm to another. Or, alternatively, they rely on even more indirect measures of affinity, such as inferences of connection from buyer-supplier relationships computed from national

level input-output data (which, in turn, are often computed from other secondary data on physical shipments among different industries in the United States).

For some, the concept of clusters is too flexible and open to abuse. Some regions have hired consultants to perform cluster analyses that largely serve to recognize or promote a pre-selected industry (Feser and Luger 2002). Alternatively, practitioners compose industry clusters on an ad hoc basis from among the firms (and related institutions) that they find close at hand. They frequently define cluster existence and membership by the attendance of firm owners or managers who agree to show up at meetings and who have enough common interest to be able to articulate and possibly act on some agenda of actions that will be to their mutual benefit. These operationally defined clusters may be unique constellations of economic activity from which it is impossible to generalize broader principles or policy implications.

There are important methodological and epistemological differences in the perspectives of academics and practitioners. Academics are usually looking to simplify, to abstract, and to generalize: to find relationships that are consistent across a wide range of firms and contexts. Practitioners are decidedly more pragmatic. They are looking for something that works and that helps explain the changing and challenging economic context in which their communities or organizations are competing.

Consequently, standards of proof vary as well. Academic critics of cluster theorizing are appalled that actual policies are being constructed on the basis of such shaky research: "[I]ndustry clusters are a clear case of policy making outrunning the evidence to support the policy in question" (Simmie 2004, p. 1095). Just when, one wonders, will there be sufficient evidence for policymakers to actually do something? Under intense pressure to develop more effective approaches to economic development, practitioners hardly have the luxury of waiting until the academic disputes are resolved (Ketels 2003).

The thinking behind clusters is cursed with being vague, comprehensible, and basically true. It is vague because there are so many different dimensions to clustering and because they have been described from many different academic perspectives. It is basically true despite disagreements about the details—and there are many. The bulk of the literature confirms that clustering or agglomeration is a powerful force in explaining the location of economic activity (Rosenthal and Strange 2004). (See also Section V below.) Unlike many theories that are complex or often counterintuitive, the thinking behind clusters is comprehensible. Ordinary human beings can grasp the idea that firms might be more successful if other firms are nearby, they are likely to know of some remarkable successes (such as Silicon Valley), and the cluster concept has been explained in relatively nontechnical terms (for example, Porter's diamond). Further, clusters have been explained in the more accessible language of business strategy rather than in the arcane mathematical vernacular of urban and regional economics (Feser and Luger 2002). The accessibility of the cluster concept can be an advantage. Policymakers, economic development practitioners, and perhaps most important, cluster participants can grasp its major aspects. As a result, unlike some tools of regional analysis, which can only be used and understood by highly

trained professionals, cluster analysis can be used to engage a wider audience in discussions about the economy and it provides a much better basis for informing them about economic issues and policy options (Feser and Luger 2002)

Some of the problems of clusters are perhaps better understood as strengths, particularly if clusters are not viewed as a narrow economic principle to be proved or falsified. Separately, two sets of authors have called for cluster analysis to be regarded as a mode of inquiry (Benneworth and Henry 2004; Feser and Luger 2002). Drawing from a range of academic perspectives can provide a richer view of the different factors shaping an industry cluster.

It seems likely that both academics and practitioners must continue to tolerate some ambiguity. As Feser and colleagues (2001, p. 9) point out, “The complexity of the cluster concept as well as the significant range of policies that clusters might inform dictate that no single definition is appropriate for all analytical or policy needs." The most potent antidote to ambiguity and competing definitions is for both academics and researchers to step back from the objective of making sweeping, universal statements or hypotheses about clusters and to be more nuanced in their descriptions and analysis of different kinds of industry clusters. Rather than working to prove (or disprove) that clustering generally is a benefit to economic performance, research would better be directed to discovering the specific characteristics of clusters that lead to such performance.

III. Cluster Drivers: The Micro-foundations of Clustering

Why do clusters exist? What is it about clusters that is likely to improve economic outcomes? Describing the underlying processes that cause firms to co-locate is a key to defining clusters, to resolving (or perhaps just understanding) the babble of disagreement about what constitutes a cluster, and to using the cluster concept to fashion an economic development strategy or program. What is the glue that holds clusters together? What is it about clustering that confers some economic advantage on firms (and workers and other economic actors) and that causes clusters to be formed and to persist over time? These cluster drivers are sometimes called "micro-foundations" of clustering. The term is drawn from microeconomics, the branch of economics that deals with the behavior of individual economic actors, including firms.

The short answer to these questions is that clusters exist and grow because firms and other economic actors draw some advantage from proximity that is unavailable, at least to the same degree, in other locations. There are seven different micro-foundations for clusters (shown below). There is no single cause of clustering, and different clusters exhibit different combinations of these micro-foundations. The importance of each micro-foundation is also likely to vary over the life cycle of a cluster. Some factors are more important to the establishment of a cluster, while others play a larger role in its growth. Understanding each of these different micro-foundations is essential to making use of the cluster concept and, perhaps, to reconciling the conflicting definitions of clusters themselves.

Micro-foundations of Clusters

- Labor Market Pooling
- Supplier Specialization
- Knowledge Spillovers
- Entrepreneurship
- Path Dependence and Lock-In
- Culture
- Local Demand

The first three of these micro-foundations—labor market pooling, supplier specialization, and knowledge spillovers—make up Alfred Marshall's trinity of reasons for clustering. Later analysts identified the other micro-foundations listed in the box.

My analysis of these micro-foundations draws from the academic literature on clustering. Each of the academic disciplines with an interest in clustering acknowledges most of these micro-foundations, at least in passing, but most observers seem to have their own preferred micro-foundation for explaining the existence and impact of clustering.

The fact that there are many different drivers for clustering may be one of the principal reasons why it is so difficult to agree on a definition of a cluster (and likewise to test for the economic

effects of clustering). Some clusters may exhibit one or only a few of the various micro-foundations. Others may exhibit several. It seems likely that different clusters will have different mixes of micro-foundations and that over time an individual cluster may be driven more by one micro-foundation than another.[4]

The location of some industries and their consequent concentration in particular locations is undoubtedly driven by natural or other cost advantages that are not necessarily related to any of these micro-foundations: the availability of natural resources (coal and iron ore for the steel industry; timber for sawmills, electricity for aluminum) may be critical in explaining the location of some industries. Ellison and Glaeser (1999) examined the relation between access to resources and costs of key inputs and industrial concentration for a series of manufacturing industries and concluded that one-fifth of observed concentration can be statistically explained by a small set of natural advantages. A more comprehensive study, they conjectured, might be able to explain up to one-half of observed concentration.

A. Labor Market Pooling

A principal advantage that accrues to a concentration of similar firms in a particular location is that they create a strong market for the distinctive skilled labor they need. Workers find it advantageous to be in a place where there are many possible employers. This minimizes the risk from a layoff or a firm failure and creates additional opportunities for advancement. This is particularly important for highly specialized workers, as illustrated in the following quote from Marshall:

> [A] localized industry gains a great advantage from the fact that it offers a constant market for skill. Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require; while men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market. The owner of an isolated factory, even if he has access to a plentiful supply of general labour, is often put to great shifts for want of some special skilled labour; and a skilled workman, when thrown out of employment in it, has no easy refuge. Social forces here co-operate with economic: there are often strong friendships between employers and employed: but neither side likes to feel that in case of any disagreeable incident happening between them, they must go on rubbing against one another: both sides like to be able easily to break off old associations should they become irksome. (Marshall 1920, Book IV, Chapter 10, Paragraph 9)

More recently, a number of authors have argued that labor market pooling is itself a form of clustering; workers with similar occupations tend to cluster in particular metropolitan areas.

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[4] Michael Porter makes one variation of this argument when he describes the four elements of his diamond as separate, mutually reinforcing influences on clustering. Different clusters have different combinations of reliance on Porter's four forces: rivalry, inputs, suppliers, and customers.

Markusen has analyzed occupational data by metropolitan areas and computed location quotients for different occupations. Some metropolitan areas do have occupational specializations, but these are generally less pronounced than industry specializations. Markusen's application of this methodology to the Minneapolis-St. Paul metropolitan area found that occupational specialization was a far less important predictor of employment growth than industrial specialization (Markusen and Schrock 2001).

In addition, occupational data are indirect and infrequently available compared with industrial employment data. The two principal sources of data are the decennial census (self-reported occupations of individuals) and Occupational Employment Statistics (derived from survey-based data of a sample of firms to create an industry-occupation matrix, typically at a statewide level, and using this to estimate the occupational composition of local economies).

B. Supplier Specialization

In Marshall's view, a large number of industrial customers in the nearby area created sufficient demand to enable suppliers to acquire and operate expensive specialized machinery:

> [S]ubsidiary industries devoting themselves each to one small branch of the process of production, and working it for a great many of their neighbours, are able to keep in constant use machinery of the most highly specialized character, and to make it pay its expenses, though its original cost may have been high, and its rate of depreciation very rapid (Marshall 1920, Book IV, Chapter X, paragraph 8).

A large market also enables suppliers to provide highly specialized products and services. For example, a law firm with a large number of potential business clients nearby can specialize in mergers and acquisitions, while one with a smaller number of potential clients nearby may be able to specialize only in corporate law or business law in general. As Porter (1990) emphasizes, the benefits to supplier location in clusters run both ways. Suppliers gain from the nearby market for their output, while client firms in the cluster gain from easy access to a range of services. The interaction between buyers and suppliers can trigger quicker and more effective responses to technical problems or demand changes, helping all the firms in the cluster.

The logic of supplier specialization has been variously documented. A leading characteristic of Italian industrial districts has been the successive specialization of firms in different steps in the production process (Bianchi, Miller, and Bertini 1997). Some analysts have used input-output data to identify which industries buy from and sell to other industries (Feser and Bergman 2000). Studies of individual clusters' value chains show the contribution of different industries to a cluster's final output. Porter (1998) has prepared detailed diagrams of purchasing and product and services flows for the California wine industry and the Italian footwear industry, among others. Klier (1999) and other researchers have documented the location patterns of first-tier suppliers to the automobile industry.

C. Knowledge Spillovers

The third element in Marshall's trinity of causes for industry clustering is knowledge spillovers. The concentration of many people working on a similar set of economic problems produces a widely shared understanding of an industry and its workings.

> When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade get from near neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated; inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas (Marshall 1920, Book IV, Chapter X, Paragraph 7).

Economists now routinely refer to same-industry knowledge spillovers as "Marshall-Arrow-Romer" externalities, acknowledging Marshall's discussion of spillovers in industrial districts, Arrow's (1962) identification of the importance of learning-by-doing, and Romer's (1986) analysis of increasing returns under the banner of new growth theory. The latter explains changes in long-term growth resulting from the nonrival quality of knowledge, and knowledge spillovers are a key element of many formal models of new growth theory. Unlike physical goods, knowledge can be infinitely shared and reused without reducing its usefulness to any individual actor.

The extent and existence of knowledge spillovers has become perhaps the most discussed and debated of the Marshall's three points. Krugman (1991) pushes knowledge spillovers to the bottom of the list (Marshall actually mentions it first), arguing that because data on knowledge spillovers are so sparse, economists ought to get as far as possible without having to consider the most ephemeral of Marshall's three micro-foundations. A variety of studies have documented the role of knowledge spillovers in various industries. Several have used patent data to measure flows of knowledge among firms and across regions. Jaffe, Trajtenberg, and Henderson (1993) found that, controlling for relevant research activity, new patents were more likely to cite previous patents in the same metropolitan area or state than to cite more distant patents. From this, they concluded that knowledge is relatively localized. They also found that this relationship decays relatively slowly over time. Qualitative studies based on interviews and surveys have confirmed that ideas flow freely in a diverse range of clusters, including Silicon Valley (Saxenian 1994), the U.S. steel industry (Hippel 1988), and among wireless engineers in Scandinavia (Dahl and Pedersen 2004).

Despite the clever work that has been done with patents and a small body of survey evidence about the nature of interactions among cluster participants, the mechanisms for transmitting information within clusters are poorly understood. Several authors make an important distinction between explicit knowledge (codified facts that can be reduced to writing) and tacit knowledge ("know-how" possessed by individuals and organizations and that is embedded in routines and networks, but not necessarily codified). Tacit knowledge, it is argued, resides in

clusters and is harder to communicate over long distances. Local clusters have a "buzz." Face-to-face contact is an efficient way to trade information in situations in which the economy is changing and tacit information is relatively important, as in the early stages of intellectual projects when problems are not particularly well defined. Face-to-face communication is also symmetrical and is both contingent on trust and reinforced relationships among participating parties, which limits free rider problems and enables parties to exploit the nonrival character of information (Storper and Venables 2003). Clusters provide a context where economic actors with complementary but often ambiguous and incomplete information can find partners and exchange this information (Mills 1991).

One objection to this localized model of information flows is that it may insulate firms from potentially valuable information generated in other places and lead to an inbred thinking and a lock-in that produces economic decline (Simmie 2004). In a global economy with an international division of labor, links to knowledge in other places is especially important. Sometimes industries do lock into modes of thinking that inhibit adaptation to market changes (arguably a perennial problem among domestic automobile manufacturers), but there is nothing about clusters that necessarily inhibits their ability to also tap into global knowledge flows. Knowledge flows are a combination of local buzz and global pipelines. Firms rely on the knowledge strengths of their local cluster and also maintain external connections. Often membership in a cluster provides the entrée to global contacts (Bathelt, Malmberg, and Maskell 2002).

D. Entrepreneurship

One limitation with the Marshallian Trinity is that while it explains what sustains clusters, it does little to answer the question of what, or who, causes clusters to form in the first place. In effect, many cluster theories presuppose the existence of firms or essentially assume that the firms that populate an industry have already been called into existence. The only relevant question in these theories is where firms should be located. Yet firm formation is a critical ingredient in economic growth and plays out differently in specific places.

Schumpeter (1934) underscored the critical role of the entrepreneur in driving economic development by creating new products. Entrepreneurship includes both the willingness of individuals to form new businesses and the willingness of owners of existing businesses to undertake new ideas. Trying new ideas implies the willingness to take risks. Some places have more entrepreneurs or more conducive environments to entrepreneurship than others, and this shapes their development.

Where entrepreneurs are located and where they establish new firms can have an important impact on clusters. Entrepreneurship is inherently local. Individuals start companies on the basis of prior experience and interests, building on local contacts and business knowledge. Entrepreneurs are also bound to place by family connections and generally want to avoid the personal costs of moving at the time they establish their businesses (Feldman, Francis and Bercovitz 2005).

This reasoning would lead one to expect new firms to be formed in locations with a pre-existing concentration of related economic activity. The evidence on this subject, however, is mixed. Rosenthal and Strange (2005) studied the geography of new firm formation in major industry groups in the New York metropolitan area and found that localization, measured by employment in a new establishment's own industry, is positively associated with the rate of new firm formation and associated employment growth. The effect is most pronounced within one mile of existing industry concentrations.

An analysis of industry concentrations in three-digit manufacturing industries from 1972 to 1992 showed that new firm births tended to de-concentrate industries slightly, whereas the effect of firm closures was to reinforce agglomerations (Dumais, Ellison, and Glaeser 2002). This suggests that new firms are somewhat more likely to be started outside existing concentrations, but firms outside existing clusters are also more likely to fail. Although this is the general result, the pattern is different for different industries at different times.

Studies of specific industries suggest that clusters support entrepreneurial activity. Almeida and Kogut (1997) found, for example, that new startup firms in the semiconductor industry were founded by local entrepreneurs with previous experience in the same industry. They also were more likely to draw on local knowledge, as measured by patent citations, than were larger, established firms. In the biotechnology industry, individuals build knowledge and reputation, and then later capitalize on the value of that knowledge by starting, or helping to start new firms (Audretsch and Stephan 1999). More than 80 percent of the scientists in California research institutions who went on to start their own biotechnology firms did so in California, and a majority of U.S. scientists starting firms launched them in the state in which they had done their academic research (Zhang and Patel 2005).

Entrepreneurs play an important role in selecting and applying new ideas. In the standard neoclassical world, it is assumed that the economic value of any idea is equally apparent to all economic actors. The experience that potential entrepreneurs accumulate in clusters, particularly their understanding of the practical problems to which new technologies can be applied or the potential new markets for innovative products, means only a few people will perceive any particular business opportunity. Different entrepreneurs will make very different use of the same technology, based largely on their prior business knowledge and experience (Shane 2000).

E. Path Dependence and Lock-In

The basic model of clustering is static; it looks at the pattern of economic activity at a particular point in time. As economies evolve over time, however, the distribution of firms and workers can have affect future opportunities. Economic development is, to some degree, path-dependent: the set of opportunities available to any particular place will be shaped by the economic activities it has already established.

At both a global and a local level, knowledge creation is an increasing returns process. That is, the cost of creating new knowledge is lower the more knowledge already exists. For this reason, there is a propensity for the market to "lock in" certain patterns of activity. A number of economists, led by Brian Arthur (1990) and Paul David (1985), have developed the theoretical framework for understanding this process, which is variously labeled “increasing returns,” “positive feedback,” or “QWERTYnomics.” They suggest that in many industries, particularly high tech, the combination of high upfront costs and low marginal costs, network externalities, and complementary investments produces a dramatically different marketplace than found in conventional decreasing-return industries. The seminal example of QWERTYnomics, the typewriter keyboard, demonstrates how develop can lock-in on any one of many possible trajectories (David 1985). The increasing returns to a particular technology (the arrangement of the keyboard, the establishment of a center for a particular industry) can create powerful incentives for further growth, which creates a positive feedback loop that cements the technology’s early advantage. The implication is that the economy is not so much a Newtonian system with a predetermined outcome, but an evolving biological system characterized by multiple possible outcomes, which are subject in part to chance (Arthur 1990).

In the case of clusters, the independent but complementary decisions of a range of economic actors—entrepreneurs, workers, and investors—all converge to reinforce growth in initially successful places. Over time, workers are drawn to places with many potential employers. Likewise, firms are attracted to pools of talented labor. Moreover, successful clusters in effect generate additional human capital (from the experience workers and managers gain in the cluster). Much the same logic applies to investors (particularly risk equity investors) and firms that supply inputs and specialized services.

Krugman (1991, p. 66) asserts that “small accidental events start a cumulative process in which the presence of a large number of firms and workers acts as an incentive for still more firms and workers to congregate at a particular location. The resulting pattern may be determined by underlying resources and technology at some very aggregate level; but at ground level there is a striking role for history and accident.”

Path dependence has several important implications for understanding industry clusters and opportunities for economic development. First, it implies that small, chance events can play an important role in triggering the formation of industries and their clustering in particular locations. Krugman (1991) points to the example of the carpet industry, centered in Dalton, GA, which grew out of the local craft of tufted textiles. Second, path dependent models imply that there are many possible outcomes for market systems, meaning that it may be impossible to predict industry location patterns. Third, once established, industry clusters tend to lock in to particular locations. Thus, there may be substantial opportunity to influence a cluster's location in the early stages of its development and almost no ability to affect it once it becomes set in place. Furthermore, path dependence implies that many of a region's future opportunities for development will come from building on, extending, or recombining existing specializations in new ways.

Relatively few studies explicitly examine whether path dependence is a factor in cluster development. Henderson's (1997) examination of clustering in metals, machinery, and electronics industries finds strong evidence of what he calls “dynamic externalities”: future growth of an industry in a region is a function of that industry’s past concentration in the region. These dynamic externalities limit firm mobility because new locations for an industry do not offer a stock of local trade secrets, and the longer dynamic externalities persist, the more difficult it is for industries to shift locations.

Positive feedbacks and path dependence figure prominently in the formation and growth of technology clusters. In a comparative analysis of Silicon Valley and competing regions, Bresnahan, Gabardella, and Saxenian (2001) find that positive feedback helps drive cluster growth in places that are nimble “first movers” and operate as a formidable barrier to success for latecomers and imitators. In their view, major technological changes create inflection points or opportunities for new clusters to emerge and grow through positive feedback. The technological shift from mini-computers to personal computers was such an inflection point for Silicon Valley. Scandinavia’s wireless industry cluster centered on Sweden's Ericsson, and Finland's Nokia emerged from a similar watershed shift to wireless telephones from wired systems.

The growth of the biotechnology industry in the United States during the 1990s also exhibits positive feedback effects. Although research has become more dispersed, key measures of commercial activity (new firm formation, venture capital investments, and research funding from pharmaceutical companies) have become more concentrated in a few leading industry clusters (Cortright and Mayer 2002).

F. Culture and Embeddedness

The preceding drivers for clusters—labor market pooling, supplier specialization, knowledge spillovers, entrepreneurship, and path dependence and lock-in—are all largely independent of the nature of the social relationships between the owners, managers, and workers in firms. One can make the case for each of these effects without changing any of the basic assumptions about the purely self-interested behavior of individual economic actors.

However, observers of industry clusters have noted that one of the important concomitants of clustering, at least in certain places, is the social relationships among economic actors. Many of these social relationships are geographically localized. People are not simply workers or managers; they are also consumers, citizens, church-goers, kin, and community members. Different economic systems support and give rise to different social arrangements. Different social arrangements, in turn, support different economies. As the social and institutional perspective on economic life emphasizes, economic systems are embedded in social systems, not separate from them. Therefore, it is often difficult to describe economic systems separately from the social systems to which they belong (Granovetter 1985).

Because it is difficult to quantify culture, the evidence about the roles of culture and embeddedness in clusters is drawn chiefly from qualitative studies. These studies show that both the manifold social connections among economic actors and the culture of particular places play important roles in shaping economic behaviors such as risk-taking, cooperation, and information-sharing, all of are also important to clustering. Putnam Nanetti, and Leonardi's (1993) study of regional variations in economic development in Italy help to explain why industrial districts proliferate in Northern Italy, but are almost completely unknown in the Southern Italy. Saxenian's (1994) comparative analysis of Route 128 in Boston and Silicon Valley highlights fundamental cultural differences between the two areas and attributes California's superior economic performance to its openness and tolerance of failure. The role of culture also pervades institutions and limits the development of clusters. Feldman attributes the relative weakness of Baltimore in developing a biotechnology cluster (despite Johns Hopkins being the nation's leading medical research institution) to a persistent culture unwelcoming of entrepreneurship (Feldman 2004).

Although the role of culture and social interactions is not explicitly a part of other micro-foundations of clusters, it is connected to them. Social interactions may be important parts of the interaction of labor markets, as workers learn of jobs from their contacts with other workers. Similarly, knowledge spillovers undoubtedly depend, in part, on the informal rules and patterns of interaction between people from different firms. Some of Porter's (1990) descriptions of firm structure and rivalry allude to the role that social interaction plays in enabling or encouraging the behaviors of managers in firms. Culture may be particularly important in helping local economies and clusters adapt to change over time.

G. Local Demand

Most of the explanations of industry clustering address the supply side of the economic equation: firms cluster because of production advantages or efficiencies that stem from similar firms nearby. In some instances, however, consumer demand plays an important role in forming and establishing industry clusters.

Porter (1990), as well as Scitovsky (1992), argue that demanding local consumers can pressure firms to innovate and to maintain and improve product quality, which in turn improves their competitiveness in other markets. It is the character of local demand, rather than the size of the local market that is most pivotal in prompting innovation. National passions—whether for high-speed driving in Germany or fashion in Italy—pressure local producers to upgrade their products. National passions translate into internationally competitive clusters with striking regularity (Porter 1990; Storper 1997).

Home market demand is a feature of many new economic geography models. With scale economies in production and positive transportation costs, companies find it profitable to locate in markets with the greatest density of consumers. In models of imperfect competition, firms compete by product differentiation (which economists call "Chamberlinian" or "monopolistic" competition) and, accordingly, firms find it profitable to locate in places with great variety of demand.

Variations in tastes and preferences among regions may be one of the sources of chance events that trigger the formation of industry clusters. Oregon's sporting goods and apparel cluster, including firms such as Nike, Adidas America, and Columbia Sportswear, traces its roots to the popularity of running and jogging in Eugene in the 1960s. Consumer data show that Oregonians are much more likely to engage in almost every form of outdoor recreational activity than are average Americans (Cortright 2002).

H. Commentary

Many different forces prompt industries to locate in clusters. The micro-foundations described here are best understood as complementary rather than competing explanations for industry clustering. The relative importance of each of these factors is likely to vary substantially across clusters (e.g., some may depend principally on labor market pooling, while others may be driven by knowledge spillovers) and over the industry life cycle (entrepreneurship may be important to the formation of clusters, while QWERTY effects may be more important to their growth).

Because there is no single or settled definition of industry clusters and many competing theories about what drives clustering, different investigators can examine the same set of facts and reach different conclusions about the key drivers. Consider Silicon Valley, undoubtedly the most studied industry cluster anywhere. Its success is variously attributed to defense spending and government procurement (Markusen 1991), to the higher education institutions (Rogers and Larsen 1984), to a unique business culture and set of relationships (Saxenian 1994), to the vision of an extraordinary academic leader (Krugman 1991), and to a long and deep history of radio and television industry entrepreneurship (Sturgeon 2000). An element of truth lies in each of these explanations, but there is no obvious way to sort out or arbitrate among them.

Alternatively, for some clusters the role of the various micro-foundations of industry clustering may be a bit like the solution to Agatha Christie's *Murder on the Orient Express*—everyone did it. The problem is that many analysts only look at a cluster from the perspective of one (or a few) of the different micro-foundations and consequently may miss the importance of others.

Relatively little research has looked comprehensively at all these effects and separated their contributions to the formation or growth of particular clusters. Most academic research focuses on one or a few micro-foundations and marshals evidence to test their salience.

The multiple, overlapping micro-foundations of clusters have important implications for academics and practitioners. Academics should likely concede that it is difficult to model or characterize clusters only by looking at a subset of these forces. For practitioners, the different micro-foundations are a useful checklist of characteristics to be investigated when researching clusters. They may also be used as a framework for developing specific actions to help develop the cluster (a point to which Section VI returns).

IV. IDENTIFYING AND ANALYZING CLUSTERS

Analysts have employed a wide range of tools and techniques to describe and analyze clusters. This section briefly reviews some of the methods and data and describes their key strengths and limitations.

Broadly speaking, two approaches have emerged: top-down analyses, which generally rely on quantitative data to deduce the industrial structure of a regional economy; and bottom-up analyses, which examine the inner workings and interfirm connections of a particular cluster in a particular location.[5] Different disciplines have tended to rely on different techniques. Most economists use some variation of the top-down approach. Planners, economic development practitioners, and some consultants have developed bottom-up approaches. Each approach is illuminating, but neither is complete.

The best way to understand clusters is to strike a balance between these two approaches and use them in tandem to fuel an ongoing, interactive discussion and analysis of clusters in a regional economy.

A. Top-Down Approaches

The logic of top-down approaches is deductive. They are usually designed to answer questions such as, How much does a region's economy depend on a particular industry? or How much does industry specialization affect the growth of a region?

Top-down and Bottom-up Methods in Cluster Analysis

Characteristic	Top-down	Bottom-up
Research Question	How Much?	How?
Approach	Quantitative	Qualitative
Principal Data	Secondary Data	Primary Data
Methodology	Statistical Modeling	Case Studies
Industrial Proximity	Classification System	Descriptive
Scope	Nationwide, Multi-Industry	Local, Single-Cluster
Dominant Logic	Deductive	Inductive
Measures	Employment, Patents, Wages, Output, Sales	Relationships, Institutions
Findings	Broadly Applicable	Narrowly Limited

[5] Some studies, including a few excellent ones, combine both a top-down and a bottom-up approach to examining industry clusters. Most cluster studies, however, lean heavily to one approach or the other. I present this typology not to criticize any particular study, but to highlight the key differences in analytical approach that characterize most cluster studies.

1. Sectors Versus Clusters

The most common approach to identifying and measuring industry clusters is to examine geographic variations in employment—using employment data by counties, metropolitan areas, and states—among different industrial sectors, using the Standard Industrial Classification (SIC) system (and more recently by the new North American Industry Classification System (NAICS)) to categorize industry. Implicitly, most authors use these classification systems as a metric for establishing the similarities or differences between firms. If firms are in the same classification, they are generally assumed to be related; if they are in different classifications, they are assumed to be unrelated.

Porter (2003) offers one of the most ambitious and comprehensive attempts to classify state and metropolitan area employment by industry cluster. He uses the geographic correlation between industries at the state level, information on input-output relations, and his own professional judgment to assign industries to clusters. He developed 41 traded-sector industry clusters, each consisting of about 29 four-digit SIC code industries. (Industries can be part of more than one cluster.) On average, he finds that each four-digit industry was part of approximately two clusters.

This statistically driven operational definition of clusters is, to put it mildly, dramatically different from the definition of clusters Porter outlines in his earlier work. Consider the California wine cluster. As diagrammed in Porter's 1998 study, it includes a wide range of different industries, including fertilizers and pesticides, grape-harvesting and winemaking machinery, packaging, glass, public relations, food and restaurants, and education organizations. In contrast, in his 2003 study, wine and brandy appear as a subcluster in agricultural products and none of the other industries is included in this cluster.

Industry classification systems represent a useful way of assessing industry connections but, as with any taxonomy, they have important limitations. First, individual establishments are assigned only a single classification even though they may have a range of products and production capabilities. As Desrochers (2002) points out, an industry classification system is an inadequate way to characterize fully the similarity or diversity of firms. Establishments are classified by a single code even when they have many capabilities and produce may different products, frequently employing a range of techniques and disciplines in the process. Ideally, classification systems should be composed of mutually exclusive categories, but the branches of industry, unlike the branches of a tree, criss-cross and intersect across many dimensions.

Second, clusters are not always contained within a single industry classification. As a result, they may be undetected by a statistical analysis that looks only at relative concentrations within individual industries (Porter 1998). Some clusters cut across a wide swath of industry classifications. Consider automobile manufacturing, which purchases steel and aluminum, plastics, rubber, glass, textiles (upholstery), and a vast array of computers and electronic gear. Some clusters may be defined by an underlying similarity in production technology rather than the similarity of end products. In Connecticut, for example, some of the largest producers of plastic parts and

employers of plastics technicians—Lego, BIC, and Schick—are not classified as "plastics" companies (Rosenfeld 2002a).

Third, classifications have an element of arbitrariness. From the 1930s until just a few years ago, most economic statistics were compiled using the SIC system. Recently, however, NAICS has superseded SIC with important ramifications. Consider the electronics industry. The SIC system separated the production of computers (part of SIC 35), electronics (SIC 36), and electronic instruments (part of SIC 38) into three different, two-digit industries, while NAICS places all three in the same three-digit industry group, NAICS 334. (A three-digit NAICS industry represents a level of aggregation similar to that of a two-digit SIC industry.) Analysts of industry-level diversity would reach very different conclusions depending on which classification system they used. Similarly, the now-superseded SIC system had a much finer set of categories for manufacturing firms than for services.

Fourth, some clustering may occur at too fine a level to be detected with the industry aggregation commonly used in statistical analyses. An analysis using two-digit SIC code data may miss a specialization at the three- or four-digit SIC level or at an even more disaggregated level that SIC misses entirely. (A similar point applies to NAICS.) One would be hard pressed to identify Northern Minnesota's snowmobile industry cluster (Munnich, Schrock, and Cook 2002) or Kentucky's houseboat cluster (Rosenfeld and others 2000) by examining data on transportation equipment manufacturing.

Fifth, NAICS makes it more difficult to measure certain industry clustering. Unlike the SIC system, NAICS classifies establishments on the basis of their production processes. In NAICS, unlike in SIC, a firm's auxiliary establishments (establishments that provide support services for other establishments in the same firm) are typically in different industries from the same firm's production or direct service-providing establishments. A warehouse or headquarters of an automobile manufacturer, for example, is classified as part of the warehouse industry or the headquarters industry, rather than as part of the automobile industry. Therefore, the employees at GM headquarters are treated as part of a new "headquarters industry" rather than as part of the automobile industry (Office of Management and Budget 1998). The new category "Management of Companies and Enterprises" (NAICS Sector 55) contains nearly 50,000 establishments and 2.9 million employees. Under the SIC system, these would generally have been assigned to the industry that was being managed.

Sixth, different data sources apply classification concepts differently. The Dun and Bradstreet database classifies the sales and service offices of manufacturing firms as part of the manufacturing industry, while government agencies generally classify such offices as part of the wholesale trade sector. It is unclear which approach is superior, but the emerging differences are significant. Dun and Bradstreet data identify roughly twice as many manufacturing establishments as the Census Bureau (Holmes and Stevens 2004).

2. Measures of Concentration and Dispersion

The "location quotient" is commonly used to measure the extent to which a region is more specialized in an industry than the nation as a whole. The location quotient is defined as the ratio of a particular industry's share of local employment to that same industry's share of national employment.[6] A location quotient of one means that an industry represents the same share of the local economy that it does of the national economy. Values higher than one indicate an industry is relatively more concentrated in a geographic area than in the nation. The location quotient can be used to compare the extent to which a given region is specialized in various industries or to compare different regions' degree of specialization in a given industry. It can also be a starting point for identifying industry clusters. High location quotients in a group of related industries in a particular region suggest that a cluster exists.

The location quotient generally applies to a single geographic area (a state or county, for example). Feser and his colleagues (2001) have developed a measure of the similarity of industry specializations across several geographic areas. Their index, the "G statistic," measures whether adjacent counties have similarly high levels of an industry concentration. This measure is useful in identifying clusters that span county boundaries, which may be useful in parts of the country with small counties or for clusters that would be expected to have a wide geographic span.

To determine whether a particular industry is concentrated in a small number of regions or dispersed widely across many regions, researchers often use a Gini coefficient (Krugman 1991). The locational Gini coefficient is calculated by summing the differences in shares of total employment and specific industry employment for each region in an analysis. If an activity is exactly as dispersed nationally as total employment, the Gini coefficient is zero. If all employment is concentrated in a single jurisdiction, the Gini coefficient approaches 0.5. Krugman found that, in 1987, the typical U.S. manufacturing industry was roughly as geographically concentrated as was the U.S. automobile industry.

Ellison and Glaeser (1999) developed an adjusted measure of industry concentration to account for randomness or "dartboard" effects, the idea that industries with smaller numbers of firms will, all else equal, appear to be more concentrated than industries with large numbers of firms, even if the underlying process of location is the same in both industries. The Ellison-Glaeser measure adjusts the Gini coefficient for the relative concentration of firms in the industry, essentially measuring the amount of clustering that occurs over and above what one would expect from randomness.

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[6] Alternatively, one can use payroll to compute the location quotient. Ideally, one would prefer to use output or value-added to compute location quotients and other measures of industry concentration, but these data are seldom available below the national level for detailed industry categories.

3. Input-Output Relationships

Location quotients and Gini coefficients measure the concentration of a single industry, but an important feature of clustering is that they are frequently composed of firms in different industries linked by buyer-supplier connections. Several analysts have used input-output tables to discern localized connections between industries. Input-output tables use data on sales or shipments between firms in different industries to estimate which fraction of the inputs used by one industry are purchased from all other industries. For example, apparel firms purchase cloth from textile firms, or aluminum firms purchase electricity from utilities, machinery makers purchase parts from metal working shops, and a wide range of firms purchase transportation or professional services (advertising, accounting) from outside vendors.

Feser and Bergman (2000) use national input-output data to group U.S. manufacturing industries into 23 broad clusters. They apply these national groupings to North Carolina to identify those industries most likely to be connected by buyer-supplier relationships. The results, they caution, provide only a first approximation of likely flows. They do not definitively identify links.

In theory, input-output data should straightforwardly identify specialized supplier industries. In practice, however, there are problems. Most input-output data are collected at the national level and estimated for relatively aggregated industry definitions (typically the two-digit SIC or three-digit NAICS industry level). Although the purchasing patterns are representative of most firms, considerable variations may occur in purchasing patterns within industries and across regions. Regional purchase coefficients (estimates of the amounts of particular inputs purchased locally) are often based on assumptions that are difficult to verify. Generally, the technical coefficients of models are assumed to not vary by firm or over time, both unrealistic assumptions (Bishop, Brand, and McVittie 2000). Some practitioners question the accuracy of regional purchase coefficients used in such regional input-output models as IMPLAN and Regional Economic Models, Inc. (REMI). Regional purchase coefficient estimates are based on 20-year-old trade relationships derived from state-level commodity flows reported in the 1977 Census of Transportation and include only shipments of goods, not services. Some models use "expert judgment" to estimate weight-value ratios to convert shipment data (weight) to purchases (value) (Listokin and others 2002).

Hill and Brennan (2000) used factor analysis to identify the Cleveland-Akron region's principal driver industries and used input-output data to identify the principal buyer and supplier industries to which they were connected. Held (2004) applied the same method to identify industry clusters in four metropolitan areas in New York State. Unlike the Porter methodology, which assigns every industry to the same cluster nationally, this approach generates a different set of industry cluster definitions for each geographic area analyzed.

4. Other Cluster Metrics

Employment data, plentiful and readily available, are the staple of most cluster analyses. Several cluster studies, however, have developed measures that explore other aspects of

clustering. These include identifying knowledge concentrations with patent data, examining labor flows, and harnessing industry-specific data.

Because knowledge spillovers seem to be a key driver of clustering, one way to identify clusters is to measure the geographic scope of those spillovers. It is difficult to measure knowledge production in industries directly, but innovative approaches are emerging to discern the role of new ideas in particular places and industries. One of those ways is to use data on patents, which are classified according to the type of technology employment and the address of the first-named inventor. For example, Jaffe and co-authors (Jaffe, Trajtenberg, and Henderson 1993) used patent data to measure the geographic extent of knowledge spillovers, given that each patent makes reference to previous relevant patents.

Patent data have important limitations. Not all innovations are patented, wide variations exist over time among firms and across technologies in whether innovations are patented, most patents have negligible economic value, and patent data have reliability problems (Desrochers 2002). Despite these problems, patents remain the best single source of statistical evidence about knowledge flows. However, practitioners and researchers should use them with appropriate care (Worgan and Nunn 2002).

Another way to identify clusters is to examine patterns of worker mobility between firms. If the firms in a cluster draw on a common labor pool, workers who change jobs may be more likely to move to firms within the cluster than to those outside it. Power and Lundmark (2004) used taxation and civil registry records from Sweden to show that labor market mobility is significantly higher within that country's information and communication technology cluster than in the economy generally. Unfortunately, published U.S. economic data provide little insight into the movement of workers among industries at the regional level. In the coming years, however, it may be possible for U.S. researchers to make use of the new Local Employment Dynamics (LED) data series compiled by the U.S. Census Bureau to track flows of workers across firms.

Often the most useful way to study industry clusters is to use data that are unique to the industry. Business directories and industry association memberships often provide extensive lists of firms in a variety of industries that have close relationships to one another. Klier (1999) used a privately compiled directory of automobile industry suppliers to study clustering in the automobile industry. In the biotechnology industry, federal funding for health research, private-sector venture capital investments, and publicly disclosed research and development agreements between pharmaceutical and biotechnology companies are important indicators of activity (Cortright and Mayer 2002). Administrative data, such as the Environmental Protection Agency's Toxic Release Inventory, also identify individual firms by industry and location (Holmes and Stevens 2004).

The top-down approach is a logical starting point for most cluster analyses, especially when one is describing how a regional economy operates. A good analysis will begin by computing employment concentrations using one or more of the standard techniques described above. One

should dig deeper, however, using alternative sources of data to complement and extend the analysis.

B. Bottom-Up Approaches

Bottom-up studies are more narrowly focused, examining a subset of industries or a limited set of areas. They often focus on a particular local economy, look at a single industry cluster, employ primary data, and use surveys and interviews to collect data. They generally try to draw inferences about the mechanics of clustering from their observations. They are usually designed to answer questions that begin with "how" (but not "how much"), for example: How did the information technology cluster in Silicon Valley get started? or How do firms in a cluster recruit and train workers?

It is interesting to note that Marshall's initial formulation of industry cluster theory more than 100 years ago was not based on any statistical analysis, but rather on firsthand observations of firms in England. During the past decade and a half, a range of qualitative techniques—surveys, interviews, and case studies— has helped illuminate the processes and dynamics of industry clustering in particular locations.

1. Basic Qualitative Methods

Qualitative methods have shone a new light on the development and dynamics of industry clusters. Much of the rediscovery of Marshallian principles in the Italian industrial districts was prompted by studies of the operation and behavior of individual firms and the institutions that developed to support them (Brusco 1982, Piore and Sabel 1984, Putnam, Nanetti, and Leonardi 1993). Saxenian's (1994) comparative study of interfirm relationships and labor force mobility in Silicon Valley and Route 128 was founded principally on 160 in-depth interviews with entrepreneurs, industry leaders, corporate executives, and leaders of local business organizations. Porter (1990) and his researchers conducted hundreds of interviews with business executives, labor leaders, academics consultants, bankers, industry experts, and others to document the role of clusters in shaping national competitive advantage. As part of a study of industry clusters in San Diego, Porter's Monitor Group used a survey of 160 business executives and in-depth interviews with about 35 executives (Porter 2003).

Scholars have developed systematic methods to gather detailed information about the composition, history, competitive strategies, and comparative performance of regional industry clusters. Markusen (1994), in an approach she calls "studying regions by studying firms," describes a multistep process, beginning with a screen (location quotients) to identify candidate industries, following by analyzing industrial directories and trade association lists to identify individual companies within candidate industries, and contacting key personnel to interview. Markusen also suggests a method for diagramming relations with other firms and important institutions, both within the region and elsewhere. Others have suggested additional refinements to these qualitative methods as well as cluster study enhancements (Austrian 2001).

In general, qualitative methods should be viewed as part of an interactive and iterative process. Analysts can use preliminary data to develop a working cluster definition and test it and modify it on the basis of interviews. This process can, in turn, lead to extensions and refinements of the interview strategy to explore connections to other firms or industries not identified in the preliminary data analysis. Interview subjects can also be helpful in identifying quantitative data sources.

2. Genealogies

Firm-specific genealogies of industry clusters are a useful tool for documenting the path-dependent quality of cluster development and evolution. In many cases, industry clusters have formed when employees at one firm have left and started their own rival firms. This process repeats itself over successive generations. Perhaps the best documented case of this process of spin-offs and startups is in Silicon Valley. The region's first semiconductor firm was Shockley semiconductor. Several of its key employees left to form rival Fairchild. Companies descended from Fairchild (including Intel), accounted for about half of the semiconductor producers two decades later (Rogers and Larsen 1984).

Genealogy charts of industry clusters in particular locations have been developed for the machine tool industry in Cincinnati (dating from the nineteenth century) (Scranton 1997), for the German printing machinery industry (Porter 1990), and for the biotechnology industry in San Diego (Porter 2003). Mayer (2003) prepared a genealogy of electronics industry firms in metropolitan Portland, illustrating the predecessor firms of startup companies, the appearance of new entrants from outside the region, and the various technological specializations of different firms. Genealogies are, however, time- and labor-intensive and by their nature are often incomplete. Moreover, because they are compiled ad hoc, there is little basis for comparison across metropolitan areas.

3. Case Studies

Case studies of specific regions have produced some of the most evocative and insightful work on industry clusters. Using the qualitative methods described above, usually combined with relatively simple statistical analysis, several authors have written compelling descriptions of the origins, struggles, and economic performance of several leading industry clusters. These studies usually weave together descriptions of entrepreneurship, the development of technology and markets, the role of skilled workers and industrial organization, and the local institutional environment.

Among these works are studies of well-known clusters—Silicon Valley (Saxenian 1994), the Hollywood film industry (Scott 2004)—and also obscure ones—the Kentucky houseboat cluster (Rosenfeld and others 2000) and the Minnesota snowmobile industry cluster (Munnich, Schrock, and Cook 2002).

Case studies are particularly useful to policymakers. They are more accessible to the lay reader than most academic work, and by addressing many of the different dimensions of industry simultaneously, they provide a more balanced view of the various factors that produce clusters. Nevertheless, case studies have important limitations. They almost invariably focus on successful clusters. They may also give the reader the impression that copying the institutions or tactics that worked in one locale at one time will produce similar results elsewhere at some very different time.

C. Commentary

The wide variation in analytical methods is not surprising, given the broad and conflicting visions of what constitutes a cluster and the wide range of disciplines of those studying clusters. Just as there is no single definition of a cluster, there is no single tool or method for analyzing them.

Feser and Luger (2002) argue that cluster analysis should be treated as a mode of inquiry rather than a narrow technical process. Employing a range of methods and drawing from different academic disciplines foster a broader view that can more confidently identify a cluster and develop a richer understanding of the forces that shape its success or failure (Benneworth and Henry 2004).

Many cluster analyses would benefit from a better balance between the top-down/quantitative and bottom-up/qualitative approaches. Neither approach alone is likely to produce definitive results. Most quantitative approaches rely heavily on the inherently imperfect taxonomies of industrial classification schemes. Purely data-driven methods tend to discount historical and institutional factors and usually cannot assess the nature of interfirm relationships. Although qualitative analysis can overcome some limitations and can reveal much about the dynamics of clusters, many case studies suffer from their own problems. Many are promotional, designed to market a cluster or convince local policymakers of its importance, and cluster definitions are so idiosyncratic and methods so opaque that it is difficult to assess the reliability or importance of their findings. The most useful studies combine quantitative and qualitative approaches. They use data appropriately to help frame the analysis and rigorously investigate issues of performance and structure, and they use qualitative methods to explore the story—the historical, institutional, and entrepreneurial factors—behind the numbers.

Cluster analysis is a useful way of provoking and structuring public policy discussions about the future of a regional economy in a way that engages and informs a wide range of constituencies, including industry leaders, public officials, supporting institutions, and the general public. A cluster analysis should be integrated with these public discussions and policymaking processes, tapping the knowledge and insights of actors in the cluster and focusing research on those issues of greatest importance to the region (Feser and Luger 2002).

In some respects, the best way to understand a cluster is to engage in efforts to organize cluster participants to think systematically about their relationships to the industry cluster. Much of the information about the characteristics and dynamics of any cluster is in the minds of those who work in it daily. These people usually have a strong self-interest in better understanding the cluster.

The process of, for example, diagramming a cluster's membership, identifying key institutions, and assessing competitiveness produces information with real economic value to firms. As a practical matter, studying and organizing an industry go hand in hand.

V. CLUSTERS AND ECONOMIC PERFORMANCE

How do clusters influence the performance of regional economies? Does clustering encourage economic growth and higher incomes? Is specialization in a particular industry associated with increased vulnerability to economic cycles? These are just some of the questions research on clusters strives to answer.

Clusters as a concept are useful in describing regional economies and discerning which industries are the key drivers of economic growth. This section outlines four aspects of economic development that cluster analysis can help to inform: 1) the types of clusters that drive local economic growth; 2) the merits of concentrated employment in a single industry versus greater industry diversity; 3) the effect of clusters on wages; 4) the effects of cluster on poverty. Finally, while globalization has changed the context for economic competition, it appears to have reinforced rather than reduced the importance of clusters. Clusters now tap global markets and are frequently connected to other similar or related clusters in other countries.

A. The Geography of Clustering and the Importance of Traded Industries

A fundamental distinction made in most cluster analyses is between traded and nontraded industries. Traded industries, those businesses that sell their goods and services in competition with businesses located in other states and increasingly in other nations, are the most common focus of cluster analysis. Nontraded or local industries chiefly serve the demand of the local population and include a wide range of retailing, personal services, local government, and most health care.

Two studies have analyzed the distinctions between traded and nontraded clusters, both using comprehensive assessments of the geographic concentration of all industries in the United States. Porter (2003) classified 879 three-digit SIC industries as traded, local, or natural resource dependent, finding that the local sector of the economy is typically the largest source of employment, accounting for about two-thirds of U.S. private employment. Most goods production is traded, but a large number of service industries are also traded. Average wages, worker productivity, and patenting per worker are all higher in traded sectors than in local industries. Porter also found that traded industries are more geographically concentrated than local industries.

Holmes and Stevens (2004) used 1999 county-level data classified according to NAICS to examine the relation between metropolitan area size and clustering. They divided all U.S. employment into four quartiles ranging from least urbanized counties to most urbanized and computed the location quotients for different NAICS sectors and industries. They constructed a measure of industry urbaness on the basis of the difference between the location quotient of the most urbanized quartile and that of the least urbanized quartile.

Industries, they find, divide into three broad groups: rural-focused, including agriculture, mining, and manufacturing; diffuse, including retail trade, health care, and construction; and urban, including transportation and warehousing, financial activities, information, and professional services.

The diffuse sectors generally correspond to nontraded goods. Although the pattern of results is similar both at the broad sector (two-digit) or the narrow industry (six-digit) level, some broad sectors are composed of a mix of specialized and diffuse components. For example, financial activities include both concentrated segments (commodity contracts) and diffuse segments (consumer lending).

These studies show that the regional industry specialization is typically the region's traded industries. Leading theories of economic development hold that these traded, specialized industries are the foundation of regional prosperity.[7] Hence, it is important to focus economic development efforts on the traded, regionally specialized sector of the economy. The diffuse, nontraded sectors of the economy generally reflect the distribution of the nation's population. No state or metropolitan area can reasonably expect to expand its economy by developing a higher than average concentration of grocery stores.

B. Specialization Versus Diversification

A key question in economic development is whether it is better for a state or region to pursue specialization (build on existing concentrations of industry) or diversification (developing a variety of industry concentrations). There are two conflicting views on this question. The first, associated with Marshall, Arrow, and Romer, holds that places with a greater concentration of industries (a "localization" economy) will be more successful. Locales with a high density of firms and workers with similar interests will lead those firms and workers to add to and refine knowledge in a cumulative way. In contrast, Jane Jacobs and followers hold that more industrially diverse places ("urbanization" economies) will be more successful. Diversity promotes economic success through some combination of variety and serendipitous interaction, which leads to new ideas and occasionally to new industries.

This latter group also argues that specialization can be overly risky, on the same lines that placing an entire investment portfolio in a single company or narrow group of investments is riskier than diversifying. If an area is too specialized in a particular industry, it runs a greater risk of economic dislocation when demand for that industry's product declines. Even Marshall acknowledged that excessive specialization was a liability: "A district which is dependent chiefly on one industry is liable to extreme depression, in case of a falling-off in the demand for its produce" (Marshall 1920, Book IV, Chapter 10, Paragraph 12).

Similarly, although specialization may help an industry cluster further develop and refine a particular technology, it may insulate it from other useful knowledge. Over time an industry cluster

[7] Export base theory holds that a region's traded industries drive regional prosperity because they inject new spending into the region's economy. Many economists believe that specialization is essential to regional prosperity (although the empirical evidence on this is mixed, as shown later in this paper). Because of the empirical association between traded industries and regionally specialized industries, both theories lead to the conclusion that regional economic success depends on traded, regionally specialized industries.

may become inbred and suffer from “groupthink”; a too-similar outlook shared by cluster members that can inhibit adaptation to changing markets and technologies.

Empirical tests of these two views come to different conclusions. Early work by Glaeser and colleagues (1992) finds support for urbanization economies. Examining employment growth in cities between 1956 and 1987, they find that specialization in a particular industry is negatively associated with growth in that industry, but that employment growth in an industry is positively associated with the diversity of the largest industries in the city.

On the other hand, Henderson (1997) finds strong evidence of the importance of industry specialization. Using employment data for U.S. urban counties from 1977 through 1990 in machinery, electronics, primary metals, transportation equipment, and instruments, he found that firms, particularly in the technology sectors, grew fastest when there was a concentration of similar firms in the same county. Henderson also found evidence for diversity, although the effect was smaller.

A subsequent analysis by Henderson (2003) used Census Bureau longitudinal data on manufacturing establishments from 1972 through 1992 to estimate the effects of industry concentration and diversity on firm-level productivity. He found strong effects of same-industry concentration on productivity at the county level, particularly for nonaffiliate (i.e., branch) manufacturing plants. However, he found little evidence for positive effects of diversity on productivity.

Other studies have considered whether specialization or diversity has a more positive effect on spillover growth. An analysis of state-level change in employment from 1976 to 1989 found no spillover between growth in manufacturing and growth in services (Garcia-Mila and McGuire 1998). At a broad level, this finding is contrary to the urbanization position. However, spillovers between particular industries are somewhat different from more general urbanization economies, which are based on the idea that overall industrial diversity contributes to regional economic success. The Garcia-Mila and McGuire finding does not imply anything about the economic benefits of overall diversity.

Data on patenting and knowledge flows suggest that knowledge spillovers occur primarily within industries rather than between them. This finding broadly supports the importance of localization economies. Using data on patenting in the high-tech industry, Acs, FitzRoy, and Smith (1999) found no evidence that research and development spillovers from one industry are associated with employment growth in others, although their analysis was consistent with specialization. An analysis of technological specialization in Europe, measured by patent rates, finds that specialization is associated with growth in most industries, although not in textiles and primary metals (Dalum, Laursen, and Verspagen 1996). The same, however, may not be true for technology adoption. Harrison, Kelley, and Gant (1996) studied the rates of adoption of numerically controlled machines in the metal working industry and found evidence of urbanization effects (size of metropolitan area) and no evidence that specialization promoted the adoption of the new technology.

Ultimately, it is difficult to subdivide metropolitan areas neatly into "diverse" and "specialized" categories. Even diversified cities are made up of many specialized clusters (Desrochers 2002). Measures of industry similarity—inferred from industrial classification code—do not necessarily reflect the degree of specialization or diversity within a particular industry. A study of clustering in the Netherlands examined the relative effects of related and unrelated variety on employment and productivity growth. Related variety is measured by the degree of employment variation within two-digit industry classifications, while unrelated variety is the variation in employment across two-digit industry classifications. The study found that related variety—more variation in the composition of employment in the same two-digit industry—was associated with employment growth. It also found that unrelated variety was negatively associated with unemployment growth, confirming the portfolio theory that a range of dissimilar industries buffer a region from external shocks (Frenken, van Oort, and Verburg 2005).

The effects of specialization and diversity may be very fine-grained and specific to different metropolitan areas. A comparison of a dozen leading urban information technology centers shows that variations in the composition of their industrial specializations within the broad category of information technology (hardware versus software, innovative capacity, product diversity) explain much of the variation in their performance in the aftermath of the technology bust and 2001 recession (Daly and Valletta 2004).

There are important limitations in applying any of these analyses of the effects of industry concentration (localization) and industry diversity (urbanization) to industry clusters. First, industry sectors, which are the focus of the studies described here, do not necessarily correspond to cluster definitions. A concentration of employment in one or more SIC or NAICS codes is not the same as an industry cluster. As noted above, clusters frequently cut across customarily defined sector lines and include suppliers in other industries, service providers, and supporting institutions as well as labor and nonlabor inputs and customers.

Second, diversity itself is generally correlated with urban size. Larger metropolitan areas generally have a more diverse industrial composition—more industry clusters—than smaller metropolitan areas. As a result, it is frequently difficult to disentangle the effects of urbanization and specialization. The critical question is whether more or less specialization is an economic advantage or disadvantage for metropolitan economies of a given size. As a practical matter, the only way to become more diverse may be to become larger. Few analyses have examined whether concentration or diversity results in better economic results for similarly sized metropolitan areas.

Third, these findings may be of limited policy relevance. The portfolio analogy breaks down when it comes to action because it is not apparent that regions have any simple way to dramatically alter their industrial portfolios. Unlike an individual investor, regions do not have the option of calling their broker and selling off a portion of their industrial base and investing the proceeds in a range of alternatives. Making the case that specialization or diversity produces superior economic outcomes is very different from proving that there are any practical ways for regions to accomplish such a change.

The competing studies suggest that in some cases specialization may be beneficial while in others diversification may be more advantageous. All else equal, regional leaders would prefer a diverse range of specializations rather than just one or a few. This would enable them to reap the benefits of specialization while minimizing the risks of an overdependence on a single industry or group of related industries. In addition, because specialization helps if a region happens to be specialized in industries that are growing rapidly at any particular time (Cheshire and Malecki 2004), regional leaders would also like to be able to shift their region's industry mix toward the fast-growing industries.

Regions, however, have at best limited opportunities to change their industry mix. Regional industry specialization tends to persist over time (Henderson 2003), suggesting that regions with an industry concentration will be the best positioned to increase it and, conversely, those regions without a particular concentration will find it difficult to create one, either indigenously or by attracting firms from other locations. Opportunities to dramatically change the concentration of particular industries hinge on dramatic shifts in industry structure or technology. For example, Charlotte, NC, has emerged as a financial center in the wake of years of consolidation in the banking industry following the liberalization of interstate banking. Boston, San Francisco, and San Diego emerged as important centers for the bio-pharmaceutical industry with the advent of new knowledge about genetics.

C. Clusters and Wages

In theory, the higher productivity associated with clusters should be associated with higher wages for workers in the cluster. External economies in the labor market—more precise matching of workers to tasks because of a greater availability of skilled workers, finer specialization of the workforce, and knowledge spillovers—should help make workers in clusters more productive than their counterparts outside clusters. In a competitive market, this productivity should be reflected in higher wages.

Relatively few studies, however, have examined the relation between clustering and wages. Using detailed worker data from the 1990 census, Wheaton and Lewis (2002) examined the effects of industrial and occupational specialization on manufacturing wage levels across 220 metropolitan areas. They find positive correlations between both industrial and occupational specialization and wage levels. For the typical metropolitan area, a doubling in employment concentration in a particular industry is associated with a 2 percent increase in wages.

Using a similar data source, Gibbs and Bernat (1998) investigated the effects of industry clustering on wages, finding positive and significant cluster wage premiums for 14 of 18, two-digit manufacturing industries nationally. Overall, wages for workers in industry clusters were about 6 percent higher than for workers in the same industry in a nonclustered location.

Drennan and colleagues' (2002) study of wages in broad industry groupings in metropolitan areas found relatively higher wages in manufacturing and producer services in places that specialize

in those industries but relatively lower wages in distribution and consumer services in places that specialize in those industries.

All these studies considered the effects of clustering on wages in the cluster. In theory, clusters that pay higher wages may also bid up the price of labor in local labor markets generally, as other firms are forced to compete with industry clusters for workers. No studies have directly examined this question, although Porter (2003) found a strong correlation between average traded-sector wages and average local-sector wages, which tends to confirm the theory.

D. Clusters and Poverty

Very little attention has been paid to the connections between poverty and industry clusters in the United States. An August 2005 search of abstracts of scholarly articles on the EBSCO Host Academic Search Premier and ABI/INFORM databases using the search terms “industry cluster” and “poverty” produced no citations.

There may be a social and organizational mismatch between low-income and low-skill workers (and the social service networks that serve them) and industry clusters. There is some evidence that the lack of social connections to work, and not physical proximity, is the principal economic challenge for disadvantaged workers (Pastor, Dreier, and Lopez-Garcia 2000). Social interaction in clusters is mostly informal, and even formal organizations focus on common problems affecting profitability. Social service agencies often view the private sector as undifferentiated businesses and are often unaware of clusters and their specific needs. The geography of clusters also seldom coincides with the geography of social service organizations (Rosenfeld 2002b).

Nevertheless, a few examples exist for how clusters may bolster opportunities for low- and moderate-income populations. Oregon's nursery industry cluster has created substantial opportunities for persons previously employed on a seasonal, migrant basis to obtain full-time, year-round employment (Cortright and Provo 2000). Assessments of the weaknesses of current job training programs have identified a lack of employer engagement, poor understanding of regional labor markets, and a need for networked, industry-driven efforts. Clusters could be a useful framework for addressing all these issues (Giloth 2000). Several job training efforts have also applied cluster information, including Wisconsin’s Industry Partnerships Project (Center on Wisconsin Strategy 2005). Multi-employer approaches may be critical to developing job ladders that allow workers to move among firms as they develop their skills (Herzenberg, Alic, and Wial 1998).

A recent United Nations Industrial Development Organization report provides a perspective on the effects of clusters on poverty in less developed countries (Nadvi and Barrientos 2004). Although the context differs from that of the United States, some of the key findings and policy implications may be applicable. The report finds limited empirical evidence of the effect of clusters on poverty. Successful clusters may upgrade the productivity of workers and the competitiveness of industries, but there are often dislocations, and upgrading produces both winners and losers. Losers are particularly likely among those with the least skills and weakest labor market attachment. The

report distinguishes between efforts simply to promote clusters in poorer areas and efforts to encourage cluster upgrading in ways that maximize clusters' poverty-reduction impact. It favors the latter type of policy. Upgrade incumbent worker skills and promoting local entrepreneurship are especially important.

E. Clusters and Globalization

Most cluster analysis focuses primarily on the highly localized interactions of firms and workers. From the outset, however, clustering has been seen as an important component in describing how firms and regions respond to the globalization of markets and competition. Analyses of clusters in Italian industrial districts (Piore and Sabel 1984) and even Porter's (1990) *Competitive Advantage of Nations* addressed the question of how localized concentrations of firms could compete effectively in global markets.

Globalization has created increased opportunities for some cities and regions to refine and deepen their specializations to provide services to worldwide rather than simply national markets. Sophisticated financial and producer services have become increasingly concentrated in a few global cities. This trend has been fueled at least in part by the growth of transnational corporations, which tend to be disproportionately located in the largest cities in any nation (Sassen 1999). At the same time, many of the lower-skilled manufacturing jobs in metropolitan areas have been lost due to productivity gains and competition from lower-cost labor in other countries, producing deindustrialization (Pastor, Dreier, and Lopez-Garcia 2000).

Storper (1997) examines the connections between national exports and local industry clusters. International trade data show that, at the national level, countries have distinctly different product specializations and productive strengths. The United States, for example, is a strong exporter of science-based high-tech products. Italy's exports are primarily design-intensive. These strengths can be traced to regional industry clusters and to the process of product-based technological learning (continuous and localized interactions between buyers and sellers), which occurs primarily in industry clusters. Consequently, national economies can be thought of as mosaics of specialized industry clusters that promote competitiveness through continuous learning and innovation.

The globalization of economic activity, coupled with the vertical dis-integration of firms, has led to an international division of labor. In many industries, different countries specialize in different parts of the production process. In the disk drive industry, research, design, and engineering take place in a few places in the United States, while manufacturing has shifted to Southeast Asia. The industry represents a pattern of "dispersed concentration" with significant clustering of research in Northern California and clustering of production in Singapore (McKendrick 1998).

Globalization has produced new clusters outside the United States. The underlying roots of these clusters are labor and knowledge flows to and from established clusters in the United States. India and Taiwan have emerged as major producers of high-tech products. Activity in each country

is clustered—in Bangalore in India and in Hsinchu in Taiwan. Each of these regions has strong connections to industry clusters in the United States. Hsinchu's growth was propelled by the re-emigration of U.S.-educated Taiwanese engineers, who brought financial capital, management skills, technical capability, and a wealth of contacts with Silicon Valley firms (Saxenian 1999).

VI. CLUSTERS AND PUBLIC POLICY

What should mayors, governors, economic development officials, and other public leaders concerned with state and local economies do with the industry cluster concept? How should the business community respond to this public-sector discussion of clusters? What lessons have been learned from the successes (and failures) of cluster development efforts to date?

Clusters represent a fundamental organizing framework for understanding local and regional economies and for developing economic strategies. Local leaders, the media, the public, and businesses themselves can gain a better perspective on their region's challenges and opportunities by thinking in terms of clusters. Although not impossible, it is extremely difficult for public policy to call clusters into existence; claims that one can create a new cluster should be treated with extreme skepticism. However, the underlying micro-foundations of clusters offer a range of strategies that economic developers can potentially apply to strengthen their existing industry clusters. The cluster organizational model can be applied across the breadth of the traded sector of a local or regional economy. Nothing about it implies or requires picking winners among local industries. Clustering is also a dynamic process. Regional leaders should understand that the best opportunities to diversify their economies will come from building on, extending, and combining existing cluster strengths.

One of the hallmarks of the academic research is that its authors have been generally reluctant to offer policy advice from a field that is still evolving. Even bold theorists have been reticent to conclude that a new theory necessarily implies any change in appropriate policies. Nonetheless, the cluster concept has fundamentally different implications than the conventional wisdom that has guided much state and local economic development policy in the United States. This section outlines some key lessons in that regard.

A. Clusters as a Framework for Policy

The most basic question is how to fit clusters into existing thinking about economic development. In this setting, clusters are best viewed as an organizing principle for economic development, a useful framework for building an understanding of a regional economy and undertaking action, rather than as a policy panacea. By itself, clustering does not determine economic success. But a cluster analysis can help diagnose a region's economic challenges and opportunities and identify what a region might do to influence its economic future.

Too often economic development focuses on individual firms and specific events (expansions, relocations, layoffs). Such approaches often miss the opportunity to address the underlying causes of industry growth and development. The cluster approach can help deepen the practice of economic development to build better communications among the firms that make up the regional economy and to focus public policy on those issues that are likely to have the greatest long-term effect on regional growth.

An initial step is to use the cluster framework to describe and analyze the regional economy. At a fundamental level, elected officials and economic development practitioners should view their economies as collections of industry clusters rather than simply as many individual firms.

A further implication of cluster theory is that different regions have very different sets of development opportunities derived from their existing industry clusters and the related human capital and knowledge that those clusters have generated (Drabenstott 2005). The path-dependent quality of development means that growth in any region is most likely to come from extending, refining, or recombining existing strengths.

Another key implication of cluster theory is that regions should work with groups of firms in clusters rather than with individual firms. Working with groups of firms is likely to offer economies of scale, but perhaps more important, it will shift the focus of discussion from firm-level rent-seeking (subsidies, tax breaks) to more widely shared competitive problems. For example, job training grants to individual firms frequently simply substitute for firm expenditures on company-specific training, while multi-firm grants prompt companies to identify industry-wide skill needs. If firm-level economic development subsidies are used at all, cluster thinking should lead policymakers to focus them on cases that strengthen an existing cluster. It should also lead them to assess their region's industrial strengths and opportunities realistically rather than to chase the industries that are currently fashionable.

In a policy context, the utility of cluster theory should not necessarily be judged by whether it represents a perfect description of regional economic functions, but rather by whether it is a better mental model than the alternatives routinely used. In a policy environment where public officials have traditionally focused on industrial recruiting, tax incentives, and other subsidies for the construction of new plants, and faddishly invest in everything from convention centers to ballparks to biotechnology, principally in imitation of others, using the cluster concept to visualize the structure of a regional economy represents a major advance. However, there are risks. The flexibility of the cluster concept means that, like some other flexible concepts, it will occasionally be used inappropriately (Feser and Luger 2002). Public officials should resist cluster studies that are purely promotional. Only those studies that present a frank and objective portrayal of a region's clusters and, in particular, their competitive strengths and weaknesses in contrast to those of other regions, are likely to have much credibility with the private sector and be useful as a basis for policy.

B. Creating Clusters

There is general agreement that it is difficult or nearly impossible for public policy intentionally to create industry clusters where they do not already exist. Despite a handful of instances in which public policy avowedly set out to change a region's economic base (Research Triangle Park in North Carolina is frequently cited), failures are far more common (as evidenced by the lengthy list of places that set out to create the next Silicon Valley). Most successful clusters have evolved serendipitously. Although public policies have occasionally been a catalyst to cluster

growth, their effects are as likely to be inadvertent as intentional (Rosenfeld 2002b). Cluster critics are in agreement on this point (Martin and Sunley 2003).

The tantalizing paradox of clustering is that it implies that the location of economic activity is not preordained and that, therefore, public policy (and other factors) can make a difference. Yet, at the same time it is virtually impossible to say what it takes to successfully create a new industry cluster in a particular place.

The best public policy advice for "creating" clusters is for communities to focus on establishing the right conditions for new industry clusters to emerge, and then recognizing and nurturing those clusters that establish themselves. Some of the key conditions include institutions that support knowledge creation, a business culture that supports entrepreneurship, a lack of barriers to the creation of new firms, and relatively easy availability of capital. Collectively, these and other measures create the trials or experiments (new firms), some of which may grow into clusters.

The evidence of the path-dependent nature of development suggests that new clusters are most likely to emerge from the extension of existing local knowledge and expertise, or in combination with other new ideas. Consequently, the most fruitful way to develop new clusters may be to build on those unique assets that cannot be easily replicated elsewhere (Feldman and Martin 2004).

C. Policy Measures and Micro-Foundations

No set policy prescription emerges from the cluster literature. Our analysis of the micro-foundations of clustering suggests a menu of actions that could reinforce the advantages of clustering. It is likely that different measures will be appropriate for different clusters at different times. Policy measures can work to create or enhance each of the micro-foundations of industry clustering, for example:

- Labor Market Pooling: labor market information, specialized training
- Supplier Specialization: brokering, recruiting, entrepreneurship, credit
- Knowledge-spillovers: networking, public sector research and development support
- Entrepreneurship: assistance for startups, spin-offs
- Lock-In: work to extend, refine, and recombine existing distinctive specializations
- Culture: acknowledge and support cluster organization
- Local Demand: aggregate and strengthen local demand.

The process of selecting appropriate policies is likely to be best informed by a detailed knowledge of the challenges and opportunities facing each industry cluster. The cluster approach implies a demand-driven approach to designing and implementing economic development activities. Instead of deciding to offer a program or set of services (a supply-side approach) and allowing firms to choose to participate, governments would consult with a group of firms forming an industry cluster (the demand side) and, with their advice, select the appropriate set of services to deliver.

Suggested Actions for Cluster Development (Rosenfeld 1997)

- Learn how businesses interact and clusters work
- Support clusters because of their economic dominance, strategic importance, or leadership and potential
- Focus on subsidiary systems and satellite systems in more rural areas
- Improve technical support services
- Invest in social capital and social infrastructure
- Empower and listen to cluster leaders
- Encourage cross-fertilization of ideas across clusters
- Recruit companies that fill gaps in cluster development
- Develop and organize supply chain associations
- Support employee/entrepreneurs

D. Organizing and Targeting Economic Development Efforts

Developing a cluster presupposes that public policymakers are well informed about their clusters and have a sound understanding of their competitive needs. This may not, in fact, be the case; many clusters lack the informal or formal institutional arrangements for identifying and articulating common interests. A first step in implementing a successful cluster development policy may be to help organize the members of a cluster to identify the cluster and discuss its competitive position.

A perennial question in economic development is whether public policy can or should favor some firms or industries over others. Some critics deride cluster development efforts as a futile or ill-advised attempt to "pick winners" (Martin and Sunley 2003). It is certainly possible that a cluster policy could result in politicians choosing favorites, but there is nothing inherent in the notion of clusters that requires them to do so. A cluster development process can be economywide and open to a wide range of clusters.

Moreover, it is likely that public policymakers will interact with clusters whether or not they pursue an industry strategy. Many industry clusters interact with a wide range of state and local government functions—taxation, environmental, health and safety regulation, transportation, and education, to name just a few. If an industry cluster encounters a particular problem, such as the need for additional trained workers, whether and how well local education and training agencies react to the challenge could have a significant impact on the region's economy.

Public policy efforts to promote and support clusters can be divided into two broad groups: top-down and bottom-up. Top-down efforts represent national or state programs to organize industry clusters across industries and frequently in a variety of regions. Bottom-up efforts are often locally organized, one-off activities that focus on a single industry cluster in a single location.

Large-scale, top-down approaches have generated the most public attention and received the closest scrutiny but may not be the best examples of cluster policy at work. A key factor seems to be the willingness of firms to participate in clustering; this tends to be more assured in cases in which clustering forms from the bottom up (Fromhold-Eisebith and Eisebith 2004). Because industries differ considerably in their competitive situations and willingness to collaborate, some groups of firms may be ripe for collaborative action and others not, and this may change over time. Consequently, there is no universal best-practice blueprint that can be applied across regions.

Some may ask a more basic question about the policy implications of clusters: if clusters are a regular feature of industrial economies, should we not just leave it to the market to determine the optimum level of clustering in a particular location? At a minimum, because of the importance of local institutional factors to industry success, state and local governments need to be aware of the clusters that operate as their economic drivers. But more important, because many of the benefits of clustering are external to individual firms, there may be unrealized opportunities to improve the efficiency and productivity of all firms in the local economy. Strengthening clusters can be a win-win proposition rather than a zero-sum game.

E. Addressing the Risk of Excessive Specialization

The principal theoretical objection to developing public policies to promote existing clusters is that it may increase the vulnerability of a region to recession. This argument comes in two variations. First is a pure portfolio effect—the risks of too narrow an economic base. Second is that excessive specialization may generate an inbred industry with limited ability to adapt.

The question whether it is better, in the abstract, to be diverse or specialized may actually be of limited policy relevance to states or cities. At any given time, existing specializations are a *fait accompli* and the relevant policy question is what to do with them. Not even the harshest critic of specialization has suggested that the policy implication is that a region abandon or neglect its established specializations. If a region has a specialization, it probably is wise to do whatever one can to maximize its prospects for success-–diversify by starting with existing industries, build on strengths, make sure these industries are dynamic. This is likely to be the case, economically as well as politically, even when there is no certainty of success. Given the difficulty and uncertainty of creating new clusters, it is not at all clear that it will be easier to become more diverse. Moreover, as discussed in Section IV, the measures of specialization used in the research are not precise enough to capture all the possibilities for pursuing development by refining a specialization or by developing related variety (as opposed to unrelated variety). Finally, although the logic of clusters suggests that recruiting unrelated industries may be fruitless, it does suggest that some places may have genuine opportunities to recruit those businesses that are a good fit with the existing industry cluster, for example, where there is an opportunity for a specialized supplier or where a new firm can tap into an existing specialized local labor force.

F. The Research Agenda for Cluster Policy

Although much has been learned about clusters, it seems clear that the research agenda could be focused to shed more light on questions that would be helpful to policymakers. If we accept that "cluster" is an umbrella term that covers a method of inquiry, then it would be helpful to foreswear further debates about a correct definition of clusters and instead work toward a more widely shared, multidimensional method for characterizing different clusters.

Similarly, it may be impossible to make fully generalizable statements about the advantages or disadvantages of clustering. As the debate about specialization and diversity shows, the evidence is mixed. The needs of policymakers would be better served by research that explains which kinds of clusters succeed under different circumstances. Statistical analyses might be more useful if they focused on a narrower range of industry clusters but also incorporated other variables known to be important to clustering, such as industry life cycle, local institutional differences, and variations in innovation and entrepreneurship activity. The case study approach would benefit from a more comparative and rigorous approach. Comparing a range of similar clusters over time might help reveal which factors were most influential in shaping cluster evolution. (Saxenian's work on Silicon Valley and Route 128 is an example.)

Cluster research may end up being a blend of art and science. Clustering is a complex phenomenon. As the research shows, the stories of how specific clusters—from Italian industrial districts to Silicon Valley—develop and evolve resonate with a wide audience. The challenge will be to use statistical tools and techniques more creatively to help describe the workings of individual clusters, to marry data to the case study and storytelling approach, rather than to attempt to uncover universal relationships across a disparate set of industries.

What Cluster Policy and Practice Are Not

Clusters have caught the attention of economic development policymakers and practitioners. However, what cluster policy and practice do and do not mean remains a source of confusion. Because clusters are often discussed as part of public-sector economic development efforts, some assume that cluster initiatives are just some new kind of government-led economic development program, one that might involve favoring some industries over others. The following are four common misconceptions about cluster policy and practice.

Not (Just) A Public-Sector Activity. First and most important, clusters do not depend on the public sector. Clusters are about the relationships between private-sector firms that share common inputs, similar technology, or related markets or draw on particular sets of worker skills. Ultimately, participating private-sector firms decide whether there is a cluster and who its members are.

Not a Program. Does the importance of clusters mean that we ought to have a new "cluster" program for our state or for individual communities? To be effective, the public-sector approach to clusters has to cut across programs, departments, and levels of government. Clusters become a way for all government entities (as well as private firms) to think about the way their activities influence the private sector of the economy. Particular arms of government with a special mission or competence (e.g., a state agriculture department working with food processors) may lead efforts to work with some clusters, but clusters cannot be treated as a separate program or activity.

Not Creating Clusters or Picking Winners. Although government policy can play an important supporting role, it is abundantly clear that government can almost never create clusters where none exist. Some people fear that working with or developing industry clusters involves government picking winners. A cluster view, however, does not involve ranking or excluding any industry. Much of the U.S. economy can be perceived as composed of clusters. Policymakers and practitioners can as readily work with large, well-established, and slow-growing clusters just as with smaller, newer, and faster-growing clusters.

Not "One Size Fits All." A final concern about clusters is that there is a single set of policies or activities that is required to make a cluster successful. In fact, clusters form a basis for addressing systematically the important differences between industries and tailoring one's thinking, conversations, and actions to the particular challenges and characteristics of each industry. Some industry clusters may value a strong formal industry organization and cooperate very closely on issues of market development, while others may rely on less formal collaboration. Too frequently, public economic development efforts present the private sector with a predetermined array of programs and services. Clusters give policymakers and practitioners a way of crafting their efforts to develop each industry by addressing its most pressing concerns.

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