Regional Clusters in a Global World: PRODUCTION RELOCATION, INNOVATION, AND INDUSTRIAL DECLINE

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We are in the midst of a global reallocation of production activities. Driven by the surge of newly industrialized economies, trade liberalization, and decreasing transportation and communication costs, more and more production activities are shifting from high-wage to low-wage countries. According to the newest available estimate, annual worldwide spending on sourcing was estimated to reach $6 trillion in 2004—up from $3.7 trillion in 2001. While China is fast becoming the world’s leading sourcing hub, India is seen as the main recipient of development activities from Western Europe—particularly as regards information and communication technology.

This should not come as a great surprise to most governments and managers, since such developments have been predicted for some time. What may be surprising for both politicians and companies is the speed with which companies in China and India are catching up technologically, thus making them potential competitors to producers in Western Europe and the USA. As a consequence, Chinese and Indian firms are fast in building competitive inroads into a number of industries. For example, close to 80% of Wal-Mart’s suppliers are now Chinese. In comparison, less than 10% of Wal-Mart’s products came from outside the United States. Similar sea changes can be found in a range of industries as Chinese and Indian manufacturers are building up capabilities paired with superior access to low-cost production. Similarly, the traditional competitive advantages of regional clusters are being challenged, as was the case with Chinese newcomers undermining the global dominance of the ceramic tiles cluster in the Sassuolo region in Italy. A growing number of political commentators, industrialists and researchers fear that—driven by the realities of competition—

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virtually all production competencies will migrate from developed countries. Some even claim that innovation activities will follow, since the development of new knowledge is strongly intertwined with production activities. The co-location of production and technology development determines the ability to learn, and with it the ability to innovate by reducing cognitive distance and competitive learning possibilities. This is what is alleged to have happened to a number of industries in the U.S. in the 1980s. Thus, it is claimed, companies will be “hollowed out” and the competences necessary for inducing technology development will gradually shift to low-wage countries. Hence, relocation activities and their consequences to industry competitiveness are regarded with the greatest suspicion.

How does the massive relocation of production activities to high-growth and low-cost countries influence the organization of innovation activities in regional clusters? How will the pressures and opportunities created by globalization affect the innovative virtues of clusters? Because of their innovative capabilities, regional and national clusters are front-runners with regard to export market shares, turnover growth, and entrepreneurship. Internationally, the role of clusters as drivers of national competitiveness has attracted the attention of industrial policy makers. It will be of crucial importance for managers and policy makers alike to determine the impact of increased relocation of industrial activities on the future competitiveness of these regions.

Globalization is currently being driven by advances in information technology, and new perspectives are required in order to understand the ongoing relocation patterns. A multifaceted view is needed that takes into account the interplay and variety of technological and institutional settings across industrial regions. This article presents a framework for understanding the underlying logic of production relocation activities and their possible impacts on cluster innovativeness. It is based on case studies from four representative regional clusters.

Towards a New Understanding of Globalization and the Innovative Capabilities of Regional Clusters

Porter defines clusters as geographical concentrations of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions in a particular field linked by commonalities and complementarities. In organizational terms, a regional cluster is a production system, configuring and governing a local set of input-output relations with a widespread and complementary division of tasks. The input-output system is the functional core of the economy, involving a collection of activities leading to the production of a marketable output. In most cases, production control is distributed, suggesting a fine division of labor, where the direction of resources and activities takes place as an ongoing negotiation between interdependent actors.

Most researchers agree that the ongoing reorganization of production following the extended outsourcing, offshoring, and internationalization of sourcing is a sign that new organizational patterns are replacing existing forms.
We are witnessing the creation of a world economy with an increasingly regional architecture. Drucker describes this as one of the greatest organizational and industrial structure shifts of the century, while others see it as a drift away from the M-shaped MNC and towards an industrial form defined by extended vertical specialization. Still others herald it as the coming of new twenty-first century organizational forms, where virtual organizing and networking come into their own.

Economists tends to see the relocation of industrial activities to low-cost countries as an inevitable result of the liberalization of international trade and investment policies, combined with decreasing transportation and communication costs. First, faced with an increasingly global competition, companies within a regional cluster must seize opportunities to reduce their manufacturing and development costs, thus offsetting any competitive advantages their global competitors may have. Second, the reduction of manufacturing and development costs may increase performance in terms of increased productivity and profitability (at least in the short run), which may then satisfy investors and company shareholders. In these new realities, the strategic importance of mastering manufacturing seems to be decreasing. Manufacturing matters only to a limited extent and “that’s a good thing.” The question raised by the strong growth of new sourcing hubs at the expense of local production is whether things are moving too fast. Are such rapid developments harming the high-wage country’s ability to maintain its competitiveness, and should political action be taken in order to mitigate, or at least readjust to, this shock? While the relocation of production activities is not new, what is new is that not only “simple” or “standard” production activities are being moved, but also knowledge-intensive work. This is what is also known as the hollowing out phenomenon.

However, the beliefs on which many of the received concerns are based were formulated in the mass-production rather than the digital era of manufacturing. According to Gereffi, the era of digital globalization replaces that of trade-based globalization. Where the former was strongly contingent on and driven by the rapid and diversified industrialization of a number of developing countries, the latter is characterized by the functional integration of physically dispersed activities, suggesting a new role for regional clusters as integrators of skills and resources. The importance of space and co-location of activities is changing as the global diffusion of Internet technology speeds ups. In the digital era, the political, economic, and technological forces affecting companies’ ability to transfer production activities to low-cost countries also transform the organization of industry, making it increasingly possible to partition and modularize production chains and bridge large geographical distances. Research suggests that the increased modularity of manufacturing and development resources has created new norms for activity coordination and co-alignment, which spur global activity coordination and configuration. In regional clusters, new business models surfaces that focus on the development of network positions, knowledge management, and global configuration of activities.
The realities of the normalization of the world economy leads to interesting paradoxes in current theories of the hollowing-out phenomenon. This has been labeled “Wintelism,” a development where formerly critical skills become commodities, available from contract producers, and where the ability to connect electronic components and find commercial use for new products has become the new key success factor. The resurrection of the U.S. entertainment electronics industry came as a surprise to most commentators on international competitiveness. One result of the new economic realities of the digital economies is that industries that were previously dominated by vertically integrated companies (thereby ensuring a high degree of ownership control over both product development and manufacturing activities) are now dominated by firms that control a single component or activity in the entire system of value-adding activities leading up to the manufacturing of a product. This has been called the “deconstruction model,” where companies control entire industries based on separating the information-rich part from the commodity parts of the value chain.

These and other findings suggest that the growth of global sourcing and offshoring has no general ramifications for all companies, but is shaped by the characteristics of manufacturing in specific sectors. Because regional clusters are formed by actors and institutions through complex socio-cultural processes, conventions for configuring and coordinating economic activity differ. The critical question in the industries that have been transformed or which are now emerging is the status of production processing competencies as a strategic weapon or a commodity. Where production capabilities are scarce, they are a potent strategic weapon, leading to positional advantages vis-à-vis competitors. However, when production capabilities have a commodity-like character and are accessible with few or no entry costs by a broad range of suppliers, knowledge-driven competencies gain in comparative merit as levers for strategic achievements.

There are two important research streams that address the core design aspects of manufacturing organization and the role played by information and coordination costs. These research streams can provide novel insights for understanding the underlying aspects of economic organization and governance of manufacturing industries: digital knowledge production and the development of modular product architectures. These two fields are interdependent and both point to powerful forces driving production-relocation processes. However, they are also distinct in the sense that, whereas modularization focuses on the relationship between standardization and costs of coordination, the underlying re-localization driver of digitalization relates to the relationship between knowledge codification and the possible de-contextualization of activities. While the modularization perspective mainly focuses on the rise of standards as a consequence of globalization and their effect on coordination costs (and, in turn, location costs), the digitalization perspective discusses the physical versus digital character of value-adding activities leading up to the manufacture of a product.
The Digitalization Approach

One of the basic factors involved in the physical mobility of activities concerns the digital content of activities performed to create a specific output. New information technology has changed competitive realities in a number of industrial sectors. Industries strongly reliant on the collection, processing, and distribution of information (such as the music industry, travel agencies, and other information-processing service industries) are currently undergoing massive changes as value chains are disrupted and reconstructed.40 Value-added physical activities are the manipulation of physical matter to increase the market value of a processed good, while digital activities concerns the manipulation of symbols with a similar purpose.41 Value-adding activities leading to the fabrication of a typical final output are neither purely physical nor digital. However, the bundle of production activities required can be either predominantly physical or digital.42 At one extreme, some products can be delivered as code sets. The conversion of products from physical to digital (e.g., encyclopedias) is one example.43 However, digitalization also influences process technologies. Digital processes add value to a range of products and they complement, convert or replace physical activities in a wide range of production processes.44 Many of the value-adding activities leading to the assembly of a car or camera have changed from physical to digital, or digital activities have been added to the existing physical activities in order to add value to the product.45 This not only relates to the nature of the product, but to business models as a whole. As the share of the total value added leading up to the manufacture of a specific product has become increasingly digital, the importance of interlinking production activities through ownership and/or physical location becomes less obvious.46 An important impact of digitalization relates to its capacity for storing, processing, and transmitting information. Explicit knowledge of manufacturing processes and techniques can be transferred and used across distances with little or no cost, allowing for de-localization of regional production activities47 or for unbundling and distributing activities that previously were interrelated by economies of information.48

Digitalization of activities is an important underlying force for understanding the variability in location and configuration of value-added chains. Even though digitalization affects almost all industries, it does so in very different ways. Most regional outputs can be located within a spectrum, with digital activities at one end and physical activities at the other.49 While the established music industry is experiencing a global shakeout and the entry of new actors, other industries (such as producers of apparel goods) find that physical manufacturing still plays a major role in coordinating activities and in deciding the structure and location of the value chain.

The Product Architecture/Modularization Approach

A second and equally important dimension concerns the architecture linking product components. A “component” is as separable part or
subassembly.\textsuperscript{50} The way in which the components fit together in order to add to the desired output is referred to as the product (or service) architecture.\textsuperscript{51} This architecture may be either modular or integral. Modular architectures suggest that a simple link among components and functional elements can be found, allowing for clearly specified interfaces among components. Integral architectures involve complexity, where the interfaces among components are unsettled and the interlinking among development and production activities is densely coupled. This is directly connected to the complexity of coordinating and managing interdependencies in the basic input-output system of the region and in a broader perspective of managing activities that span organizational and/or territorial boundaries. As pointed out by Garud and Kumaraswamy, organizational systems, like technological systems, consist of components that interact with each other within an overall architecture or an institutional framework, and which are strongly intertwined.\textsuperscript{52} The production system equivalent of product architecture is the extent to which coordination is supported by the development and establishment of international standards, which provide the springboard for modularization\textsuperscript{53} and for economies of substitution.\textsuperscript{54} Global standards provide an embedded form of coordination that reduces the need for managerial coordination in globally dispersed production activity chains and endow memory on the organizational system.

Digitalization is a transformative force, shaping both the future organization of business and the globalization process. However, the conversion from physical to digital activities has not affected all industries in the same way. While few are unaffected by the normalization of activities, differences in technologies, managerial beliefs, and institutional rigidities mean that the impact of the transformation is unevenly distributed across business spheres. The suggested framework can provide some insights into the role of production relocation and industrial decline in different business enterprise arenas, each reflecting different competitive situations and corresponding business possibilities and challenges for the firms in them. These arenas are shown in Figure 1. Each represents an ideal type form, with distinctive characteristics. Moreover, it is assumed that the characteristics of each arena will affect the nature and dynamics of relocation and the way in which relocation affects innovativeness. The concept of an arena is used in accordance with institutional theory as an interlock of underlying forces defining a social space and constitution of actors, where particular industrial logics or recipes of actors evolve and others are suppressed.\textsuperscript{55}

**Methodology and Data Collection**

The data collection was based on a multiple context and multiple case study approach. Case studies investigate contemporary phenomena within their real life context where the boundaries between a phenomenon and its context are not clear.\textsuperscript{56} Contrasting cases that have been selected based on their divergent characteristics can facilitate further theory development. A reading of research and policy reports on Danish regional clusters identified 26 regional
clusters. Based on this sample, together with interviews with industrial associations and other experts, I selected four regional clusters reflecting diverging territorial dynamics. For each region, representative companies, leading local key tenants, and MNE linkages were identified and interviews carried out.

In order to ensure that the regional clusters studied were sufficiently divergent, the modularization and digitalization dimensions have been operationalized. The modularization dimension was addressed with respect to the dissemination and importance of industry-wide standards for manufacturing outputs within the particular regional cluster. Standardization can take on the form of enacted as well as de facto standards, the latter arising from market-based “standards wars” between powerful competitors and negotiated standards, where industrial players seeks to agree on a common standard.57

The second dimension addresses the role of digitalization in the value-adding activities leading up to the final product. This dimension involves determining whether the specific features of a given product are the outcome of mainly digital or physically informed activities. To assess the nature of value-adding activities I used industry reports as well as presentation materials and informal discussions with industry experts. Table 1 provides an overview of the regional clusters.

**The Interface Developer Arena**

The location of this arena in the upper left quadrant of Figure 1 means that manufacturing activities are hyper-mobile and can easily be relocated in physical space, since coordination costs are low and activity transportation and
TABLE 1. Overview of Regional Case Studies

<table>
<thead>
<tr>
<th>Regional Cluster</th>
<th>Wind Turbine Regional Cluster</th>
<th>Telecommunications Regional Cluster</th>
<th>Stainless Steel Regional Cluster</th>
<th>Business Software Regional Cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location of Region</td>
<td>Middle and West Jutland, Funen</td>
<td>North Jutland</td>
<td>The Triangle (East Jutland)</td>
<td>Greater Copenhagen Area</td>
</tr>
<tr>
<td>Approximate Number of Companies</td>
<td>90</td>
<td>45</td>
<td>170</td>
<td>250</td>
</tr>
<tr>
<td>Export Value (2003)</td>
<td>€510 Million</td>
<td>€45 Million</td>
<td>€82 Million</td>
<td>N.A.</td>
</tr>
<tr>
<td>Approximate Number of Full-Time Employees</td>
<td>21,000</td>
<td>4,000</td>
<td>6,000</td>
<td>10,000</td>
</tr>
<tr>
<td>Key Regional Actors and MNE Linkages</td>
<td>Risø National Laboratories (Denmark)</td>
<td>RTX (Denmark)</td>
<td>GEA (Germany)</td>
<td>Computer Science Corporation (CSC) (U.S.)</td>
</tr>
<tr>
<td></td>
<td>Vestas (Denmark)</td>
<td>Motorola (U.S.)</td>
<td>Alfa Laval (Sweden)</td>
<td>Oracle (U.S.)</td>
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<td></td>
<td>Siemens (Germany)</td>
<td>Texas Instruments (U.S.)</td>
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<td></td>
<td>General Electric (U.S.)</td>
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<td></td>
<td>Suzhlon (India)</td>
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</tbody>
</table>

Relocation costs are negligible. This also allows for a competitive climate characterized by hyper-competition and competing learning activities. Under these circumstances, continuous learning and standard development drive the competitive game, resulting in highly volatile competitive situations where there is no differential advantage to holding definitive positions in terms of production facilities. This requires flexible and adaptive organizational forms to enable business actors to react swiftly to changing business conditions. This also results in the ability to avoid conflict with local specialists, since, under conditions of frequent and abrupt changes, core competencies may rapidly become core rigidities. Here, a key requirement is maintaining an open and widely accessible network of potential partners in order to be able to tap potential financing. For the interface developer arena, maintaining and winning wars of domination (or at least gaining access to the next global standardization attempt) require both access to learning possibilities outside the region and being part of a dynamic learning environment, where the cognitive division of work is never-ending as actors jockey for position in the race for learning. Thus, a mixture of learning,
collaboration, and occasional rivalry among actors in the area of production facilitation and development activities is to be expected in this arena. Manufacturing activities, on the other hand, will relocate swiftly, in accordance with the whims of the global factor markets. Configuration follows a footloose and unstable pattern. Since manufacturing chiefly assume the role of commodities, activities can be moved and coordinated without excessive switching costs.63

**Case: The Telecommunications Cluster**

The telecommunications cluster located in the North Jutland region is internationally known for its development of telecommunications standards for such things as cordless cell phones, mobile phones, and naval communications equipment. Apart from a substantial number of local actors, several MNCs such as Motorola and Texas Instruments have also invested heavily in R&D activities in the area. Historically, the regional cluster evolved from the many small and medium-sized radio and television producers. As market conditions tightened in the 1960s and 1970s, some local producers started to develop and manufacture maritime communications equipment, spurred by demand from the substantial local fishing fleet. In the 1970s, Aalborg University was established in the regional capital of North Jutland. From the very beginning the engineering faculty collaborated extensively with local producers of telecommunications equipment. The accumulation of skills in the telecommunications cluster attracted numerous MNCs, which invested heavily in the area through acquisitions and greenfield investments. This in turn spurred both development and production activities. Thus, the region has played, and continues to play, a strong role in the development of global communications standards such as the GSM and GPRS standard for mobile phones, the Bluetooth standard for wireless data transfer between computers and accessory equipment, the DECT standard for cordless phones, and the coming 4G standard for mobile communications.

Originally, the industry was strongly dominated by electromechanical skills where, for most players, control over manufacturing tasks was a key success factor. Production facilitating and follow-up activities depended on having control over manufacturing. However, the increasing importance of telecommunications standards as a key driver of value has given rise to extensive modularization, both in telecommunications and in a range of related industrial activities, including consumer electronics, computers, and various electronic appliances. These capabilities have led to the increasing importance of the development of customer interfaces or the design of chip sets. This in turn has promoted a strong modularization of activities where the development and refinement of technical abilities of customer interaction with products are only weakly linked to production tasks. In consequence, control over production capacity has ceased to be a strategic weapon for most developers of telecommunications equipment, and these activities are therefore increasingly left to global specialists such as Solectron and Flextronics. This has resulted in a gradual loosening of the linkages between manufacturing, production facilitating, and follow-up activities, as more and more producers in the area have given up
large-scale production activities while still holding on to ramp-up activities and the production of highly specialized small-scale activities. Production activities are configured and coordinated worldwide by actors who move more or less effortlessly in and out of production activities. Making linkages with increasingly specialized global firms instead of relying on locally vested manufacturing competencies is at the core of the regional dynamics. The density of these linkages transgressing the region directly affects its competitiveness (as pointed out elsewhere in studies of strategic behavior in clusters).

This is illustrated by the firm RTX, a development house specializing in cordless equipment and one of the chief architects behind the DECT standard. RTX is a large company by Danish standards, with more than 500 employees, mostly engineers. It counts several MNCs among its customers, including Texas Instruments, Sony, Microsoft, and Panasonic. RTX relies on an extensive and internationally oriented network of contract manufacturers, suppliers, and development partners within and outside the region. This enables the company to offer turnkey product solutions from its subsidiary RTX products, as well as being able to take on virtually any role in product development or production activity for its partners. From the beginning, RTX has relied on sourcing production competencies externally and has always sourced production capabilities, primarily in Asia. It has shown little interest in manufacturing capabilities in the local hinterland, which is in accordance with the ground rules of the interface developer arena.

The ability of RTX to perform production-facilitating as well as production follow-up tasks, using external specialists such as contract manufacturers for production processing, is fairly typical of many of the actors in the telecommunications industry. Their customers are typically large producers of telecommunications equipment or specialists for whom they develop tailored solutions. In both cases, purchasing is usually either left to engineers or is a rather standardized operation, i.e., a large number of actors can relatively seamlessly act as strategic chimeras and adopt different roles in the business network. This also means that lay-offs (including the more than 1000 employees who were laid off when a local branch of the Singaporean Electronics manufacturer Flextronics closed down their operations in the region in 2004) seem to have a limited effect on the innovative capabilities of the remaining actors in the cluster. What is of utmost importance, however, is the ongoing collaboration and knowledge exchange among actors specialized in production-facilitating and follow-up activities. Thus, as the market for talented engineers and the strong collaboration with research environments at Aalborg University continue to play a strong role, the ability to innovate seems to be unaffected by the relocation of production.

The Relationship-Development Arena

The upper right quadrant in Figure 1 contains activities that are highly digital in nature but where the relationship among product components is characterized by integral product architectures, suggesting that the interface between
components (such as software routines) is complex and not possible to decouple.65 Here, it can be expected that the relocation of manufacturing and development activities is easily achieved, due to near-frictionless transportation and adaptation. It is therefore possible for business actors to provide services and conduct activities from great distances, as in the case of the interface developer arena. Unlike the interface developer arena, however, the technological architecture does not allow for partitioning and decoupling of activities—suggesting increased interdependency and mutual adaptation of activities and resources in buyer-seller relationships. These adaptations are contingent on close interaction between users and producers—at least in critical steps of the development of the production/consumption activity. The quality of the services offered by actors in this arena is highly dependent on the knowledge generated from previous interactions with customers, making interaction and relationship-building among users and producers a key strategic concern. This can be seen, for example, in cases where most of the value-added activities carried out consist of complex software development or other forms of programming, but where frequent and close interaction among actors may be strongly dependent on proximity in social space. In these cases, production processing may be relocated to the extent that clear-cut interfaces can be established among well-defined tasks.

Case: The Tailor-Made Business Software Solutions Cluster

A regional cluster of companies in the greater Copenhagen area specializes in the development and production of business software in relation to specific standard solutions (such as the SAP enterprise resource planning system) or various solutions from providers of de facto software standards (such as Microsoft Windows).66 This cluster is composed of approximately 350 firms and includes a large affiliation of SAP as well as multinationals such as CSC and Oracle. Based on national industry statistics, there are an estimated 10,000 employees in the area.

Developers of tailored software solutions need to balance both global and regional pressures. Globally, the emergence of India as a key programming resource means that providers of software solutions face pressure from customers who think they can bargain for lower prices. However, the successful development of tailored software solutions depends on intensive user-producer interaction, since the software is often highly context-specific and involves individual firm strategies as well as local norms and political requirements. Close interaction with customers in specifying solutions also means that developers gain insights into a customer's modus operandi, which is hard for competitors to imitate. Long-standing relationships between customers and developers are therefore fairly common. Often, the maintenance and development of software solutions are specified in long-term contracts. For instance, Comlog, a producer of navigation fleet software tailored to individual customer needs, has long-standing relationships with approximately 100 customers. Services offered include not only software development, but also data storage. Other developers have similar business models. Customer proximity is therefore an important
aspect here—both in relation to production-facilitating and follow-up activities, since continuous improvement and development activities are essential. Programming is globally mobile to only a limited extent, provided that functionality can be fully specified and clear-cut interfaces can be established during development. This means that software developers are constantly seeking for ways to routinize or modularize specific tasks that can be left to others (external to the region). This is done to concentrate on those development tasks that are integral in nature and that give them superior customer knowledge. This may vary from case to case, however, suggesting that local and global manufacturing activities must be co-aligned on a continuous basis. One example is Kring Technologies, which has offshored programming activities to India, employing a group of 60 software developers in Gurgaon, 30 kilometers from New Delhi. The use of the Internet as a key technology for achieving virtual proximity between its Danish and Indian activities means that customers are able to follow development progress hour by hour on Kring’s online project management system. It also means that the company can involve Indian programmers online when negotiating with customers. Other local producers of tailored software (such as Key2know or Systematic) have experimented with introducing modularization through the use of standard protocols in order to define the interfaces between components and to outsource development activities. The experience from these activities is quite similar: Given the intricate relationship between components and functional elements in business software packages, coordination costs across physical and cultural space exceed benefits.

**The Knowledge-District Arena**

In the lower right quadrant of Figure 1, production activities are often territorially bound and coordination costs high due to the intricate and complex nature of the activities. Production and innovation are deeply intertwined, since learning is context-bound and contingent on ongoing trial-and-error processes. This calls for close interaction and physical proximity of complementary production tasks. This is a situation often said to characterize the “traditional” industrial district. Here, production and innovation activities are strongly affected both by the ability to perform physical activities in close proximity and by territorial coordination dynamics in the form of frequent interaction and integral production architectures. User-producer relationships are embedded in local norms, where actors’ willingness to cooperate and share knowledge is supported by the sanction mechanisms of a highly transparent internal market of knowledge that is opaque to outsiders.

In these cases, development, manufacturing, and customer relationship management activities are difficult to separate territorially. In particular, global outsourcing may lead to the loss of complementary competencies and impair the learning capabilities of the region, as suggested by students of “traditional” regional clusters. In industrial areas, where local competencies have been destroyed as tasks were outsourced from the region, this has led to the loss of
skilled workers and regional decline. An example of the loss of innovativeness due to production relocation is the defense industry in Southern California.70

Case: The Wind Turbine Cluster

From a small base at the beginning of the 1970s, the Danish wind turbine cluster has grown by leaps and bounds throughout the 1980s and 1990s, with annual turnover growth rates of over 50%. Employment in the industry has increased considerably, from approximately 18,000 in 2000 to an estimated 21,000 in 2002.71

Today, Denmark is recognized as the leading knowledge hub for wind turbine production in the world, with a market share of more than 50% measured in installed worldwide MW capacity.72 Danish wind turbine producers continue to hold a strong market position and attract international buyers of both wind turbines and components, thanks to a fine division of labor among innovative and highly specialized suppliers.

The technical architecture of a wind turbine is complex and integral in nature. Wind turbines must be carefully designed and subsystems strongly interrelated in order to survive their extreme working conditions and the demand to function as unmanned power stations. Furthermore, producers are constantly trying to improve on existing designs in order to increase the energy efficiency of the turbines, which requires constant improvement of materials, components, and product designs, involving an increasingly wider range of local suppliers motivated to participate in emerging design activities. For these reasons, industry-wide component standards defining the interface between the various components have failed to emerge.73

Although wind turbine production is driven by supply-side learning pressures, value-adding activities are strongly tied to trial-and-error processes and adjustments. This implies that offshoring would be preferential to outsourcing.74 Some of the major producers, such as Vestas (the largest turbine manufacturer in Denmark) and LM Glasfiber (the world leading producer of turbine blades) have offshored production activities to Bangalore, India. However, the main motives for offshoring have not been local factor endowments such as production costs, but local political pressure for a large share of local production content combined with transportation costs. The components of wind turbines are constantly increasing in size, making transportation (of the blades in particular) prohibitively expensive. Interestingly, three of their Danish suppliers (ECM, Brd. Jensen, and Rool) have chosen to offshore and co-locate in close physical proximity to them, establishing their production activities in India and using supplier contracts with LM Glasfiber as a bridgehead in their relocation process. Likewise, Vestas recently established a production site in Tianjin, China, due to the Chinese authorities demand for a 70% local production content. Here, Vestas decided to offshore rather than to outsource in order to ensure local control. These and similar cases suggest that offshoring may take place as a bundled activity as other actors from the cluster “colonize” a foreign area in order to maintain vital connections for innovation in manufacturing as well as produc-
tion-facilitating and follow-up activities towards consumers. Moreover, the linkage back to the “mother cluster” remains important. If this strategy is successful, this cluster may gradually grow into a “hub of hubs” or a learning region, following a very different trajectory of globalization than the other arenas examined here.

So far, this process of outsourcing production has not affected the location of production-facilitating or follow-up activities from the region. Moreover, outgoing relocation activities are rather limited. Incoming relocation activities seem to be more pronounced, with a growing number of both national and international actors either establishing companies in the regional cluster or taking over existing firms. Multinational players such as Suzhlon (India) and Siemens (Germany) have recently entered the region through takeovers or greenfield investments.

**The Bridge-Building Arena**

While production activities in the lower left quadrant in Figure 1 are predominantly physical in nature, the interface between them is well defined, and it follows a modular production architecture. Here, the ability to capture economic rents through describing product and/or component interfaces and coordinating activities across large distances becomes a decisive competitive competence. For example, bicycle manufacturing is based on a modular system where interfaces between components are standardized, allowing for decoupling of activities and decreasing assembly costs.\(^7\) Thus, if you are able to bridge component suppliers and the retail channel, using qualified insights into supplier performance and combining this with branding excellence, you are likely to be successful in this market. Production activities are highly physical, as the bulk of production steps leading to the manufacturing of bicycles depend on physical processing activities. However, well-defined and specified production tasks mean that production activities may be relocated fairly easily once the design and initial trial production runs are in place. Thus, the ability to innovate is less dependent on mastery of production activities, and companies may be able to develop and maintain a rich array of product variants with very little costs. Therefore, the outsourcing of manufacturing activities alone is less likely to affect the competitive abilities of actors operating in this arena. However, once production capacity becomes less important as a competitive weapon, companies that have built their competitive capacity around their production capabilities will be facing serious trouble, as is often the case in clusters whose main activities are in industries that are becoming increasingly mature and where a specific design dominates, giving way for knowledge codification and standardization of interfaces. Notwithstanding, the ability to master complex and intricate logistical flows and coordinate project-based and entrepreneurial production networks enables an entirely new type of company to appear: the relationship builders. This also affects the qualification level of the work force, as engineers and administrators increasingly replace skilled blue-collar workers.
Case: The Stainless Steel Cluster

The stainless steel cluster is located in the “triangle area” of the Jutland Peninsula, linking the three cities Kolding, Vejle, and Fredericia. The cluster consists of producers specializing in process equipment for the food industry. While production equipment is based largely on modular components, it requires a lot of adaptation to individual customer needs. To a large extent, therefore, sales are driven by projects. The region consists of a large number of small and medium-sized subcontractors specialized in steel processing and component development, as well as of three large international manufacturers of food-processing equipment, Alfa-Laval and GEA, who dominate the world market for process equipment. There is a fine-grained division of work among subcontractors, who until recently have focused strongly on production processing. Innovation activities are heavily reliant on trial-and-error processes among suppliers and producers but are clearly dominated by the user initiative. In other words, the large producers of process equipment are in control of product-development activities; and though suppliers’ know-how and input are important, it is mainly in the latter stages of product development and installation activities. However, as their large customers increasingly outsource work from the region to low-cost areas, the pressure on the subcontractors increases. These producers outsource work for a number of reasons, though mainly because of labor costs and the emergence of new market possibilities in countries such as India and China. Recently, for instance, Alfa Laval moved a significant part of its activities from the triangle area to India. In general, subcontractors in the triangle area are well aware of the ongoing transformation and follow various strategies in order to respond to these challenges and retain customer relationships. A common characteristic of these strategies seems to be an effort to retain production-facilitating activities within the region and also to maintain some control over manufacturing competencies. This is achieved by partitioning and maintaining ownership control of critical or core production activities, leaving more standard work to suppliers outside the region. One strategy is to try to meet the costs of their Asian counterparts, taking over the strategies of their customers. In these cases, subcontractors become bridge-builders to competitive factor cost markets, outsourcing activities to suppliers directly or through sourcing agencies in the sourcing markets. One example is Ribe Maskinfabrik, which is increasingly replacing its production skills with the ability to control production-facilitating activities (such as concurrent product design) and production follow-up activities in terms of servicing customers’ logistical needs worldwide. In order to do so, they have expanded their logistics and engineering department substantially and drastically reduced the skilled and unskilled work force. Another sourcing strategy involves following customers abroad, using offshoring as a vehicle for coping with the pressures of global transformation. This strategy has been followed by the company Steel Partner, which developed relationships with domestically located global contractors and followed these to India, using the relationships developed locally in doing so. Here, developing capabilities for offshoring is an important part of managing this process.
Interestingly, the internal organization of these companies is strongly affected, since the skills relating to production processing diminish and production-facilitating or follow-up abilities become increasingly prominent. One obvious change vector relates to the increasing importance of industry-wide systems for component tracking and logistics handling. Here, inventory is clearly replaced by information, increasing the digital content in value-adding activities. Business models thus emerge where production processing is at the periphery rather than at the core of activities carried out within the region. In addition, the distinctive skills of these producers are the ability to master logistical flows and orchestrate inputs from a range of suppliers in a way that meets customer expectations and co-aligns with the logistical flows of customers’ construction projects. Thus, key requirements for competing with skilled suppliers from Asia include relationship management and coordination control as well as knowledge of production activities and skills necessary to monitor such activities.

Case Analysis and Discussion

The cases presented here demonstrate differences in the way globalization and the relocation of production activities affect the innovation process and the global competitiveness of regional clusters. What seems to be common to all cases is that in the struggle to achieve control of the key success requirements within each line of business, sourcing and relocation play very different roles. These cases demonstrate the link between relocation dynamics and the digitalization and modularization dimensions. An overview of the regional clusters and how they are located in the proposed framework is shown in Table 2, which also shows the effect on production activities and how this affects innovation abilities.

The regional clusters show that there are obviously different relocation dynamics at play. They also show that both regional and ownership-based relocation of manufacturing activities have different impacts on the innovative ability of the regional clusters. As expected, manufacturing capabilities matters less in regional clusters where they are becoming world market commodities due to emerging global standards and modularity and where a large number of the value-added activities are being digitized. As shown in the stainless steel cluster, what is left of manufacturing capabilities in the region became part of production-facilitating or follow-up capabilities. This may serve as a skill-containing device, enabling the company to maintain some control over production-processing abilities at a distance or ensure that ramp-up capabilities are maintained. Like the clothing industry (which still has the ability to produce a pilot collection for use that can be sent around the world for visual inspection by suppliers), it is important to maintain some manufacturing skills in. In the stainless steel cluster, however, knowledge-building processes are less tightly knit to the iterative trial-and-error production processes than elsewhere.

In the wind turbine cluster, on the other hand, production-facilitating, manufacturing, and follow-up activities seem to be closely linked to innovation.
Here, there is strong interdependence across the component interfaces, and the product architecture is integral rather than modular in nature. Consequently, proximate iterations, frequent and informal exchange of know-how, physical meetings between co-specialized users and producers, and the exchange of skilled personnel (among component suppliers, producers, and even users) remains crucial for the further development of wind turbines and wind power facilities. The physical relocation of manufacturing activities will most certainly have a negative affect on this innovation dynamic, which is less likely to be affected by ownership relocation. At least in the case of the Danish wind turbine

### TABLE 2. An Overview of Relocation Dynamics and Physical Relocation of Production in Investigated Regions

<table>
<thead>
<tr>
<th>Relocation Dynamics</th>
<th>The Telecommunications Region in Northern Jutland</th>
<th>The Wind Turbine Region in West Jutland</th>
<th>The Stainless Steel Region in the Triangle Area</th>
<th>The Business Software Development Region in Greater Copenhagen</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface Developer</td>
<td>Knowledge District</td>
<td>Bridge-Building</td>
<td>Customer Relationship-Constructor</td>
<td></td>
</tr>
<tr>
<td>Regional proximity of manufacturing activities not important for innovation; physical relocation of manufacturing and/or follow-up activities does not affect innovativeness or spur economic decline.</td>
<td>Regional proximity of manufacturing activities very important for innovativeness, both in terms of linking manufacturing with development and follow-up tasks; relocation of manufacturing will have a negative impact on innovation ability and may threaten regional competitiveness.</td>
<td>Regional proximity of manufacturing somewhat important for developing competitive production-facilitating tasks, and for serving customers or suppliers efficiently; global outsourcing must be matched with the maintenance of local manufacturing skills.</td>
<td>Regional proximity of manufacturing activities somewhat important; pressure towards modularization which may become subject to global outsourcing.</td>
<td></td>
</tr>
<tr>
<td>The Importance of Locally Controlled Manufacturing Activities for Regional Competitiveness</td>
<td>Regional ownership and proximity of manufacturing activities not critical for regional competitiveness; ownership of production-facilitating activities somewhat important.</td>
<td>Regional control of both manufacturing and facilitating activities are important.</td>
<td>Regional ownership of manufacturing and R&amp;D activities less important; ownership of logistical control activities somewhat important.</td>
<td>Regional ownership of manufacturing important for envisaging production systems where virtual proximity can be facilitated.</td>
</tr>
</tbody>
</table>
industry, a massive inflow of foreign capital throughout the 1990s and continuing in the 2000s seems not to have significantly affected the abilities of the cluster.

The innovative ability of producers in the telecommunications cluster seems to be unaffected by the relocation of manufacturing activities. In the case of telecommunications, global contract producers provide a dense and widely available network of production capabilities. Digitized value-adding activities are increasingly important compared to physical activities. Moreover, interfaces with suppliers of manufacturing capabilities are highly modularized and can thus be controlled over large distances. In addition, modularization affects all activities involved in the design, production, and distribution of electronic equipment for telecommunications. A growing number of production-facilitating tasks, such as programming and even the design of user interfaces, may be left to suppliers with whom the developers of telecommunications equipment have little or no physical proximity. What seems to be needed here is to identify the critical development capability and rely on knowledge suppliers as well as on suppliers of production capabilities and specialized distributors. In these cases, entry and exit costs to the value-added chain are negligible, and producers operating here can simply design customized value chains to fulfill specific customer orders and then dismantle them after use at little or no cost. Hence, the relocation dynamics of the telecommunications cluster resembles what has here been labeled the interface developer arena.

Managerial and Academic Implications

Economies such as China and India will undoubtedly make inroads into the European and U.S. markets in the years to come. However, if the experiences of such diverse industries as textiles and telecommunications are any guide, the future is not quite as bleak as some pessimists and politicians would have us believe.

The political, economic, and technological forces furthering companies’ ability to transfer production activities to low-cost countries also transform the organization of industry, making it increasingly possible to partition and modularize production chains and bridge large geographical distances. The increased modularity of manufacturing and development resources creates new norms for activity coordination and co-alignment, which in turn spurs global activity coordination and configuration.

The important lesson for policy makers in the West is to understand the forces shaping this development and to be aware of the new possibilities for industry and the political means needed to help companies embrace them. Rather than harnessing companies to maintain production activities in the interface developer arena, the bridge-building arena, and in the relationship development arena, the focus should be more on harnessing companies’ ability to configure and activate resources and activities through being superior relationship managers and network strategists. Managers must strengthen their organi-
ization’s ability to orchestrate network activities. Policy makers must help companies by ensuring that these skills are given priority in educational systems. Moreover, managers must take a critical look at their production activities and their real role in providing market value. This may in some cases mean that production is a critical and vital activity for ensuring innovation abilities in the region, but may also mean that production activities not necessarily need to be maintained locally.

Another implication is to inform policy makers about the diversity of regional clusters and how this also should impact on the politicians’ attempt to envisage and direct their policy efforts in support of economic development. Studies of regional clusters and how they contribute to economic performance have been used to inform regional and national policy makers for crafting strategies for economic development. However, too often their interpretation of regional studies has primarily been to develop a list of critical factors derived from the most successful regional clusters, such as studies of Silicon Valley or the military complex in California. These studies and their applications have contributed to the development of “the regional brand” in cluster policies at the expense of more detailed and facetted analysis of how regional clusters differ and whether the presence or absence of specific characteristics in fact contributes to sustained economic development. For instance, inspired by the studies of high-tech regional clusters in the U.S., many countries emphasize the creation of regional clusters of innovative firms around universities in order to stimulate regional economic development. One example of these efforts is the Dushu Lake Park project in the high-tech area around Suzhou in China. However, as pointed out by Mowery and Sampat, there is little evidence in support of the underlying argument that universities somehow cause this development.

The rationale for the location of development and manufacturing differs across arenas just as the ability to implement and capture value from knowledge generation through university-driven R&D efforts is likely to differ. Universities disseminate knowledge through their provision of graduate students, specialized facilities and equipment, and by prototyping new products and processes. However, the underlying norms for generating scientific and industrial knowledge often differ to an extent that the utility of these efforts are strongly depending on the absorptive capabilities and knowledge generation practices of surrounding entrepreneurial communities. In arenas with a high degree of modularity, where manufacturing and development technologies can be partitioned, the possibilities for utilizing formalized knowledge generated in universities are more obvious. This is in contrast to arenas characterized by a high degree of integral organization of production, where knowledge is chiefly developed through the trial-and-error interactions of users and producer communities.

Policy makers and managers alike must challenge old assumptions on the innovation dynamics of regional clusters and embrace a more multifaceted and dynamic view in order to deliver fresh and useful insights on global relocation.
Notes


43. Hagel and Singer, op. cit.

44. Macher, Mowery, and Simcoe, op. cit.


46. Hagel and Singer, op. cit.


52. Garud and Kumaraswamy, op. cit.
57. Sammut-Bonnici and McGee, op. cit.
61. Christensen and Raynor, op. cit.
62. Shapiro and Varian, op. cit.
65. Ulrich, op. cit.
67. Storper and Harrison, op. cit.
72. Ibid.
73. Ulrich, op. cit.
74. Bettis, Bradley, and Hamel, op. cit.