Clusters and Cluster-Based Development Policy

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Abstract

Clusters and cluster policy have become a dominant paradigm in the world of both economic development theory and practice. Cluster theory suggests that firms that are part of a geographically defined cluster benefit from being part of that cluster and that these benefits result in growth in economic activity and output for the region. From here it is only a short step to argue that economic development practitioners can devise policies that can facilitate cluster development through various forms of intervention. Yet despite the large amount of writing on clusters, there is substantial vagueness and ambiguity about the concept itself as well as how clusters work to bring about economic growth and whether policies put in place to build or strengthen clusters actually achieve the desired result. In this article, the authors conduct a review of literature related to clusters to try to set forth what we know and do not know about clusters, what remains uncertain, and what the implications are for economic development practitioners.

Cluster theory and its application, and cluster-based economic development policy have been in the forefront of regional economic development theory and practice during the past two decades. Cluster theory suggests that firms that are part of a geographically defined cluster benefit from being a part of that cluster and that these benefits result in growth in economic output for the region. These benefits accrue as a result of colocation or geographic proximity that, in turn, does two things: (a) creates lower input costs for firms through agglomeration economies and (b) facilitates knowledge spillovers that produce innovation and increased productivity. Consequently, firms in clusters that generate these benefits will be more competitive,[1] and regions with effective clusters will experience greater growth.

Our objective in this article is to examine how and in what ways clusters contribute to regional economic growth and what actions can be taken to enhance this process.

What Is a Cluster?

Porter (1998), who is the most frequently-cited advocate and analyst of cluster policy, defines clusters as "geographic concentrations of interconnected companies and institutions in a particular field, linked by commonalities and complementarities" (p. 78). However, Porter's definition is only one of many in the literature, and, despite the widespread use of cluster analysis and strategies, the actual meaning of the term is somewhat imprecise and ambiguous. Indeed, Martin and Sunley (2003) argue that the term *cluster* "has acquired such a variety of uses, connotations and meanings that it has, in many respects, become a 'chaotic concept' . . ." (p. 10). They list 10 different definitions of "cluster" that they found in their review of the literature (p. 12).

Nonetheless, there is a common core to the concept. In an attempt to capture the broad meaning of the term, we define regional clusters[2] expansively to consist of firms in a region producing similar or related products, using similar processes, or engaging in similar functions (headquarters; research and development). These clusters also include related actors and entities, such as the regional suppliers and customers of these firms, pools of specialized labor (occupations) in the region employed by these firms, public, and public–private programs that provide services to cluster members (e.g., customized training by community colleges) and institutions (e.g., universities, community colleges, industry and trade associations, public and private sector organizations). The presence of these clusters is posited to produce cost-savings to firms or knowledge spillovers, or both, that generate product or process innovations.[3]

An obvious question that flows from this definition is whether "clusters" is simply a new and somewhat more accessible term for agglomerations and whether the benefits

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of clusters are merely what urban and regional economists have long termed *agglomeration economies*. Cumbers and MacKinnon (2004, p. 960) ask, for example, "What is the added value of the cluster approach to existing theories of agglomeration?" It seems clear that our definition—and that of most but not all others—incorporates traditional agglomeration economies. But are clusters more than that? Drawing on Gordon and McCann (2000, p. 515ff), we can identify two different forms of clustering, each coming from different traditions and operating in somewhat different ways.

The first is what they term *pure economies of agglomeration*. Agglomeration economies result from firms locating in geographic proximity to each other. The cost-savings that result from lower input costs and increased productivity are external benefits to firms that come about through this proximity. Gordon and McCann (2000) note that agglomeration economies neither presume nor require any cooperation among actors. "The fundamental point here," they argue (p. 517), "is that a variety of mechanisms by which the external economies are achieved . . . operate simultaneously, often indirectly, and cumulatively." There are several literature reviews of the econometric literature, and there is broad agreement in these reviews that the agglomeration component of the cluster concept has positive effects on various measures of regional economic performance.[4]

The second is the "social network model" of clustering. While Gordon and McCann (2000) assert that this model arises primarily from the sociological literature on institutions, the concept, captured in the term *knowledge spillover* (sometimes called Marshall–Arrow–Romer [MAR] externalities, named after the three economists most responsible for developing the concept), is also clearly present in the agglomeration economy literature. In this model, informal networks of individuals *across* firms (and also across other related institutions, such as trade associations, universities, research institutes, and labor organizations) result in the transmission of tacit knowledge that leads to innovation and the adoption of advanced and improved techniques related to production processes, marketing, and research. These networks are based on interpersonal relationships and trust and are said to embody social capital that is embedded in them. Gordon and McCann (2000) note that there is nothing inherently spatial about the social network model, although it has explicit spatial applications (p. 520).

Given the overlap between social networks and MAR externalities, the difference between "clusters" and what are traditionally thought of as agglomeration economies appears rather small. To a large extent, this appears to be a case of old wine in new bottles. However, the old wine did not appear to be very much in demand or to lead to much in terms of implications for economic development policy and practice when it was labeled "agglomeration economies." Replacing the label with the newer and sexier "cluster" terminology seems to have made a major difference in that respect.

There are several implications of our definition. First, while all regions have clusters, not all clusters produce high growth. Indeed, if a region has a cluster consisting of industries, the demand for whose products is low or declining, or whose production processes emphasize low-skilled labor, the contribution to regional economic growth is likely to be small, no matter what other institutions are connected to it.

A second implication is that even within a cluster consisting of the same components (industries, research facilities, educational and training institutes, and others), a cluster in one region may be more effective than the same cluster in another area at producing economic growth. Glasmeir (2000) says, "The benefits realized from geographical clustering appear to be specific to certain industries at certain stages of development in certain places, and are only realized under particular conditions." Some of the differences may, of course, be due to inherent differences in the economies of the different regions. Some may be due to clusters that are in different stages of the product cycle for output that is at the core of the cluster. But some may be due to the quality of the clusters: either the interaction of cluster members or the way in which clusters are organized or embedded in institutional and area cultures.

As Porter (2000b) notes, "the mere presence of firms, suppliers, and institutions in a location creates the potential for economic value, but it does not necessarily ensure the realization of this potential" (p. 264). For example, certain kinds of highly-embedded social networks may actually retard innovation and growth. Porter notes (p. 252) that "when a cluster shares a uniform approach to competing, a sort of groupthink often reinforces old behaviors, suppresses new ideas, and creates rigidities that prevent the adoption of improvements." Gordon and McCann (2000, p. 521) cite Granovetter (1973), whose research showed that networks with weak ties, "characterized by pluralistic and open-ended network building strategies in which actors cultivate more extensive sets of links," are more likely to produce innovation than strong and tight ties among a smaller number of like-minded people.

A third implication relates to scale: What is meant by geographic proximity or colocation? Do some types of clusters require only clustering at the regional level? Do some types require closer clustering at a subregional level, and, if so, must they be centralized in a downtown location, or can they also be effective if at a suburban node? The forms of clusters that require face-to-face contact and personal interaction have historically implied geographic proximity at a relatively circumscribed subregional level—for example, the downtown core city area. One question is the extent to which the telecommunications revolution has eroded the need for proximity at a subregional level in favor of clusters more widely dispersed across the region. Other forms of clusters, such as the agglomeration economies resulting from the pooling of labor with a wide variety of skills and experience, clearly accrue at the labor market (regional) level.

As indicated by the above discussion, clusters are a complex and elusive concept. One way of trying to come to grips with them is to attempt to classify different kinds of clusters according to their characteristics, with the expectation that different kinds of clusters will be susceptible to different kinds of interventions.

Cluster "types" might be constructed through a variety of classification criteria. They might be classified in terms of the nature of their *members* (which of the various types of constituents described in our definition are cluster members—e.g., see Porter, 2000a), by *the type of processes* by which they are produced (Gordon & McCann, 2000, divide processes into traditional agglomeration economies, industrial complexes, and social networks), by the *core driver(s)* of the cluster, by whether the goods and services that they produce are in *fast- or slow-growing sectors nationally*, by the nature of the *labor force skills* (low-skilled, high-skilled) at their core, by the *kind of product produced* (high-tech, biotech, low-skilled, etc.), by the function (headquarters, production facilities, research and development) at the core of the cluster (see Duranton & Puga, 2004), or in many other ways.[5]

There are other typologies in the literature that are relevant to the specific research purposes of their authors. For example, Markusen (1996) creates a typology of a certain kind of cluster—industrial districts—based on the size of the firms that are part of it, their linkages and networks within and across the district, and the distribution of power among firms. Feldman and Audretsch (1999) classify clusters according to their ranking of the importance of different academic disciplines for the cluster and the level of innovation of the industries related to the cluster. Rosenfeld (1997) describes cluster typologies based on the evolution of the clustering process: working or overachieving clusters, latent or underachieving clusters, and potential clusters. Nolan, Morrison, Kumar, Galloway, and Cordes (2011) refer to the importance of occupation cluster analysis. They define occupation clusters as "groups of occupations that share a similar knowledge, skills, and other characteristics, such as formal education levels, training, wage levels, and availability of benefits" (p. 28) and provide an overview of 15 knowledge-based occupation clusters.[6] The key but underresearched question is whether typologies can be developed that classify clusters according to important characteristics that allow policy makers to address different kinds of interventions to different kinds of clusters.

What Are the Processes Through Which Clustering Fosters Economic Growth?

What are the processes and mechanisms through which we would expect clusters to generate economic growth? We focus on the two main processes identified earlier—(a) agglomeration economies and (b) social networks—since these are the models that produce benefits external to an individual firm as opposed to arrangements initiated and organized by an individual firm.

Agglomeration economies are external benefits that accrue to firms as a result of colocation. That is, they are real benefits to firms in the form of input cost reductions or productivity gains that result from other firms and large numbers of people located in the same area.[7,8] As Phelps (2004) notes (pp. 972-973), clustering through external economies of agglomeration fosters economic growth through one or both of two processes:

1. by lowering the cost of inputs to production (pecuniary economies) of a firm benefiting from the external economies, and
2. by increasing the firm's productivity so that it is able to produce more output per unit input (technological economies).

There are many different processes through which these benefits may occur. These include labor market pooling, worker matching (more workers mean better matching), input sharing, supplier specialization through the growth of supplier and subsidiary industries, development of a common infrastructure, niche consumer markets, knowledge spillover competition (through which firms learn by observing their competitors—see Rosenthal & Strange, 2004, pp. 20-21), and culture and modeling behavior (Rosenthal & Strange, pp. 21-23; Saxenian, 1994). Bergman and Feser (1999, p. 8) provide additional examples of proximity-based agglomeration economies, such as "increased market power through brokered buying and selling, the better availability and use of specialized repair facilities, shared infrastructure, reduced risk and uncertainty for aspiring entrepreneurs, and better information."

Below, we discuss the most important of these various processes, the links through which they presumably affect firm output and thus regional economic output. (Empirical evidence on the extent to which they actually do so is presented later, in the section titled "Clusters, Cluster Policy, and Economic Growth: What Does the Empirical Evidence Say?")

Labor Market Pooling

Large agglomerations provide a substantial supply of labor with a variety of different skills and occupational specialties. What are the external economies that result from this?

First, the ability to replace an inferior worker with another, more productive one available in the area is a productivity gain that accrues to a firm through agglomeration. As Duranton and Puga (2004, pp. 2086, 2092) note, a large labor pool improves both the probability of a match and the expected quality of the match. Second, since a large area will have a labor force with many diverse and specialized skills, firms in industries or engaged in processes with needs for

specific specialized skills are more likely to find them in a large area, and people with those skills are more likely to be attracted to an area where they know these specialized skills are in demand. These are agglomeration economies that result from both input cost reductions and productivity gains from firms. Firms achieve input cost reductions by paying lower wages because of a larger supply of specialized workers; productivity gains come about when workers with these specialized skills provide greater output per input than would less-specialized workers.[9] The geographic scope of this, as with many of the benefits resulting from labor market pooling, should occur throughout the entire labor market area (the metropolitan area).

Input Sharing/Supplier Specialization

The presence of a large number of firms producing the same types of goods or services or requiring the same types of inputs provides external benefits to these firms if specialized suppliers locate within the region to provide that input. These may be urbanization economies if the specialized services (e.g., accounting, legal, advertising services) apply to a wide variety of industries or sectors, or they may be localization economies if they are specialized to a particular industry or a related set of industries. The latter may be suppliers of inputs necessary for the production process, or they may be professional services tailored to individual industries.

Suppliers of physical inputs into the production process decide to locate in an agglomeration if there are enough customers in the region so that the reduced cost of transporting supplies to their customers will make up for the increased costs of locating there (higher land costs, higher labor costs, greater congestion, etc.). As a consequence of the clustering of these specialized suppliers in the region, firms purchasing these inputs will pay lower transportation costs for inputs than they otherwise would have. These are cost-reducing economies that ought to accrue through the location of these supplier firms anywhere in the region and even beyond, although the closer these firms are located to their customers in terms of transportation time and costs, the greater the savings should be. Supplier firms locating close to their customers will also benefit from increased physical accessibility to their customers, who will in turn receive more customized service (a productivity-enhancing external benefit). Suppliers of producer services to firms may also decide to locate in close proximity to their customers to reduce the accessibility costs of personal contact and to increase their understanding of customer needs—in other words, colocation will reduce transaction costs.

Market Aggregation

The cost of goods or services produced in a large agglomeration may be reduced substantially in such agglomerations through reduced transportation and marketing costs to local consumers. Goods or services for which there is sufficient final demand in the area to justify producers locating there will increase regional economic growth through import substitution, with resulting positive economic multiplier effects as local employees of these firms spend money throughout the regional economy. For goods or services whose demand is confined to a relatively small percentage of the population (niche goods) and whose purchase requires physical presence (although a smaller number now, perhaps, as a result of Internet sales), location in a large agglomeration may be necessary to aggregate enough purchasers to make a profit or to be close to the few buyers and to reduce search costs for consumers. Expensive and personalized goods that require personal inspection are examples. To reduce transaction costs to consumers, these specialist shops are likely to be located in a very small and easily accessible geographic area, traditionally in or close to the central business district.

Note that all three of the processes described above occur largely or completely through market processes; they do not necessarily require deliberate intervention for the external benefit to be achieved, although it is possible to envision policies that would enhance these processes. For example, providing land or transportation infrastructure may encourage suppliers to locate in greater proximity to each other, workforce development programs focused on cluster-specific skills may increase the skill levels needed for the cluster, labor force intermediary institutions may help to provide more efficient worker-job matching processes, and other supporting institutions could provide specific support to the industry at the core of the cluster through research and development, innovations, and technology transfer.

Knowledge Spillovers

Knowledge spillovers, or MAR externalities, named after the three economists (Marshall–Arrow–Romer) most responsible for contributing to the concept, are frequently discussed in the literature on agglomeration economies. However, the processes through which they occur are perhaps better understood through the social network model. MAR externalities result from the concentration of many people working on problems in a similar or related set of industries, skill sets, and processes that produce a widely shared understanding of the problem and its workings. The result is greater innovation with respect to product, process, or marketing that lowers costs and generates greater productivity or both for firms in the region. This in turn provides a competitive advantage for firms in the region and consequently greater regional economic growth.

The logic of these knowledge spillovers is straightforward, but how they actually occur is less so.[10] Marshall (1890), in his original exposition on agglomeration economies, writes, with respect to knowledge spillovers, the following:

When an industry has thus chosen a locality for itself, it is likely to stay there. . . . 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 ideas.

Duranton and Puga (2004) observe that "a fundamental feature of learning is that in many (if not most) cases, it is not a solitary activity taking place in a void. Instead, it involves interactions with others and many of these interactions have a 'face-to-face' nature" (p. 2098). Cumbers and MacKinnon (2004) extend this directly to firms and argue that "spatial proximity between specialist firms facilitates the creation and exchange of tacit knowledge, viewed as a crucial form of competitive advantage in a work in which codified knowledge is easily replicated and rendered ubiquitous" (p. 962).

But what are the processes through which these knowledge spillovers occur? Marshall's iconic quote, widely cited in writings about clusters, that knowledge is "in the air" is graceful and memorable but does not provide much information, either to researchers or practitioners, about how these spillovers occur. Do they require personal interaction and face-to-face communication? Do they occur through informal networks—and, if so, of what sort? Can they be encouraged through creation of more formal networks? Are they part of a region's culture, or of the culture of an industry or skilled workers in a region?

Those who approach knowledge spillovers through social network analysis emphasize culture and embeddedness: the social relationships among economic actors, many of which are geographically localized. Economic systems are embedded in social systems, not separate from them. Presumably a certain kind of work ethos or certain kinds of cultures are more likely to produce economic growth. It is also hypothesized that specific types of networks and network relationships are more likely to produce sustained economic growth.[11] Porter (2000b), for example, argues that "social glue binds clusters together, contributing to the realization of this potential. . . . Relationships, networks, and a sense of common interest undergird these circumstances. The social structure of clusters thus takes a central importance" (p. 264).[12] Newlands (2003, p. 523) reviews several case studies of flexible specialization in central and northern Italy and comes to much the same conclusion.

Malmberg and Maskell (2006, pp. 4-7) set forth three processes through which learning occurs as a result of knowledge spillovers. They term the first *learning by interaction* or *the vertical dimension of spatial proximity*. "The vertical dimension" refers to firms that interact with each other in a production chain relationship, which requires

some kind of coordination through interaction. They note that

> studies of industrial innovation quite consistently show that new products are developed in response to signals from, and often in interaction with, customer firms. The most sophisticated and demanding customer firms are of particular importance here, especially if their demand is in some way anticipatory, i.e., helps producer firms understand what the global market will request tomorrow, or the day after tomorrow. (p. 5)

The second, *the horizontal dimension of spatial proximity*, relates to firms in the same industry located closely enough to each other that they can observe, compare, and monitor the behavior of each other. Malmberg and Maskell (2006) observe that "spatial proximity helps firms identify and imitate superior solutions while combining them with ideas of their own" (p. 7).

Finally, there are knowledge spillovers that occur as a result of what Malmberg and Maskell (2006) term *neighborhood effects*. They refer to these as "local buzz":

> Buzz refers to the information and communication ecology created by numerous face-to-face contacts as people and firms within the same industry collocate. . . . This buzz consists of specific information and continuous updates of this information; intended and unanticipated learning processes in organized and accidental meetings; the application of the same interpretative schemes and mutual understanding of new knowledge and technologies; as well as shared cultural traditions and habits, which taken together make interaction and learning less costly. (p. 7)

This appears to be an elaboration of Marshall's famous "in the air" statement and, unfortunately, provides little more understanding of the processes through which this kind of knowledge spillover occurs.

Borrowing from the organizational learning/networking literature, we also know that learning occurs primarily through interaction in informal networks of near-peers, but it also may occur through leadership replacement or new hires who bring their experience from other organizations. All these processes are arguably more likely to occur when similar firms and similar occupation clusters are geographically proximate to each other.

What Do We Know About How and Under What Conditions Clusters Form?

The above discussion relates to the mechanisms and processes through which clusters operate. Most of what we know about cluster *formation* results from research on agglomeration economies. With respect to agglomerations, Krugman (2000, p. 53) argues that increasing returns to scale are the rationale for agglomerations; industries locate in proximity to

each other to take advantage of the reduced marginal costs that occur as production increases in the area as a whole (see also Duranton & Puga, 2004). Colocation occurs naturally and without coordination through independent decisions of firms operating in their own interests.

Some of the literature on cluster formation is concerned with why clusters of a particular kind locate and thrive in particular places. While natural features may account for the location of, for example, natural resource clusters, many argue that initial location is a matter of idiosyncratic circumstances or simply luck, followed by processes of "path dependence" and "lock-in." Economic development is to some degree path-dependent: The set of opportunities for any particular place will be shaped by the economic activities it has already established, so chance events are important, and there is a propensity for the market to "lock in" on certain patterns of activities. Product and profit cycle theories (see Markusen, 1985) suggest, however, that lock-in does not last forever, and when a product reaches mass production stage it may move to lower cost production sites.

The literature also suggests that a region's social and cultural systems play an important role in network formation, information exchange, and collaboration across organizations. All these are important components of cluster formation and may help explain why clusters are more likely to form in some regions than in others. Clusters form through historical accidents, spin-offs from existing clusters, and activities of individual entrepreneurs and then expand in place as a result of lock-in, path dependence, and cultures that are conducive to shared trust through social interactions, face-to-face communication, social networks, and other means. In a later section of this article, we examine the evidence of whether clusters can also be formed as a result of public policy.

Cluster-Based Economic Development Policy?

The rationale for cluster-based economic development policies is provided by Michael Porter, who has been the most persistent and effective proponent of such policies:

> Since clusters involve powerful externalities across firms in a location, and associated public goods, there is a strong rationale for public policies. In the presence of positive externalities market failure will lead to underinvestment in specialized skills, scientific knowledge, and specialized infrastructure that benefits the entire cluster and increases competition by lowering the barriers to entry of new firms. Public policy that provides rules, mechanisms, and incentives for capturing external economies will improve productivity and, with it, job, wage, and innovation growth. (Porter, 2009, p. 5)

According to Porter, industry-level and firm-level policies should increasingly be replaced by cluster-based policies,

because the latter are more efficient, minimize distortions to competition, and are better aligned with the nature of competition in the modern economy (Porter, 2009, p. 2).

What does "cluster theory" suggest in terms of actual economic development strategies and policies that might be applied? Bartik (2008, p. 15) observes that "if clustering boosts productivity in a knowable and predictable way, this has extremely strong implications for policy. If we know that some firms expanding in the cluster would boost productivity at other firms, we should provide subsidies to help those firms expand." However, he adds that "the problem is that no one knows how large such agglomeration economies are, and at what scale of industry or urban activity these agglomeration economies are most important. . . . Therefore, it is difficult to use such cluster findings as a strong rationale for subsidizing one set of industries rather than another."

Motoyama (2008) also adds a note of skepticism, stating the following:

> A limitation of the theory is its feasibility and whether and how government can effectively fill-in the missing components of the cluster. For example, if a specific element in a cluster is missing, such as the suppliers, a logical policy consequence would be for the government to provide grants to attract or nurture them. However, in reality, there is hardly such a case unless the government plans to form a cluster from scratch. The private sector is not blind and has usually looked for business opportunities. Even if there is a gap, how and how well government can promote the missing components is questionable. The more difficult part is to promote the interconnectedness of a cluster. If firms in a cluster do not have sufficient spillover or synergistic effects, what can government do? The current cluster theory may point out that government should do something about it but does not explain how. (p. 360)

Duranton (2009, p. 38) argues that research clearly shows that cluster benefits are real, but that they are also quite small. Instead of pursuing such benefits, he urges economic development policy makers to focus on "the cost curve" and thus attempt to reduce costs associated with place through more traditional public sector policies related to land use planning, urban transport, and provision of local public goods. He also notes that the various mechanisms that produce clustering benefits (e.g., labor pooling, knowledge transfer through networks, and others) are difficult to identify empirically and call for very different policy approaches.

Despite what some see as the lack of straightforward implications of "cluster theory" or the cluster framework for public policy, others have suggested clear policy implications. Martin and Sunley (2003, pp. 23-24) write that the cluster framework suggests a focus on strengthening existing clusters by helping to promote the supply of local and regional public goods that are absent because of market failure. They suggest four such means for strengthening clusters: (a) by creating cooperative networks and encouraging dialogue

between firms and other agencies; (b) through collective marketing of a region's cluster specialties; (c) through providing firms with local services, such as financial advice, marketing, and design; and (d) through identifying weaknesses in existing cluster value chains and attracting investors and businesses to fill those gaps. Rosenfeld (2010) holds that there are essentially three types of economic development policies that flow from cluster theory: (a) associational encouragement (i.e., efforts to encourage information exchange and knowledge spillovers); (b) provision of specialized services to identified clusters; and (c) targeted investments, including research and development and recruitment.

Porter (2009) argues for the following approach:

> Public policy at the cluster level should begin with the collection of information that identifies the existence of clusters. . . . Government has an important role in assembling information about cluster composition, membership, employment and performance. . . . Another potential role for government in cluster development is to *convene* cluster participants if private sector institutions have not already arisen to do so. Once clusters are organized through trade associations or other means, government agencies need to become active participants in dialogs with cluster participants to understand local constraints to productivity and identify gaps and weaknesses in public policy. Another dimension of cluster policy is *incentives* to spur collective investment by cluster participants in assets that benefit many cluster participants, such as university research centers, community college curricula, or testing facilities. In some cases, public investment in assets involving cluster externalities is also justified. (p. 5)

Brun and Jolley (2011) propose reframing industry cluster identification for a region so that it is not only conceived as an expert-led technical analysis but also engages stakeholders in a collaborative process. The authors describe a collaborative method for identifying clusters in Chatham County, North Carolina. On the basis of their experience, they conclude that the collaborative approach to identifying clusters can improve the analytical quality of cluster analyses, provide information about community preferences, foster community and political acceptance of the results, and develop new cluster definitions and improved implementation.

What kinds of public policy have actually been adopted as part of the cluster-based approach for which Porter provides the above rationale? Drawing on work by Cortright (2006), Feser (2008), Mills, Reynolds, and Reamer (2008), and Rosenfeld (1997, 2010), we list below a set of policies, strategies, and lessons that these authors suggest are relevant to economic development practitioners:

1. Learn how businesses interact and clusters work.
2. Support clusters based on their economic dominance, strategic importance, or leadership and potential.
3. Improve technical support services.
4. Support cluster expansion through recruiting companies that fill gaps in cluster development.
5. Develop and organize supply chain associations.
6. Support entrepreneurs through assistance for start-ups and spin-offs.
7. Encourage labor market pooling through providing labor market information, specialized training.
8. Encourage knowledge spillovers and networking through public sector research and development support.
9. Facilitate market development through joint market assessment, marketing, and brand building.
10. Represent cluster interests before external organizations such as regional development partnerships, national trade associations, and local, state, and federal governments.

Most of the individual policies described above have existed long before there were intentional and explicit "cluster-based" economic development policies. The difference, to the extent a difference exists, is the target of the policy or policies—that is, an identified cluster rather than a single industry sector or sectors or individual firms—and the way the policies are combined.

They also differ in what they *do not* attempt to do. As Porter (2009) notes,

> Cluster-based policies, unlike sectoral or industrial policies, should be neutral with regard to industry or type of economic activity. . . . Cluster policy is thus fundamentally different from sectoral or industrial policy, whose fatal flaw is their focus on favoring particular types of economic activity, picking winners, and attempting to artificially bias competition in favor of a particular country or region. (p. 6)

However, as Martin and Sunley (2003) observe, in practice, this neutrality is frequently violated, with practitioners engaging in an effort to identify clusters that are more likely to produce growth on which to focus, a strategy not unlike the picking-a-winner strategy common in industry-based economic development policy.

Clusters, Cluster Policy, and Economic Growth: What Does the Empirical Evidence Say?

In this section, we review the empirical literature that examines, first, the effect of clusters on economic growth and, second, the effect of explicit economic development cluster *policy* on growth.

The Effect of Clusters on Economic Growth

We begin by asking the extent to which empirical research supports the positive effect of clusters on economic growth. Such an effect is suggested by the theoretical propositions discussed in the earlier section titled "What Are the Processes Through Which Clustering Fosters Economic Growth?"

Relatively little literature is directed at testing the effects of clusters in terms of the broad, cross-cutting way that we, along with Porter, Cortright, and others, define them. There has been a very substantial research literature directed at agglomeration economies, which are, as we have noted, at the core of the cluster concept. Most of this literature is concerned with whether cities or regions that are larger or denser have better economic performance. Better economic performance would imply that firms operating in these areas are taking advantage of the agglomerations provided in these areas (though it is sometimes pointed out that it may also be possible that more productive and profitable firms choose to locate in large urban regions). Some literature is focused on why agglomerations occur—that is, asking the question, "Why do cities grow?"

The empirical literature consists of two quite different strands: (a) econometric studies employing data from a large number of areas and (b) intensive case studies of clusters in one or two locations.

The econometric literature consists mainly of studies that attempt to explain the growth in aggregate regional output, personal income, wages, or employment by using variables that theory and the empirical literature have identified as determinants of growth. Examples of possible explanatory variables employed include measures of physical capital, human capital, labor market performance or labor force characteristics, and geographical characteristics. These serve as control variables to which an independent variable is added as a measure for the extent of clustering or of agglomeration economies. The variable added to measure cluster or agglomeration differs substantially depending on the particular aspect of clustering or agglomeration economies that each paper wants to test, and in many cases these variables bear little relationship to the concept of clustering as we have defined it. These include, among others concentration indexes (Glaeser, Kallal, Scheinkman, & Shleifer, 1992; Henderson, Kuncoro, & Turner, 1995; Huallacháin, 1992; Waldhorn, Egan, Park, & Gollub, 1998), measures of localization economies (see, e.g., Barkley, Henry, & Kim, 1999), or simply regional population or employment size in the aggregate or in a specific sector (see, e.g., Glaeser & Gottlieb, 2009). Hill and Brennan (2000) make use of a mathematical technique called "hierarchical cluster analysis" to sort the various industrial sectors into groups of sectors that are most like each other and different from other groups.

Perhaps the most elaborate systematic effort to define clusters of related industries is the U.S. Cluster Mapping Project (CMP) developed by Porter (2003, 2009) and expanded through the U.S. Economic Development Administration (EDA)-funded Cluster Mapping Project. The project, which is based on the original U.S. CMP and is led by Porter's Institute for Strategy and Competitiveness at Harvard Business School, seeks to establish a set of state-of-the-art, publicly available cluster definitions that are consistent across the United States (Delgado, Ketels, & Zyontz, 2012). The project's cluster identification methodology is complex, but essentially, it identifies three types of industries with different patterns of competition: (a) local, (b) natural resource dependent, and (c) traded. To measure the relationship among traded industries, Porter (2003) uses pairwise correlations of industry employment across locations, a type of correlation that he refers to as a "locational correlation," as a means of identifying clusters of industrial sectors.[13]

The problem with using some measure of industrial concentration (e.g., location quotients[14] or the Herfindahl Index[15]) is particularly acute because of such a measure's lack of correspondence to the concept of a cluster. If, as is likely to be the case, parts of a cluster fall within different traditional industrial or service categories, then a real cluster may be obscured or even go unrecognized. Cluster boundaries rarely conform to standard industrial classification systems, which fail to capture many important actors in competition as well as linkages across industries. Indeed, as Cortright (2006) notes, clusters conceptually are likely to *cut across* industrial classifications.

Thus, the empirical evidence is difficult to interpret, both because researchers do not always use the same conceptual definition of clusters and because the operational definitions—that is, the way in which clusters are measured—vary enormously. As a result, findings may differ substantially because researchers are examining different things but calling them all clusters.

There are several reviews of the econometric literature, and there is broad agreement that the agglomeration component of the cluster concept has positive effects on various measures of regional economic performance (see, e.g., Glaeser & Gottlieb, 2009; Rosenthal & Strange, 2004).[16]

Duranton (2009) cites Rosenthal and Strange (2004) to summarize the findings from the empirical literature: "The range of estimates for the mean elasticity for labor productivity to local industry employment is between 2 and 10% with a midpoint around 4 or 5%" (p. 31). In other words, doubling specialization in an activity and area is associated with an increase in productivity of approximately 4%, although the numbers can be lower or higher depending on the industry. He concludes that there are positive effects of clustering, but the literature also strongly suggests that it takes an extremely large increase in specialization to get more than minor effects on local productivity and wages.

Duranton (2009, pp. 31-32) argues that the effects estimated in the literature are very modest, and that even these modest effects may exaggerate the true causal benefits of clustering on productivity. He notes that most studies fail to control for possible reverse causation or simultaneity—for example, the possibility that clustering may not lead to high local productivity and wages, but instead that high local productivity and wages may lead to clustering. If causation is in the latter direction, then most results from the literature would be biased, exaggerating the magnitude of clustering effects.

Another research literature examines whether diverse urban environments or more concentrated ones, usually measured by the degree of industry concentration, are more likely to lead to economic growth and innovation. A high degree of industry concentration indicates strong clusters and the presence of localization economies, while industrial diversity is seen as evidence of broader urbanization economies and is less consistent with clusters as a driver of growth. Thus, some researchers argue that a positive relationship between industrial concentration and growth is evidence of the importance of clusters, while evidence of a relationship between diversification and growth indicates clusters are less important.

Jacobs (1969) argues, for example, that more diverse cities will grow faster than concentrated cities. New ideas are formed by combining older ideas. Cities allow for the mixing of many different industries and occupations; ideas from different areas get combined and growth occurs. So more diverse cities will tend to grow faster than concentrated cities (as cited in Glaeser, 2000).

Cortright (2006, pp. 39-42), Feldman (2000, p. 303), and Rosenthal and Strange (2004, pp. 2132-2136) review these studies and find mixed results. Rosenthal and Strange (2004, pp. 2135-2136) observe that in many of the studies, specialization (as operationalized through some measure of industry concentration) is not related to employment growth, firm births, and so on, while diversification is. But in a large region, an industry could have a large-enough presence—even though it represented only a small percentage of total employment—to still garner localization economies in a diversified economy. In other words, it may be the absolute size of a sector rather than the relative degree of concentration of the sector in the economy that matters.

More recently, Delgado, Porter, and Stern (2012) evaluated the role of regional cluster composition in the economic performance of industries, clusters, and regions, by examining both the impact of agglomeration among related industries and simultaneously accounting for convergence (declining output growth rate in a region or industry due to diminishing returns) within a given industry. They find that industries participating in a strong cluster have higher employment growth, higher growth of wages, a higher number of establishments, and higher patenting. They also find that new regional industries tend to be created where there is a strong cluster environment. In a related paper, Delgado, Porter, and Stern (2010) find that regional industries located within a strong cluster experience higher growth in new business formation and start-up employment, and that they also matter for the formation of new establishments of existing firms.

The above studies are mostly concerned with the agglomeration economy component of the cluster concept, although in some cases this also incorporates the knowledge spillover (MAR) concept. However, the knowledge spillover, networking component of the concept is not directly tested in these studies.

The studies that attempt to focus more directly on knowledge spillovers are mostly intensive case studies of specific areas. For example, Saxenian's (1994) study on Silicon Valley and Route 128, von Hippel's (1988) study on the U.S. steel industry, and Dahl and Pedersen's (2004) study among wireless engineers in Scandinavia, all of them based on interviews and surveys, confirmed that ideas flow freely in each of these clusters (as cited in Cortright, 2006, p. 21). Saxenian's (1994) intensive case study compared Silicon Valley and Route 128 in the Boston region and asked, "Why has Silicon Valley adapted successfully to changing patterns of international competition while Route 128 appears to be losing its competitive advantage?"

She concluded the following:

> Silicon Valley has a regional network-based industrial system that promotes collective learning and flexible adjustment among specialist producers of a complex of related technologies. The region's dense social networks and open labor markets encourage experimentation and entrepreneurship. Companies compete intensely while at the same time learning from one another about changing markets and technologies through informal communications and collaborative practices. . . . The Route 128 region, in contrast, is dominated by a small number of relatively integrated corporations. Its industrial system is based on independent firms that internalize a wide range of productive activities. Practices of secrecy and corporate loyalty govern relations between firms and their customers, suppliers, and competitors. (pp. 2-3)

Other studies have analyzed this issue quantitatively. For example, Jaffe, Trajtenberg, and Henderson (1993) found that new patents were more likely to cite previous patents in the same metropolitan area or state than to cite more distant patents. From this finding, they concluded that knowledge is relatively localized.

The most directly relevant research consists of studies that focus directly on the concept of clusters rather than on proxies for agglomeration. Huallacháin (1992) identified 18 geographic clusters consisting of related two-digit industries and examined the relationship between the strength of each of these clusters and regional employment and income growth for the 150 largest metropolitan areas in the United States. He found that 5 of the 18 clusters studied had a positive effect on both employment and per capita income growth. The five clusters were (a) high-order services, (b) high-tech manufacturing, (c) state and local government, (d) textiles and construction, and (e) insurance. The retail trade and recreation service clusters were notable among the clusters that were positively related to metro employment growth but did not have any relationship with income growth.

Feser, Renski, and Goldstein (2008) attempted to assess the effect of clusters by analyzing technology clusters in the Appalachian Regional Commission region from 1998-2002. They identified several different technology clusters and their

locations in each of the 406 counties in the region. They then divided the counties into high employment growth and low employment growth counties over the 1998-2002 period and analyzed whether the high-growth ones had a greater presence of technology-based clusters in 1998 than did the low-growth ones. They conclude that "We found little evidence that technology industries in spatial clusters in Appalachia created more jobs than the same industries in noncluster locations" (p. 343). They are extremely cautious in placing the findings as being specific to a particular place over a particular time period.

To what extent does the empirical literature separate out the effects on regional economic outcomes of the very diverse processes that lie behind agglomeration economies that we discussed above? Rosenthal and Strange (2004, p. 2146) ask what the studies on productivity have to say about the various microfoundations of agglomeration economies and answer "not much." Hanson (2000) echoes this: "We have relatively little understanding of the precise type of externalities that contribute to agglomeration." Individual studies find evidence consistent with human capital spillovers across workers, localized knowledge spillovers in the innovation process, and regional cost and demand linkages between firms (p. 489). There is little work that attempts to estimate the relative impact of these different effects.

The problem, Rosenthal and Strange (2004) observe, is that "agglomeration economies whose sources are knowledge spillovers, labor market pooling, or input sharing all manifest themselves in pretty much the same way" (p. 2146). As Gordon and McCann (2000) note,

> a variety of mechanisms by which the external economies are achieved . . . operate simultaneously, often indirectly and cumulatively, so that individual sources of the agglomeration process cannot be isolated or individually identified. . . . The only observable manifestation of their existence may thus be the realized efforts on productivity, growth and local factor prices. (p. 517).

Finding reasonable measures of each of these as a means of sorting out the effects while controlling for the others is very difficult.

However, Gordon and McCann's (2000) conclusion that information transfer or knowledge spillover is the "process" behind the findings they review is indirect evidence of their effects at best. Indeed, as Cumbers and MacKinnon (2004) write, "The importance of locally specific forms of knowledge circulating through the labour market has been identified as a key feature of successful agglomerations such as Silicon Valley (Saxenian, 1994). Yet few detailed studies have sought to test this proposition empirically" (p. 964).

The Effect of Economic Development Cluster Policy on Economic Growth

In the preceding subsection we reviewed the empirical literature on the extent to which clustering as a process affects economic growth. In this subsection we examine the empirical literature on the effects of explicit economic development cluster *policy* on economic growth.

This is a short section because, as Delgado, Ketels, et al. (2012) observe, "So far there is little empirical evidence of the overall effectiveness of . . . different cluster programs" (p. 4). There are many case studies of specific cluster-based initiatives, most of which focus on the processes through which cluster-based policy is applied or operates. Very few actually undertake systematic evaluation of outcomes. As noted above, Feser et al. (2008) attempted to assess the effect of clusters—not cluster-based policies, although the creation of clusters is presumably the object of such policies—by analyzing technology clusters in the Appalachian Regional Commission region from 1998-2002. They did not find that technology industries in spatial clusters created more jobs than the same industries in noncluster locations. Instead, several authors point to benefits not related to specific policies but more to processes. For example, Cumbers and MacKinnon (2004, p. 962) observe that "in a regional context in particular, a clusters approach seems to provide development agencies with a new and compelling rationale for both identifying a limited number of sectors to support—generally those that are deemed to have the highest growth potential—and defending and justifying this to those interests that are consequently excluded." Observing Arizona's cluster strategy, Waits (2002) concludes that "best practice is the use of cluster working groups to help policy makers better understand an industry, the challenges it faces, and the most valuable assistance government can provide" (p. 39).

What Are the Implications of Cluster Theory and Research for Regional Economic Development Practice?

The most important implication for practice is that clusters provide a conceptual framework through which a regional economy can be analyzed and understood. Conceptual frameworks are not necessarily correct or incorrect; they are ways of looking at the world, and their utility lies in the understanding and insights that looking at the world through that framework provides. Indeed, as evidenced by its widespread adoption, the cluster framework has proven to be a useful and durable framework, one that is clearly superior to seeing the world solely through the frame of industrial sectors, the previous dominant framework.

A cluster framework thus suggests that economic development policy makers and practitioners should focus not solely on individual export sectors but on the wider set of firms, actors, and institutions that form a cluster and help determine the cluster's competitiveness, including export industry supply chains. Surely this provides a better understanding of how regional economic processes work and is more likely to lead to regional economic performance than

does a focus solely on economic sectors. As one example, Cortright (2006) notes that "cluster theory" suggests that regional economic development practitioners should work with groups of firms rather than with individual firms. He also argues that use of a cluster framework "will shift analysis from firm-level rent-seeking (subsidies, tax breaks) to more widely shared competitive problems" (p. 47).

What does this suggest for economic development policy and practice? Here the world begins to look a bit more murky. Use of a cluster framework does not directly lead to answers to the difficult questions for regional economic development. Duranton asks whether cluster-based strategies in the face of limited resources even make sense given the small payoff relative to more traditional local policies. There is widespread agreement that it is not possible to create clusters where there is not an initial base for the cluster to grow on. There is less agreement on whether it is possible to identify "emerging clusters" or whether clusters can only be identified "in the rearview mirror"—that is, after they already exist. Should policy be directed at specific clusters or at concerns that are the foundation of virtually every cluster (such as, e.g., human capital and public infrastructure)? If a cluster-based policy makes sense, should the policy be targeted at specific clusters or at things that any promising cluster can take advantage of? If targeted then toward what kinds of clusters should policies be targeted, and how should those policies be selected? And what kinds of specific policies make sense? To none of these questions does using a clusters framework provide definitive answers.

Cortright (2006) writes that most researchers agree that "no set policy prescription emerges from the cluster literature." In particular, the silver bullet of creating new clusters seems unattainable. As he notes,

> The tantalizing paradox of clustering is that it implies that the location of economic activity is not preordained and that, therefore, public policy . . . 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. (p. 48)[17]

But while it may be the case that clusters cannot be created where they previously have not existed or where they are very weak, can *existing* or *emerging* clusters be built on and made more effective? Given that the literature we have reviewed indicates that clusters develop naturally through market processes and individual actions of firms, workers, and residents (consumers), is it possible for direct and intentional intervention to improve cluster operations—and, if so, through what kinds of policies or practices?

Porter (2003, p. 564) suggests that public policy should be concerned with upgrading all clusters that exist in a region. Others argue that economic development policy should focus resources on a small number of the most promising clusters, although Martin and Sunley (2003, p. 24) argue that if policy

is too focused, "it starts to look like old industrial policy and too close to the discredited notion of 'picking winners.'"

It is important to note that all regions have clusters, but not all clusters produce high growth. Indeed, if a region has a cluster consisting of industries, the demand for whose products is low or declining or whose production processes emphasize low-skilled labor, the contribution to regional economic growth is likely to be small, no matter what other institutions are connected to that cluster. Likewise, a cluster consisting of the same components (industries, research facilities, educational and training institutes, and so forth) in one region may be more effective than the same cluster in another region at producing economic growth.

And while all regions have clusters, it makes little sense, despite Porter's injunction, for regional economic development policy to focus on clusters for which export demand is declining or clusters that produce primarily low-skill, low-wage jobs. Moreover, regional economic development policy should take into account that regions exist in a competitive environment and the same cluster specialty cannot be competitive everywhere. Despite the fact that a very high proportion of regional cluster-based development plans focus on biotechnology, life sciences, or information technology clusters, it is just not possible for every region to have such a cluster. Some regions are simply better positioned to be competitive in a cluster than are other regions.

Therefore, an economic development policy informed by cluster theory would proceed by first identifying clusters in the region that produce goods and services for export, are competitive or have a competitive advantage in doing so, and have some existing concentration in the region—that is, the region already has assets in the cluster that it can build upon. It would then further focus on those clusters for which external demand is increasing or expected to increase. In many cases, the broad clusters are readily apparent. The next step is to identify the cluster components, the cluster driver(s), and the interaction between the driver(s) and other components. Not all cluster components are created equal. The cluster driver in the Detroit region, for example, is the automobile industry. The cluster includes the headquarters function, engineering, research and development, and production plants, although these have had a diminishing presence. Efficient supply chains in the region make the industry and the region more competitive; however, the supply chains without the industry are unlikely to be able to sustain a cluster.

The purpose of the above exercises is to search for gaps, inefficiencies, and market failures among the relationships of these components to one another that might be improved through direct intervention and then to fashion interventions (programs, structures, activities) addressed to these. In this regard, cluster-based economic development places particular emphasis on determining whether and how information exchange among cluster members, beyond that which already occurs through knowledge spillovers, can be improved.

At a broad level, the question of which clusters to focus on reduces to the same kinds of questions economic development policy makers have developed answers to through more traditional frameworks, and the policy implications are also similar:

- Focus on clusters for which the region has existing assets, as evidenced by some existing concentration.
- Focus on clusters for which the region has a competitive advantage relative to other regions. Focus on clusters that are growing nationally.
- Focus on clusters for which an intervention strategy is possible and for which intervention will make a difference in terms of affecting economic development objectives.
- Focus on clusters whose impacts or externalities particularly serve public purposes (e.g., employ more entry-level labor or promote energy

What We Don't Yet Know About Clusters: An Agenda for Future Research

Our review of the cluster concept and cluster-based economic development suggests a variety of avenues both for future research to improve our understanding of how clusters work and for future product development to assist policy makers and practitioners in designing and implementing regional economic development policy.

As our review suggests, we know a good deal about how clusters operate, but much less about how they are formed and, in particular, the extent to which they can be assisted either in their formation or in operation through public policy. This, of course, is the critical question for public policy makers. There is widespread agreement that it is unlikely that completely new clusters can be created where some foundation and elements of the cluster do not already exist. But can "emerging clusters" be identified and encouraged to develop through public policy? Since efforts to identify emerging sectors occur frequently in economic development plans, one obvious research project would involve a simple assessment of their effectiveness: To what extent have clusters that have been identified as "emerging" actually emerged? Can public policies be identified which, when used, are more likely to lead to the successful emergence of clusters?

There are a variety of research and development questions that relate directly to public policy. Since clusters result from natural processes—private sector, organic, market-driven activity—can public policy improve the functioning of clusters, and, if so, through what means? Cluster-based economic development policy has many advocates, but even they acknowledge that there is a dearth of evidence about how cluster-based economic development policies, activities, and practices have actually performed. Systematic objective evaluation research on cluster-based economic development policy outcomes is badly needed.

It is possible, indeed likely, that clusters differ by type, by place, and by stage of development and that these differences have important implications for policy and practice. Some types may be more susceptible to successful policy intervention than others, and different types may require different kinds of interventions. While, as we have noted, there are some efforts to develop cluster "typologies," none of the existing ones is very helpful to policy makers. This suggests another important area for research and development: How can clusters be best characterized (i.e., sorted into relevant classifications through typologies) so that they provide relevant information to economic development practitioners by answering questions such as these:

- What kinds of clusters work best for different types of regional economies?
- What are the kinds of interventions most appropriate for different kinds of clusters?

The key for economic development policy makers is whether and how knowledge spillovers can be encouraged through efforts to make networks more effective. Research is needed on what kinds of policy efforts can accomplish this. Can, for example, "cluster brokers" bring about more effective network operations? Does providing government financial assistance for network operations, organizing more formal networks, or providing venues such as conferences around issues relevant to a network, result in knowledge spillovers?

Summary

Clusters are widely heralded as a new and innovative approach to economic development analysis and policymaking. Yet as our literature review and discussion suggest, there are many concerns and uncertainties about the approach. Indeed, the very definition of what is meant by the terms *cluster* and *cluster policy* is contested, with different researchers and proponents having different meanings they attach to these terms. At their core, clusters appear to be very similar to the traditional concept of agglomeration economies, a very important but hardly novel explanation of how spatial clustering produces real productivity gains.

The policy implications of clusters are also unclear. There is general agreement that clusters cannot be created where little or no foundation for the cluster exists. There is disagreement on whether "emerging" clusters can be identified, how to do so, and since clusters are naturally occurring, and whether they can be effectively promoted through public policy. Presumably, public intervention would attempt to identify market imperfections that prevent or hinder these natural occurrences and undertake corrective action. Most of the corrective actions undertaken or advocated turn out, not surprisingly, to be rather traditional economic development policies or practices but directed at clusters. Furthermore,

explicitly articulated cluster policies have rarely been systematically evaluated and, to the extent that they have, appear to have had limited impact.

Nonetheless, despite the above critique, the cluster approach does have highly important and positive implications for economic development analysts, policy makers, and practitioners. Its primary contribution lies in the conceptual framework that it provides: Economies are much better viewed as linked clusters of activity *across* various industrial sectors rather than as isolated sectors defined by the NAICS code at whatever level of specificity. This rather simple insight has produced very important changes in how regional economies are analyzed and at what regional economic development policies should be directed. The cluster approach is thus more of a lens through which a regional economy can be more productively examined and understood than it is a set of prescriptive policies. Indeed, once the cluster policy lens is in place, the application of more traditional approaches makes more sense and is likely to be more effective. Nevertheless, since the test of a conceptual framework is its utility in understanding the world, cluster analysis easily qualifies as an important approach.

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Notes

1. However, causality may move in both directions: Clusters might make firms more productive and thus more competitive, but more productive and competitive firms might come together to form a cluster. See, for example, Duranton (2009, p. 32).

2. Clusters are not necessarily regional in nature; they may form in a geographic area smaller or larger than a region or they may be aspatial, depending, for example, on the Internet for interaction.

3. Whether or not clusters do result in such cost savings and product or process innovations, and the extent to which they do so, is an empirical question.

4. See, for example, Delgado, Ketels, et al., (2012); Duranton (2009, p. 31ff); Glaeser and Gottlieb (2009); and Organisation for Economic Co-operation and Development (2008).

5. Enright (2003) characterizes clusters along various dimensions: geographic scope, density, breadth (range of horizontally related industries), depth (range of vertically related industries), activity base, geographic span of sales, strength of competitive position, stage of development, nature of the technological activities, innovative capacity, and ownership structure. He also uses several categories to characterize the state

of development of clusters: working clusters, latent clusters, potential clusters, policy-driven clusters (chosen by government to support, but which lack a critical mass of firms), and "wishful thinking clusters" (lacking a mass of firms and any source of advantage).

6. The 15 occupation clusters defined in this study are as follows: (a) Agribusiness and food technology; (b) Arts, entertainment publishing, and broadcasting; (c) Building, landscape, and construction design; (d) Engineering and related sciences; (e) Health care and medical sciences; (f) Information technology; (g) Legal and financial services and real estate; (h) Managerial, sales, marketing, and human resources; (i) Mathematics, statistics, data, and accounting; (j) Natural sciences and environmental management; (k) Personal services; (l) Postsecondary education and knowledge creation; (m) Primary/secondary and vocational education, remediation, and social services; (n) Public safety and domestic security; and (o) Skilled production workers (technicians, operators, trades, installers, and repairers).

7. The literature identifies many different kinds of agglomeration economies. An initial distinction can be drawn between agglomeration economies that result from the colocation of firms that are similar in nature in terms of goods produced, processes, skills required or functions (called "localization economies") and those that result from the colocation of a large number of firms, even if they are diverse (called "urbanization economies" or if the focus is on their diversity, "Jacobs economies" after the writings of Jane Jacobs). While the most common conceptual definitions of clusters focus attention more on localization economies, many of the processes incorporate both. Pure urbanization economies essentially depend on size, and there is relatively little that economic development practitioners can do to affect their presence.

8. Duranton (2009) notes, however, that at a certain size diseconomies of agglomeration (e.g., congestion) begin to set in and impose external costs on firms in the area.

9. Note that while input cost reductions through greater supply of specialized labor will reduce wages, higher productivity of a worker will increase worker wages, and the result may well be higher wages per worker.

10. For a review of efforts to explain these spillovers, see Le Galès and Voelzkow (2001).

11. See Putnam's (1993) study of Italy, Granovetter's (1973) findings on the strength of weak ties, and Safford's (2009) study comparing Allentown, Pennsylvania, and Youngstown, Ohio.

12. However, despite these claims by Porter (2000b), Martin and Sunley (2003, p. 16) contend that:
"the social dimensions of cluster formation and cluster dynamics remain something of a black box in Porter's work . . . [and] the problem of conceptualizing and empirically analyzing knowledge networks and other 'soft' socio-cultural-institutional features of clusters and spatial economic agglomerations is not, of course, confined to Porter's work."

13. Employment in each industrial sector (as identified by a three- or four-digit SIC code) is correlated with employment in each other industrial sector across all regions. This yields a locational correlation for each pair of industrial sectors. A traded sector and other nonlocal sectors with which it has sufficiently high locational correlation coefficients are designated as a cluster. It is assumed that the relationship among these

14. "Location quotient" is the ratio of the percentage employment in a particular sector in the regional economy to the percentage of employment in that sector in the national economy.

15. A Herfindahl Index is an index of diversity (or concentration).

16. Behrens, Duranton, and Robert-Nicoud (2010), however, note that income inequality also rises with regional size.

17. See also Cumbers and MacKinnon (2004, p. 965) and Newlands (2003, p. 528) for similar reservations and cautions.

industrial sectors with high locational correlations does not vary across regions (see Delgado, Ketels, et al., 2012).

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