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Cluster Mapping as a Tool for Development

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June 2017

This report builds on the foundational work on cluster mapping that Prof. Michael E. Porter has led at the Institute for Strategy and Competitiveness (ISC), Harvard Business School over the last two decades. He launched the U.S. Cluster Mapping Initiative in the late 1990s, developing the first robust set of data-driven cluster definitions. They were applied in his 2003 paper on U.S. regions (Porter, 2003) and in subsequent research papers with other scholars that fundamentally changed the perception of clusters in the U.S. policy community (Delgado, Porter, Stern, 2010, 2014). The cluster definitions were then further developed, leading to the current benchmark cluster definitions (Delgado, Porter, Stern, 2016).

Cluster mapping data was made available by ISC both through its website and location-specific analysis and reports. All U.S. governors received a customized cluster mapping data deck in 2002. In 2010 the data was offered to a wider practitioner community through the U.S. cluster portal www.clustermapping.us. The website, developed with support from the Economic Development Administration, provides in-depth open data on regional cluster portfolios across the U.S. and offers a platform for cluster-oriented economic development organizations to collaborate and profile their work.

In the meantime the cluster mapping approach developed at ISC has been adopted in a wide range of countries, including all member countries of the European Union, Canada, Mexico, and India. Further research efforts have been conducted in countries ranging from Australia, Brazil, China, and Russia to Turkey. The Institute for Strategy and Competitiveness offers its support to these and all other countries that want to use cluster mapping as a part of their economic development strategy.

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Cluster Mapping as a Tool for Development

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Cluster Mapping as a Tool for Development

Economic development is associated with broad-based changes in many aspects of a country's economy. An aspect that has gained increasing attention over recent years is the systematic changes in economic geography and sectorial composition that can be observed as countries reach higher levels of prosperity. As they develop, economies see activities shift to higher value-add activities within existing industries, to higher value-add industries, and they become able to successfully compete in a broader set of industries (Hausmann et al., 2013; Ketels, forthcoming). Conversely, growing divergence between locations within a country – also reflected in different specialization patterns – can undermine overall prosperity growth (OECD, 2013). Understanding these trends and using evidence on how they play out in specific locations has become a critical piece of intelligence to inform policy action.

Clusters, regional concentrations of economic activities in related industries connected through local linkages and spill-overs, are an important conceptual tool in these efforts. They provide a way to understand the interplay between location, value chains, and regional specialization patterns. While the concept of cluster has been well known for a long time, advances in the way clusters are identified and measured, have over the last decade opened up new insights into their role in modern economies.

What you can learn from this note

- The role of clusters in locational competitiveness and economic development
- Preconditions and key steps of a cluster mapping project
- The use of cluster mapping data in economic policy making

Cluster mapping describes the quantitative measurement of the presence of clusters across regions within a country or group of countries. It is based on common definitions that identify cluster categories as groups of industries that empirically tend to be connected through localized spill-overs and linkages. Cluster mapping data provides insights into the specific economic geography of a country, the geographic footprint of a specific cluster category, and of the specialization profile of a given region.

Cluster mapping has so far largely been pursued in advanced economies with robust statistical systems and national data collection agencies. It is in these economies that cluster mapping data has started to

be used to inform and motivate policies. A new wave of efforts is underway in emerging economies where data coverage and quality is more limited. The case-based literature already shows that clusters are present also in less advanced economies (Yusuf et al., 2008; Zeng, 2008). What is missing, is the systematic cluster mapping data to assess their overall role in countries at this stage of development.

Cluster mapping, research findings, and policy use

- The EU Cluster Mapping data is a regular input to the process of creating Smart Specialization Strategies across all EU regions. The data it has generated has for example been used to identify regions particularly well positioned to attract new emerging industries (Ketels/Protsiv, 2016)
- The US Cluster Portal is used by SelectUSA, a part of the US International Trade Administration, to attract foreign investors. The data generated for the portal has enabled research that has led to the adoption of cluster-based programs, like the SBA cluster program (Mills et al., 2008)
- The Canadian cluster making project has, for example, revealed that the lower prosperity of Canadian provinces relative to their US counterparts was largely based on lower productivity within Canadian clusters, not a less favorable mix of clusters (ICP, 2002)
- The Mexican cluster mapping effort revealed the neighboring states of Puebla and Tlaxcala to have a strong position in automotive clusters. As a result, partners from the two states have decided to create the "Automotive Cluster of the Central Region (CLAUZ)" as a joint entity.

The purpose of this concept note is to outline a framework for conducting cluster mapping in developing and emerging economies. The main audience are World Bank country directors and task team leaders that want to consider whether a cluster mapping effort might be feasible and valuable in their area of responsibility. The note also aims to inspire a discussion within the World Bank as to whether the World Bank Group could pursue cluster mapping as a data service to the global community, much as it does in efforts like the Doing Business and the Logistical Performance indicators. The note consists of three key sections outlining the conceptual foundations of cluster mapping, the practical steps in implementing cluster mapping, and the way cluster mapping data can be used to inform policy practice. It is accompanied by a 'pre-launch startup pack' for countries that want to engage in cluster mapping, providing a step-by-step guide on how to proceed. That startup pack, written by Richard Bryden, is available on the ISC website at www.isc.hbs.edu.

1. What is cluster mapping

Cluster mapping describes the process of systematically measuring the presence, size, and performance of clusters across locations, applying common definitions of cluster categories derived from evidence about patterns of location-specific linkages and spill-overs across locations. This section provides first an overview of the conceptual underpinnings of cluster mapping, outlining its role in locational competitiveness. It then discusses how the methodological approach towards cluster research has evolved over time, with cluster mapping emerging as a new approach. A final part provides an overview of key empirical insights that the research on cluster mapping has generated.

1.1. The conceptual foundation: Clusters, competitiveness, and economic development

Clusters, regional concentrations of economic activities in related industries connected through local linkages and spill-overs, have long been known to be a feature of market economies. Alfred Marshall famously described how, in an economy with an increasing division of labor, related activities tend to be found in the same places. Jane Jacobs made the connection to urban areas, where groups of such clusters created broader linkages and dynamism, and challenged the relevance of clusters as simple agglomerations of narrow industries. Giacomo Becattini emphasized the social embeddedness of clusters as linkages between people. A wide range of regional economists used clusters as a tool to understand the dynamics of place and of relatedness across sectors. Michael Porter then approached clusters from the perspective of a business scholar, noting how clusters shape the strategic options faced by companies located within them. His work was motivated by the observation that in many industries a few locations account for a dominant share of the leading companies. It deeply transformed the perception of clusters in the modern economy, and triggered a wide range of cluster-based efforts around the world (Huggins/Izushi, 2011; Ketels/Keller, 2015).

Clusters are more than agglomeration – they describe agglomeration in sets of related industries rather than in overall economic activity. And clusters therefor exist in urban as well as in rural locations.

Clusters are also not just sectors – they capture the specific geographic footprint of economic activities that analyses of, for example, national export specialization miss. And they look at groups of industries because of the evidence that these industries are systematically related through local spill-overs and linkages, not because they belong to the same statistical classification.

Key points in this section

- Clusters are local concentrations of economic activity in related industries, connected through local linkages and spill-overs
- Clusters are embedded in a broader framework of competitiveness; they emerge in response to circumstances in a location and enhance the economic performance of activities in that location
- Clusters exist at all stages of economic development once a location moves beyond subsistence and isolation. As locations reach higher levels of competitiveness, the nature and sophistication of clusters changes in systematic ways
- The cluster-based approach to competitiveness has similarities with a range of other concepts that move beyond single-factor and sector- or location-neutral frameworks. Cluster mapping data is valuable in the context of these other approaches as well, not only as a foundation for narrowly defined cluster efforts

1.1.1. What is a cluster?

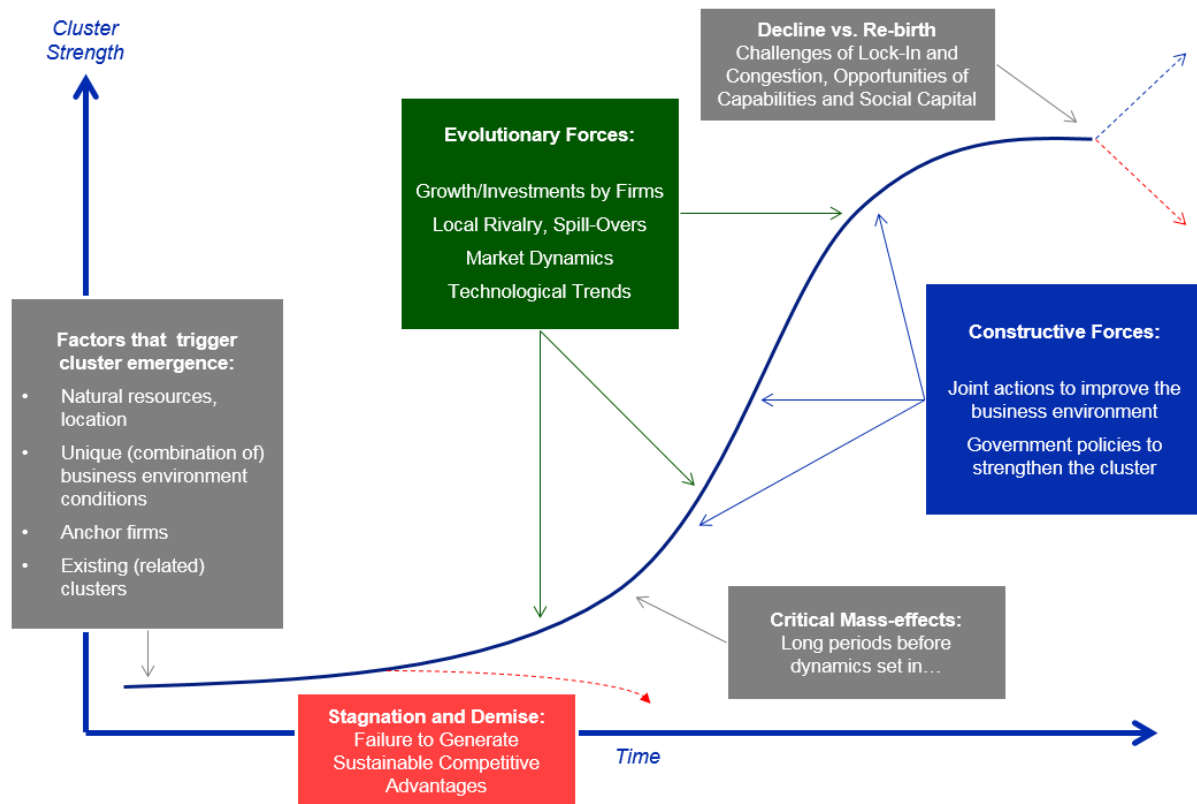
Clusters rest as a conceptual idea on a number of key dimensions:

- First, they are *groups of related industries* and the economies of scope that such relationships help unlock. Clusters are thus not simply a concentration of economic activity in a narrow industry, driven by economies of scale. They are much more related to the notion of related variety, where dynamism emerges from the combination of capabilities and activities that are complementary, not identical. Which specific activities are related can change over time as technologies, business models, and industries change.
- Second, they are shaped by *geographical proximity*. Clusters reflect the specific nature and density of local connections; for example in a deep local skill pool, local knowledge spillovers, and the opportunities for deeper collaboration among local partners. They do not ignore or question the relevance of relationships that stretch longer distances; global value chains and knowledge networks have clearly grown in importance over time. The cluster framework suggests that local and global connections play complementary but different roles. Local clusters can be the sources of unique competitive advantages, providing access to a specific set of local circumstances and partners. Global linkages add capabilities that are missing locally – no location provides everything - but can be copied by rivals from other locations.

- Third, they are driven by the *interplay of collaboration and competition* among related activities within a given location. Clusters provide benefits already as the mere co-location of related activities, for example knowledge spillovers and deeper and more specialized input markets. But the dynamic power of co-location becomes significantly enhanced if the co-located entities start to engage with each other. This can happen through collaboration, for example in joint research or training efforts. But it can also happen in the intense local competition among rival firms, forcing them to adopt more differentiated strategies as well as enhancing productivity and innovation.
- And fourth, the dynamics that can emerge in clusters is driven by the *critical mass* that a specific location achieves in a set of related industries. If the set of activities and entities locally present is small, the number of possible linkages is small as well. As the number of players grows, the possible interactions grow more than proportionally. This drives an S-shaped growth path, where clusters start showing significantly higher performance and growth once they move beyond a certain size.

Clusters emerge naturally as the benefits of co-location affect the growth of firms differently across locations and enhance specific locations' attractiveness for firms that are moving. The process of cluster emergence is shaped both by the decisions firms make about their investments and ways of competing and by the decisions governments and other institutions make about relevant qualities of the cluster-specific business environment. Within the location it is the interaction of evolutionary and constructive forces that drives the specific development path of a cluster (Braunerhjelm/Feldmann, 2007; Sölvell, 2008). And in the marketplace these specific conditions and the cluster that it supports are constantly challenged by other locations offering rival business environments and cluster profiles.

The Evolution of Clusters

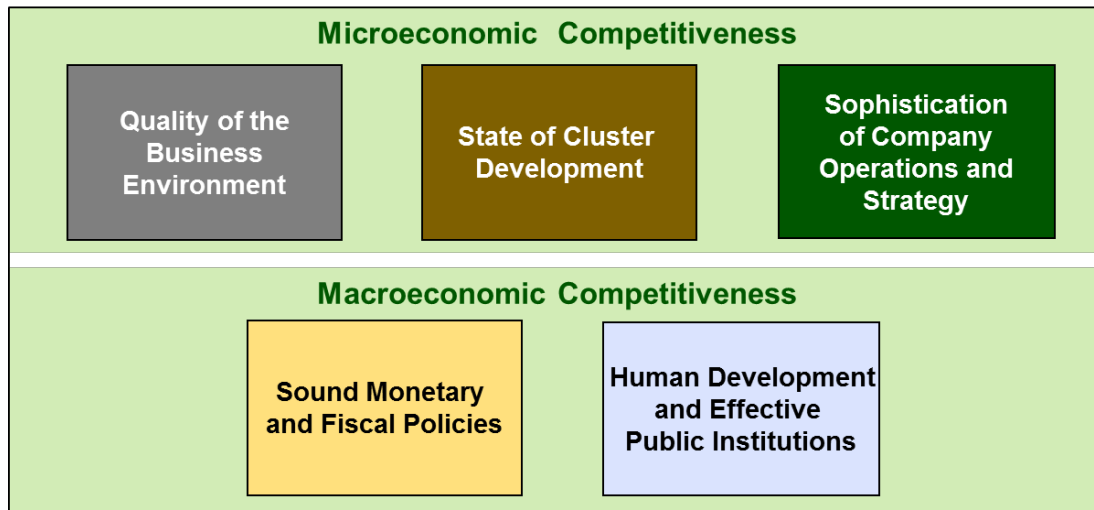


1.1.2. Clusters and competitiveness

Clusters are embedded in a broader framework of locational competitiveness, especially in Porter's work (Porter, 1990; Ketels, 2011). Locational competitiveness captures the set of factors that drives differences in productivity and ultimately in prosperity across locations. The competitiveness framework proposes a way to organize the range of factors that matter, ranging from broad institutional and macroeconomic policy circumstances to many specific microeconomic conditions. Among microeconomic factors the focus has traditionally been on individual business environment factors, especially the rules of the game governing market competition and rivalry and input factors and capabilities, like skills, infrastructure, and capital. Porter's work emphasized that these factors systemically interact, i.e. their impact on productivity depends on the quality of many other dimensions of local business environments. Rather than applying generic policy solutions locations need to

understand their specific circumstances to set appropriate priorities for upgrading their competitiveness.

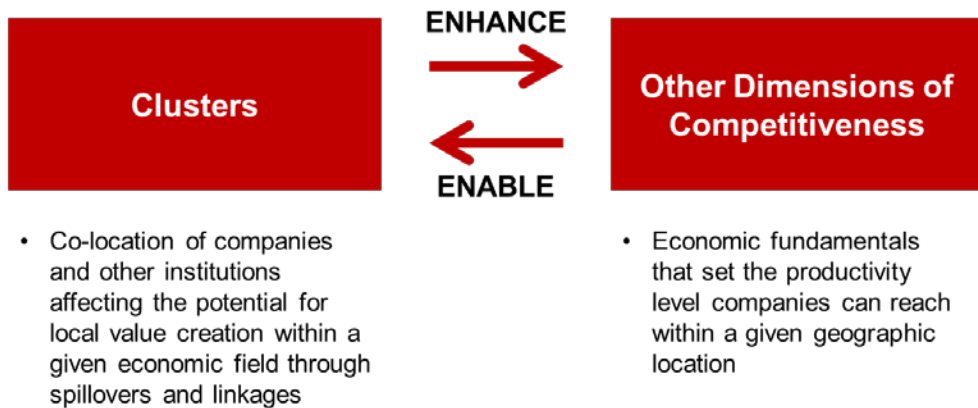
Dimensions of Competitiveness



Source: Porter et al., 2006

Clusters are within the competitiveness framework an important part of a broader set of drivers that need to be seen in their interplay; they are not an isolated or only source of economic performance. The presence and performance of a cluster is affected by the quality of the business environment in which it operates. Clusters thrive where the combination of specific business environment qualities creates unique value for a specific set of related industries. Dynamic clusters with strong linkages enable firms to draw the full value out of the local assets and capabilities that exist in a location. And clusters drive the further upgrading of business environment qualities, either through the direct incentives they provide to individual firms or from policy makers or in the opportunities for joint action.

Clusters and Competitiveness

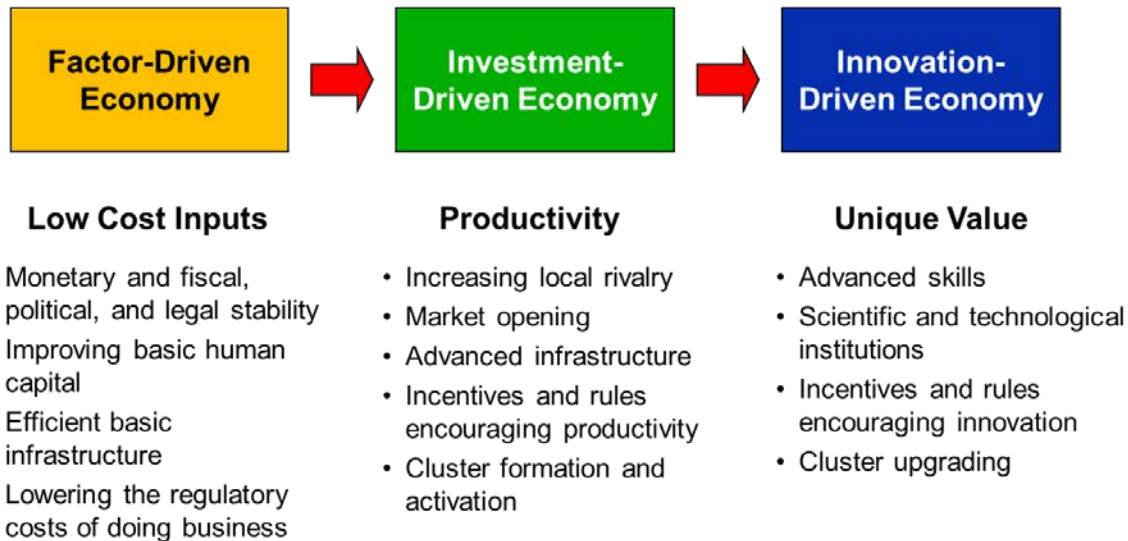


1.1.3. Clusters, competitiveness, and economic development

As locations develop to support increasingly higher levels of prosperity, the foundations of their competitiveness and the role of clusters change. At the initial stage, they compete primarily on the factor inputs that they can naturally offer, whether these are access to specific natural resources or abundant low skill labor. More advanced economies then compete on their efficiency in performing certain economic activities, driven by business environment conditions that enable skill and capital accumulation. Locations at the frontier of economic development then compete on their ability to drive innovation, offering new products, services, and business models based on a business environment that supports knowledge creation and entrepreneurship.

When locations compete primarily on factor endowments, clusters emerge around specific factors, including low cost labor that are available in abundance. These clusters tend to be shallow, focused on a narrow set of activities in which they can successfully compete. And quite often they are concentrated in the few locations within a country that are through their infrastructure connected to the global economy. As locations compete on the efficiency of the business environment, broader clusters of related and supporting industries emerge. And with larger parts of the country becoming effectively connected to the global economy, the range of locations in which clusters emerge also increases. Once innovation becomes the critical driver of competitiveness, clusters become even more important, and active collaboration within these clusters becomes a critical success factor.

Stages of Economic Development



Source: Porter, Michael E., *The Competitive Advantage of Nations*, Macmillan Press, 1990

Clusters can exist at all levels of economic development. What has received traditionally most attention in the literature is the tendency for less developed locations to be focused on industries with lower productivity and wages. Development has accordingly been described as a process of structural transformation towards higher value-added activities, with first manufacturing and then services gaining a dominant share in the economy. In parallel, however, it is also the nature of clusters that changes: Their depth increases as a cluster adds more specialized suppliers and service providers, enabling companies to raise productivity levels. And their breadth increases as locations become capable of supporting a growing number of clusters, often in clusters that are linked, and draw on some common underlying assets and capabilities.

1.1.4. Related frameworks

The cluster framework is related to a range of other schools of thought. While there are differences, both conceptually and in the implications for policy, there is a significant complementarity between the insights that these different approaches deliver (for a broader discussion see Ketels, forthcoming).

- The literatures on structural transformation (Lin, 2016) and on economic complexity (Hausmann et al., 2013) share with the cluster framework a focus on the role of sectors. They are driven by the empirical findings on the relationships between locations' stages of economic development and their sectoral profiles. In short, more prosperous locations are active in more and different sectors than less advanced locations. The cluster work sees these patterns mostly as the reflection of underlying changes in locational competitiveness. The new structural economics and the work on economic complexity see them instead as evidence that sectoral composition is a fundamental driver of economic performance. The former positions clusters as a tool and organizing principle to achieve competitiveness upgrading. The latter argues instead for the proactive development of more sophisticated and attractive sectors.
- The work on urban areas (Glaeser, 2011; Storper, 2013), as well as the new economic geography literature (Fujita et al., 2001) and the research on regional innovation systems (Asheim/Gertler, 2005), share with the cluster framework the focus on the role of location. They are more concerned with the overall density of economic activities in a location, irrespective of specific sectorial divisions. The empirical observations that urban areas register higher prosperity and a growing share of economic activity provides the empirical backdrop to this work. The cluster work views urban areas as locations that can due to their economic size support a range of often related clusters. The urbanization literature interprets the data as evidence that the heterogeneity of economic activities drives performance, and that some general qualities of urban locations, particularly their attractiveness for a skilled workforce, are crucial.
- The work on global value chains (Gereffi/Fernandez-Stark, 2011) finally shares a focus on the importance of linkages. While cluster research has traditionally focused mostly on local linkages, the global value chain work looks at industry-specific linkages across locations. It responds to the observations that value chains in many industries are increasing 'unbundled' across locations (Baldwin, 2006). The cluster literature views global value chains as a natural addition to specialized local clusters, as the global pipelines that naturally interact with and complement the local buzz. It is a reminder that cluster-based policies should not focus exclusively on strengthening local linkages but view the local linkages as a way to support a unique positioning in global markets and industries. The value chain literature is instead often more focused on understanding how locations can enter and enhance their position within value chains.

A common feature of these approaches is that policy action needs to be context-specific and evidence-based. Cluster mapping is a tool that provides decision-relevant information that policy makers need to design and implement effective action. The value of cluster mapping data is thus not limited to a situation where cluster-based efforts are planned, or where a cluster-based understanding of competitiveness is shared by core stakeholders. Cluster mapping data is useful for a much wider range of location- and sector-specific policies.

1.2. The cluster mapping method

Much of the initial research on clusters was focused on case studies, often in locations that stood out through their visibility as global hubs in their respective fields of, for example, technology (Silicon Valley, Boston), finance (London, NY), or movies (Hollywood). This work provided rich input for concept development and emphasized the many dimensions of clusters as complex systems. But these case studies were not well placed to test the hypotheses that are embedded in the underlying conceptual framework. Even when the presence and impact of a cluster could be shown for a specific case, it remained unclear how widespread this phenomenon was and whether the relationships between clusters and performance held more widely.

A further challenge emerged as the cluster concept inspired policy action. Case studies appeared that were strongly interest-driven, defining and measuring specific clusters in ways that aimed to maximize the perceived size and thus political clout of a given cluster. Even where these studies followed transparent standards, the definitions used were ultimately ad-hoc and did not support comparisons across locations. This made testing the conceptual hypotheses of the cluster framework problematic, even as the number of studies significantly increased over time.

In the academic literature a more quantitative set of studies on the impact of agglomeration emerged that addressed some of these concerns. However, the definitions of clusters remained ad-hoc and the focus was often on studying a specific mechanism of local spillovers. Also, the datasets applied tended to be limited to specific sectors or locations. This work provided much more robust evidence that these spill-overs do exist and matter. But they did not answer the more comprehensive questions about the overall importance and impact of clusters in the economy.

Cluster mapping as the quantitative measurement of cluster presence emerged as a reaction to these concerns (Porter, 2003; Delgado et al., 2016). It was designed with a specific set of goals in mind: Generate an operational definition of clusters that is grounded in the conceptual framework and evidence-driven in its particular form. And then apply these definitions to quantify the role of clusters in modern economies in a comprehensive way to enable systematic comparison across locations based on transparent and evidence-driven criteria and systematically test key predictions of the cluster framework about the relationship between cluster presence and economic performance outcomes.

Key Features of Cluster Mapping	What Cluster Mapping is NOT
• Quantitative measurement of economic activity in related industries • Comprehensive across the economy • Comparison of the size and profile of clusters across locations • Based on common standards • Data-driven definitions • Interest in the overall impact of all types of local linkages and spill-overs on economic geography	• Qualitative analysis of the dynamics and linkages within clusters • Focused on specifics of individual regions and regional clusters • Location-specific analysis of performance drivers • Definitions of clusters to match specific local circumstances • Policy or expert-set definitions • Measurement and analysis of specific linkages and spill-overs

The cluster mapping method proceeds in three steps: First, cluster categories have to be defined based on some evidence of local relatedness across narrow industries. Second, these definitions are then applied to translate existing industrial statistics into a cluster mapping data set that can be further analyzed. Third, the cluster mapping data set is analyzed to derive insights into the role of clusters in the country's economy and competitiveness. The remainder of this section will describe these steps in more detail.



Data category choices

The foundational work on cluster definitions had to make choices on the data to use when operationalizing core conceptual dimensions of clusters (Delgado et al., 2016). In these choices trade-offs had to be made between data availability and alignment with the conceptual idea:

- Narrow industries were measured through the industrial classification system used by government to capture sector-specific data about firms. Industrial classification systems change relatively slowly, and often fail to capture new areas. This is a particular concern in activities related to services or emerging technologies where sufficient granularity is often missing. Other approaches to identify groups of companies operating in more targeted ways have been used in some cases (see Mateos-Garcia et al., 2014, for an example). But for a comprehensive analysis there is no viable alternative but to use data by narrow industries as defined in the industrial classification system.
- Locations were measured by geographic units used by statistical agencies for data reporting, which are often administrative units of government. Administrative regions are often misaligned with the patterns of spill-overs, either by cutting through existing clusters or covering an area that is too wide. Again, other approaches using data on the specific geographic location of individual economic activities have been applied to generate more appropriate boundaries defining economically meaningful regions. But here, too, it is not practically feasible to generate locational boundaries endogenously for the entire economy.

The 'noise' that these issues introduce is likely to downplay the role and impact of clusters, because they lead to measures that include activities not central to the cluster dynamics while missing others that should be included.

1.2.1. Creating cluster definitions

A key ambition of cluster mapping is to create operational definitions for clusters that are comparable across locations and comprehensive in covering all parts of the economy. Cluster mapping also aims to derive these definitions in a process that is transparent and driven by evidence rather than the result of expert or policy choices.

The first attempt at cluster mapping was based on co-location of employment by industry (Porter, 2003). Spurious correlation was a serious concern, and the expert choices needed to deal with this problem reduced the transparency of the process. The latest approach to defining clusters of related industries has proposed a number of steps to overcome some of these challenges (Delgado et al., 2016). It looks both at the co-location of employment and establishments as well as at input-output relationships and similarities in skill use. Using such a range of indicators reduces the potential for spurious correlation. And it proposes an algorithm that generates different sets of cluster category definitions based on a small set of structural choices (like the overall number of categories) and allows a comparison of these sets based on a transparent set of criteria. Using such a rules-based approach does not eliminate all expert choices, but it raises the transparency around where and how these decisions are made.

Cluster definitions group industries that are related through local linkages and spill-over. The foundational work on cluster mapping has used region-specific data on co-location of employment and establishments as revealed evidence of such linkages. The analysis also applied national level data on input-output relations and similarities in skill use across industries, two of the key channels of spill-overs discussed in the literature, to address possible issues of spurious correlation in the co-location data. An algorithm was then applied to find the best match of industries to clusters, uniquely allocating each individual industry group to a specific cluster (or 'cluster category'). This categorization of industries into groups are the cluster definitions.

The full list of cluster categories and the narrow industries that they include as derived by foundational work on cluster definitions is available at <http://clustermapping.us/content/cluster-mapping-methodology>.

Do all industries cluster? Local vs traded industries

The clustering of firms in specific groups of related industries occurs where firms have a choice of where to locate, i.e. their location is not determined by the market they serve, and where the benefits of agglomeration are meaningful.

An empirical look at the economic geography reveals the existence of two different types of industries: One set of industries, which are called 'local', are present pretty much everywhere with a size roughly proportional to the overall economy of the region. In these industries firms have to be located in the market that they serve; they compete with local rivals and are restricted in their growth opportunities by the size of the local market. Another set of industries, which are called 'traded', show a much more skewed distribution of economic activity: some locations have a lot of activity while others have none. In these industries firms have a choice where to locate; they compete with rivals from a range of locations in a market that is national or even global in nature.

For local industries the notion of clusters is less relevant. They might have linkages in terms of input-output relations, skills and other factors but these dynamics evidently do not drive where they are located across regions. For traded industries, however, cluster dynamics play a powerful role: only the benefits of clusters can explain why these firms are not dispersed to avoid the direct competition with rivals for local input factors.

The core cluster definitions were created based on U.S. data: among all the major economies the U.S. provides the most detailed data on economic activity by narrow industries and locations. And the locational footprint of industries in the U.S. is likely to be less distorted by market barriers and other frictions to trade and factor mobility across locations than elsewhere. As any economy the U.S. has its particular specialization profile with weaknesses in areas in which the U.S. hardly competes, like shipbuilding. But as the largest integrated national market in the world its economic geography is likely to provide the least biased foundation for the generation of benchmark cluster definitions. An alternative bottom-up effort in Canada to generate cluster definitions with a similar methodology generated very comparable results (Spencer et al., 2010). For developing and emerging economies competing in activities and with competitive advantages very different from the U.S. the differences could be much more meaningful. This is an issue to address in the interpretation of results.

1.2.2. Applying cluster definitions

The cluster definitions can then be applied to existing data sets on industry-specific economic activity by locations. The data is aggregated into cluster categories, resulting in a matrix where for each combination of cluster and location a data point captures a specific indicator of economic activity.

The core indicator that all cluster mapping efforts aim to capture is employment. Employment is a core measure of economic activity, and it is also linked to how firm-level value creation is translated into regional prosperity. The next range of indicators cluster mapping efforts look at are wages and value-added. These indicators provide further insights into the productivity of economic activity, a core measure in the context of the competitiveness framework. Depending on data availability other indicators are also useful: Counts of establishment and of new businesses can sharpen the understanding of the profile of a cluster. Data on exports, R&D spending, or patenting can provide further insights into the performance of a cluster. Data on the skill profile of employees and on investments/capital stocks can sharpen the view on how companies in a specific cluster compete.

The structure can be easily used to also include other indicators, for example the number of companies that have certain characteristics, like having raised capital or achieved some level of quality certification. The key challenge for adding further indicators beyond employment and wages to the cluster data set tends to be the lack of data availability for industries at the regional level.

1.2.3. Analyzing the cluster data

The cluster data can be analyzed in multiple ways. One perspective is to compare different types of industries in terms of their performance. The cluster data allows the distinguishing of traded and local industries as well as the different cluster categories. A second perspective, focused on traded industries, is to compare strong clusters, i.e. locations in which a location achieves critical mass, with locations in which the respective industries are less strongly represented. A third perspective is to compare locations, either entire national economies or regions within a country, to identify differences in the presence and the respective pattern of clusters.

The specific analysis to be conducted depends on the specific questions raised. Researchers and policy makers considering cluster-based policies are often interested in general evidence on the relative

importance of clusters in the economy, and on the impact of cluster presence on economic performance. Policy practitioners implementing cluster-based policies are instead more focused on the diagnostics of specific locations and clusters.

1.3. Key observations from cluster mapping efforts

Over the last decade cluster mapping efforts in line with the approach outlined above have been launched in a range of countries, the United States and the countries of the European Union are the most visible ones. These efforts have generated a number of important insights on economic geography in the modern economy that underline the value of cluster mapping (Delgado et al., 2010, 2014; Spencer et al., 2010; Ketels/Protsiv, 2013, 2016). They have also generated a number of analytical instruments and categories that can be applied by other locations that engage in cluster mapping.

The first three groups of results that are discussed in this section are direct outcomes from the analysis of the empirical data. The last two are also grounded in this data but refer to broader implications on how to think about location and diversification in new ways. Together these findings have provided a general motivation for cluster-based policies.

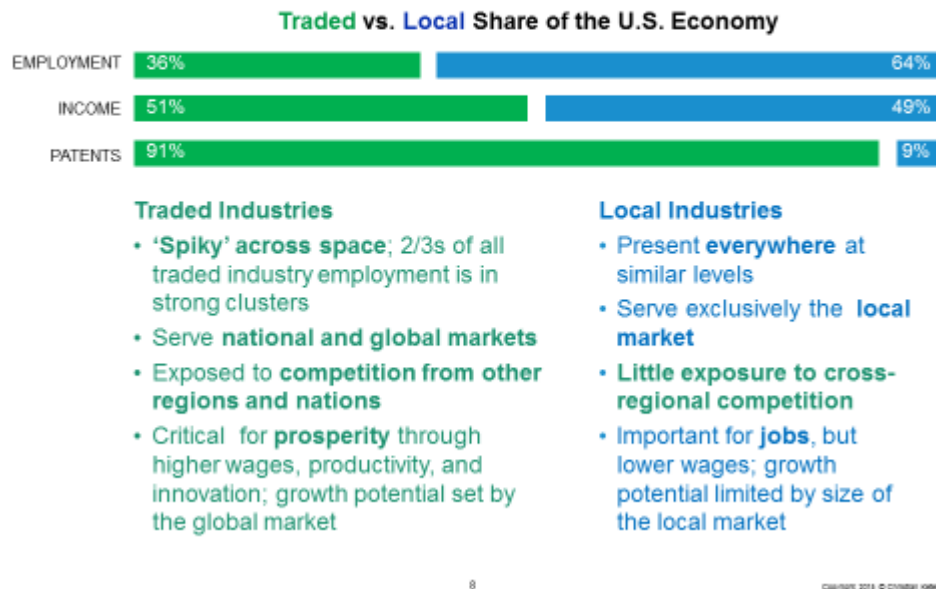
1.3.1. Traded and local industries

The empirical data reveals fundamental differences between traded and local industries. Traded industries report significantly higher productivity and productivity growth than the average of the economy, and they account for the vast majority of research-driven innovation as reflected by patenting and formal R&D spending. Local industries in turn account for the majority of jobs and job creation. The higher productivity of traded industries is related to a higher degree of capital intensity, both human and physical. Their lower dynamism in terms of employment is related to a pace of productivity growth that is higher than the growth in demand for the goods and services these industries offer.

The differentiation between traded and local industries provides a more granular perspective on two parts of the economy that face very different dynamics. Both are important contributors to the economic well-being of a location, but they play different roles: Traded industries are like the engine; if they are not successfully competing on national or global markets, a location cannot reach higher levels

of prosperity. Local industries are like the powertrain and tires; if they are not efficient, the power of the engine is not translated into actual prosperity for the location.

Clusters and the Nature of Competition

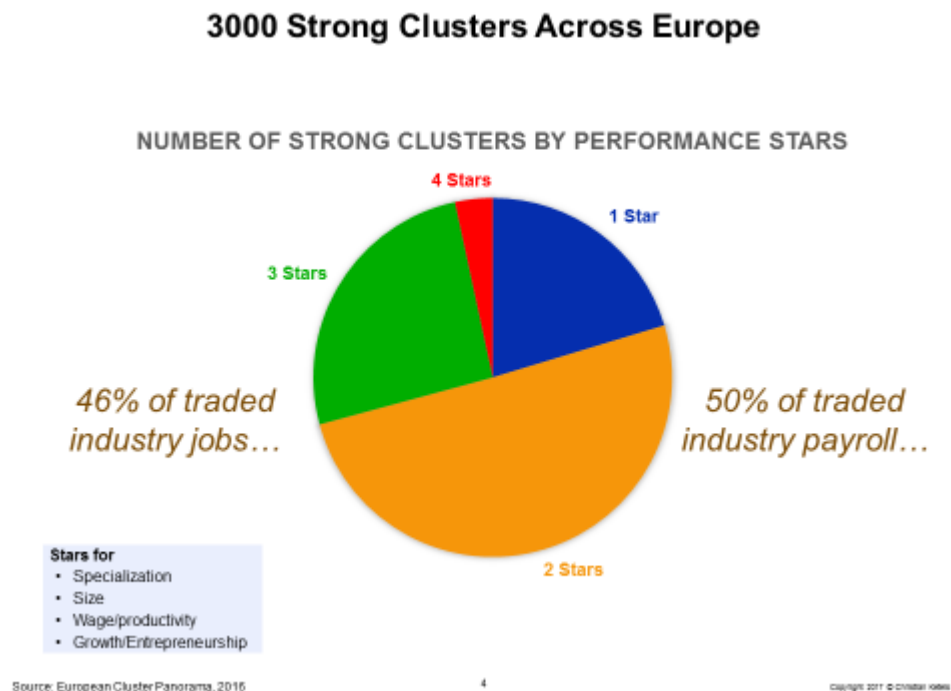


1.3.2. Strong clusters

The dynamics of clusters are driven by critical mass within a set of related industries, a cluster category, in a specific location. But what exactly is the cut-off value at which critical mass starts to become meaningful? There is no simple empirical answer from the existing research. And the differences in geographic concentration patterns across cluster categories suggest that the answer might also be different by category. Existing cluster mapping efforts have applied relatively simple ad-hoc cut-offs: For both the U.S. and the EU, the top 20% of locations by location quotient, i.e. relative employment specialization, subject to a minimum absolute size were designated as strong. In Europe additional degrees of strength were introduced in a ‘star-ranking’ providing up to three additional stars to strong clusters that also ranked in the top 20% of European regions by productivity/wages, job creation, and entrepreneurship/presence of high-growth start-ups.

The empirical analysis indicates that the 20% of locations that by design are designated strong clusters account for between 40% and 70% of all employment and wages in a given cluster category, reflecting the highly skewed nature of economic geography in these groups of industries.

Importantly the data also reveals a significant amount of churn among strong clusters: while being strong today gives you a good opportunity to be strong also tomorrow, changes in competition, technologies, and market demand see some clusters lose their position to others every year.



1.3.3. Cluster presence and economic performance

The data then supports the hypothesis that strong clusters generate strong economic performance in a range of dimensions that policy makers are concerned about.

In terms of wages, there is a positive relationship between cluster strength and wages. However, the data also shows that a range of other locational factors influence the absolute wage level in local

clusters. Controlling for those, the research finds benefits that are in the range of other studies of agglomeration effects, of between 2% and 7% higher wages (Ketels/Protsiv, 2013).

In terms of job growth, the cluster effect countervails the convergence effect that sees locations with high employment in a location add jobs relatively less than locations that are catching up. The key dynamics of job growth are in the related and supporting industries that are part of a strong cluster but in which the region has not yet reached high concentration levels. Recent research has also looked at the differential impact of crises on strong clusters vs other locations: for the recent period in the U.S. it finds strong clusters to be more resilient, probably because these groups of related firms have found it easier to react and find other uses for their capabilities.

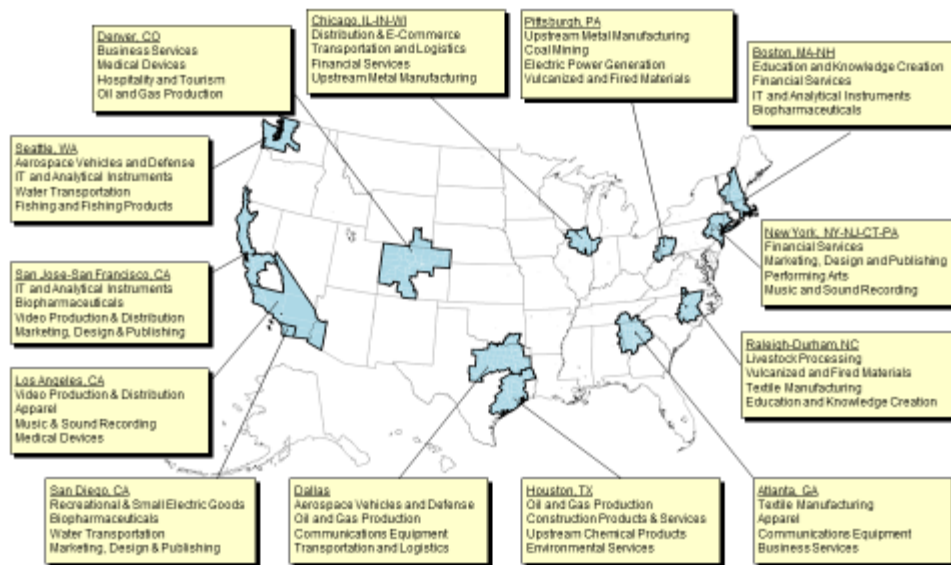
In terms of entrepreneurship, there is evidence that shows strong clusters to be both a strong breeding ground for new companies, and an environment where survival and growth rates are higher than elsewhere.

1.3.4. The role of location

Clusters exist everywhere. This is not a statement of intellectual chauvinism but reflects the empirical observation that indeed all types of regions are characterized by the presence of clusters. There is a tendency for more prosperous regions to have more of their employment in strong clusters. But this effect is relatively weak. More dominant are the differences in the depth, range, and type of clusters that change as locations develop and reach higher levels of prosperity.

The data reveals that each region has its own distinct cluster portfolio; this gives each region a distinct platform to compete on. While there are groups of locations that aim to attract the same type of activities, they tend to offer different combinations of assets; they are not just better or worse on one dimension that matters exclusively. The data also shows that each cluster category has its own economic geography in terms of where the strong clusters are located. Because different clusters have different needs in terms of business environment conditions, many regions can successfully compete for some set of economic activities. These observations differentiate the cluster framework from other schools of thought that ultimately argue that there is one dimension of competitiveness that matters, with some locations succeeding and many others destined to fail.

Clusters and Regional Specialization



Source: Prof. Michael E. Porter, Cluster Mapping Project, Institute for Strategy and Competitiveness, Harvard Business School; Richard Bryden, Director.

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Clusters are both a reflection and a driver of the underlying competitiveness of a location. They emerge as locations develop competitive advantages relevant for a specific set of economic activities. And they reinforce and leverage the benefits of the business environment qualities that exist.

1.3.5. Heterogeneity across cluster categories

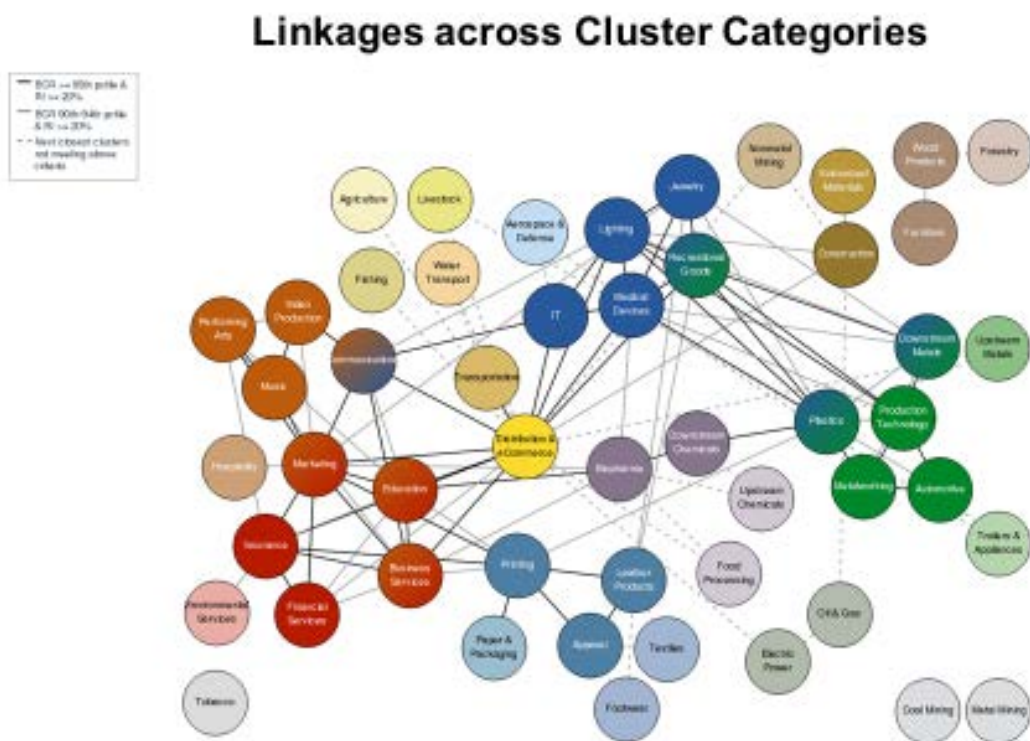
Cluster categories differ significantly in their overall size, growth, performance and many other dimensions. Partly this is an artefact of the way the data is being collected; by far the largest cluster categories are different service categories for which the industrial classification system is much less granular than for industrial activities. But partly it also reflects underlying differences in the nature of specific markets and industries.

The data also shows significant differences within cluster categories. This supports the view that it matters not only which industries you are in, but how well you perform in them. Many studies on industrial transformation and other sector-focused studies focus only on the prior. Cluster research indicates that how well you do is critical, and is significantly affected by cluster strength.

A closer look at the data furthermore indicates that not only the performance but also the profile of activities differs significantly across locations within a given cluster category. While the automotive cluster in Southern Germany is highly research-intensive with a high share of advanced services, the clusters in Hungary and Slovakia are much more focused on production and final assembly. Understanding a cluster requires understanding its role in an industry's value chain, not just which broad cluster category it belongs to.

1.3.6. Relatedness across clusters

The cluster definitions discussed above assign each narrow industry to only one cluster category. The reality is more complex as different aspects of the empirical data reveal. Already in the analytical work on deriving cluster definitions it became apparent that industries tend to have linkages of different intensity with a range of other industries and clusters. This information is available to identify which clusters are most significantly related to each other.



Source: US Cluster Mapping Portal

The empirical analysis indicates that the presence of related clusters has an impact on cluster-level performance. This data is also consistent with the literature on related diversification that shows that new industries are more likely to emerge in a location if they are related to industries or clusters that are already present there (Neffke et al., 2011). Some new work has attempted to leverage these findings by developing broader groupings of related clusters and industries in which new combinations might emerge.

1.4. Related conceptual approaches and tools

Cluster mapping is a specific tool within a broader range of analytical instruments that can be deployed when working with clusters. It is important to understand both its potential and its limitations when launching a cluster mapping effort. The issue is not that one of the analytical tools is necessarily better than the other; it is that they answer different questions and have different requirements. Cluster mapping provides the broader context in terms of the overall economic geography within a country. This is particularly important for policy makers at the national level: the geographic footprint of economic activity provides important information about barriers to cluster emergence that might exist. But it is also important for decision makers at the regional or cluster level: they can learn about the specific cluster mix in their location and the locations that as peers or rivals provide the most important benchmarks. The additional tools listed in this section can then be used to design a specific action agenda that can help enhance a cluster's position in this context.

1.4.1. Alternative approaches: measuring industry relatedness

A central issue for cluster mapping is the way that industry relatedness is operationalized. Alternative approaches have devised somewhat different ways to do so, coming up with classifications that are different in detail but often much less so in overall nature from the cluster definitions.

First, there are a range of approaches that define groups of related industries based on a single factor. Some focus on knowledge-spillovers, others on technology, and some look at similarities in skill use (for example Martin et al., 2013). Each of them has their value, particularly in understanding the nature of the specific local linkages that they represent. But while they make the point about the importance of location and the specific driver they discuss, they have hardly been used to generate location-specific diagnostics or policy recommendations.

Second, the literature on related variety emphasizes the need to understand cross-industry linkages enabled or enhanced by proximity (Neffke et al., 2011). Its interest is then to understand how such linkages affect the evolution of regional economies and their specialization patterns. Compared to the other approaches this literature spends little focus on empirically deriving which industries are related to each other. It relies largely on the proximity of industries within the industrial classification system which is strongly based by similarities in technologies used.

Third, the literature on economic complexity does as the cluster mapping work look at revealed evidence of linkages, not the linkages themselves. As the key indicator it looks instead at the co-occurrences of exports by industry across countries (Hausmann et al., 2013). Conceptually it sees these exports as the embodiment of underlying capabilities. And these capabilities can be combined in different ways, enabling the country to export new products and services.

Fourth, there are a number of studies that use the cluster terminology but focus only on the locational pattern of a specific type of activity, not on the linkages across related sectors. This is, for example, the case in the identification of ‘patent clusters’ that look at the geographic patterns of patenting activity across locations around the world (Bergquist et al., 2017). This approach is inspired by the urban and regional innovation system literature, where it is the location that is described as a ‘cluster’ based on the existence of economy-wide linkages and spill-overs.

1.4.2. Complementary tools: generating location-specific insight

Cluster mapping aims to provide a comprehensive perspective on the presence of clusters across regions and different sectors of the economy. This data allows individual regions and clusters to compare their profile and performance systematically with peers. But for the development of action plans a deeper and more location-specific analysis is needed. A range of tools is available to conduct such additional analysis (for a more detailed discussion see World Bank, 2009). Cluster mapping can help identify possible issues; these complementary tools can then analyze root causes and develop options to address them.

First, the competitiveness analysis, often concentrated on the quality of the cluster-specific business environment conditions for which Michael Porter coined the term ‘diamond’, looks at the fundamental inputs that firms find in a given location. It is at this level that much of the specific policy action needs to happen, for example by launching specific workforce skill programs, removing regulatory barriers, or

providing specialized infrastructure. The diamond analysis identifies the foundational conditions in the location, while cluster mapping documents the breadth and depth of economic activities that have emerged on this basis.

Second, industry structure analysis studies the dynamics and average attractiveness of a given industry. It is a critical tool for firms that need to make a strategic choice about market positioning. But it also provides essential insights for locations that have to explore what type of upgrading activities will be of most value. The industry analysis, often drawing on the five forces-framework also introduced by Michael Porter, provides a perspective into competitive drivers and trends, while cluster mapping captures the economic geography of hotspots that have emerged on this basis.

Third, network analysis is concerned with capturing the specific linkages that exists between entities within a cluster as well as with entities elsewhere. It thus provides important information about a critical aspect of cluster dynamics and external linkages. In some cases it will indicate that a location's weak performance is driven by poor collaboration among co-located entities, not the business environment or the mere mass of activity. Network analysis shows who collaborates with whom at what level of intensity, while cluster mapping identifies the entities that are co-located and could collaborate.

And fourth, policy mapping captures the organizations and policy initiatives that have a direct impact on a specific cluster. It looks at the current attempts to enhance the competitiveness of a cluster, and thus provides a critical starting point for any policy recommendations. A key aspect that has gotten increasing attention is the way a cluster has organized itself to upgrade its performance; it is often the 'how' that drives the ultimate impact on competitiveness, not just the individual set of actions, i.e. the 'what'. Policy mapping captures what has been attempted so far, cluster mapping how this has affected the nature and performance of the cluster relative to other locations.

2. A Practical Guide: Implementing Cluster Mapping

This section defines criteria for a cluster mapping effort to be most valuable, and then outlines key steps to take when launching a cluster mapping project. The ‘pre-launch startup pack’ attached to this report translates these principles into a practical guide for World Bank teams and their clients.

Key points in this section

- Check whether cluster mapping is appropriate, feasible, and related to key challenges facing the relevant economy
- Mobilize and finance a research team, identify and involve key stakeholders, and define timeline, deliverables, and how cluster mapping data is going to be used in specific policies
- Plan and execute the core steps of the cluster mapping effort:
 - Data audit
 - Generation of cluster definitions
 - Data acquisition
 - Generation of cluster mapping data set
 - Descriptive statistics and overall observations
 - Public platform for data access

2.1. When to do cluster mapping

Insights into the cluster composition of its economy are useful for any location that has the ambition to upgrade its economic performance and understands the value of evidence-based policy making. But the value of a cluster mapping effort depends on the context in which such an initiative is taken. Three issues in particular should be considered before launching a cluster mapping project.

First, the value of cluster mapping rests on its ability to provide a comparative perspective across different regions. This makes it a particularly valuable tool for larger economies with multiple distinct regions. This is the context under which distinct patterns of cluster specialization are most likely to emerge. And they are also the conditions under which comparisons across regions can provide the most powerful insights. The existing or on-going cluster efforts in countries and regions like the United States, the European Union, Canada, Mexico, China, Brazil, and India all fall into this category.

For smaller economies, including those that are effectively one economic region, cluster mapping can still be valuable if it is done in a way that allows comparison with other locations. This can happen either by doing a joint effort among a group of neighboring countries that have a high level of economic integration, or by adopting the cluster mapping approach of relevant peer countries.

Second, the insights that cluster mapping can generate depends on the quality of the data that is available. While it is in principle possible to collect primary data for a cluster mapping effort, in practice such an approach is prohibitively costly. The choice on launching cluster mapping thus needs to be made based on existing data sources. At the minimum, there needs to be recent data on industry-specific economic activity covering large segments of the traded industries in the economy. While countries generally have some regional and some industry-specific data not all have the combination of both of these dimensions. In terms of industry-specificity the higher the level of granularity that is available, the more cluster categories can capture actual groups of related industries rather than staying close to traditional sectors. Data that is specific at the level comparable to the 3- and 4-digit level of the North American Industrial Classification System (NAICS) is a useful benchmark. In terms of the specific indicators of economic activity employment levels are the absolute minimum, followed by data on wages. Annually updated data is ideal but since patterns of economic geography do not tend to change very fast a lower frequency of between 3-5 years can also work.

In emerging and developing economies data coverage issues related to informality are a particular concern. In India, for example, more than 80% of all employment is not part of the formal economy, and thus generally not covered in the public statistics. Commercial data sources might capture some of the informal firms but not all. A related issue is the bias of government statistics towards certain sectors or firms. Manufacturing activities and larger firms tend to be better captured, which both limits and distorts the results of cluster mapping. Even for such a smaller set of activities cluster mapping can make sense given that it captures the parts of the economy most integrated into the global economy. But it is important to be aware of the limitations that the lack in coverage imposes.

Third, while cluster mapping data is among the fundamental indicators that all economies should have access to, a cluster mapping is more valuable if it sheds light on policy issues that are particular pressing in a given location. This ensures that key stakeholders in the policy and business community are open to engaging with the data and insights that cluster mapping can generate. Cluster-based data is particularly useful for countries that want to pursue sector-specific policies. It then provide information on the industries affected, directly as well as indirectly, and the regional impact that such policies are likely to

have. But cluster mapping data also provides insights into a number of cross-cutting issues, and should be a key pillar of more general competitiveness diagnostics. It can reveal issues like a lack of traded industry employment, a low concentration of traded industry employment in strong clusters, or strong regional imbalance in cluster presence. All of these point towards barriers in the functioning of markets or weaknesses in policies that are not sector- or location-specific but have a strong impact on the nature and strengths of clusters across the economy.

Check list: Go or No-Go for a cluster mapping effort

- Does the effort **cover a large enough number of distinct regions** (or is embedded in a larger study that generates comparable data from other regions) so that comparisons are meaningful?
- Is **sufficient data** available? The minimum requirement is data that comprehensively captures employment at the level of 3 to 4-digit industries for a significant number of traded industries at the level of subnational regions like states or provinces
- Is the cluster mapping data likely to **address key current policy challenges or opportunities** for the economy?

2.2. Preparing for a cluster mapping effort

Once a political decision has been made to engage in a cluster mapping effort, the necessary resources and capabilities have to be mobilized. The planning also needs to define key deliverables and a timeline for delivery.

The team of analysts or researchers required to conduct a cluster mapping effort is relatively modest; usually between 3 and 5 people are involved. The skills required include project management, economics with a focus on economic geography, regional economics, and microeconomic policies, and statistics with particular experience in managing larger data sets. The latter usually requires familiarity with standard statistical and econometric packages. Strong econometric skills are an advantage, especially for the further analysis of the cluster data, but are not essentially in generating the cluster mapping data set. The relevant skills can be found both in academic research institutions and specialized consulting firms. In both cases it is important that the government is a strong visible owner of these efforts, so that the data is perceived as neutral and officially endorsed.

The team has to be connected to relevant stakeholders. This includes particularly representatives of the government's statistical office as well as those government ministries and agencies in charge of policies that will be able to draw on the cluster mapping data. The early involvement of the statistical office is important to over time embed cluster mapping in the traditional reporting of the government. Without it there is a danger that the cluster mapping effort remains a one-time initiative that ends once the initial project is over. An early and on-going dialogue with the intended users of cluster data in the government is critical for the data to have an impact on policy making. Without this dialogue there is a danger that the cluster mapping effort remains a research initiative, generating data that policy makers feel no ownership of and do not understand. While this data can still be useful, for example for investors or the business community interested in the specialization profile of specific locations, it then has much less impact than it should and could have. A third group is the relevant group of think tanks, industry associations, and academic researchers. Keeping them informed can raise the quality of the subsequent policy debate, and help overcome reluctance based on a misunderstanding of what cluster mapping is.

The immediate outcome of a cluster mapping effort is a cluster mapping data set and a documentation of key descriptive statistics. A further deliverable could be a website to make the data easily available to regions, government agencies, and businesses. From a policy impact perspective it is beneficial to link these operational outcomes to specific policy efforts, for example a comprehensive competitiveness assessment or the design of a new regional or cluster program. Without such an integration in the policy process cluster mapping can remain an academic exercise without impact on policy making.

Cluster mapping efforts usually take between 6 and 9 months. The largest uncertainty is around the time it takes to acquire the existing data, because this is where the team has to rely on external partners like the statistical office or a commercial vendor. The time needed for creating and analyzing the data depends on the team resources mobilized. Budget is largely required to finance the research team but there might also be costs involved for acquiring the relevant data.

A key issue to consider already in the design phase of cluster mapping is a plan for shifting from a one-time project to a stable structure for updating and developing the cluster mapping data. The responsibility could ultimately be located in the statistical office, an existing research institute or government think tank, or a new entity like a cluster or competitiveness observatory. The World Bank could also play a role here, covering a group of countries. An ultimate decision (which also needs to include a financing structure) will be hard to make at the outset. But it is useful to be aware of this issue early on and make such a decision part of the final phase of the initial cluster mapping effort.

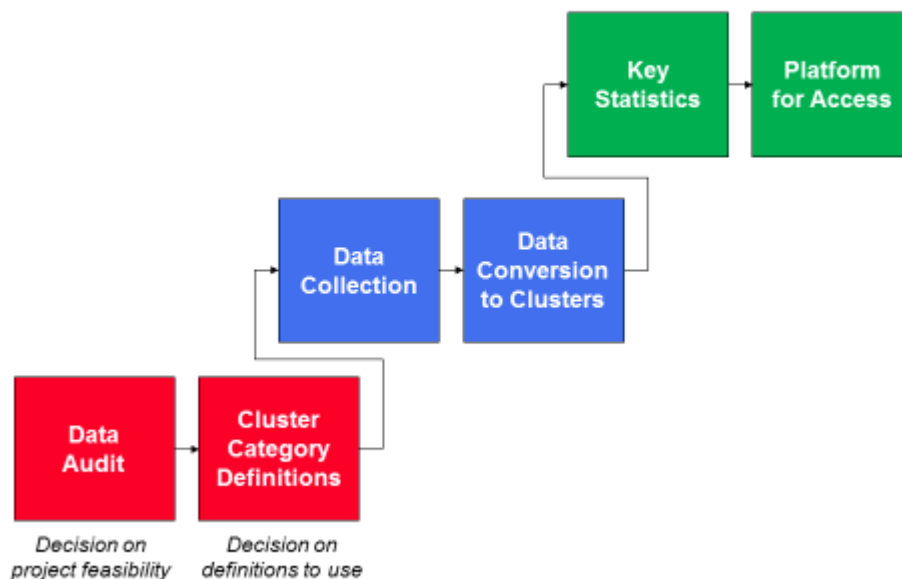
Check list: Getting ready for the cluster mapping project

- Mobilize and finance a dedicated research team with skills in project management, economics, and statistics
- Engage **key stakeholders** in the statistical office, government agencies, and the business and academic community
- Define **project goals and deliverables**, including a post-project structure to continue updating the cluster mapping data

2.3. How to do cluster mapping

The cluster mapping effort proceeds in three main phases, with two steps each. First, decisions have to be made about the data to include and the cluster definitions to use. Second, the raw data on economic activity by region and narrow industry has to be acquired and aggregated towards the level of cluster categories. Third, the cluster mapping data set is analyzed to generate an initial set of descriptive statistics and observations which are then made available to decision makers and the wider public.

Cluster Mapping Project: Key Steps



2.3.1. Data audit

The initial assumptions about data availability need to be reviewed in a data audit. The audit can generate more specific insights into the methods used for data generation by the original sources to be used, including coverage, frequency, and types of indicators covered. With the decision made to launch such an effort it might also be possible to unlock further relevant data that exists in the statistical office but is not readily available or made public. This could relate to data at a more granular level of region or industry, or to other dimensions of economic activity covered.

Beyond the data that can be linked directly to clusters, i.e. data that is available for narrow industries at the level of regions, it is useful to also identify data sources for indicators that are region-, industry, or even economy-wide. Total employment can be useful to assess how much of the workforce is captured by the cluster mapping data; this is especially important if the data used for cluster mapping only includes specific industries or types of firms. Regional GDP, employment, wage, and population data is useful in relating cluster portfolio strengths to regional economic outcomes. Exports or FDI for specific industries can be useful to link to the geographic footprint of clusters in the relevant industries.

2.3.2. Cluster definitions

Cluster mapping relies on the use of cluster definitions that are comprehensive, transparent, evidence-based, and comparable across locations. For the cluster definitions there are two main options: Either to use the cluster definitions developed in the context of previous cluster mapping efforts or create a new set of definitions based on the data of the country in question. The first option is in general preferable:

- Deriving cluster definitions puts significantly higher demands on data availability than merely applying the definitions already existing
- Using a national data set is likely to introduce biases given the nature of the local economy in terms of its specialization patterns
- National definitions will introduce a bias in comparisons with other countries that are using different existing cluster definitions

If the decision is made to apply the existing cluster definitions, they need to be translated from their existing form in 5-digit NAICS industry codes into the industrial classification code that the country in

question is using. In some cases a conversion matrix might exist, in others the definitions of industries have to be used to create a match. For cases in which such a match is difficult, either because definitions are overlapping or because the data is available only at higher levels of aggregation where industry codes include NAICS codes from different clusters, the properties of the underlying data need to be analyzed. For example, it is useful to look at geographic co-location patterns within the country as well as the relative size of industries that combine to a higher level category.

If the decision is made to generate a new set of cluster definitions, it requires the collection of the type of data used in the previous foundational cluster mapping work, i.e. data on co-location of employment and establishments, as well as national level data on input-output linkages and overlaps in skill use. This data could then be analyzed using the algorithms developed by Delgado et al., 2016, to generate cluster definitions. Differences between these new definitions and the existing benchmark definitions could be a reflection of different economic circumstances, for example the specialization in different sectors or types of activities that align across locations in ways not seen in the U.S. But they can also be the reflection of higher barriers to factor mobility and trade that exist relative to the U.S., in which case it is much less meaningful to use them as a benchmark to look at cluster presence.

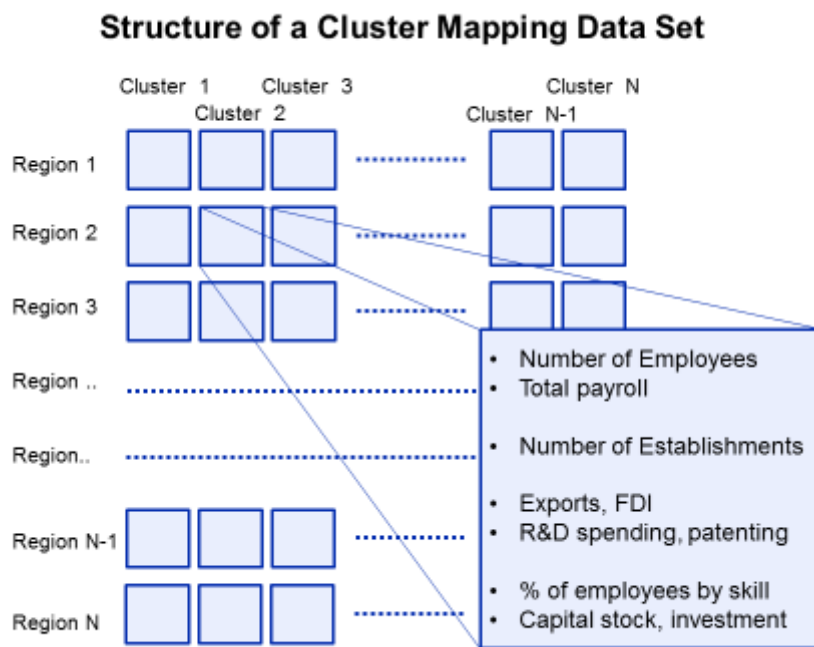
2.3.3. Data acquisition

The data sets identified as the source of the input data have to be acquired. There might be public data sets but in some countries commercial private data providers offer better data. An issue is whether the results of the analysis can be published, either in terms of aggregate findings (which is usually not a problem) or also in terms of cluster and region-specific data (which can be problematic, especially when in small regions and clusters that data allows conclusions on individual firms).

Another issue is whether the data has full coverage or represents a sample that needs to be adjusted to account for the full population of firms. If the data is only a sample, it has to be extrapolated to reflect the full size of the respective type of firms in the economy. There is also always a process of data cleaning and quality control. There can be mistakes in data transmission or collection, and there might be issues when data suppression leads to indicators given as a range rather than a distinct data point.

2.3.4. Cluster mapping data set

The existing data has to be aggregated towards cluster-level information for the target level of geography, using the cluster definitions derived in step 2. Note that this step has to be taken for every indicator that is covered, for example employment, wages, and establishments. This step leads to the core cluster mapping data set with a matrix structure as depicted below.



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2.3.5. Descriptive statistics

The data can be used to create a core set of descriptive statistics and accompanying graphics to visualize the data. For the statistics on cluster presence it is necessary to operationalize the notion of a 'strong cluster', i.e. a group of related industries in which a location has reached critical mass. The main existing studies have selected the top 20% of regions by location quotient and an absolute employment level above 500 full-time employees (Ketels/Protsiv, 2016); see section 1.3.2 above. For the calculation of location quotients it is necessary to specify whether regions are compared to the overall national economy or to a broader grouping of economies.

In terms of descriptive statistics, the following core topics may be covered:

- National benchmarks: traded industries and clusters
 - Share of traded industries in the overall economy (employment, establishments); comparison of levels vs local industries (wages, job creation)
 - Share of cluster categories in the overall economy (employment, establishments); comparison of levels (wages, job creation)
 - Share of strong clusters in the overall economy (employment, establishments); comparison of levels vs rest of the economy (wages, job creation)
- Regional and cluster perspective
 - Share of employment in traded industries, strong clusters by region; number of strong clusters by region
 - Share of strong clusters in national activity by cluster category (employment, establishments); comparison of levels to other locations (wages, job creation)
- Regional/cluster profiles
 - For each region show its cluster portfolio (LQ and change in national share by cluster), including national ranks for each cluster on the core performance metrics (employment, wages)
 - For each cluster category show its geographic footprint of absolute employment by regions, including location quotient, job creation, and average wage

The data can also be useful to compare the average performance of a specific groups of regions, for example those with the highest share of employment in strong clusters, on aggregated measures like GDP per capita and regional wage with those of the remaining regions. Other potentially interesting cuts are between metropolitan areas and rural regions, where it is possible to compare share of employment in strong clusters or the cluster categories in which the respective type of region is most often strong.

2.3.6. Cluster mapping portal

In many cases it is useful to make the cluster mapping data set itself publicly available, not just a report on key descriptive statistics or overall findings. Such 'open data' portals have been launched in a number of countries, both to provide critical information to policy makers at the regional level and to companies that are considering the attractiveness of different locations.

Such data portals can be created with different levels of ambition and functionalities. At the minimum, a website can be created to download the entire data set as well as key reports. With existing software packages it is now also fairly easy to create websites that include geographic maps to allow accessing data for specific regions, or to create other functions that allow users to choose specific clusters or indicators. Some existing portals have also added further functionality, for example a connected data set on regional economic performance and competitiveness, a registry of cluster-based organizations, and further tools for web-based collaboration across clusters.

The choice about which level of sophistication to aspire for with a cluster mapping portal depends on the policy objectives as well as the available resources. Making data available for the policy community and expert users can often be easily done. Designing a web-site that engages a broader community of practitioners, including many who are not familiar with the concept of clusters, is a more ambitious undertaking that requires different ways of communicating the content and a more developed set of tools to select and analyze the data.

3. The Use of Cluster Mapping Data in Informing Policy

3.1. From clusters to cluster-based economic development

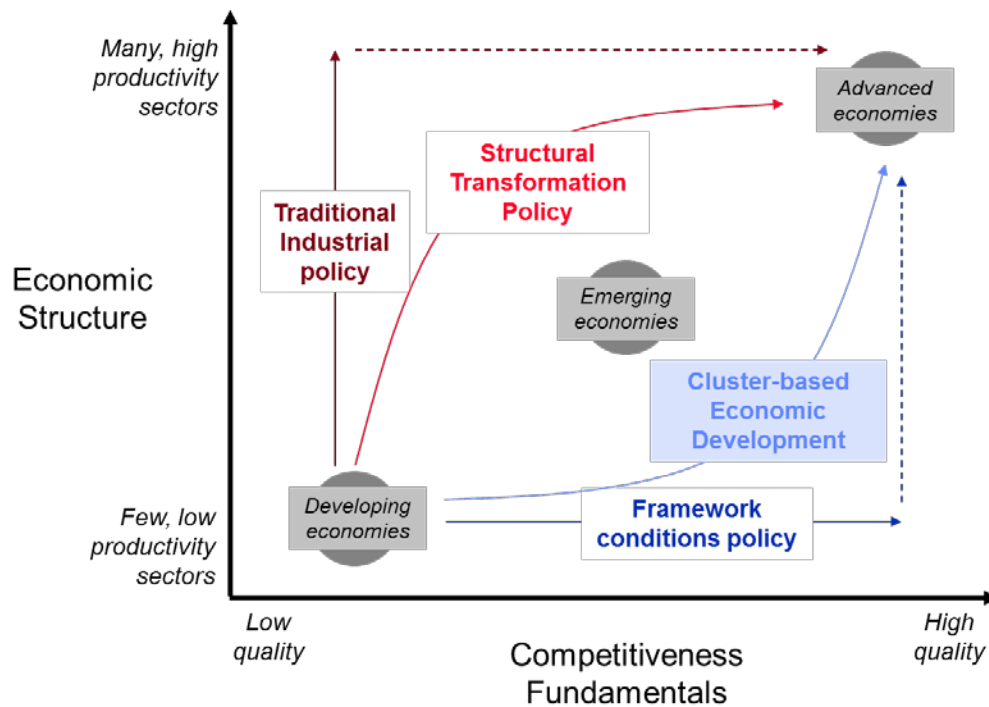
When the cluster concept gained new visibility in the early 1990s, it triggered a debate about the policy conclusions to draw. The data showed that clusters existed and that cluster presence often coincided with higher levels of economic performance. But whether these observations justified policy interventions, and if so which ones, remained unclear. There were concerns that cluster policies, especially efforts that tried to create clusters in the spirit of traditional industrial policies, might lead to distortions and rent-seeking, undermining rather than enhancing competitiveness and prosperity.

The thinking on cluster-based economic development that has emerged since then has largely taken a different direction. It is based on the view that clusters emerge naturally in the market process, and are not created by government even if policy affects their evolution. But there are a number of potential market failures that create room for government or public-private actions to enhance competitiveness (Waits, 2000; Rodriguez-Clare, 2005, 2007; Ketels/Memedovic, 2008; Crespi et al., 2014):

- While co-location in clusters occurs naturally, collaboration and the strengthening of linkages between firms and other entities do not happen automatically. There can be collective action problems or other transactions costs and barriers that government action can help to overcome.
- There are traditional market failure arguments for government interventions in terms of skill development, innovation, and so on. Organizing such activities around clusters can enhance their effectiveness: Cluster-based organizations can organize the dispersed information about what actions are most valuable in a specific context, and they can mobilize the coalition of public and private entities that needs to act jointly for these efforts to have their full impact.

This new thinking on cluster-based economic development has some similarities to the literatures on new industrial policies (Rodrik, 2004; Warwick, 2013), on structural transformation (Lin, 2016), and on economic complexity (Hausmann et al., 2003). But while these ideas tend to focus on the need to change the economic structure of an economy, cluster-based policies see those changes more as an outcome of changing underlying competitiveness fundamentals. In contrast to the traditional perspective on improving cross-cutting framework conditions, however, cluster-based policies propose to enhance fundamentals in a cluster-specific way, working with existing clusters and emerging clusters related to existing strengths (Ketels, forthcoming).

Comparison of Development Approaches



The approach of cluster-based economic development is also related to the discussion about whether policies should be location-specific or neutral, coming down clearly on the side of the prior (World Bank, 2008; Barca et al., 2012). This related literature on locations tends to be focused on the question of agglomeration of overall economic activity, and on the potential of unequal development across locations. The cluster-based view is more concerned with identifying the specific development opportunities that any location has, whether it is urban or rural. It is based on the observations that all locations have their own portfolio of clusters and that each one of them is facing its unique circumstances for developing and strengthening competitiveness through cluster-based efforts.

Over time, more than two decades of experience with the practical application of cluster-based economic development approaches has become available. While there is significant heterogeneity, the vast majority of efforts has not fallen into the old industrial policy-traps that critics were concerned about (see, for example, Maffioli et al., 2016). Many of these efforts have achieved a positive impact on

firms and regions. The type of challenges that emerged are often more related to execution, including the following issues:

- cluster programs are pursued as a new 'silo' within different, sometimes competing, parts of government
- cluster efforts are focused on a specific activity prioritized by government, for example networking, and fail to address the broader strategic needs of the cluster
- cluster efforts are not sufficiently connected with a wider strategy for the regional economy they are part of, including the portfolio of other clusters in the region

The nature of cluster-based efforts is affected by the existing circumstances in a location, in particular the nature of public and private institutions and the broader approach towards economic policy. In advanced economies cluster initiatives as a new type of public-private platform play a large role (Lindqvist et al., 2003). Policy actions tend to focus on enabling collaboration and networking. In emerging and developing countries it is instead more often a government agencies that takes the lead, and the actions themselves focus more on attracting firms and shaping the cluster-specific business environment (Yusuf et al., 2008; Zeng, 2008). But there exceptions: the Latin American model has much more similarities to the approaches in Europe (Pietrobelli/Rabelotti, 2006).

An assessment of cluster initiatives in developing and emerging economies supported by international aid and financial institutions highlighted another challenge: the clusters that these entities work with are often those that face the most difficult starting positions in terms of the quality of the cluster-specific business environment and the context for collaboration (trust, governance) (Ketels et al., 2006). The assessment of the World Bank's industry-specific actions reflects additional challenges: A lack of an overall framework for upgrading competitiveness easily leads to actions that remain isolated and that thus fail to have the full impact they could have (Independent Evaluation Group, 2016).

3.2. Specific insights cluster mapping data can generate

The type of cluster-based initiatives that have been launched in recent years can benefit from the insights and rigor that cluster mapping data provides. But cluster mapping can generate insights for a broader set of policy issues that do not necessarily involve cluster-based efforts in a narrow sense.

3.2.1. Competitiveness diagnostics

There is an increasing recognition that national growth strategies need to be aligned with the specific circumstances in a location. The World Bank aims to provide such a diagnostic as part of its Systematic Country Diagnostics (SCD) (World Bank, 2014). Cluster mapping data can enrich such a diagnostic by providing a more general perspective on the sectoral and geographic profile of the economy. The national benchmark data in particular can help identify whether there seem to be barriers to cluster emergence. This could be related to distortive policies or to a lack of integration across regions within the country.

The particular pattern of cluster presence, both where they are and who they are, provides insights into the foundational competitiveness of a location. Clusters emerge as a reflection of underlying competitive advantages, both in terms of business environment conditions and other factors such as geographic location. Cluster data can thus provide important revealed evidence to inform the competitiveness diagnostics of a country.

The competitiveness of the Great Lakes-St. Lawrence Region: A cluster-based view

Eight U.S. states and two Canadian provinces collaborate under the umbrella of the Great Lakes-St. Lawrence region in areas related to environmental protection, infrastructure, and more recently also economic development. The U.S. and Canadian cluster mapping data were merged to provide a cluster-based analysis of this economy that accounts for about a third of the combined U.S. and Canadian GDP. The data revealed that the region's lagging performance was driven by the eroding performance of the region's traditionally strongest clusters; it was the competitive position of core firms in these locations that was the problem, not a lack of agglomeration or weaknesses in the cluster-specific business environment. The study also identified areas of dynamism, often in emerging clusters related to IT or water-related technologies, and in medium-sized cities with strong academic institutions (Ketels, 2015).

3.2.2. Regional strategies

Clusters are by their nature regional; and region economies are by their nature a collection of clusters. Data on cluster portfolios are then a critical aspect in a process to develop regional economic strategies (Porter, 2003). As for a country, the cluster data reflects specific qualities of the business environment.

Regions have to consider their value proposition as a place to do business, and reflect on how this value proposition is translated into advantages for specific types of economic activities, i.e. clusters.

Cluster mapping data can also help regions make more informed choices about efforts to accelerate structural change. They can identify clusters in which the region has already achieved critical mass but where there might be opportunities for enhancing the sophistication of activities to achieve higher levels of value-added and productivity. And they can identify clusters and industries related to existing areas of strength in which the region has some relevant assets to successfully compete (compare to Hausmann et al., 2013; Lin, 2016). The process of exploration in attractive new sectors can thus be focused on those that are most aligned with a region's capabilities.

Jerusalem: Strong assets, weak clusters

When the city of Jerusalem was working on a new growth strategy, the cluster-based analysis provided important insights. It clearly showed that the weak economic performance of the city was strongly related to a very low share of employment in strong clusters of traded industries. A further analysis of the business environment revealed that these clusters were weak despite strong assets in terms of human skills, top academic institutions, and other assets. What was lacking, was a coherent strategy to leverage the economic potential of these assets. The Jerusalem 2020, a five-year growth plan for Jerusalem's economic development, suggested specific investments that would be targeted at mobilizing the portfolio of clusters in the city, with a view to generating shared benefits across the different parts of its population (Porter/Ketels, 2015).

3.2.3. Functional or Industry-specific actions

Many policy programs have a specific scope in terms of function, like FDI attraction, or sector, like electronics. Cluster mapping data can help to inform these policies both in terms of their geographic dimension but also in the way they capture the relatedness between narrow industries. And they can engage the private sector by identifying areas of critical mass and groups of relevant partners that need to be involved. Cluster-based efforts put such policy actions within a public-private context, providing a platform for quick feedback from firms regarding government's plans and joint action where needed (Dinh, 2017; Fernández-Arias et al., 2016).

A specific example are efforts to help countries engage with global value chains. These value chains are in essence a combination of regional clusters in different countries. Cluster mapping data can reveal how opening up to global trade can affect individual regions in terms of global value chain engagement. It can then also support the diagnostics of the regional cluster to identify ways to broaden its profile to include more related and supporting industries.

Another practical example is the creation of industrial parks. Often these are designed around a particular offering in terms of physical infrastructure in connection with financial incentives, often also with tariff rules that disconnect them from the rest of the local economy. Cluster data can provide insights into what type of activities should be targeted for a specific industrial park to strengthen and leverage the existing local economy. And it can inform where industrial parks might have the highest likelihood of success given the current structure of the economy and the insights it provides about existing assets and capabilities.

A similar logic applies to foreign direct investment attraction, the development of workforce skills, or the upgrading of SMEs. In each of these cases cluster mapping data can help identify the regional opportunities and groups of entities through which the general policy ambitions can be translated into concrete action targeted at the needs of the relevant firms.

Some countries have the ambition to support specific sectors of the economy. Cluster mapping data can help guide these efforts both in a conceptual and in a practical way. Conceptually it highlights the need to think about sectors through the cluster lens, i.e. in terms of groups of related industries. Many traditional sectoral initiatives have ignored these linkages, creating conflicts along supply chains or neglecting the importance of related and supporting industries. Practically, cluster mapping data then helps to identify where the relevant economic activity takes place; a key necessity to anchor action in the local knowledge about opportunities and needs. Again, many traditional efforts have neglected both this local knowledge and the need to engage the local decision makers that have a strong influence on the environment in which these sectors operate.

3.2.4. Cluster initiative actions

Finally, cluster mapping data also can help cluster initiatives to make more informed choices about their strategies and to track their evolution over time. The particular benefit from cluster mapping is that it provides the opportunity to compare specific clusters across regions based on a consistent

methodology. Clusters can identify potential peers in value chains as well as rivals for similar types of activities. They can compare size and performance, and they can look at relative trends over time.

Importantly, cluster mapping also provides clusters with systematic information about other clusters in their own region. These other clusters might provide complementary assets or capabilities that can enhance a cluster's strategic positioning. Or they can outline opportunities for firms to shift into related fields of economic activity.

While cluster mapping provides an important foundation for the analysis that cluster initiatives have to do, it is important to recognize the need for additional instruments to be used. Cluster mapping's focus on comparability across locations implies that it can lack specificity and alignment with local conditions. For a strategy process in a cluster the cluster mapping data will thus often be the starting point, not the answer. A specific action agenda needs to be based on further research, for example a granular understanding of the specific profile of the local cluster, a deep analysis of the cluster-specific business environment, an analysis of the local linkages and networks, an outward looking review of the competitive dynamics in the markets in which the clusters' firms operate, and an assessment of current status of government.

Apart from these specific insights cluster mapping data can provide a range of related insights that are critical for national-level policy makers: Regions are heterogeneous in their cluster profile and competitiveness; national policy needs to find ways to respond. Industries differ in their competitive dynamics and geographic footprint; policies at all level need to recognize these differences. And clusters are a key feature of all economies; policy makers need to explore how they can best leverage them as a tool for competitiveness upgrading.

3.3. Complementary actions: making cluster mapping work

Cluster mapping efforts create a set of data and insights on economic activity across industries and locations. While this provides the opportunity for more informed policy choices along the lines discussed above, such changes in action often require further actions to materialize.

A first step is to provide training to policy makers. They need to be exposed to the conceptual framework of competitiveness and clusters and related concepts to appreciate the way in which cluster

mapping data might be used. This can happen in the context of a wide range of different perspectives and views; the important aspect is to provide policy makers with a broader sense of how clusters, regions, and specialization play a role in the context of prosperity and development. Apart from this broader background policy makers also need practical insights and examples for how the data can then be used in program design and execution.

A second and related step is the creation of a community of policy practitioners working with cluster data and cluster-based economic development efforts more generally. This is a field in which practices are still very much emerging, especially in developing economies. In the absence of existing and agreed upon practices that can be communicated through training much of the learning and tool development has to happen through joint efforts by practitioners. This is one of the motivations behind initiatives like TCI, the global network of practitioners in cluster-based economic development.

Third, countries need to be willing to actively integrate the cluster mapping data in their policy practice. This can happen in many different ways, such as requiring applicants to relevant government funding programs to analyze the cluster data to making policy choices that directly reference and use this data. National governments can also charge their agencies, for example the entity driving foreign direct investment attraction, to organize its activities around the clusters revealed by cluster mapping.

Finally, cluster-based policy action requires entities that can give individual clusters a voice and make them an actor. A new policy action to consider is thus the support for cluster initiatives as a new type of public-private intermediary. These organizations come in many different forms, depending on local circumstances (Lindqvist et al., 2003). What they share is a nature as platforms for collaboration within the cluster, a management in the spirit of the private sector, and a focus on enhancing the overall competitiveness of the cluster, not just the provision of a single service or support function.

4. Conclusions

Policy making has in recent years become significantly more evidence-based. While in the past there was a sense that ‘big ideas’ had to be rolled out in quite similar ways across countries, there is now a much stronger recognition that local circumstances need to drive choices about action priorities and ways to implement them. Cluster mapping is part of a wide range of initiatives, including many efforts by the World Bank on Doing Business, Logistical Performance, and many more, that aim to provide policy makers with robust and actionable data to make those choices. Cluster mapping provides particular insights into specialization patterns of an economy, capturing relevant linkages across industries that often get missed in traditional sectorial studies. And it provides insights into the geographical footprint of economic activities, emphasizing the importance of regions and of the locational impact of policies, even those that are notionally neutral across sectors and industries.

Cluster mapping is an important foundation for cluster-based policies, an approach that leverages the natural existence of clusters to better channel government policies and overcome barriers to collaboration among public and private sector entities. But cluster mapping is neither necessary to run cluster initiatives nor is it in its value limited to these type of actions. Cluster initiatives benefit from cluster mapping efforts, but require a significant degree of complementary analysis and tools to capture the specific context of a given cluster. Cluster mapping enables comparisons across locations based on a robust, data-driven standard. This type of information is powerful as part of a broader competitiveness analysis at the national or regional level. It puts individual clusters into the context of regional cluster portfolios, and gives insights into the broader patterns of economic geography across regions within a country.

Cluster mapping data has bearing on key practical choices World Bank clients are facing in implementing particular policy tools: Which location in our country is given its existing profile best suited to connect with a specific global value chain? What sectors should we try to attract to our industrial park in order to maximize the opportunities for interaction with the existing business community in the region? Who are the most relevant industrial partners if we want to launch programs for SME upgrading or workforce skill development in a given location? Where are the most promising opportunities for upgrading and structural change within and across industries given our existing economic base? The answers to all of these questions require location and sector-specific information of the type cluster mapping provides.

Clusters exist in all locations that have integrated into a larger national or global economic context. They thus provide a relevant dimension for analysis in action also in the countries in which the World Bank is active. But it is important to recognize the practical limitations on data availability that often exist in these countries: this input paper aims to identify what the specific data needs are. And it is equally important to understand that the policies that cluster mapping data can inform in developing and emerging economies will have to be appropriate to that specific context. Copying approaches that work well in advanced economies can easily fail if they are transplanted into economies with very different challenges and institutional structures. Developing approaches that are aligned with these circumstances do, however, offer significant promise; that is what the experience suggests. And the World Bank can play a powerful role in supporting the emergence of better practices among its clients. Cluster mapping is one important step on this path.

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