RETHINKING CLUSTER INITIATIVES

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Industry clusters—groups of firms that gain a competitive advantage through local proximity and interdependence—offer a compelling framework for local and state leaders to analyze and support their economies. Both theory and academic research suggest that firms and regions benefit from clustering, evidence that has led to widespread adoption of clusters within the economic development field. But there are glaring gaps between the recognition that clusters play an important role in an economy that demands concentration and specialization and the practical ability to develop initiatives that help firms within clusters become more competitive and spur growth.

The purpose of this paper is to help regional leaders focused on economic development confidently and knowledgeably embrace cluster initiatives where they make sense, and, where they do not make sense, recognize that there are potentially equally powerful alternatives. This paper draws on a literature review, interviews with cluster experts, and five in-depth case studies that reflect successful, if exceptional, cluster initiatives. Specifically, the report covers:

▶ **Why clusters matter: Regional economies grow and decline based on their ability to specialize in high-value industries and then evolve those specializations over time.** The practice of cluster-based economic development aims to capture the economic advantages that accrue for firms when they cluster together in place—what academics call agglomeration. Agglomeration helps firms be more productive through three mechanisms: *sharing* tailored facilities, infrastructure, and suppliers; *matching* workers productively through deep labor markets; and *learning* through dense, knowledge-rich environments that facilitate knowledge exchange and innovation between

interdependent firms. Regions grow based on their ability to provide environments where firms want to cluster. While the drivers of agglomeration are not perfectly understood, several factors appear to matter, including the abilities to: spur continuous innovation; develop dynamic entrepreneurship systems that replenish economies with good jobs; and engage strong local academic, civic, and public institutions that can facilitate these processes. However, there are real headwinds in all these areas that leaders must confront. Even as it is becoming more crucial to gain a foothold in advanced technologies and industries, most regions face narrower pathways to success and more limited investment capabilities, only reinforcing the importance of understanding whether cluster dynamics are viable in a regional economy and making investments large enough to counter these headwinds.

► **Identifying and prioritizing clusters:**
Successful cluster initiatives begin with a combination of data and qualitative analysis to identify and prioritize cluster opportunities in service of broader economic development goals.
Regional leaders can rarely create clusters from scratch, which means that cluster

identification and prioritization must ensure that potential cluster opportunities meet basic criteria. Specifically, clusters contain a critical mass of firms that are geographically proximate and economically interdependent. Of the criteria above, interdependence is the most complex and arguably the most important for understanding how to design interventions. Practitioners can examine at least three sources of interdependency in their regions: industry product and supply chains, occupations, and technological know-how. Moving from identification to prioritization, regional leaders can consider six factors to distinguish between many cluster opportunities:

1. Specialization;
2. Composition of firms (e.g., one big firm or many small firms);
3. Development stage (e.g., potential, emerging, established, declining, etc.);
4. Intensity of inter-firm dependence;
5. Reliance on complex knowledge; and
6. Ability to create inclusive employment opportunities.

This stage of the process may identify that non-cluster interventions are the regions' best bet (see box).

NON-CLUSTER INTERVENTIONS TO SUPPORT GROUPS OF FIRMS

For many U.S. regions, cluster initiatives may not be the most effective strategy to support regional economic development. Therefore, this paper reviews several ways to organize and design interventions for groups of firms beyond clusters (see page 38). Some of these strategies focus on groups of companies that share certain challenges and opportunities based on their stage of growth, such as startups or middle-market companies. More broadly, policies and investments related to process and product innovation, training and skills development, and infrastructure are all viable ways to address the shared needs of firms without relying on a cluster framework.

▶ **Cluster interventions: Beyond identification, scaling and strengthening clusters requires additional work to identify cluster constraints and opportunities, and subsequently the development of market-oriented responses that are able to draw on the capabilities and resources of the cluster's firms.** We explore five potential areas of intervention that could support clusters, each of which could apply to the economy overall but may be more efficiently pursued by targeting a group of firms with uniquely shared challenges and prospects.

1. **Information and networks**: Clusters may suffer from information gaps—both internally and externally—that hinder their potential. Internally, cluster initiatives provide information and research to educate firms and other internal stakeholders about opportunities and priorities for shared action. Externally, evidence-based promotion of clusters can address information failures among firms and investors outside the cluster that may benefit from cluster dynamics.

2. **Talent development:** Cluster-based talent development strategies work with

employers to address specific skills and competencies needed in that cluster. Necessarily, these strategies involve universities, community colleges, and even the K-12 system to develop talent pipelines around in-demand occupations in the cluster.

3. **Research and commercialization:** Firm learning is a foundational aspect of clusters. Research and development activities within universities, other research institutions, and private sector firms may yield more impact if coordinated, which oftentimes requires overcoming different mandates, cultures, and business models between these actors. Cluster intermediaries can help provide this coordination function.

4. **Infrastructure and placemaking:** Investments in tailored infrastructure or real estate may be warranted for several reasons. First, infrastructure itself may be a critical precondition for cluster growth, such as a logistics facility or high-speed broadband connection. Second, interventions related to research commercialization or talent development may require physical investments, such as applied research

labs or training facilities. Finally, an identifiable physical presence can strengthen the cluster's brand identity.

5. **Capital access:** The final intervention in this framework is access to capital, or lack of it. Young firms, which research suggests are critical to driving both innovation and net job creation, need capital to grow. Yet, capital providers may suffer from information gaps that limit their ability to invest in particular clusters, which cluster intermediaries seek to overcome through a "broker function" that connects entrepreneurs to sources of growth capital.

FIVE CLUSTER CASE STUDIES INFORM THIS REPORT

Central Indiana – Central Indiana Corporate Partnership
CICP is a CEO-led "holding company" that houses six distinct economic development initiatives, including cluster initiatives such as AgriNovus (agriculture biosciences) and BioCrossroads (life sciences).

Milwaukee – Water Technology
Led by The Water Council, Milwaukee's water cluster has established the region as a top global hub for innovation and solutions to the world's water challenges.

St. Louis – Agriculture Technology
Driven by BioSTL, the Danforth Plant Science Center, and the St. Louis Economic Development Partnership, St. Louis has focused on the agricultural technology cluster to spur dynamism in the region.

Syracuse – Unmanned Aerial Systems (UAS or Drones)
Drawing on long-standing expertise in radar and sensors, the Central New York region is positioning itself as a leading center for drone testing and innovation.

Upstate, South Carolina – CU-ICAR (Automotive)
The Clemson University International Center for Automotive Research is a 250-acre research and technology campus that anchors Upstate South Carolina's thriving automotive cluster.

▶ **Cluster organizational structures: A review of five cluster initiatives offers critical lessons in how best to organize, launch, and sustain cluster-based economic development.** Across the five case studies, as well as other cluster efforts, three basic models emerge: *cluster hub*, in which one organization acts as the clear lead and driver (e.g., The Water Council (Milwaukee)); *shared leadership*, in which two or three organizations act as highly collaborative joint leads (e.g., Unmanned Aerial Systems (Syracuse) and Agriculture Technology (St. Louis)); and *holding company*, in which one organization leads multiple cluster initiatives (e.g., Central Indiana Corporate Partnership (Central Indiana)).

FIVE TRAITS OF SUCCESSFUL CLUSTER INITIATIVES

Ultimately, the most successful cluster initiatives have five traits:

1. Focused on establishing a robust ecosystem, not quick job gains

Cluster initiatives must be focused on establishing a robust and regenerating ecosystem that produces the innovation, talent, and economic opportunities that firms need to thrive. These initiatives must be first and foremost about the growth and competitiveness of existing firms in the cluster (as well as the needs of related entities, like academic institutions), and not just on job growth.

2. Industry-driven, university-fueled, government-funded

The strongest cluster initiatives are private sector-driven, with interventions catalyzed by groups of firms that believe they will benefit by working collectively to fill gaps in the cluster ecosystem and staff with industry expertise and a collaborative mentality. Research universities provide needed innovation and talent, and public investment is critical. Federal, state, and local governments have made major investments to support each cluster initiative and give it early credibility.

3. Placing a collective big bet on a unique opportunity

The most successful cluster initiatives are in regions willing to place strategic bets on distinct cluster opportunities. These places have a long-term mindset and are unafraid to "pick winners" from the broad array of potential alternatives. They recognize that resources are scarce and competition is high, and that the only way to distinguish themselves is by funneling their energy and investment into a limited number of truly unique specializations.

4. Championed by passionate, dedicated leaders

Individual leaders have proven invaluable in championing each successful cluster initiative. These leaders typically emerge from businesses operating within the sector, driven by a new vision and clear purpose, and/or as CEOs of the lead cluster organizations. They are thought leaders who recognize a unique opportunity, have crafted a compelling narrative, and are willing to dedicate the time needed to launch and sustain a bold cluster initiative.

5. Anchored by a physical center

Most of the cluster initiatives profiled have created a physical center to serve as visible proof that the region is a major hub for the cluster and to provide a space that facilitates knowledge spillovers between firms, academic researchers, and related enterprises. While companies and assets involved in the cluster are often scattered throughout each region, these centers tie them together. These centers may take the form of a single building, an urban district, or a suburban campus. One note of caution: Though real estate development can play an important role in cementing a cluster that is already robust, it cannot create a cluster.

A basic tenet of good economic development practice is that interventions should be organized around addressing the shared needs of groups of firms. This mindset enables regions to approach economic development not as a succession of reactive and opportunistic business attraction efforts, but rather as a series of strategic investments designed to spur self-reinforcing cycles of growth and development. Most regional economic development entities rely on industry clusters as the organizing principles for their work to the point that clusters are practically synonymous with economic development strategy. Virtually every regional economic development strategy has a set of six to eight "priority" clusters at its core.

The ubiquity of clusters makes sense. Clusters have been the focus of a large body of research. Since Michael Porter introduced the concept through his book *Competitiveness of Nations* in 1990, more than 1,350 academic articles have focused on clusters.[1] Porter's research defined a cluster as a "geographical proximate group of interconnected companies and associated institutions in a particular field, linked by commonalities and externalities."[2] Subsequent academic work has documented many benefits for the firms that are part of clusters and the regions that have them. And the concept is easy for economic development organizations (EDOs)

to embrace. Built upon strategy ideas that are familiar to business leaders and illustrated with well-known examples, it offers an appealing way to engage stakeholders while also appearing to be a rigorous science.

The widespread adoption of clusters as an organizing principle for economic development is a mostly positive development. Clusters are simply the reality of how regional economies are organized, and the concept can help EDOs develop industry-specific expertise that enables them to deliver relevant services to firms and strategically attract investment.[3]

But the reality is that regions do not see clusters as just a framework for understanding their economy and organizing programs. The popularity of clusters stems from the idea that *cluster initiatives*—major investments aimed at addressing the growth constraints of a cluster in which the region has a competitive advantage—can change the economic trajectory of a region. When regions embrace clusters, it is because they want to emulate, for example, Pittsburgh's transition from a depressed steel town to a center of robotics innovation. Though these aspirations are often taken to extremes—many regions proclaim a desire to be the "next Silicon Valley"—they are ultimately grounded in reality. As the next section argues, a series of trends are increasingly concentrating economic growth and opportunity in fewer and fewer places. As compared to the agrarian or manufacturing eras, the digital economy appears to demonstrate "winner-take-more" geographic dynamics. There is a justifiable worry among many regional leaders that they are being left behind in an era of uneven growth.[4]

In the context of transformative change, the track record of clusters has been far less positive. A cursory look across today's economic development landscape reveals a glaring gap: For all the compelling and widely-accepted attention given to the concept of clusters over the past three decades, cluster initiatives in U.S. regions have, for the most part, failed to live up to their expected potential.

This failure derives from several factors. Regions often fail to identify the right clusters, often choosing unrealistic or generic targets like biotech and advanced manufacturing. Many regions only go as far as marketing their clusters to attract businesses, rather than building robust local ecosystems to support the needs of existing firms in the cluster. And many lack the fiscal and institutional capacity to sustain even well-designed efforts for more than a few years. But most, believing that there are no alternatives to organizing an economic development strategy, diligently return to the drawing board every five years to try again.

Thus, as many economic development organizations are currently in the midst of a "remaking" in response to rapid economic change and disruption, cluster-based economic approaches also demand a rethink.[5]

That is the purpose of this paper. We aim to help regional leaders focused on economic development confidently and knowledgeably embrace cluster initiatives where they make sense, and, where they do not make sense, recognize that there are potentially equally powerful alternatives. We will have succeeded if fewer regions fall into the trap that most currently do—making inconsistent and ineffective investments in four or five clusters at once, or a major investment in an ill-conceived, aspirational cluster that has little chance of gaining traction. Our core argument is that cluster initiatives are a potentially powerful, but not universally applicable, basis for strategy, and that successful ones require economic development leaders to correctly identify clusters, prioritize few enough that they are able to make focused investments in them, design interventions that matter to firms, and create organizational structures that enable public-private collaboration and sustain momentum.

This paper 1) outlines why clusters matter to regional growth and evolution, 2) offers a framework for how leaders concerned with regional economic growth and opportunity should identify clusters and organize their cluster initiatives, and 3) presents alternative models for places that do not have distinct clusters or have economic development objectives that are better achieved in other ways. Accompanying the report are five in-depth case studies that demonstrate how these concepts are applied in successful cluster initiatives in a variety of industries and regions.

I ndustrial specialization and clustering undoubtedly have a role in regional economic growth, which is one reason why the concept receives so much attention in regional economic research and practice. But there are many factors that shape how local economies grow and evolve that must be understood before adopting a clusters approach. This section aims to situate industry clusters within the broader technology and economic trends that contribute to regional economic development.

The practice of cluster-based economic development aims to capture the economic advantages that accrue for firms when they cluster together in place—what academics call agglomeration. The geographic concentration of the U.S. economy exemplifies the power of agglomeration: Currently, about three-quarters of the country's production occurs on just 12 percent of the nation's land. How and where firms and industries situate themselves arises from the pull of agglomeration, countered by the push of associated costs such as higher rents or greater traffic congestion. Economists argue that the benefits of agglomeration to firms occur through three foundations: *sharing, matching, and learning.*[6]

The first foundation involves the benefits that arise from the *sharing* of various inputs that firms require. These include access to shared facilities (e.g., research labs or logistics centers),

shared supplier bases, and the productivity gains that occur from the specialization that being in a larger market allows. For instance, the scope and scale of the movie industry in Los Angeles has created a market for shared facilities, such as studio lots and specialized suppliers, focused on diverse activities, from digital animation to entertainment contract law. The industry's large presence creates enough demand for these specialized suppliers to perfect a specific niche activity, which in turn yields greater productivity within the cluster.

The second foundation of clustering is *matching.* The larger an industrial cluster, the better chance of matching workers with the jobs in which they can maximize their productivity. Take Washington, D.C.'s public policy and lobbying cluster, for instance. Only in Washington, D.C.– where the federal government creates such a large policy research cluster–could professionals

expect to make such seamless transitions between government, lobbying groups, trade associations, and think tanks. A similar dynamic occurs with computer scientists in Silicon Valley or auto engineers in Detroit.

The third foundation of clustering is *learning*. To create new products and services, firms and people must acquire new capabilities.[7] For decades, economists have argued that environments that cluster different types of firms and people are more likely to experiment and innovate.[8] Moreover, once new knowledge is generated, it is more likely to spread through the economy if firms and people are nearby.[9] These spillovers help people and firms develop new capabilities, which in turn spur economic growth.[10] Clusters are both an outcome and a facilitator of individual and firm learning.

Economic activity will concentrate if firms benefit from sharing, matching, and learning, and it will go elsewhere if these agglomeration forces weaken. The U.S. economy has undergone several industrial cycles in which this phenomenon takes place. During the Industrial Revolution and through the first half of the 20th century, manufacturing concentrated intensely in the Northeast and Midwest. However, as manufacturing products and processes became more rote and transferable, these activities spread to the American South and eventually abroad, mainly to East Asia.[11] Accelerating the geographic spread of manufacturing was a company-level focus on core competencies, with multinationals outsourcing certain activities to suppliers with different capital and labor requirements and costs. This firm restructuring contributed to an increase in clustering by business function, where cities began to sort themselves into "headquarter towns," "logistics centers," or "production hubs."[12]

In his book, *The Keys to the City,* Michael Storper posits that the regions that manage to continually benefit from agglomeration throughout these cycles do so by effectively specializing, adapting, and respecializing.[13] While

there is still no consensus among economists about what conditions best allow for this, there are a few hints. Regions need to specialize to drive productivity, but successful regions seem to specialize in a certain way. Rather than specializing in a single industry, regions that experience robust job growth tend to have a presence of economic activities that are related enough to allow for effective specialization but offer enough variety that they can evolve into new industries and activities should the old ones experience decline.[14] For example, Detroit's decline was both attributable to the decline of the auto industry *and* the lack of a new growth industry to replace it. Silicon Valley, on the other hand, has experienced many cycles of industrial decline (e.g., computer manufacturing, semiconductors, etc.), yet has always found a new but related set of activities that generate the next growth cycle (e.g., software development, artificial intelligence, etc.).

How this evolution occurs is still somewhat of a "black box," but several factors clearly matter. The ability of regions to support the creation of young, high-growth firms seems to be particularly important, as these are the vehicles for innovation and the quality job creation that results.[15] Sometimes these high-growth ventures spring up out of nowhere, but more often they branch out from an existing trunk of local knowledge and capabilities. Entrepreneurship rates, for example, are higher within a region's existing industrial clusters than in the economy as a whole.[16]

Institutions and infrastructure matter as well. A region's schools, universities, and research centers determine the quality of workers and the amount of local innovation. A region's physical and digital infrastructure shapes how workers connect with businesses and how businesses connect with each other. And the networking, information exchange, and collective action enabled by civic institutions—such as chambers of commerce, business leadership organizations, and industry associations—can shape a region's resilience to shocks by galvanizing

and activating leadership networks to address shared challenges.[17]

In sum, local economic development demands effective specialization and respecialization, driven by innovation, entrepreneurship, and strong institutions. However, there are headwinds to U.S. regions, especially small regions, in all four areas.

First, economies are becoming more specialized by function and less specialized by industry, which is providing greater economic rewards to those regions that can gain footholds in the most advanced functions in the economy, such as technology, corporate management, and finance.[18] As mergers and acquisitions have concentrated headquarter functions into a few global cities, fewer mid-size American cities can claim to be command and control centers of major global companies.[19]

Second, some economists argue that new innovations—the development of ideas, products, and processes that improve productivity—are becoming less impactful than they have been in previous centuries, curtailing growth.[20]

Third, entrepreneurship has been undergoing a long-run national decline. That national view, however, disguises how new firm creation is becoming increasingly concentrated in large places, allowing them to replenish their economies while smaller cities and rural towns become less dynamic.[21]

Fourth, the quality of local institutions, while moldable, varies considerably across cities and regions as well.[22] Quality institution-building often arises from uniquely capable leaders, and there remains little clear guidance on how to create and steward effective institutions in service of robust firms and industries that lead to broadly shared economic growth.

The result of these trends is that, even as it is becoming more crucial to gain a foothold in advanced functions and industries, most regions face narrower pathways to success. This only reinforces the importance of understanding local cluster dynamics and then ushering investments and policies in a coordinated approach.

III. METHODOLOGY AND CASE STUDY SELECTION

This project deployed several research methods. The report reflects insights gathered from interviews with many of the foremost academic experts on the subject of clusters and economic development, extensive review and synthesis of relevant research published over the past three decades, and the lessons from Brookings research and extensive engagements in cities and metropolitan areas. This base of research led to the identification of five exemplary cluster initiatives that further informed this framing paper and, through detailed case studies that accompany this paper, illustrate applications of its findings.

The five case studies were selected primarily on the basis of their sustained success in fostering the growth and development of specific clusters. The selection was also driven by a desire to illustrate a variety of interventions, organizational models, and funding sources in regions of differing size and economic trajectory. Two of the case studies Central Indiana and Upstate, South Carolina are primarily focused on the key organizations at the center of their respective cluster initiatives, whereas the other three case studies are focused on the entirety of the cluster. This is to ensure that, taken together,

the case studies capture important details about effective lead organizations, but also a broader view of the variety of actors that collaboratively make cluster initiatives work. The case studies are:

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▶ **Milwaukee – Water Technology:** Led by The Water Council, Milwaukee's water cluster has established the region as a top global hub for innovation and solutions to the world's water challenges.

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▶ **Upstate, South Carolina – CU-ICAR (Automotive):** The Clemson University International Center for Automotive Research is a 250-acre research and technology campus that anchors Upstate South Carolina's thriving automotive cluster.

TERMS | REGION AND EDO

Throughout this paper, the term "regions" is used to describe the primary groups of organizations and leaders involved in developing economic strategies for the metropolitan area, such as elected officials, chambers, economic development groups, trade associations, universities, and philanthropies. "EDO" is specific to state and regional economic development organizations and practitioners.

How clusters are defined—meaning the framework and technique used to understand how firms depend on one another—matters because the interventions required to strengthen a group of firms bound together by supply chain relationships are different than the interventions required to strengthen a group of firms bound together by occupational similarities or shared technological expertise. In other words, a cluster strategy can fail if the cluster itself is not properly understood. And prioritizing clusters—determining which one or two clusters in a region have the most growth potential and best align with economic development goals—matters because, as the case studies accompanying this paper demonstrate, supporting a cluster can be expensive and time-consuming. Many cluster strategies fail because regions spread resources that would barely be sufficient to develop one cluster across four or five.

This section offers a framework to help economic development leaders identify which clusters exist (if any) and decide which of those should be prioritized for a full-fledged cluster strategy. Because cluster development has been a nearly universally accepted approach to economic development practice for so long, many practitioners believe that they already know their clusters and have well-established priorities. Therefore, this section begins by outlining the conventional wisdom and flawed assumptions that undermine many cluster initiatives long before interventions have been designed or implementation has begun.

COMMON MISTAKES

Starting without a goal in mind

Practitioners often assume that identifying clusters is the same as developing a strategy. Without first identifying a broader regional economic development goal, they undertake cluster studies and design strategies, for which the goal is simply to grow the identified clusters. This approach is backwards. Growing a cluster is not a goal in its own right. Rather, clusters are a way to understand what matters to groups of firms in order to create policies and programs that achieve broader economic development goals, which might relate to overall job growth, innovation capacity, or economic inclusion.

There are numerous ways to identify and prioritize clusters; the appropriate method will differ according to what a region is trying to accomplish via cluster development. If a region's goal involves overall job growth, it might identify clusters based on supply chains in order to understand gaps and create a more targeted entrepreneurship or business attraction effort. If that same region instead adopted a goal related to inclusive growth, it might instead identify clusters based on occupational similarities in order to create a better workforce development system. A clear understanding of the end goal is also a prerequisite for deciding which clusters to prioritize. Many regions contain a variety of clusters. There is no scientific answer as to whether it is better to focus on growing an emerging, high-wage industry or reviving an older, larger, relatively low-wage industry. The answer is entirely contingent on the region's broader goals. When regional and state leaders do not have a clear purpose for why they are investing in clusters, they tend to fall victim to the tendency to create a new strategy based on different "trendy" clusters every five years, never making the consistent investments or gaining the deep industry knowledge that make cluster efforts work.

Relying exclusively on data

Most regions assume that the "right" clusters can be identified through analysis of employment and output data. In reality, cluster identification is more art than science.[23] One key problem is that, though clusters involve complex cross-sector relationships that extend both vertically and horizontally, many regions fail to escape the confines of rigid and hierarchical groups of NAICS codes. Any group of related NAICS codes that are large, growing, or specialized are deemed to be a "cluster." Relying on NAICS codes can either overstate the size of a cluster (because firms with a similar NAICS code do not necessarily relate to one another) or understate it (because a cluster may be centered around a few NAICS codes but also draw in a broad network of suppliers). Further, even when used carefully, there are shortcomings in the NAICS system, such as its inability to accurately describe fast-evolving industries or companies that make products that span traditional boundaries.[24] For understanding the complex linkages between firms and sectors, there is no substitute for on-the-ground business intelligence.

Another data challenge is that location quotients (LQ), a measure of specialization, are a predominant method by which practitioners identify clusters, but LQs as a measure, and specialization as a concept, can be misleading. The primary problem with LQs is that there is no clear "cutoff" at which an industry should be considered a cluster: Studies have used values ranging from 1.25 to 3 (indicating, respectively, that the industry is 0.25 to 3 times more concentrated in the region than nationally). Another measurement problem is that, since certain industries are very highly concentrated in just a few regions, a local industry can be a top performer but still have an LQ below one.[25] An industry may have a low LQ but have considerable growth potential because the

market for its products is large, and vice versa. Finally, LQs can be misleading in that a high value might reflect a single large firm rather than a true cluster of related firms. Besides these measurement issues, specialization is potentially misleading from a conceptual standpoint. Specialization comes in two forms, relative and absolute. Many regions focus on relative specializations (industries with high LQs) when there is reason to believe that absolute specialization (industries that are large, but because they are in large metro areas are not ranked as highly in terms of LQ) matters more to regional outcomes, such as higher wages.[26]

Confusing clusters with target sectors

Most regions are unwilling to truly prioritize among potential clusters. This is in part due to the justifiable desire to create a diversified economy. Another major factor, however, is political pressure. This can take the form of "bottom-up" pressure from major employers or industry groups exerting influence on the selection process (out of concern that being left out will deprive them of public resources or attention) or "top-down" pressure from political leaders that may fear the reaction of those firms or may have ulterior motives for including certain clusters. The outcome is that most regions claim six to eight industries in which they have some specialization as priorities or targets. These targets are often understood to be clusters, though usually most of them are not. The target industries are either too small to truly exhibit cluster dynamics (defined later in this section) or are so broad as to be meaningless to the firms that are purportedly part of them ("advanced manufacturing" is a common example).

In theory, there is little downside to having many targets. Economic development organizations should have a broad understanding of the local economy, and the marginal cost of doing marketing for one additional industry is small.

But the danger is that, after publicly committing to targeting six to eight industries, EDOs feel compelled to spread limited funds and attention equally among them. (These "targets" often encompass half or more of the traded-sector economy.) Given resource constraints, this prevents practitioners from gaining an adequate understanding of any one cluster or making investments large enough to change the trajectory of the cluster. Actually identifying clusters that can form the basis of an effective strategy requires moving beyond targets and picking one or two specific priorities (some of which may be components of broader targets or combinations of smaller targets).

Trying to create clusters from scratch

Clusters cannot be created by force of will—virtually every successful cluster has emerged from entrepreneurial activity that relates to some historical industry strength in the region. Yet, mistaken assumptions that economic development strategy must revolve around clusters and measurement errors that give places a false sense of strength in certain industries can lead regional leaders to chase fads in which they have no real specialization or asset base. Biotechnology or life sciences is a common example—many regions add hospital employees to their cluster definitions to claim they have specializations in these industries, which are in fact highly clustered in just five to ten cities. This has resulted in many futile and expensive efforts to grow local biosciences industries. In the few cases in which clusters might be said to have been created from scratch, the process either required several decades of sustained, strategic government investment (such as North Carolina's life sciences investments in Research Triangle Park) or major incentives for firm attraction (such as the automotive cluster in South Carolina). These approaches are increasingly unrealistic, however, as firm relocations have declined and incentive deals have become more expensive.

Presuming that clusters exist

The concept of clusters is flexible enough (or is at least widely understood to be) that nearly any region that begins with clusters as the predetermined foundation of a strategy can easily stretch the definition until several plausible examples emerge. But not every group of similar firms is a cluster. By failing to distinguish between the two, regions end up pursuing unrealistic and expensive cluster initiatives without considering more efficient and effective non-cluster interventions.

NON-CLUSTER APPROACHES

A key point of this paper is that where cluster dynamics exist, investments in them can be a powerful economic development tool. Where the underlying conditions are absent, however, attempting to build a cluster can be an extremely expensive and high-risk prospect. In part for this reason, there is no shortage of skepticism among academic experts about the efficacy of cluster strategies. This paper, therefore, seeks to provide strategic alternatives to cluster-based approaches. These alternative approaches are relevant to all regions, but especially to those that do not find strong clusters based on the guidance below. The section describing non-cluster approaches is at the end of this paper.

IDENTIFYING CLUSTERS: BASIC CRITERIA

Many regions assume that strategies must be based on clusters, so they begin the strategy process by conjuring clusters from the data without first establishing basic boundaries for determining whether a group of firms truly is a cluster. Since clusters generally cannot be built from scratch, it is important that practitioners attempt to distinguish between a seemingly similar group of firms and a true cluster. The basic criteria for a cluster are that it must contain: (a) a critical mass of firms that are (b) geographically proximate and (c) economically interdependent. There is much debate as to what constitutes the minimum threshold for each of these criteria. This section offers some guidelines.

Scale

There is no consensus as to how many firms are needed to make a cluster. Cluster initiatives have been built around groups of fewer than 10 firms.[27] Some argue that critical mass occurs when a core group of firms has attracted specialized suppliers, but there are also no universal criteria for how many of these are needed to qualify as a cluster. Others emphasize that a cluster must contain not only firms, but also institutions that address their shared needs.[28] Some point out that scale should be examined in concert with other criteria—the eagerness of firms to work together, for example, can trump scale.[29] Thus scale is a fundamental yet fuzzy criterion. As one report states, "one knows sufficient critical mass when one sees it...a precise definition is not possible—and perhaps not even necessary."[30] Ultimately, the scale of a cluster may matter most for prioritizing rather than identifying clusters: Assuming that a set of clusters meets the other basic criteria, size should act as a tie breaker (on the basis that the fixed costs of designing and implementing programs should be spread across the highest number of firms).

Proximity

Clusters are built on information spillovers between workers and firms, so the geographic scope of clusters tends to align with labor markets (i.e., metro areas). While the most obvious connections between firms are sometimes confined to subregional areas (e.g., knowledge spillovers around a university) or expand across states (e.g., automotive supply chains), regions are usually the appropriate scale for understanding a cluster and its needs. Nevertheless, governments tend to claim, for political reasons, that clusters exist at geographic scales that are too restrictive (city and county) or too expansive (states).

Interdependence

Interdependence does not refer to firms that simply cooperate or network in some way; it refers to firms that gain a competitive advantage from being near related firms. According to one definition, "a 'cluster' comprised of enterprises that gain no real economic advantage from their presence in the group loses all conceptual

meaning from a theoretical and policymaking perspective."[31] The economic interdependencies between firms can be described as vertical or horizontal. Though strong clusters contain both vertical and horizontal relationships, industries that draw on similar skillsets are often not related through supply chains, and vice versa.[32]

▶ Vertical: group of trading partners (including customers) that may draw upon very different labor pools, technologies, and inputs. Spans production, distribution, R&D, and headquarters. Case example: multinationals and their component suppliers and specialized service providers around BMW in South Carolina.

▶ Horizontal: group of firms, often competitors, that produce related products and operate at the same stage of the production process; may not formally cooperate or transact, but draw from a similar labor pool or rely on similar technology. Case example: startups producing agriculture-related technologies in St. Louis.

IDENTIFYING CLUSTERS: THREE TYPES OF INTERDEPENDENCE

Of the criteria above, interdependence is the most complex and arguably the most important for understanding how to design interventions. Determining *how* firms are related is more challenging than identifying whether a group of firms meet the relatively straightforward thresholds for scale and proximity. The forms of interdependency between firms in a cluster are complicated, layered, and dynamic. They include economic exchanges that are measurable to varying degrees, but also difficult-to-quantify factors like trust, culture, and institutions. Broadly, however, there are three basic sources of interdependency that practitioners can search for in their regions: industry product and supply chains, occupations, and technologies. In

larger regions, each of these three approaches might surface numerous, overlapping clusters; in smaller regions, one approach might surface clusters that the other two missed.

This section outlines the rationale for focusing on each of these three sources of clustering, what important dynamics each reveals, and what interventions each might support.

1. Product and supply chains

Rationale: Firms benefit from being part of large and dense product and supply chains. The presence of many customers allows suppliers to specialize and become more productive, while

the presence of many suppliers is efficient for customers. The interaction between suppliers and customers supports rapid learning and joint innovation. Supply chain-based definitions of clusters are the default method for cluster analysis because employment and output data is readily available at the industry level (using NAICS industry codes). This enables assessment of input-output relationships that connect firms across sectors both horizontally and vertically.[33]

Value: This approach reveals important facts about industrial organization, such as whether the structure of the cluster resembles a network of relatively equal firms connected by arms-length transactions or a hub-and-spoke system in which a central firm dictates the "production environment and social system."[34] It is also a starting point for understanding the role of local establishments within their global firms, which is important because multinational firms and their branch plants have more resources and innovate more than smaller, independent firms (and can act as a magnet for attracting suppliers).[35]

Use: The industry-based approach enables regions to understand gaps in value chains, which supports targeted entrepreneurship efforts or business attraction strategies. One example is focusing on what industry functions are prevalent in an area: where there are many branch plants, regions try to build the cluster vertically by attracting related distribution centers, R&D operations, and headquarters. This approach to cluster identification can also support efforts to connect local firms that may have complementarities that they are not acting upon (i.e., matching suppliers and customers, including startups and corporations). Further, understanding the spatial dimension of intra-cluster trade can help regions develop specialized infrastructure. This approach is evident in Upstate South Carolina's efforts to create its automotive cluster, first by attracting BMW and then strategically building out a robust supply chain (including R&D capacity) and related infrastructure investments (such as an inland port).

2. Occupations and skills

Rationale: A region's occupational or skills profile can be a driver of industry growth. According to one analysis of clusters, "human beings are the fuel for any industrial cluster."[36] As evidence, a firm is over 100 times more likely to diversify into an industry that is strongly skill-related to its core activity, compared to an unrelated industry.[37] Recognizing this, and spurred by tightening post-recession labor markets as well as shifting skills demands of industries, economic development leaders are increasingly focused on skills and workforce development to spur business expansion and retention efforts.

Value: Skill- or occupation-based connections between firms are often missed when analysis only relies on NAICS industry groupings as the unit of analysis.[38] One reason is that firms connected through product chains (i.e., with similar NAICS) may draw from very different labor pools, and vice versa. Another is that different locations of a firm with different functions (i.e., headquarters and R&D), and therefore different skills, may claim the same NAICS code. The interdependencies of all R&D operations in a region, regardless of industry, may be stronger than the connections between headquarters, R&D, and logistics establishments that are in the same NAICS industry. In short, the ways in which industries are linked via skills is far more complex and dynamic than hierarchical NAICS systems can capture.

Use: Focusing on occupations enables practitioners to identify groups of firms that could benefit from shared training programs (making it more likely that workforce programs solve a market failure rather than just substituting for firm investments).[39] It also allows economic development organizations to identify which specialized skills a region might focus on developing or attracting—namely those that "are expected to grow, are transferrable to multiple industries, offer opportunities for self-employment and entrepreneurship, and

are a good match to the existing local labor force."[40] The agriculture technology cluster in St. Louis exemplifies this approach. The cluster is not defined by typical NAICS industry groupings or supply-chain relationships, but by the group of firms and institutions that employ the region's 800 plant scientists with Ph.D.s. This understanding gave rise to interventions designed to facilitate the flow of talent between universities, research institutions, multinational firms, and startups. (A related focus on shared workforce needs also gave rise to the region's middle-skill plant science technician training programs and a five-year bioinformatics program.)

3. Technology and know-how

Rationale: Another basis of clustering—one that has received considerable attention by researchers in recent years—is technology, including the tacit knowledge crucial to its adoption and transmission. Firms are especially prone to clustering in emerging, pre-commercialization industries in which "general purpose technologies" are being developed and applied in a variety of fields, and knowledge is not yet codified.[41] In these cases, innovating firms are not "isolated, individual decision-making units" but participants in a dynamic process of learning between suppliers, customers, universities, research institutes, government, and other institutions.[42] Even in more mature industries, firms may cluster together to monitor and imitate innovations produced by rivals, share facilities and equipment, and jointly solve technological problems.[43]

Value: Focusing on how firms cluster around technology reveals crucial non-market learning interactions between firms—and other entities,

such as universities—that make groups of firms more innovative and productive. While it is often assumed that such learning occurs within narrowly defined industries, rather than within true clusters that span seemingly disconnected industries, that is changing: "The increasing complexity and interconnectedness of the modern production system has eroded the value of such conventional industrial groupings and demands an updated approach to industry analysis."[44] Many of the fastest-growing, most coveted industries defy classification (e.g., cybersecurity, nanotechnology, genomics, etc.).[45]

Use: Understanding clusters on the basis of shared technology enables regions to develop industry-relevant research centers, shared lab facilities, and incubators or accelerators. Some states have translated an understanding of the shared technological needs of firms to attract star faculty in fields relevant to local industry and to facilitate R&D partnerships. It also enables regions to employ what European policymakers and practitioners call "smart specialization," an approach in which regions make investments in specific technological capabilities based on (a) the complexity of those capabilities and (b) their relatedness to the technologies in which the region currently specializes. The goal is to develop technologies that are highly complex, but also highly related to current capabilities. Milwaukee's water technology cluster is an example of this approach. The cluster was defined by the dependence of a wide variety of firms (in different industries and with different skills profiles) on a set of basic technologies related to water equipment and services. This understanding of the cluster gave rise to a variety of interventions designed to provide cluster-specific research facilities and facilitate joint innovation.

PRIORITIZING CLUSTERS: SIX FACTORS TO CONSIDER

Some regions may find no clusters based on the above guidelines; others may find too many to realistically intervene at the scale required to make a difference. As such, the process of prioritizing which clusters to invest in is nearly as important as defining them in the first place.

This is a complex process. The typical approach is to prioritize the largest or most specialized clusters in a region. But this is not necessarily always the logical choice. Regions with strong economies, for instance, may have the liberty of making long-term bets on smaller clusters that may be transformative in the future. Choosing to focus on immature clusters may also make sense given that by the time cluster strengths are evident in the data, many are so mature that they are no longer growth opportunities (or local efforts can do little to affect their growth).[46]

Nevertheless, there are several reasons why regions should factor the size or strength of a cluster (measured in various ways) into prioritization decisions. One is that many of the benefits of clusters increase as the size of the cluster increases—larger clusters offer better opportunities for matching between employers and employees or buyers and suppliers. Another is that economic development leaders—along with everyone else—are ill-equipped to predict which industries will be strong in the future, so are safer building on current strengths. Yet another is that the discipline of focusing on existing strengths reduces the temptation to chase after trendy industries. Lastly, perhaps the most obvious reason is efficiency—the larger the cluster, the better opportunity it offers to affect the most firms with a single intervention. The following section outlines six key characteristics that regional leaders may look for in their identified clusters to establish priorities.

1. Growth potential and stage of development

It almost goes without saying that growth potential is a chief criteria for prioritizing a cluster. Besides that growth in jobs and investment is the key goal of most EDOs, prioritizing clusters that are likely to grow makes sense given that larger clusters offer more opportunities for sharing, matching, and learning, and are therefore better for firms that are part of them. To assess growth potential, researchers often categorize clusters by their stage of development. Common categories are "potential, emerging, established, declining."[47] These categories do not have strict methodologies or boundaries. They generally combine measures related to growth trends (often measured via shift-share analyses) in addition to other criteria discussed below, such as size, specialization, and composition.

The practical importance of these categories is that they help practitioners to draw a distinction between industries that are currently large and growing (and may therefore seem like obvious priorities, but are actually reaching a stage of maturity) versus those that are small (but are likely to grow and could benefit from cluster interventions). As such, "emerging" clusters are usually considered to be better priorities (there are potential justifications for other approaches, but it is risky and expensive to try to build up a specific "potential" cluster—often a euphemism for a practically nonexistent cluster—or reverse the trajectory of a "declining" cluster). Milwaukee, St. Louis, and Central New York all strongly emphasize the fact that their focus industries are worth prioritizing because they are emerging opportunities in the sense that global demand for water, agriculture, and drone technologies is set to grow rapidly.

2. Specialization

Specialization, as measured by location quotients, is often combined with size to demonstrate the strength of a cluster. Despite the problems associated with LQs, discussed above, specialization is nevertheless a key indicator of an industry's export orientation as well as how unique a region's business environment is for certain firms—which in turn points to how easy it might be for a region to maintain or secure its position as a location of choice. While nearly every region makes claims about specialization to justify prioritizing certain clusters, this was a particularly prominent part of Central New York's justification for focusing on drones. The region focused on the opportunity to take a long-standing but somewhat intangible technology strength and, through major infrastructure investments, clearly positioned itself as one of a few specialized hubs of drone research and testing.

3. Structure/composition

Many measures of cluster strength—such as size or specialization—fail to reveal anything about the structure of a cluster, which has considerable influence on how the cluster contributes to regional outcomes. Clusters dominated by a few firms are less conducive to the creation and growth of startups and can even keep small firms from benefitting from cluster dynamics like knowledge spillovers and labor pooling.[48](And large firms are typically less in need of regional intervention than small firms.) Clusters comprised of R&D and headquarters operations in a given set of industries are likely to pay higher wages than those comprised of branch manufacturing or logistics operations. Therefore, regions may want to prioritize clusters that are smaller or less specialized, but concentrated in higher-value activities. The structure of St. Louis' agriculture technology cluster—R&D operations of foreign-based multinational firms, leading research institutions, and high-tech startups—is

far more frequently cited than any measure of size or specialization, for example.

4. Intensity of relationships

Though a cluster does not require active, intentional interaction among the "members" of the cluster (value chain and occupation-based clusters can rest largely upon arms-length transactions), it aids considerably in the development of a cluster to have a dedicated core of energized members that have a shared trust, culture, narrative, and sense of membership. This culture cannot be easily engineered and usually requires dedicated institutions (often industry groups) to foster and maintain these relationships. The fact that local firms were largely responsible for catalyzing Milwaukee's water cluster effort made it possible for the region to make it a priority (alongside much larger clusters).

5. Complexity and relatedness

Clusters that are built upon highly complex knowledge are valuable because such knowledge is less geographically mobile (because it is held tacitly in the patterns of interaction between local workers), and therefore forms the basis of a more durable regional advantage. Recent research emphasizes that countries—and presumably regions—evolve by constantly branching into new products that are related to those they already produce.[49] Thus, clusters built upon knowledge that is highly complex, but related to existing regional strengths, should be prioritized. In prioritizing the water technology and drone clusters, Milwaukee and Syracuse both focused on the opportunity to evolve from historical strengths (in brewing/tanning and radars/sensors) into more complex and higher-value applications. Similarly, Upstate South Carolina has begun positioning its historical strengths in textile manufacturing, combined with its current auto manufacturing specialization, as the basis for an advanced materials specialization.

6. Inclusion

Growing concerns about the disappearance of middle-wage jobs mean that more regions are beginning to not only prioritize industries with the most potential for overall output (many of which rely largely on highly-skilled workers), but also those that are the best matches for specific sub-populations of people lacking opportunity. A number of studies have emerged that rank different industries based on their propensity for upward mobility, or relatively high pay for relatively low-skilled workers.[50] In justifying its focus on the drone industry, for example, Central New York emphasized the fact that the industry offered good middle-wage job opportunities because, while the industry is centered on knowledge-intensive R&D-oriented operations, there is also a broader manufacturing supply chain within the region.

V. CLUSTER INTERVENTIONS

While identification and intervention constitute different sections of this report, these stages are integrated, not a linear process in which identification is isolated from the practicalities of intervention. How an analyst chooses to identify (e.g., product and supply chains, occupations, technologies, etc.) and categorize (e.g., emerging, developed, declining, etc.) clusters matters for strategic interventions that support the cluster. It also reflects that the best organizations and initiatives are constantly analyzing what is happening within their cluster against dynamics in the broader marketplace to determine whether strategic adaptations are required.

More than simply identifying clusters, scaling and strengthening them requires additional work to determine what is constraining—and/or what opportunities there are to enhance—cluster competitiveness and to develop market-oriented responses that are able to draw on the capabilities and resources of the cluster's members. This section provides a framework for cluster interventions, drawing on examples from the five case studies.

Any cluster-based economic development strategy must be able to answer these basic questions, which is not achieved by simply identifying the existence of a cluster. What is the opportunity? What is constraining that opportunity? Does it make sense to address constraints collaboratively?

Indeed, it may be the case that there are clear opportunities to intervene to support a cluster, but the competitive dynamics among employers prevent collaboration around shared priorities. Alternatively, a strong and thriving

cluster may have few constraints to its growth and development, and therefore producing no need for intervention. In practice, there is rarely *nothing* to be done in regards to a cluster, but answering this question forces strategists to prioritize clusters based on their economic importance, the upside of grasping new opportunities, and the severity and solvability of existing constraints that limit the cluster's ability to achieve new opportunities.

In this section, we explore five potential areas of intervention that could support clusters[51]:

► Information and networks,
► Talent development,
► Research and commercialization,
► Infrastructure and placemaking, and
► Capital access.

Constraints and opportunities in each of these could apply to the economy overall, but may be more efficiently addressed by targeting a group of firms with uniquely shared challenges and prospects. Throughout this section, we highlight examples from five in-depth case studies on cluster initiatives.

INFORMATION AND NETWORKS

Clusters could suffer from information gaps in two key ways. The first is internal information gaps. Even though a cluster exists, individual firms that together form that cluster might be unaware of related companies or of the advantages that more intentional collaboration could yield. Cluster identification analyses and cluster road mapping both attempt to solve this conundrum. In Milwaukee, identification required a new, more granular firm-level study to uncover the true extent of the water cluster in the first place, which was hidden in traditional NAICS-code analyses. This information was a notable catalyst for the cluster's identification as well as in determining which companies could support and benefit from cluster interventions.

In Indianapolis, the life sciences cluster was a known advantage, but subtle information gaps were still present. A combination of detailed industry reports by Battelle and focus groups led by BioCrossroads uncovered underutilized technological capabilities and a set of shared interests that justified joint research efforts between Indianapolis' leading life sciences companies and universities around nutrition and metabolic diseases.

The second is external information gaps. Key stakeholders operating outside of the cluster—

or even the region or country—also experience a lack of information. Regional investment promotion activities seek to overcome these failures by raising awareness about investment and partnering opportunities within a cluster.[52] Similarly, local firms within a cluster may have limited knowledge of export opportunities outside their local and national economies. Economic development organizations seek to overcome these external information gaps through marketing, promotion, business attraction, and export assistance programs. The Water Council in Milwaukee has been particularly adept at positioning itself as a global water hub, along with Tel Aviv, Singapore, and Amsterdam.

Information gaps may also limit awareness about cluster opportunities among external stakeholders within the region or state that are needed to support cluster investment. In response to such dynamics, CICP's agriculture biosciences (agbiosciences) initiative Agrinovus has developed a public campaign called #timetotell to amplify the changing nature of the state's agriculture industry and its increased reliance on technology; highlight new, well-paid career opportunities; and promote the state as a center of not only traditional farming and food production, but also research and development.

TALENT DEVELOPMENT

Workforce quality greatly shapes firm decisionmaking. One of the dynamics that creates industry clusters is the desire among firms to share deep pools of labor that regenerate the base of knowledge within the cluster. Two of the three foundations of clusters—matching and learning—sit fundamentally at the intersection of workers, employers, and education and training systems.

Yet, mismatches still occur within labor markets. According to the Manpower Group, the share of U.S. employers reporting workforce shortages in 2016 increased from 32 percent to 45 percent, the largest increase of any large nation surveyed.[53] Part of this derives from the more advanced skills requirements for new jobs: Two-thirds of jobs now require at least some postsecondary degree or credential. And part of it arises from the inability for education and training institutions and employers to align themselves around core skills and competencies demanded in the marketplace.

In response to these dynamics, education and training policies are shifting to be more "job-driven," "work-based," and "employer-relevant." Organizations like the National Fund for Workforce Solutions have spent decades building up a network of sector-based workforce development initiatives that focus on training for high-demand occupations in growing sectors, with the recognition that aligning training programs across groups of firms with similar skills needs would aggregate demand and make it justifiable to invest in resources to train workers.[54]

Cluster-based talent development is a close offshoot of these broader sector strategies. In Upstate, South Carolina, for instance, the Clemson University's International Center for Automotive Research (CU-ICAR) has addressed very specific skills needs in automotive engineering. This program is the first of its kind in North America to cover a comprehensive set of competencies in automotive design, systems, and electronics at the master's, Ph.D., and certificate levels, and is now stretching deeper to build a homegrown pipeline of automotive engineers within the K-12 system.

Talent attraction is also a component of Upstate South Carolina's strategy, specifically through the recruitment of elite faculty through industry-endowed chairs by firms like BMW and Michelin. This investment in leading scientists helps ensure CU-ICAR's training is industry-relevant and at the vanguard of major technologies, such as autonomous driving, advanced sensing systems, human-robot interaction, and intelligent manufacturing.

In Indiana, each of the individual cluster initiatives within the Central Indiana Corporate Partnership—whether focused on life sciences, agbiosciences, or advanced manufacturing and logistics—has a talent component, but CICP felt it was important to launch a separate initiative to align employers with educational institutions. Still in its pilot phase, Ascend Indiana has recruited 39 employers and 14 higher education institutions and has begun providing tailored talent pipeline strategies with three employers.

RESEARCH AND COMMERCIALIZATION

One of the foundations of clusters is firm "learning," meaning that firms and individuals learn from one another through knowledge spillovers that are more likely to occur with close physical proximity. Universities and other research institutions are significant sources of knowledge that could be valuable for firms. Yet, as Orjan Solvell observes, clusters may contain a "research gap" that limits the productive interaction of firms and research organizations, due to different mandates, cultures, and business models.[55]

This intervention area refers to research activities intent on solving a specific industry problem that can be translated into commercial activity. Like workforce development, research and development activities may yield greater impact if coordinated with the priorities of local firms that rely on applied research to innovate. This often requires overcoming the "research gap."

These dynamics exist in St. Louis, where the agtech cluster depends on a healthy ecosystem of basic research, applied research, and entrepreneur-led commercialization. Anchoring that research base is the Donald Danforth Plant Science Center. Founded in 1998, the Center is now the world's largest independent, nonprofit plant science research center, with funding from dozens of corporate, philanthropic, university, and government partners. It employs 170 scientists, each of whom is given 20 percent of their time to commercialize their research.

INFRASTRUCTURE AND PLACEMAKING

Infrastructure—roads, bridges, transit, airports, broadband, and real estate—supports economic development broadly. But it is also being increasingly deployed in service of supporting and stimulating economic activities within specific industry clusters. At least three reasons are used to justify investments in tailored infrastructure and real estate development—with an intentional focus on placemaking—in service of clusters.

First, infrastructure itself may be a critical precondition for cluster development and growth. For instance, Central New York applied for state funding to build the necessary infrastructure to distinguish the region from national competitors in drone testing. One piece of infrastructure is particularly critical. The region is creating an unmanned aerial systems (UAS) traffic management corridor, an area (which will ultimately cover 50 miles) equipped with sensors that create an air traffic control system for drones. It will enable companies to run tests involving the integration of multiple drones in commercial airspace and generate data that can be submitted to the Federal Aviation Administration (FAA) in order gain certification for commercial operations.

Second, executing interventions related to research and commercialization or talent development may require tailored infrastructure and real estate development. For instance, the wet lab space provided at the Indiana Biosciences Research Institute (a key initiative of CICP), CU-ICAR's automotive testing facilities, the Global Water Center's co-working spaces, and St. Louis's greenhouses and other shared equipment at Bio-Research and Development Growth (BRDG) Park all represent physical investments that exist for the benefit of multiple firms within the cluster and that individual firms do not have the incentive to invest in themselves. In other words, to solve the coordination failures within the cluster, these interventions required new spaces oftentimes

stocked with state-of-the-art equipment. These developments oftentimes seek to facilitate networking and knowledge spillovers by densely collocating buildings and infrastructure in a designated area that have transportation connectivity to the rest of the city or region. [56]

Third, cluster initiative leads expressed more intangible value in having a "center of gravity" for a local cluster. Beyond simply infrastructure investment, the physical design, or "sense of place," of a cluster-oriented district or technology center may also influence the

extent to which different actors in the cluster interact on joint research and ideas exchange.[57] These physical spaces are both an outcome and an enabler of clusters. Whether 16 Tech in Indianapolis (an innovation district which the Indiana Biosciences Research Institute will anchor), CU-ICAR in Greenville, the Global Water Center in Milwaukee, or the emerging 39 North District in St. Louis, the cluster initiatives profiled in this report all tend to have an identifiable physical presence that allows stakeholders to "witness and experience the cluster in action."

CAPITAL ACCESS

The final intervention in this framework is access to capital, or lack of it. Young firms, which research suggests are critical to driving both innovation and net job creation, need capital to grow. Yet, capital providers may suffer from information gaps that limit their ability to invest in particular clusters, particularly those that are geographically distant from the cities that concentrate investment companies.

Geographic disparities in access to growth capital are easy to pinpoint, but there are debates about the best ways to intervene and address them. In the case of CICP's BioCrossroads, facilitating access to capital for young firms was critical to building a local environment in which smaller, more entrepreneurial companies could grow. To do so, BioCrossroads created the for-profit BC Initiative, which houses three seed funds for biotechnology and medical technology growth companies. As Anne Shane, a key civic leader in Indianapolis, put it: "Money on the table made it real."

More often, capital access interventions in clusters will involve an intermediary that serves a "broker function," connecting entrepreneurs to sources of growth capital, business acceleration services, and other relevant

networks. These efforts relate to broader aims to build entrepreneurship ecosystems, including incubators, accelerators, networking events, and coaching and mentoring. One example is BioGenerator, the investment arm of BioSTL, which has been a critical investor in life sciences and agricultural technology in St. Louis. BioGenerator gets involved with firms before they are ready for investment and can invest multiple times in a company, from seed to final "bridging" rounds that help firms access major institutional capital. In total, BioGenerator has invested $19 million in 73 firms, with agtech making up 20 percent of its portfolio. BioGenerator's funding comes from a mix of public, university, corporate, and philanthropic institutions.

In Syracuse, CenterState CEO (regional EDO) has launched GENIUS NY, an accelerator focused on the drone industry. It works with cohorts of six companies (admitted via competitive process) for a year. In addition to funding, companies are provided stipends and access to mentors, service providers, customers, and distributors. GENIUS NY is supported by $5 million from Empire State Development, New York state's economic development agency.

CLUSTER INITIATIVE INTERVENTION MISTAKES

Economic development organizations often struggle to move from cluster identification to strategic implementation that improves the competitiveness and productivity of the cluster's firms. One reason is that cluster strategies focus their day-to-day activities too much on business attraction and promotion and spend less time focusing on the needs of firms already in the region. Business attraction is not unwarranted, and it can be useful to build on cluster strengths. But transformative cluster strategies–or at least the ones profiled here–tend to do much more. This relates to the second reason many initiatives struggle: a lack of resources that enable large investments over a sustained period. The cluster initiatives profiled have been making sustained investments for at least a decade, and they acknowledge that success is not guaranteed. The reality is that transformative economic development agendas must be well-resourced and operate on a time horizon that extends beyond political cycles and even business cycles.

VI. ORGANIZATIONAL STRUCTURES FOR CLUSTER INITIATIVES

The five case studies produced for this project represent some of the most successful cluster initiatives in the United States. Thus, they offer critical lessons in how best to organize, launch, and sustain cluster-based economic development. The examples share several structural characteristics that contribute to their success: shared vision and strategy, strong leadership, enthusiastic private sector engagement, and a high level of collaboration and trust among the core players involved. There are, however, important differences in the specific organizational structure of these efforts. Across the five case studies, as well as other cluster efforts, three basic models emerge. The two most common are: 1) a cluster hub, in which one organization acts as the clear lead and driver; and 2) shared leadership, in which two or three organizations act as highly collaborative joint leads. A third model   the cluster "holding company" is notable but unique (the Central Indiana Corporate Partnership is the only example of this approach to our knowledge).

MODEL 1: CLUSTER HUB

In this model, one organization serves as the clearly designated hub and driver of the cluster, pushing the local economy towards a shared vision, acting as a thought leader and convener, coordinating existing assets, ensuring a collaborative environment, managing its own programs and initiatives to fill important gaps in the system, and strengthening and championing the case for the cluster locally and in targeted markets. The boards of these organizations often include leaders of the private, public, academic, and not-for-profit sectors that serve as members or strong supporters.

The Water Council in Milwaukee provides a prime example of this structure. Its early founders believed that someone in the region needed to wake up every day with a laser-like focus on the water cluster and ensure a robust, collaborative, and highly functioning ecosystem. It couldn't be another group's second priority. So, in 2009, The Water Council officially incorporated as a 501(c)(3), corporate-led, and self-described *industry cluster driver*. The difference between The Water Council and

a traditional industry association is that it has public sector investors and a true economic development mission, not just membership services. Its primary members are water technology companies, academic institutions, and local and state governments. Its core mission focuses on talent, technology, and economic development. The Water Council manages a number of important cluster programs and works closely with other cluster leaders, such as UW-Milwaukee's School of Freshwater Sciences and The Global Water Center.

Since 2010, The Water Council has grown to include 11 full-time staff, 185 members, and a 22-person board representing leading business, government, academic, and nonprofit actors. Its 2017 operating budget was $2.84 million, with revenue coming from grants, contracts, and contributions ($1.4 million); membership ($665,000); sublease of space at the Global Water Center ($526,000); the annual Water Summit ($202,000), and other activities ($44,000).

MODEL 2: SHARED LEADERSHIP

In this less structured model, two to three organizations work together to serve as the leading drivers of the cluster, with engaged participation from other state and local groups. A strong, shared vision and strategy; collaborative, trustful environment; and standing committees reduce the need for a hierarchical or highly formalized structure.

The **Unmanned Aerial Systems** cluster in Centerstate, New York is led jointly by three key entities: CenterState CEO (regional EDO), NUAIR Alliance (industry organization), and Empire State Development (state EDO). Though CenterState coordinated the early planning and FAA designation efforts, regional leaders claim

the strategy has gained traction because it does not *belong* to any one organization. While each organization has a high sense of ownership, they are held together by a strong central strategy that is universally recognized. Ongoing planning and engagement is led by the UAS Work Group, a standing committee (overseen by the regional council organized by the state EDO) that meets monthly. It includes firms and universities along with state, regional, and local EDOs. NUAIR Alliance and CenterState each handle execution of specific initiatives. Staffed by industry experts, NUAIR possesses the technical knowledge required to oversee infrastructure-related initiatives. CenterState, meanwhile, manages the GENIUS NY accelerator, given its

entrepreneurship experience and mandate. CenterState is also responsible for an array of wrap-around economic development services (marketing, events management, business expansion and attraction).

The **Agriculture Technology (agtech)** cluster in St. Louis is led by a highly collaborative group of organizations—primarily BioSTL (bioscience industry organization), the Danforth Center (world's largest nonprofit plant science research center), and the St. Louis Economic Development Partnership (regional EDO)—without strict, clearly delineated functions. The ability of these and other organizations to collaborate effectively without a single driver or hierarchical structure is largely enabled by existence of the BioSTL Coalition, a standing committee convened by BioSTL, which includes mostly private sector representatives but also an increasing number of public sector actors, including the mayor. It serves as the primary venue for setting the strategic vision for the cluster. This coalition fosters the collaborative and trustful environment that local leaders believe distinguishes it from other similar clusters. The strong and consistent private sector voice ensures that the effort stays focused on building strong companies and gives traditional economic development actors the ability to contribute without having to worry about whether their efforts are visibly driving traditional economic development metrics like short-term job creation.

MODEL 3: CLUSTER 'HOLDING COMPANY'

The **Central Indiana Corporate Partnership (CICP)** is a unique third organizational model. CICP helps drive the region and state's economic agenda by serving as a holding company that develops and stewards priority economic development initiatives (currently six initiatives), each with its own mission, board, resources, and partnership networks. By sponsoring and housing these key initiatives, including BioCrossroads and AgriNovus clusters, CICP provides a well-resourced, connected, and highly supportive structure in which new priority initiatives can gain early traction and ultimately thrive.

CICP operates both as a 501(c)(6) business league entity and a 501(c)(3) public charity (CICP Foundation) and also has ownership stakes in four for-profit C corporations housed within its various cluster initiatives. Across all its initiative, it has a staff of 73 individuals, including consultants. Its board consists of 65 members, including 55 corporate CEOs, three philanthropic leaders, and seven university presidents. The strong CEO presence on the board, experienced and passionate staff, and a strong value placed on thought leadership and market research has allowed CICP to maintain rigor, exclusivity, nonpartisanship, and credibility, while also giving it the ability to make critical decisions and gain champions to help drive the state's economy forward.

CLUSTER ORGANIZATIONAL STRUCTURE: EDOS AND TRADE ASSOCIATIONS

Based on national research for this paper and extensive experience on the ground in metro areas, it is striking how few successful cluster initiatives are housed in or driven by state and local EDOs or industry associations.

On the surface, this is perplexing given that these are typically business-driven organizations with economic development missions. However, the process surfaced simple explanations. Traditional state and local EDOs are hindered by their seeming inability to make truly strategic choices and "pick winners" (feeling the pressure to "prioritize" many sectors with limited resources) and by metrics that force activities to focus almost solely on short-term job creation. This results in a business attraction and sales focus, as opposed to one on innovation, talent development, or building a robust ecosystem. Traditional industry and trade associations are often hindered by their intense focus on membership and advocacy, as opposed to economic dynamism. There are, however, a set of successful and emerging examples. Medical Alley Association has established itself as the hub and driver of the thriving health technology and health care cluster in Minneapolis-St. Paul. CenterState CEO and Empire State Development represent two of three organizations at the center of driving the drone cluster in the Syracuse region.

This raises a key question for further study: Is it the organizational structure that matters most or the culture, leadership, and determination of core organizations? Medical Alley and CenterState CEO are demonstrating that enlightened leadership and nimble, forward-thinking economic development cultures can position EDOs and industry associations as good potential drivers of robust cluster initiatives.

The case studies revealed a number of traits that are woven throughout the most successful cluster initiatives. While many of these traits are touched on throughout this paper, this section captures the five most important overarching takeaways about what makes cluster initiatives actually work. The most successful cluster initiatives are:

1. FOCUSED ON ESTABLISHING A ROBUST ECOSYSTEM, NOT QUICK JOB GAINS

To be relevant to local firms, cluster initiatives must be focused on establishing a robust and regenerating ecosystem that produces the innovation, talent, and economic opportunities that firms need to thrive. These initiatives must be first and foremost about the growth and competitiveness of existing firms in the cluster (as well as the needs of related entities, like academic institutions), and not just on job growth.

Each of the five cluster initiatives is organized to make significant, long-term investments. They have convinced local leaders that once the region has established itself as a globally relevant center for the industry, it will attain a level of gravity that will continuously regenerate the cluster by drawing in and developing new

partners, suppliers, clients, firms, talent, and investment. This is reflected in the way they track impact, which recognizes that these growth outcomes naturally emerge from a robust cluster, but that it takes considerable time and investment to lay the groundwork. None of the profiled cluster initiatives are focused on job creation as a primary near-term goal (and several intentionally avoid talking about jobs at all). Rather, they are focused on making progress on measures such as research output, startup activity, talent development, export activity, collaboration among business and academic institutions, and attraction of grants. Even without making claims about major near-term job growth, all have been able to secure major state and local investments.

2. INDUSTRY-DRIVEN, UNIVERSITY-FUELED, GOVERNMENT-FUNDED

The strongest cluster initiatives are private sector-driven, and the key interventions are directly informed by extensive outreach to firms in the cluster. To varying degrees, the initiatives are catalyzed by groups of local firms that believe they will each benefit by working collectively to fill important gaps in the cluster ecosystem. Leading cluster organizations are staffed by individuals with strong industry expertise who understand industry trends (not just reacting to the near-term needs of individual firms), and are willing to partner and experiment. Another clear marker of successful cluster initiatives is the direct involvement of research universities, which in each of the five case studies provide vital fuel in the form of new innovations, spinoff companies, talent, and partnerships that keep the cluster vibrant.

While industry and academic involvement is readily recognized as a core pillar of successful clusters, what is often overlooked—even by those directly involved in the cluster—is the importance of funding from federal, state, and local governments. This funding is crucial to filling identified gaps in the ecosystem with new projects and programs and providing each initiative with credibility in its early stages. In Milwaukee's water cluster, the state provided $50 million to establish the nation's only School of Freshwater Sciences, while the city of Milwaukee provided $12 million in TIF funds for site preparation for the water district and other economic development support. The city of Indianapolis approved a $75 million bond fund to support site preparation for the 16 Tech district. In Upstate South Carolina, the state (through Clemson) has invested over $100 million in CU-ICAR for campus facilities and research infrastructure. In Syracuse, the FAA designated the CenterState region as one of six national drone test sites, and the state of New York has followed with over $50 million in related investment, with more to come. In St. Louis, the state of Missouri provided $25 million in tax credits to help establish the Danforth Plant Science Center. In addition, each of these initiatives has also been highly successful in securing federal grants from various government agencies to support critical work.

3. PLACING A CALCULATED BET

The most successful and potenially transformative cluster initiatives are in regions willing to stake a claim to a unique and legitimate strength. Leaders in these regions have embraced a strategic, long-term *mindset* and are unafraid to "pick winners" from the broad array of potential alternatives. They recognize that resources are scarce, competition is high, and that the only way to distinguish the region in a noisy global economy is by funneling their energy and investment into a limited number of truly unique specializations with high potential upsides. While some cluster initiatives may not require major investments, transformative change does require a strategic focus.

By focusing on a differentiated and highly relevant cluster, each region is not minimizing the importance of other industry sectors; instead they are establishing a unique identity in one cluster that can serve to open up the market for new opportunities in others. In St. Louis, the agtech cluster provides a compelling way to introduce potential investors to the region's broader technology and innovation strengths. According to Tim Nowak of the World Trade Center, agtech functions as the "tip of the

spear'' in the region's FDI attraction efforts. In Upstate South Carolina, CU-ICAR is exploring how its applied research capabilities in the automotive industry can be applied to other advanced manufacturing and energy industries. Further, the establishment of the Inland Port at Greer and Apprenticeship Carolina, which were

major investments largely catalyzed by the automotive cluster, also provide highly valuable benefits for a wide array of industries. These indicate how assets created in service of one cluster can serve as a platform to benefit other clusters.

4. CHAMPIONED BY PASSIONATE, DEDICATED LEADERS

Passionate, dedicated individuals have proven invaluable in championing each successful cluster initiative. These leaders typically emerge from businesses operating within the sector, driven by a new vision and clear purpose, and/or their positions as CEO of the lead cluster organizations. These individuals are thought leaders who recognize a unique opportunity, have crafted a compelling narrative, and are willing to dedicate the time needed to launch and sustain a bold cluster initiative.

David Johnson, CEO of both CICP and CICP's BioCrossroads life sciences initiative in Indianapolis, is the prototypical regional thought leader. He has more than a full-time job when it comes to running two related but separate organizations—and making sure the sponsors and stakeholders of each are satisfied with the pace of progress and results. But he also knows that an essential part of success for enterprises like CICP comes through his efforts and those of others to build genuine collaboration and

support within the region and across the state, and also to stay engaged with what is going on around the nation and world. He sits on councils of various think tanks (including Brookings) and frequently confers with economic development leaders from other states and regions facing shared challenges in developing effective strategies to drive economic growth at a time of both great opportunity and disruptive change. In Milwaukee, Rich Meeusen, CEO of Badger Meter and Chair of The Water Council, and Dean Amhaus, CEO of The Water Council, are the tireless and driven champions of the water cluster. The tandem is relentless in their branding and promotion of all things Milwaukee water, both in and outside of the region. Together, they identified the opportunity, built a compelling, data-driven narrative to secure critical business and government buy-in, and drove creation of strategic interventions that elevated water technologies from an undiscovered opportunity to a globally relevant cluster in less than a decade.
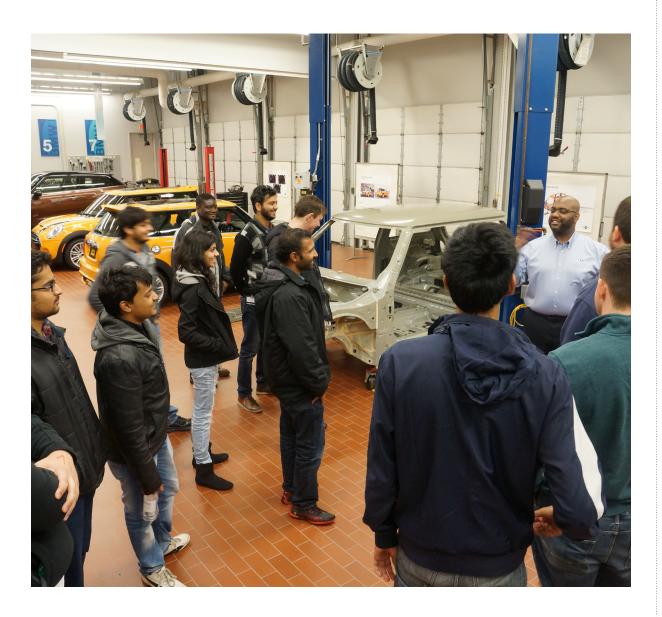
5. ANCHORED BY A PHYSICAL CENTER

Four of the five cluster initiatives profiled for this project created (or plan to create) a physical center where firms, academic researchers, and related enterprises can interact on a daily basis and that serve as physical validation of an already existing cluster. These centers represent the evolution of important cluster building efforts in the region and may take the form of a

single building, an urban district, or a suburban campus environment.

Though clusters are regional in scope, there is evidence that the knowledge sharing and innovation spillovers at their core are facilitated by face-to-face interaction. Therefore, when cluster organizations (intermediaries and

universities) need to select a location for their own operations or to house specialized equipment for firms in the cluster, they typically seek opportunities to co-locate other cluster assets. A secondary benefit is that while companies and assets involved in the cluster are often scattered throughout each region, these centers tie them together in one place and prove useful in establishing a brand identity that funders, investors, partners, and other visitors can experience firsthand. These centers, however, should be approached with caution, especially when it comes to public subsidies.

Though real estate development can play an important role in accelerating the development of a cluster that already exists, it cannot create a cluster.

Examples include Milwaukee's 98,000-square-foot Global Water Center building near downtown for the water cluster; CU-ICAR's 250-acre suburban research campus outside of Greenville, S.C. for the automotive cluster; Indianapolis' proposed 16 Tech district in the city; and the $150 million Danforth Plant Science Center in St. Louis for the agtech cluster.

WHY PURSUE NON-CLUSTER APPROACHES

A region may agree with the basic premise of cluster-based economic development—that economic development is best organized around groups of traded-sector firms, and that understanding industry dynamics is key to delivering relevant services—but decide not to pursue a cluster-based strategy. There are two broad reasons for doing so. The first is that a region may simply not have any viable clusters. There is near-universal agreement that clusters cannot be built from scratch, and there are innumerable examples of failed efforts to do so (and a few success stories, like Upstate South Carolina, which are increasingly difficult to replicate).[58] The second, however, is that cluster initiatives may not be the most effective way to deliver the outcomes that regions desire.

This skepticism takes several distinct forms. Some cluster skeptics agree that clusters can theoretically drive typical economic development outcomes, but think that it is nearly impossible for regions to dependably identify high-potential clusters or relevant market failures.[59] Others argue that deepening industry specializations—a key goal of most cluster initiatives—is an ineffective means of influencing growth because "it takes extremely large increases in specialization to get more than marginal effects on local productivity and wages."[60] Other skeptics believe that trying to replicate the characteristics of high-performing clusters is a fundamentally misguided approach because those characteristics are not the *preconditions* for development of other clusters. Rather, clusters are the *outcomes* of a complex, evolutionary, and unpredictable process in which entrepreneurs adapt technologies, start new firms, and catalyze the creation of institutions that support them.[61] Still others question whether a regional economy defined by specializations in a few key clusters is desirable in the first place.[62] Researchers have found that industrially diverse regions are more conducive to positive outcomes typically associated with clusters, such as knowledge spillovers and innovation.[63]

To summarize, many researchers consider cluster initiatives to be a distraction at best. Their many potential disadvantages mean, according to one study, "it would seem more advisable for local and regional authorities to concentrate on encouraging productivity

improvements in all local firms, as well as improving their business environments, without committing to a cluster mind-set."[64]

Ultimately, regions do not need to choose one side in this debate. Some may decide to not organize economic development interventions around specific clusters at all. But for most regions, this skepticism and the lessons in this paper will likely lead to a hybrid approach: selectively working with certain groups of firms using the framework and goals of a cluster initiative, while engaging in the rest of the economy in a cluster-agnostic way.

Many regions overlook opportunities to address the shared needs of groups of firms that are not part of clusters. This section aims to highlight some viable approaches for engaging with groups of local firms to support innovation, productivity, and growth (as well as with entrepreneurs to support firm creation). These examples are far from exhaustive. They are intended to illustrate the potential power of non-cluster approaches, so that regions do not fall into the trap of assuming that cluster initiatives are the only strategic approach to economic development.

IDENTIFYING NON-CLUSTER GROUPS OF FIRMS

The primary way to group firms that do not share cluster connections is by their stage of growth. The premise is that, regardless of industry, firms at different stages of growth share certain challenges that can be addressed by EDOs.

Startups

There are many reasons for any region to focus on meeting the needs of entrepreneurs (and potential entrepreneurs). One is that young firms drive job growth in all regions.[65] And, as described above, entrepreneurial successes can catalyze broader regional transformation that tends to be associated after the fact with clusters. Entrepreneurship is an appealing area of focus for smaller regions in particular because while many economic assets are increasingly geographically concentrated, good ideas presumably remain equally distributed across populations. Further, there is clear evidence of market failures—the United States is in the midst of a multi-year decline in firm startup rates, and there are clear needs for interventions in numerous areas including capital provision, technology transfer, and mentorship and networking.

Scale-up and middle-market firms

While they often fall into a gap between entrepreneurship support programs and the demands of retaining large employers, mid-sized firms are particularly important drivers of job growth. One study found that 1 percent of firms generated nearly three-quarters of net new job growth in the U.S. from 2009 to 2014; on average, the firms in this group grew from 10 to 30 employees.[66] However, the propensity of high-potential startups to actually scale and achieve meaningful growth outcomes has stagnated over the past several decades, suggesting that real barriers exist to not only firm creation but also scale-up.[67] Scale-up and middle-market firms (a loosely-defined category including firms with about 10 to 250 employees) face different barriers than entrepreneurs. These firms may need assistance with process innovation as they scale, expanding market access (including exports) and accessing capital and management expertise (including M&A).

GROWTH ORIENTATION:

Within each of the above size categories, only a small portion of firms has growth aspirations. Other firms (retail businesses and legacy industries) matter to local economies, but most economic development interventions—especially those that might be considered an alternative to a cluster strategy—focus on high-growth firms in traded sector industries. Interventions relevant to those firms are therefore also the focus of this section.

DESIGNING NON-CLUSTER INTERVENTIONS

This section contains a mixture of emerging and proven interventions. Some clearly apply to very young firms (i.e., accelerators), while others are best targeted to well-established middle-market firms (i.e., export support). But, as the needs of startup and scale-up firms are often very similar, many of these programs could, with small modifications, be relevant to a firms of varying sizes and growth trajectories.

The interventions highlighted in this section do not apply *exclusively* to non-cluster approaches; all could be targeted to firms within a cluster, and readers will note some parallel interventions in the cluster case studies. But none *require* targeted firms to be part of the same cluster. It is important to note, however, that while successful implementation of these types of interventions do not require *specific cluster knowledge*, each does require practitioners to have *business- or industry-relevant expertise* in such areas as manufacturing technology, the process of innovation and firm creation, or international business strategy.

Process innovation

Process innovation refers to innovations that reduce the cost of producing existing products and services, as opposed to creating new goods and services. Process innovations include adoption of software such as customer relationship management (CRM), technology such as 3D printers, management techniques such as lean manufacturing, and strategy improvements such as concerted efforts to

export globally. The importance of process innovation is often overlooked, despite the fact that, according to one survey, process innovations are responsible for between 12 and 17 percent of profits of mid-sized firms.[68] Despite these benefits, small firms tend to underinvest in process innovation, often because they can't afford outside consultants or because leaders are distracted with "putting out fires."[69] This tendency has been exacerbated by low labor costs in the post-recession era, which have discouraged investments in technology—one reason that productivity growth has been flat to slow in all but the most elite firms in every industry.[70]

SME manufacturing support:
► Manufacturing extension partnerships (MEPs) traditionally focused on implementing continuous improvement (lean) processes. One study found that MEP programs deliver productivity benefits worth more than twice what a program costs.[71] Many are adapting to reflect the changing nature of manufacturing (i.e., implementing "internet of things" systems) and to serve firms' other needs. For example, the Wisconsin MEP runs "ExporTech," an export planning program, and the Michigan Manufacturing Technology Center offers cybersecurity training.

► National labs have a mandate to transfer technology to firms, but rarely work with small companies. Several states have created innovation vouchers in the $10,000 to $50,000 range that allow small firms

to "buy" researcher hours at the labs, including Oak Ridge in Tennessee and Sandia in New Mexico. Oak Ridge also operates a "storefront" in Knoxville for collaboration with firms working on 3D printing and advanced materials.

Upgrading business practices:
► Accelerators are typically associated with technology- and capital-intensive industries in which firms' growth goals revolve around receiving venture capital or being acquired. Some emerging models, however, focus on supporting firms with more traditional growth paths. Examples include BetaSpring in Providence, which works with revenue-driven firms in locally specialized industries, and Jumpstart in Cleveland, which offers "scale-up" services for cash flow-positive firms with between 10 and 100 employees.

► According to McKinsey, the U.S. and EU economies are operating at less than 20 percent of their digital potential.[72] One intervention in this space is Canada's Digital Technology Adoption Pilot Program, in which teams of advisors were deployed to help small firms adopt digital technologies, including project management software and robotics.

Expanding market access:
► VALET is a two-year program offered by the state of Virginia that provides companies with expert assistance in developing a global sales plan, access to a network of private sector service providers, and $15,000 to spend on export efforts (including trade missions, web translation, tax assistance, and market research). Cohorts of 12 firms, across industries and averaging 111 employees and $36 million in sales, are run every six months.

► Some regions have programs to help small firms expand sales locally. East County EDC in San Diego created the Connectory, a database that enables firms to find local suppliers and is currently being used to support local entrepreneurs as well as

defense firms that want to diversify. Another example is anchor strategies, in which local coalitions identify small firms that could supply large local institutions. Examples include efforts around the University of Pennsylvania and the Cleveland Clinic.

Product innovation

The importance of product innovation—the creation of new goods and services—is widely understood. Measures of innovation are a common metric for regional economic performance for good reason: Patent rates have a larger impact on regional productivity growth than bachelor degree attainment and tech industry employment.[73] There is wide recognition of market failures that justify intervention. One is that those developing new technologies (e.g., researchers at universities) may not understand their commercial potential or have the incentive to commercialize them. Another is the "valley of death" that tech-based startups face: the time period between when federal R&D grants expire and when the firm achieves positive revenue (or an IPO or acquisition). During this period, firms need to develop business plans, invest in equipment, build prototypes, and hire employees—which requires several infusions of capital and often mentoring from experts. To add to the complexity, innovation is getting more expensive as "low-hanging fruit" have been exploited. Meanwhile, federal R&D spending relative to GDP has declined, and regions (and firms) have been left to do more on their own.

Connecting firms with researchers and universities:
► The Innovation Works Innovation Adoption Grant connects small manufacturers in rural southwest Pennsylvania to the region's centers of excellence (such as Penn State's Plastics Technology Center). Grants are worth up to $50,000 and are matched by firms. Since 2004, the program has served 150 companies, generated $2 million in matching R&D funds, and helped commercialize 30 new products.

▶ The New Mexico Small Business Assistance Program is financed by the state, with a $4.8 million budget in 2015. Since 2000, it has offered grants of up to $20,000 to 2,500 small businesses to access technical assistance at Sandia and Los Alamos national laboratories. Individual firms can use vouchers to work with researchers on product design or for access to technical equipment, while multiple businesses can apply for "leveraged projects" worth up to $100,000 per lab.

Connecting firms for networking and joint innovation:

▶ Large firms are increasingly relying on external innovation, but potential collaboration with startups is often stymied by corporate bureaucracy and risk aversion. To facilitate collaboration, Ohio Third Frontier and the Metro Atlanta Chamber (MAC) provide subsidies for firms to work with Nine Sigma to define innovation challenges and find local and global startups or researchers that may be able to solve those challenges. The Illinois Corporate Startup Challenge also seeks to connect major corporations with local startups working on relevant technologies. It works with three to five new corporations every six months, helping to define their technology needs and then identifying a curated set of potential partners that participate in a demo day.

Startup funding:

▶ The Colorado Advanced Industries Accelerator offers two grants focused on seven innovative industries: a $150,000 Proof of Concept grant for commercializing technologies from research institutions and a $250,000 Early Stage Capital and Retention grant for companies with less than $10 million in revenue that are developing technologies that can be made in Colorado and sold globally. The Accelerator program also includes export grants and investor tax credits.

▶ TEDCO, Maryland's startup and innovation support organization, offers a number of funding programs for firms at the idea, startup, and expansion phases of growth. These include the Minority Business Pre-Seed Fund, which invests up to $40,000 in minority-owned firms, and N-STEP, which helps NIST researchers commercialize technologies.

Skills and workforce training

Human capital is perhaps the primary driver of regional development. Workforce skills drive productivity, incomes, entrepreneurship, and innovation. One important predictor of post-recession regional economic performance was the ability of U.S. regions to "rewire" by helping workers shift smoothly between industries and occupations.[74] Customized job training for small to mid-sized businesses has been estimated to be 10 times as cost effective, in terms of impact on local earnings, as general business subsidies.[75] On their own, however, firms tend to underinvest in training, partially out of concern that other employers will hire away the workers that they have trained. In addition, small and mid-sized firms may simply lack the capacity. As unemployment rates have fallen to historic lows following the recovery (while, at the same time, skills requirements of many jobs have changed), EDOs are under increasing pressure to help firms find ways to reach out to new populations and provide them with new skills.

Industry-driven workforce training:

▶ Following the creation of its Drive to 55 initiative (aimed at achieving a 55 percent postsecondary attainment rate by 2025), the state of Tennessee created the Labor Education Alignment Program (LEAP), a grant program that funds local, industry-specific workforce development efforts that involve community and technical colleges, K-12 schools, economic and workforce development organizations, and industry groups. Since 2013, $20 million has been appropriated.

► All 12 Nashville high schools have been restructured as Academies of Nashville. In this model, each school has several academies with multiple pathways (analogous to a university's colleges and majors), which students follow from the 10th to 12th grades. Businesses are highly involved in designing curricula and providing students with work experience. (Recently Akron launched a similar initiative called College and Career Academies.)

Industry-driven apprenticeships:

► The SC Technical College system is internationally recognized for two programs in particular. The readySC program works directly with firms to provide customized worker screening, training, and recruitment services. Apprenticeship Carolina has provided tax credits for 12,000 workers to complete apprenticeships in 8,000 companies since 2007. The Kentucky Federation for Advanced Manufacturing Education (KY FAME) is an initiative in several regions that brings businesses together with community colleges to design and implement programs in which young workers can attain industry-relevant associate degrees while pursuing paid apprenticeships.

Digital skills:

► Utah's STEM Action Center runs programs for K-12 students focused on improving digital skills and generating interest in STEM careers. Program examples include STEM designations for elementary and high schools and industry-recognized technical certifications. In addition, North Carolina's public schools partnered with Microsoft to enable high school students to earn certifications on software programs, as well as more advanced skills such as network administration and database programming.

Infrastructure

Well-planned and highly functional infrastructure reduces transaction costs, expands firms' access to workforce, and enables trade flows (including services delivered over the internet). One study critical of cluster efforts suggests that the regional productivity gains that cluster interventions might hope to generate over the course of a decade or more could be achieved faster and more inexpensively via targeted efforts to reduce urban congestion or improve infrastructure.[76] EDOs therefore often coordinate infrastructure improvements for large firms as part of incentives packages. Some EDOs are beginning to think more about aligning infrastructure investments with the needs of clusters, but EDOs could also support infrastructure investments that matter to groups of small to mid-sized firms that aren't part of clusters.

Logistics:

► In the Upstate South Carolina region, Inland Port Greer offers rail access to the Port of Charleston 212 miles away. It supports the efforts of major manufacturers, such as BMW and Michelin, to operate on a just-in-time model. Central New York has plans to build a similar facility to facilitate access to the Port of New York and New Jersey.

Broadband:

► Numerous states are working to expand rural high-speed internet access, given its importance to the efficiency of existing firms as well as entrepreneurial and remote work opportunities. New York is in the midst of an initiative to provide nearly all of the state with broadband access by 2018, and Wisconsin and Colorado have robust programs as well.

IX. CONCLUSION

In regions across the United States, business, civic, and government leaders are trying to steward their communities through a period of disruptive economic and technological change. Cluster-based economic development has become a ubiquitous approach across large regions, smaller cities and towns, and rural areas. Yet, for all the power of the clusters approach—to diagnose economic advantages, organize institutions around those advantages, and commit shared investments to support and build on those advantages—its track record has more failures than successes.

Cluster initiatives need not be abandoned, but they do need a rethinking. With rigorous planning, large investments, and significant industry engagement, cluster-based economic development can be transformational, as the five case examples in this report indicate. But local, regional, and state leaders need to be clear-eyed about the level of commitment—both institutional and financial—that transformative cluster initiatives require and weigh that approach against many other evidence-based, industry-relevant interventions that can support economic growth and development. We hope this report can help provide insights and tools to business, civic, university, and government leaders as they undertake that important work.

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