

Creating Economic Clusters

By Athar Osama, Ph.D. and Steven W. Popper, Ph.D.

THE POLICY CHALLENGE

For years now, political leaders and policy-makers have attempted to replicate the silicon valleys in their own regions, albeit with little success. The entire enterprise of cluster advice is ridden with faulty and incomplete understanding of how clusters form and what promotes them, a lack of rigorous policy impact evaluations, and "cookie cutter" prescriptions that do not deliver. **This article calls for putting in place a plan of action** to bring sound theory and practice to bear and to resurrect the credibility of the cluster concept as a useful pillar of regional economic planning. **It poses a series of challenges** to the cluster analyst and practitioner communities that may comprehensively address the weaknesses and deliver on the promise of cluster policy.

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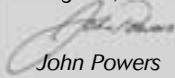
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creating ECONOMIC CLUSTERS

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In the 1980s and 1990s, the Silicon Valley propelled the world into the computer and internet age and, in the process, captivated the world's imagination as a model region for organizing economic and innovative activity. Since then, leaders around the world have tried to create economic clusters in an attempt to replicate the Silicon Valley phenomenon in their own regions, cities, and communities.

ECONOMIC CLUSTERS: AN AGE-OLD CONCEPT REVITALIZED

The phenomenon of economic and technology clusters is not new. Economic clusters date back at least to the great Hellenistic and Islamic centers of excellence such as Alexandria, Cordoba, and Baghdad, and more recently to the industrial agglomerations in the early modern United Kingdom and the Atlantic coast of the United States. What has changed as a result of the spectacular success of Silicon Valley – and later Cambridge, UK and Bangalore, India – is the renewed interest in creating clusters as an instrument of economic, science and technology, and innovation policy.

Dr. Michael E. Porter, a Harvard Business School professor, had a formative influence on the resurgence of the cluster concept when his book, "The Competitive Advantage of Nations", became an influential text for policymakers and political leaders around the world (Porter, 1990). He describes three mechanisms by which presence within an economic cluster may improve the competitiveness of its firms. First, a cluster increases productivity by providing firms access to shared best



Source: Dubai Internet City Website (www.dubaiinternetcity.com)

Dubai's Internet City is one of the several clusters planned in the Arab kingdom.

practices, a common labor and management pool, and training resources. Second, clustering drives the direction and pace of innovation within the cluster's boundaries which in turn leads to productivity enhancement in firms. Third, it speeds up the entrepreneurial process and new firm formation within clusters thus providing a positive feedback loop that feeds onto itself (Porter, 2000).

More generally, firms within a particular cluster benefit from shared resources, mobilization and concentration of specialized labor, and the creation of supporting and ancillary industry. For example, since Silicon Valley is known as a cluster of information and biotechnology firms, it also attracts a disproportionate amount of federal research dollars to its universities; trained workforce from all across the United States and the rest of the world; and law-firms, accounting firms, executive search firms, and investment banking firms specializing

Dr. Athar Osama is a Senior Executive at ANGLE Technology Group in Santa Monica, CA. (athar.osama@gmail.com)

Dr. Steven W. Popper is a Senior Economist at the RAND Corporation in Santa Monica, CA. (swpopper@rand.org)

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in information and biotechnology industries. The result is reduced overall cost of doing business, enhanced access to cutting-edge research and innovation from the region's universities and other firms, and better access to shared infrastructure and a talent pool from across the world. Despite high costs of labor and real-estate, firms continue to locate in the Silicon Valley to benefit from these advantages that seem to outweigh the associated costs.

ECONOMIC CLUSTERS AS INSTRUMENTS OF ECONOMIC POLICY

With these potential benefits – and self perpetuating competitive advantage – to be gained, many governments and regions around the world have attempted to create economic (and technology) clusters patterned on the Silicon Valley model. A 2003 study identified hundreds of cluster initiatives of varying sizes and scope including, among others, 112 in Northern Europe, 82 in Australia and New Zealand, 107 in Western Europe, and 92 in North America (Solvell et al., 2003). Another major attempt to document economic clusters around the world, led by the Institute of Strategy and Competitiveness at the Harvard Business School, has identified 838 clusters so far (van der Linde, 2004).

Many states across the United States such as Texas, Connecticut, Arizona, Rhode Island, Wisconsin, Utah, Oregon, and California have active, on-going initiatives to promote industry clustering. These clusters vary in their characteristics, such as the type of industries they include, the expectations from the cluster initiative itself, and the level of maturity of the industry cluster. Consequently, these cluster initiatives also represent a diverse mix of features, such as the size and timeframe of the initiative, the degree of government involvement, and its interaction with other instruments of economic policy.

Governments around the world have tried to use a number of policy instruments to jumpstart economic clustering including, but not limited to, development of cluster strategies and a cluster identity in regions; liberal taxation policies to promote clustering of firms; creation of science, technology, and research parks; strengthening of university-based research programs; investment in human resources development; creating branding and marketing programs to market the region's competitiveness; steps to improve the entrepreneurial environment; creation of public and private venture capital programs; and creation of institutions of collaboration.

CLUSTER POLICIES AND INTERVENTIONS: AN UNQUALIFIED SUCCESS STORY?

While the use of these policy instruments has been pervasive, they are not equally effective in encouraging cluster formation. The appropriate choice may be determined by the unique characteristics and the initial con-

ditions of the region in question. In fact, the empirical evidence on the efficacy of these policy instruments leaves important questions unanswered.

A host of practical and methodological problems work against establishing the effectiveness of cluster interventions unambiguously. These include the long gestation periods (10-15 years, generally) before a new cluster could emerge in a particular region and the difficulty of measuring the strength of particular cluster outcomes as well as the inability to see through, assess, and monitor the micro-determinants of economic clusters.

The practice of employing cluster policy is clearly a fast moving target, rapidly evolving through "learning by doing" yet far from being an unqualified success. Proponents point to the several contributions that cluster policy has already made to the theory and practice of

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regional economic development, namely, 1) providing a new way of looking at the regional economy, 2) shifting the focus of policy from industrial targeting to enhancing the competitiveness of all the regions' industries, 3) providing micro- (firm-level) foundations to macroeconomic policy, 4) providing a distinct focus and a practical orientation to regional economic policy-making, and 5) providing a framework for structuring new public-private partnerships within the regions. Critics are equally vocal in highlighting the many lingering questions about the cause-and-effect results from cluster intervention policy.

At least two underlying arguments fuel much of the criticism of cluster thinking and policies. First, more often than not, cluster policies tend to have a faddish rather than substantive character. The majority of the planned cluster initiatives that we looked at as a part of our research are based on weak empirical analysis, an unconvincing rationale for policy intervention, and a kitchen-sink approach to the choice of policy instruments (Osama and Popper, forthcoming). They are also, as we would argue later, often marred by weak institutional forms, inadequate attention to the process, and are grossly under-funded and under-evaluated.

Second, there is a dearth of evidence on the effectiveness of cluster policy interventions and their impact on actual economic clustering itself. Martin and Sunley (2003) point out that “even cluster enthusiasts find it enormously difficult to point to any examples of deliberate cluster promotion programs that have been unambiguously successful.” Simply stated, despite two decades of attempts around the world to create the next Silicon Valley, no other region of the world has clearly achieved the same level of stature – especially not through a deliberate and active cluster policy intervention.

We do not know enough to say what works and what does not in cluster policy. While practitioner and best practice manuals have been written by consulting and research firms, none have actually presented conclusive evidence in support of the policy instruments and interventions. The latter, however, continue to be recommended and accepted if not on faith, then in the promise of the potential rewards rather than concrete evidence of efficacy. Meyer-Stamer (2003) explains the continued popularity of cluster policies by highlighting the political economy of such programs. In short, cluster policies remain popular because, for politicians and policy-makers, the desire to do something about their constituents’ problems outweighs concerns about demonstrating results. Cluster policies, with their vast popularity and brand recognition, provide the means to evince control even if the reality may be somewhat less than the perception.

DELIVERING ON THE PROMISE OF ECONOMIC CLUSTERS

The doubts surrounding cluster policy need not persist. The clouds of uncertain utility and efficacy that bedevil cluster theory and practice can be challenged by putting in place a plan of action to bring sound theory to bear and to establish the credibility of the cluster concept as a useful pillar of regional economic planning. This would require looking forward by making significant advances at the cutting edge of cluster theory and practice (e.g., through the development of a theory of cluster implementation and better understanding of the inner workings of clusters.) It would also require looking back by reviving and applying some of the more established themes in the economics, public policy, and organization literature to clusters (e.g. the rationale for policy interventions, market and government failures, and the importance of evaluation, replication, and validation).

This ambitious undertaking would require cooperation by the analyst and practitioner communities to target concurrent development and validation of new ideas, foster their cross-fertilization across disciplines and between research and policy, and perform subsequent integration into what could be a “useful theory of eco-

nomic clusters”. The rest of this article outlines a 10-point agenda that, we believe, provides a comprehensive response to the weaknesses outlined here.

We present these as a challenge to ourselves as well as to our colleagues in both the analyst (the providers of cluster advice) and the practitioner (consultants and implementers of cluster initiatives) communities. This is an ambitious agenda but one that not only is necessary but also pragmatic and eminently doable.

THE ANALYSTS’ CHALLENGE: IMPROVING THE QUALITY OF POLICY ADVICE IN SUPPORT OF CLUSTERS

The first element of the two-pronged strategy to improve the conduct of cluster policy is to enhance the quality of policy advice that is delivered to regional economic leaders and planners. This requires improving the quality and relevance of the research and analysis from which the policy advice is ultimately derived. The following points highlight the cluster analysts’ challenge:

1. Define a rationale for public policy interventions in support of creating economic clusters. The case for public policy intervention is often not clearly thought through. “Broadly speaking, the arguments for cluster policy, i.e.

interventions by government or other public actors in regard to development of clusters, are not yet fully established. A host of approaches are nevertheless pursued by various policy institutions but motives vary and are often vaguely formulated” (Andersson et al.,2004).

There are several reasons for the absence of well articulated criteria. First, the case for public policy intervention in clusters has only received marginal attention in the literature. Second, more often than not, the decision to intervene has already been made even before the region’s economy

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is subjected to a rigorous analysis aimed at identifying economic clusters and cluster trends. The type of analysis then conducted often does not provide enough insight to inform policy. Third, the eagerness to (appear to) do something and the subsequent rush to intervene, often before a valid and unambiguous case for such an intervention has been made, results in a loss of high-level perspective on policy. The field as a whole would be well served by rediscovering some of the long established economic and policy science lessons and principles often ignored in the cluster literature.

There is also need to further develop and refine existing principles and rationales for public policy intervention. For example, under what circumstances, initial conditions, and applying what tests



Source: QSTP Website (www.qstp.org.qa)

The Qatar Science and Technology Park at Doha's New Education City.

may market-failure-based, competitiveness-based, and equity-based interventions be justified? What policy instruments (or interventions) make more (or less) sense within the context of each of the above-mentioned rationales for intervention? How should the rationale for intervention or the choice of instrument be affected by the life-cycle stage of the cluster, its make-up, and internal dynamics? Addressing these issues would require extensive theory building and validation through systematic analysis of successful and unsuccessful clusters of various circumstances and forms.

2. Improve the quality of linkage between cluster analysis and assessment and the subsequent policy prescriptions. More often than not, the policy advice rendered in support of economic clusters is based more on stereotypes about what clusters are (and ought to be) than the specifics of a particular cluster in question. This advice often takes a kitchen sink approach that calls for undertaking a laundry list of policy actions rather than being data-driven and strategic in choosing the right kinds of policy interventions. This approach is not only arbitrary but also goes against the well-established wisdom that all clusters are unique in their histories and make up and therefore require carefully designed interventions rather than a one-size-fits-all approach. Paying inadequate attention to the findings of the cluster analysis or doing a substandard job of analyzing the cluster(s) itself is one of the leading factors causing a disconnect between analysis and prescription.

3. As a corollary, there is need to improve the practical relevance and value of methodologies employed in cluster analysis and assessment. The art and science of cluster analysis continues to evolve with new methodologies being proposed and others refined. There is a need to consolidate some of this learning by critically evaluating and comparing the various methodologies in use and being proposed. Studying the various properties (e.g., informational value, analytical and predictive accuracy, and practical relevance) of a selected set of more commonly used clus-

ter methods (such as shift-share analysis, location quotients, and qualitative analysis) in a comparative setting could bring substantial benefits.

Several issues are worth a careful examination:

- Which of the cluster methodologies seem to provide better understanding and prescriptions and under what circumstance (e.g., type of clusters, life-cycle stage of cluster);
- How do the policy prescriptions derived from application of cluster analysis differ across different types of methodologies used;
- How large are these differences, what sort of errors and biases are introduced into the analysis, and how might the analyst safeguard against such errors;
- What sort of policy prescriptions may legitimately be derived from each of the various types of cluster methodologies; and
- How much time, effort, and money should be invested in analysis vs. strategic planning and implementation in framing a cluster-led development agenda.

Developing a better insight about the use (and abuse) of the various cluster methodologies is critical to deploying these appropriately.

4. While we desire to derive policy prescriptions from analysis of the specific cluster in question, there is a need to ensure that the resultant policy advice is also adequately grounded in the empirical evidence in general. There is often a significant gap between what is popular, and hence often prescribed, and what can be supported with well-established empirical evidence. Several examples help support this thesis.

One example is the often emphasized importance of institutions for collaboration (IFCs) for cluster formation. Yet, there is little solid empirical evidence to support that such interventions actually have an impact on cluster formation, whether independently or in addition to other interventions. In fact, some observers have even questioned the underlying phe-

nomenon that forms the basis for such advice and have presented alternative theories that may lead to considerably different policy prescriptions. Also, we know from the empirical literature that different types of industrial clusters may be subject to different dynamics and hence policy prescriptions (e.g., those promoting specialization or diversity of industrial activity) depending upon factors such as stage of cluster lifecycle and type of firms in the cluster. These considerations, however, rarely find expression in the discussions on cluster policy.

5. Finally, there is clear need to seek and develop evidence in support of cluster interventions often prescribed in the literature. The literature on economic clusters is unequivocal in its concern for the lack of conclusive evidence on many specific policy instruments as well as cluster development policy in general. These include, among others, venture capital development programs; business and technology incubators; science, technology, and research parks; workforce development initiatives; business networking programs; university-industry and inter- or intra-industry collaboration programs; special technology funding programs; and special processing zones. Many of these programs derive their legitimacy from a popular conception of their usefulness or prevalence rather than concrete empirical evidence of their efficacy. With inadequate attention paid to systematic and methodologically rigorous evaluations of cluster policy interventions, it is also impossible to fine-tune these policy instruments to respond to the particular context and circumstances of a targeted cluster.

For example, knowing that science, technology, and research parks or public sector venture capital funds tend to do better in one set of circumstances than others is a valuable piece of information for those considering policy recommendations. This kind of information, however, cannot become available unless the policy instrument is studied and its efficacy determined under a variety of contexts. A systematic effort to develop such evidence is likely to be valuable to the conduct of cluster policy in the future.

THE PRACTITIONERS' CHALLENGE: IMPROVING THE QUALITY OF IMPLEMENTATION OF CLUSTER POLICY

While the above steps are critical for improving the quality of cluster policy advice that reaches a cluster practitioner, there would always be gaps in this advice that may be filled only through more relevant research and the passage of time. Due consideration must be paid to factors that will improve the quality of implementation of whatever advice is currently available.

6. Careful attention to the choice of an implementation plan can be both a critical test of one's understanding of the cluster and an important factor in successful implementation. Should the cluster policy be implemented in a top-down or a bottom-up manner? Should the cluster policy implementation be extensive or intensive? Should implementation be well-

integrated with a region's economic policy or be a localized add-on? There are several possibilities for implementing a cluster initiative and the final choice not only depends on objectives and goals of the planners but also the type and maturity of the cluster and the political climate of the region. The key to success is not wholesale adoption of any generic implementation scenario but careful and thoughtful deliberation on what cluster policy implementation might entail in the unique circumstances of a particular cluster and how it might unfold over time. Too often cluster studies and policy documents fail to consider adequately this important aspect of the overall cluster policy.

Choice of an appropriate implementation scenario would require paying careful attention to a host of different factors:

- The make-up and dynamics of the cluster,
- The assessment of its likely evolution and the time-frame associated with it,
- A sense of the external (competitive) environment that might necessitate early action or afford a wait-and-see approach,
- The relationship between public and private actors within the region,
- The private sector's notion and expectations of what might constitute legitimate reasons for public policy intervention,
- A deep understanding of the overall economic and social policy framework in the region and the policy-making process itself, and
- A clear idea of the place of cluster policy within the overall policy environment

These are complex factors and each must shape the manner in which cluster policy is implemented. A careful consideration of these (and other) factors must determine the optimal implementation scenario that has the highest chance of delivering a successful cluster.

7. Institutional aspects of cluster policy implementation may be of critical importance to our ability to deliver on its promise. Several cluster studies and policy documents we have surveyed confirm this point. More often than not, cluster policy falls short of delving into the issues and challenges associated with the actual implementation of the policy. The most important of these issues must deal with the institutional capacity to implement a set of policy objectives in support of clusters. Many cluster studies we have reviewed present little discussion on how, from an institutional standpoint, the cluster policies might actually be implemented.

Prior to selecting an appropriate institutional form to maximize the chances of success, several issues must be addressed:

- Does the public sector organization championing the case for a cluster strategy or charged with creating clusters have the analytic and implementation capacity to undertake cluster development on its own;

- What kind of institutional arrangement does the choice of the implementation scenario dictate for the subsequent implementation of the cluster policy;
- What skills (e.g., domain expertise, analytic and implementation capability, networks, ability to form consensus, or the ability to enforce policy) does the potential implementer require;
- What kinds of alternate institutional arrangements (e.g., prime/sub, public-private partnership, joint venture, and so forth) could be best suited to the implementation envisioned; and
- How to avoid the various kinds of conflicts of interest that might arise from particular choices of institutional forms etc.

Careful attention to these considerations would ensure that the cluster initiative is provided with the institutional capacity needed to implement the policy.

8. Inadequately resourced cluster initiatives do serious injustice to the aspirations of a specific cluster/region's champions and harm to the broader practice of cluster policy. Under-funded and inadequately resourced cluster initiatives are more com-

While clusters may be championed by specific individuals or triggered by an interested public sector entity, they must be implemented by multiple actors, not the least important being the firms within the cluster. This bottom-up implementation necessitates a broad based ownership early in the life of a proposed cluster.

mon than is generally perceived. In fact, the entire issue of what it must take to develop a (set of) cluster(s) is conspicuous by its absence from the cluster debate. This is because cluster initiatives have often been used as a convenient and (currently) fashionable political slogan without much actual financial commitment behind them. Further, cluster initiatives have often been funded through existing policy instruments and/or budgets of state and local economic development agencies. It is difficult to distinguish the cluster component of these agencies' development budgets from other programs aimed at broader economic development efforts. In addition, the cost of implementing cluster strategies – an important operational issue as it is – has not attracted sufficient attention from researchers. Finally, the implementers – consulting companies, generally – also have a vested interest in non-disclosure of such proprietary financial information with the result that cluster initiatives often grossly underestimate the amount of financial resources it might take to implement a cluster policy (or strategy).

The optimal level of resources required to execute a cluster strategy successfully might vary depending

upon the circumstances of a particular cluster, the choice of implementation scenario, and institutional form. The literature on the subject provides only rough pointers, at best. The wide range of the few estimates that can be gleaned from the literature vary from a billion dollars (for Ohio's Third Frontier Program) to hundreds of millions of dollars (for the Canadian Cluster Initiative) to a few million dollars (for Basque Country, Spain). Inadequately resourced initiatives could result in seriously diminished capacity to deliver and hence dashed expectations and loss of a potentially lucrative strategic opportunity to enhance the competitiveness of regions.

9. Implementation is a process-intensive exercise that requires developing a cluster identity, coalition-building to support a clear vision, and action based on collaboration. While clusters may be championed by specific individuals or triggered by an interested public sector entity, they must be implemented by multiple actors, not the least important being the firms within the cluster. This bottom-up implementation necessitates a broad based ownership early in the life of a proposed cluster. The process of developing a cluster vision, a strategy, and an action plan provides the first and most important opportunity not only to benefit from the ideas and perspectives of a large number of actors but also get the necessary buy-in to the strategy itself. There is a growing realization, if not a clear consensus, in the practitioner community that cluster policy represents a definite shift in regional economic development planning away from top-down centralized planning and implementation to a more bottom-up, localized, and process-intensive one. Paying inadequate attention to the process element of a cluster policy (or strategy) is a fundamental mistake unfortunately all too often committed by regional government and business leaders.

The pendulum is beginning to swing in the right direction with the growing realization of the importance of process (Rosenfeld, 2001). Cluster development, in practice, implies an intensive process of community or identity-building. This forges new mental maps of a region's industrial structure within the region and outside it engendering a sense of ownership among members of the clusters and encouraging new patterns and characters of interaction among their constituents (Taylor and Raines, 2001). Waits (2000), for example, represents this growing consensus as it highlights the process-intensive character of the cluster strategy-making and implementation process in Arizona which involved sustained community interactions through nine industry advisory groups, six foundation working groups, 18 regional town halls, six public forums, and a statewide town hall meeting. The result of such extensive deliberations is, quite predictably, a clearer common vision of the region's existing and emerging clusters and com-

mitment to the strategy for enhancing their competitiveness. Cluster initiatives that do not fully incorporate and internalize this process dimension and instead cut corners in investing in the process and process-based legitimacy are less likely to succeed than those that do not.

10. Implementation approaches must focus on continuously measuring progress, adaptively fine-tuning policy, and actively managing expectations of various stakeholders. Given the considerable uncertainty and ambiguity in picking the right set of cluster policy interventions, especially at the very launch of a cluster initiative, flexibility and adaptability can be important considerations for cluster planners and regional economic and political leaders. Adaptability, however, only makes sense when appropriate measures are taken to ensure that the quality of information about the cluster and the effect of policy interventions on cluster outcomes would gradually improve over time.

Implementation and evaluation are opposite sides of the same coin with implementation providing the experience that evaluation interrogates and evaluation providing the intelligence to make sense of what is happening (Pressman and Wildavsky, 1973). Judicious use of information provided by extensive and well-developed evaluation processes that continually feed back into the implementation effort can lend support to gradually improving policy prescription and better cluster outcomes.

Performance measurement of on-going cluster initiatives has, however, not moved beyond the use of a few summary measures to justify ongoing investment. Post-implementation evaluation is even more uncommon. Only recently has there been some effort to develop evaluative frameworks for analyzing complex cluster policy interventions (e.g., Solvell et al., 2003; Diez, 2001; Osama, 2006). These preliminary frameworks must evolve and mature considerably and be validated for usefulness before they could provide the kind of information required to support an adaptive cluster policy paradigm. For example, Pickernell et al. (2005) highlight the fact that in order to better understand the clusters, there is a need not only to examine them from a structural perspective, but also examine, in more detail, the processes at work within the clusters. Achieving this kind of resolution ability cannot be farther from the reality of existing practice. It is, however, critical to the vitality and future health of the enterprise.

Somewhat related but also distinct from the above is the need to manage expectations prior to and during the implementation of the cluster initiative. Developing

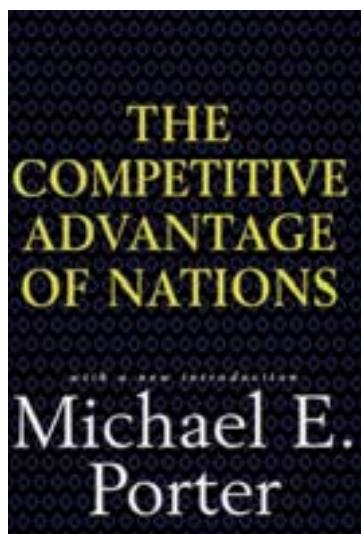
successful economic clusters requires a series of interventions at multiple levels in the socioeconomic and political systems of a region or a country for sustained periods of time. Clusters can take anywhere from one to three decades before they could achieve the aspirations of their champions. Link (1995, 2002), for example, found that the genesis of the Research Triangle cluster in North Carolina was predicated on 70 years of patient local government intervention.

When dealing with disparate stakeholders – many having time horizons considerably shorter than when the cluster could reasonably provide full return on their investment in time and resources – it is important that the right set of expectations be developed and communicated at critical instances during the life of the cluster initiative. The failure to do so could result in dashed expectations, impatience with results, and a premature perception of failure. Any of these outcomes can result in the loss of political or business support and legitimacy and can ultimately lead to the demise of the initiative itself.

These last five points, while only a preliminary attempt, define a practitioners' agenda that focuses on key features likely to differentiate the more successful cluster policy interventions and initiatives from the less successful ones. They, along with the first five points, also have significant implications for the cluster theorist and researcher. Implementation is one of most neglected aspects of cluster theory and is only now begin-

ning to receive some attention from the research and policy communities. This is broadly in line with the trends in policy research and design, more generally, where systematic study of implementation remains an area much less professionalized than either analysis or evaluation (Pressman and Wildavsky, 1973).

It is indeed our expectation that the trend towards more systematic study of implementation will grow stronger with the passage of time. Implementation may well become the centerpiece of a new and more pragmatic research agenda on economic clusters. Dramatically improving our ability to navigate the complex and confusing terrain of cluster policies and delivering on the promise of policy-supported, if not policy-induced, economic clusters would require nothing short of a theory of cluster policy implementation. This preliminary agenda merely identifies the broad outline and scope of the intellectual challenge that we face in making the concept of economic clusters meaningful, relevant, and actionable to the regional economic development community. Systematic and methodologically sound research on implementation of cluster policies is clearly a work-in-progress. 



Porter's book ushered a new era of cluster strategies.

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For an extended bibliography of cluster studies and academic/practitioner articles, please visit author's blog at: <http://techno-economics.blogspot.com>

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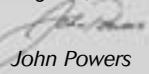
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