COMPETE "AND" COOPERATE THROUGH INDUSTRY CLUSTER PUBLIC POLICY: A CONNECTICUT CASE

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ABSTRACT

Even though the cluster-led economic development has received wide attention among policy makers since the 1900s, the ways it is implemented has been questioned by several researchers. One of the criticisms is that policy makers lack the understanding of specific causes of companies to cluster. Therefore, my thesis examines whether the public sector can enhance competitiveness of industries through the cluster-led economic development policy. More specifically, I analyze the Industry Cluster Initiative in Connecticut from the perspective of industries' competitive situation, using the BioScience Cluster and the Aerospace Manufacturing Components Cluster as cases. I use the analytical framework that I developed based on the following theories, which explain why companies cluster: theories of agglomeration economies and what I call "new theories of competition." This framework examines three dimensions of industries: (1) competitive situation, (2) drivers for clustering, and (3) the need of policy supports. I also examine how the public sector (state of Connecticut) responded to the industries' needs. The main findings are that first, clustering is one way for companies to effectively respond to their respective competitive situation. Second, the public sector can effectively support the competitive strength of industries and critical roles are: (1) to encourage creating cluster organizations through which companies start collaboration, and (2) to provide a menu of public sector supports that are available for companies in respective clusters according to their priority needs. This menu addresses both: (1) cluster-specific issues, and (2) cross-cutting economic infrastructure issues. Ultimately, my argument is that when the clustering makes economic or strategic sense, the industry cluster approach can be an effective strategy for the public sector to promote the development of the industry. Finally, I suggest policy implications and areas for future research: other forms of competition in the global economy, possible trade-offs among activated clusters, difference between cluster organizations and trade associations, possible mismatch between political and economic boundaries, mechanism to align related departments, and merit of choosing the industry cluster approach over other economic development strategies.

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ACM	Aerospace Components Manufactures
CONNSTEP	Connecticut State Technology Extension Program
CURE	Connecticut United for Research Excellence
DECD	Connecticut Department of Economic and Community Development
DOL	Connecticut Department of Labor
EDA	Economic Development Administration, U.S. Department of Commerce
Governor's Council	Governor's Council on Economic Competitiveness and Technology
HHS	U.S. Department of Health and Human Services
HUD	U.S. Department of Housing and Urban Development
MAA	Manufacturing Assistance Act
R&D	Research and Development
Yale OCR	Yale Office of Cooperative Research

CHAPTER 1. INTRODUCTION

Since the 1990s, cluster-led economic development has received wide attention among policy makers at federal, state, and local levels in the United States. Early adopters were Arizona, Massachusetts, Florida, and more. The goal is to achieve economic growth through industry clusters, a group of related industries that are geographically concentrated in a certain area, in order to take advantage of stimuli that arise between supplier and buyer industries or industries that share common inputs. This industry cluster approach is not necessarily entirely new and should be considered an extension of the traditional growth-pole approach used in the 1960s and 1970s that counted on investing in large infrastructure projects or on attracting large enterprises' plants, and the industrial-complex approach used during the same period (Isard 1975) that stressed the inter-industry linkages among groups of industries, such as petrochemicals. These were followed in the 1980s by the entrepreneurial approach that targeted especially high-technology industries (Clarke and Gaile 1992). The difference, however, would be its focus on geographical scale (region), industrial organization (interfirm relationships), economic inputs (non-physical and value-added factors), and local economic, industrial, skill and institutional bases. Many researchers have studied the cases of industry clusters such as Silicon Valley (Saxenian 1994), Arizona (Waits 2000), South California (Christopherson and Storper 1986), and Orange County (Scott and Paul 1990). When it comes to the ways policy makers have implemented the industry cluster approach, some researchers have reservations. For example, Doeringer and Terkla (1995) argue that states that adopted the cluster approach identified clusters by mechanical criteria such as the concentration of employment in a single industry, and thus lacked the understanding of functional relationships among industries and the dynamic economies of clustering. Similarly, Enright (1996) points out that some industries do not cluster or do so for different reasons, and that developing policy without the understanding of such features will therefore fail. What these arguments seem to suggest is that for

policy makers to effectively implement the industry cluster approach, they have to take account of industry's economic and strategic reasons to cluster and be fashioned accordingly.

This thesis shares this proposition. Thus, the purpose of my thesis is to examine whether the public sector can enhance competitiveness of industries through the cluster-led economic development policy. More specifically, I analyze the Industry Cluster Initiative in Connecticut from the perspective of industries' competitive situation. Using the two industry clusters in Connecticut, I demonstrate that first, clustering is a key for competition for industries, albeit for different reasons, and thus the public sector can support multiple industries under the Industry Cluster Initiative. Second, given the different priorities among industries, however, I also argue that the public sector should offer demand-driven services. The public sector can also do so by supporting industry clusters in two ways by analyzing: (1) cluster-specific issues, and (2) cross-cutting economic infrastructure issues (explained later). The critical role that the public sector can play is (1) to encourage to create of formal cluster organizations through which companies start collaboration, and (2) to provide a menu of the public sector supports that are available for activated clusters as well as industries, according to their priority needs. These arguments are the result of examining three dimensions of the bioscience and aerospace industries.: (1) competitive situation, (2) drivers for clustering, and (3) the need of policy supports. Ultimately, my main argument is that clustering is one of the possible ways for industries to effectively respond to their competitive condition. And only when the clustering makes economic or strategic sense can the cluster approach be an effective strategy for the public sector to promote the development of the industry.

I demonstrate these arguments by examining two industry clusters in the state of Connecticut. Bioscience is the emerging high-technology industry in the state that has a research and development (R&D) function, whose competitive pressure is a quick discovery of new drug candidates. Aerospace components manufacturing is a mature industry that suffers from de-industrialization and faces higher demand from major customers to lower its total cost, which includes unit price, delivery time, and quality performance. In spite of these differences, my findings show that in both industries, the very competitive pressure drives companies to collaborate and to work as a cluster. Incidentally, these two clusters

composed of companies that are mainly horizontally-related, suggesting that companies compete and cooperate with each other.

Taking account of these differences and similarities of the two industries, the state of Connecticut appears to have developed a sophisticated institutional arrangement to implement the Industry Cluster Initiative. Arguably, it is too early to assess whether the Industry Cluster Initiative in Connecticut is a success, given the fact that it is a relatively new approach in the state having started in the mid-1990s. However, the Connecticut approach has interesting elements from which we can learn. One of such elements is its demand-driven process and institutional arrangement: the state took an inclusive process soliciting commitments from the private sector and also left the decision whether to launch the Industry Cluster Initiative in the first place to business leaders as well as whether to work as organized cluster groups. It means that all industry clusters that are operating officially in the state are based on business leaders' demand. Second, the state encouraged industries to create a formal cluster organizations, through which companies start to collaborate and take initiative to implement cluster agenda. Another important element is that the state supported industry cluster activities by addressing both (1) cluster-specific issues and (2) cross-cutting economic infrastructure issues. Connecticut explains economic infrastructure (what they call economic foundations) as the cross-cutting issues that have major effect on the growth and competitiveness of *all* industries and defines them as the combination of: (1) skilled, adaptive and innovative human resources; (2) accessible technology; (3) available capital; (4) advanced physical infrastructure; (5) pro-competitive tax and regulatory climate; and (6) high quality of life (Connecticut's Industry Cluster Advisory Boards 2000, pp. 7-8). Connecticut considers specialized and high-quality economic infrastructure essential to productivity and innovation driven competition.

For various reasons, promoting industry clusters has corresponded to businesses' economic or strategic reasons and the state has effectively played a facilitating role. Examination of two clusters, demonstrates that the critical role that the state played is: (1) to encourage to create of formal cluster organizations through which companies start collaboration: and (2) to provide a menu of the public sector supports that are available for activated clusters as well as industries, according to their priority needs.

This menu is in the form of both: (1) lowering-cost, and (2) capacity building for productivity enhancement. The state institutionalized both types of supports to activate clusters and to handle economic infrastructure issues under the umbrella of the Industry Cluster Initiative.

Finally, it should be noted that the industry cluster approach is only *one* of the economic development strategies: others may focus more on distributional aspects, human resource capacity building (workforce development), modernization of mature industries, regional disparities, environmental impacts and others, than competitiveness of economy. However, the focus of this research is to examine whether the public sector can promote competitiveness of industries, assuming that the Industry Cluster Initiative has been already chosen as a strategy for economic development. Thus, although it is important, to address the benefits and costs of choosing the industry cluster approach over other economic development strategies, it is beyond the scope of this research. Similarly, clustering is *one* possible way for industries to compete effectively in a global economy. For example, Ellram (1991) discusses supply chain management as a way to compete in a globalized market, compares it with other organizational forms such as vertical integration and obligational contracting. Gereffi (1994) notes the spatially disperse patterns of global corporation productions, and calls such a spatially expanding supply chain global commodity chain, suggesting that the global corporation is controlling the production all along the chain. Clustering is not necessarily mutually exclusive with these forms of competition, however the discussion of the issue is again beyond the scope of this research. I acknowledge that there are many ways for companies to compete in a global economy and that the supply chain[1] of major industries is becoming global and each node of the chain plays specific functions (e.g., R&D, raw material sourcing, production, distribution center, and marketing) that have different locational

[1] In literature, it is often referred to as production, value, commodity chains, or logistics. It is "a logistics system of all activities that facilitate the flow of goods (and information) from the purchase of raw materials to the delivery of goods to final consumers." (Polenske 2001, p 263). Supply chain management is a coordinated approach to customer-supplier relationships aiming at aligning all elements of the supply chain (from raw material source to the sale to the customer) in order to reduce costs while maintaining a high level of customer service (Polenske 2001, p. 272). By improving the efficiency with channel partners rather than at individual company level, supply chain management can improve the competitiveness of a given firm.

implications. In this research, however, I focus the discussion on how clustering can be a key for industries to compete and how the public sector can support it.

1.1. DEFINITION OF INDUSTRY CLUSTERS

There is no general definition of industry clusters (Enright 1996; Feser 1998). Most researchers agree that spatial proximity among companies is the bases but do not agree in terms of the appropriate geographical scope of concentration, type and size of constituting companies, or actors included in the cluster (companies only or companies and supporting institutions).[2] Still others stress, as key attributes of cluster, vertical (buyer-supplier) and/or horizontal (competing companies producing same or similar products) interconnection, spatial division of labor among specialized companies, presence of central actors (a large firm in a "driver industry"[3] or research center), product or process innovation, collaboration within the respective supply chain, learning and trust among companies, or the quality of industry's network (Piore and Sabel 1984; Harrison 1992; Rosenfeld 1995; Porter 1998a; Hill and Brennan 2000). Similar related terms such as agglomeration, industrial districts, regional clusters, and business networks add further complexity (For the efforts to clarify terms, see Harrison 1992; Rosenfeld 1995; Enright 1996; Jacobs and de Man 1996). For practical use, for example, the United States Department of Commerce, Economic Development Administration (EDA 1997, p2) defines industry clusters as "agglomerations of competing and collaborating industries in a region networked into horizontal and vertical relationships, involving strong common buyer-supplier linkages, and relying on a shared foundation of specialized economic institutions. Because they are built around core export oriented companies, industry clusters bring new wealth into a region and help drive the region's economic growth."

[2] Examples of supporting institutions include governmental agencies, universities, standard-setting agencies, think tanks, training providers, and trade associations (Porter 1998a, for example).

[3] Often export-oriented companies compose the industry that brings dollars back to the local economy and contribute to the advancement of the local economy with its backward linkages.

In this thesis, three elements constitute an industry cluster: (1) spatial proximity, (2) collaborative activities, and (3) supporting institutions, because they are the most relevant elements for the state of Connecticut to officially recognize industry clusters. For the official recognition and the entitlement to seed money, industries in Connecticut have to be organized and demonstrate the existence of core business leaders, a start-up plan to work on collaboratively, and a formal organization to make a contract with the state and to carry out the cluster's agenda. Thus, Connecticut places high value on collaborative relationships among businesses and on supporting institutions to implement activities. Such officially organized clusters are referred to as "activated" clusters in Connecticut to distinguish them from a group of companies merely concentrating in a certain area.

1.2. METHODOLOGY

I use an analytical framework based on two theories that consider industry clusters keys for competition but offer different explanations about what drives companies to cluster. One includes the theories of agglomeration that stress economies of scale and positive externalities (agglomeration economies), which assumes that since companies compete on prices reducing input costs is the key for competition. The other is what I call "new theories of competition," a combination of different theories that explain the different aspects of competition such as productivity (Porter 1998a), "invisible factors" i.e., labor quality, entrepreneurial skills, corporate strategy, labor-management environment (Doeringer, Terkla, and Topakian 1987), collective response to competition (Best 1990), flexible specialization (Piore and Sabel 1984), collaboration economies, transfer of knowledge, and partnership with government (Doeringer and Terkla 1995). Based on these two theories, I show the drivers for competition and the drivers for clustering in two industries in Connecticut, biomedical and aerospace component manufacturing, and then show whether they match with the policy responses. I mostly rely on interviews with companies in the cluster organizations, the cluster organizations themselves, other service providers, and the state agency. To supplement the interviews, I use several published reports and documents, including the annual trade outlook (International Trade Administration 2000; Standard and Poor 2001),

the report that summarizes the recommendations from business leaders to the state (Connecticut's Industry Cluster Advisory Boards, 1998), the progress reports (DECD 1999, 2000, 2001) and newspaper articles.

1.3. THESIS OUTLINE

Chapter 2 first discusses the change of economic development policies to show why industry clusters have received wide attention as a new approach for economic development. The chapter then presents two theories, agglomeration economies and new theories of competition, to explain two dimensions of industry clusters as a key for competition, and outlines a set of roles that the public sector should play to promote industry clusters against the current complex competitive situation. Chapter 3 and 4 examine the case of the Industry Cluster Initiative that was officially launched in Connecticut. Chapter 3 introduces the process of launching the initiative, analyzing the role of the public and the private sector in the process as well as the institutional framework set as a result of the process. Using two industry clusters (bioscience and aerospace component clusters) in Connecticut, Chapter 4 discusses the competitive pressures that companies face in each industry that have become drivers to form a cluster. In other words, companies in these clusters have compelling reasons to collaborate to deal with the competitive pressure even though they have competitive relationships. This chapter also examines how the public sector responded to the needs of two clusters and how important the intervention was for the competitiveness of each industry. Finally, Chapter 5 summarizes the key elements and lessons from the Connecticut case and concludes with policy implications on the role of the public sector in the industry cluster initiative.

CHAPTER 2. ANALYTICAL FRAMEWORK FROM LITERATURE

2.1. EMERGENCE OF CLUSTER-LED ECONOMIC DEVELOPMENT

In order to understand the emerging interest in industry clusters among policy makers, it is useful to note the changes in how economic development tools and policies at local and state level have changed over the last several decades (e.g., Clarke and Gaile 1992; Eisinger 1995; Waits 2000). During the 1960s and the 1970s, most regional policies focused on stimulating economic growth through investing in large infrastructure projects or attracting large-scale plants. This is the growth-pole policy, expecting the multiplier effects of large facilities through backward linkages with local economies. Accordingly, policy makers pursued the low business cost approach to influence the business location decision and used infrastructure provision, land development, subsidies for capital, credit guarantees, and other tax benefits as development tools. However, the growth-pole policy achieved only a limited success, partly because newly attracted companies were not integrated into the local economy and partly because policy makers did not pay enough attention to the economic and social prerequisites that were necessary (Enright 1996; Feser 1998). In the 1980s, the development policy started to instead focus on nurturing existing businesses and promoting local entrepreneurship. In particular, high-technology industries received attention because of their high growth potential. Thus, policy makers encouraged research collaboration between universities and local companies, science parks, high-technology incubators, venture-capital funds, and export assistance. Some examples that adopted this approach and succeeded are the Research Triangle in North Carolina and the electronics and communication industry in Austin, Texas. The successful public sectors were called "entrepreneurial," because they were focusing on business creation rather than attraction and assumed greater risks and responsibilities to facilitate the value-creation by the private investors (Clarke and Gaile 1992). However, few regions have been able to develop new high-technology industries, partly because it is difficult to predict which sectors will grow

and partly because development of high-technology industries depends on research infrastructures that take a long time to develop.

Eisinger (1995) notices another shift in the focus of economic development policy in the early 1990s, which includes the focus on leveraging and capacity building, job training, industrial modernization, and industry clusters (some call this trend "the Third Wave"). Although the Third Wave has not replaced traditional economic development approaches, the cluster-led economic development has increasingly received attention from state and local economic development officials (Waits 2000).[4] To illustrate this proliferation, the United States Department of Housing and Urban Development (HUD 1997) argues that regions are the locus of economic growth, for which clusters are the key. Similarly, the United States Department of Commerce, Economic Development Administration (EDA) produced a report based on 17 cluster-led initiatives across the United States,[5] and noted, "healthy regional economies are composed of clusters and their supporting economic infrastructure"(1997, p. 2).

Although the cluster approach has some characteristics similar to the traditional approach,[6] it has different focus on geographical scale (region rather than narrow urban area or government jurisdiction), industrial organization (broader organizational form that links industries rather than individual company or industry), and economic inputs (non-physical and value-added factors such as quality of life, technology, and education in addition to production input costs or transportation costs) (HUD 1997, p. 4). The cluster approach also places greater attention on local economic, industrial, skill, and institutional bases (Enright 1996), which means that the cluster approach in general has greater variation among cases as it emphasizes the local context and its unique feature (Porter 1998a). For example, the 17 cluster-led initiatives that the EDA (1997) refers to in the report are the consequence of different economic challenges they faced, ranging from de-industrialization accelerated by trade

[4] Early adopters (early 1990s): Arizona, Florida, Massachusetts, and Illinois. Relatively recent adopters: California, Rhode Island, Colorado, Twin cities (MN), Los Angeles, and Connecticut (Waits 2000, p. 37).
[5] Arizona, California, Connecticut, Florida, Ohiao, Oregon, Washington, Camino Real, Monterey Bay Area (CA), Silicon Valley (CA), South East Los Angels (CA), Ventura County (CA), Jacksonville (FL), St. Louis (MO), Southwestern Pennsylvania, East Tennessee, and Austin (TX).
[6] For the debate on similarities and differences between the industry cluster approach and others, see Harrison

liberalization, economic downturn due to dependence on a few dominant industries particularly defense industries, rural and less developed economies, and economic isolation especially of inner cities. This variation has resulted in the differences among the cases in terms of geographical scale, number of clusters to support, initiatives taken by the public or private sector, and funding source.

2.2. THEORIES OF AGGLOMERATION ECONOMIES AND NEW THEORIES OF COMPETITION

Many researchers have explored the economic rationales for companies to cluster, which date back to Marshall, Weber, and Hoover. Recent reviews on this theme include Harrison (1992) Doeringer and Terkla (1995), Enright (1996), and Feser (1998).

Two theories are well known: industrial location theory and the industrial-district theory based on Marshall's concept of external economies. By agglomerating with companies in the same industry or in different industries with input-output relationships, companies achieve cost savings in terms of transportation and transaction costs. In addition, Weber explains that agglomerating companies may enjoy the external version of economies of scale that is typically achieved within a plant (i.e., large-scale facilities enjoy the lower unit costs of production)(Feser 1998). Agglomeration may also allow companies to enjoy positive externalities that Marshall identifies. The externalities are benefits for companies that arise from the pools of common factors of production such as land, labor, capital, energy, sewage and transportation, access to which promotes enhanced supply of such resources (capital and labor migrate for their larger market) as well as greater specialties (Harrison 1992). As a result, the long-term factor prices will fall. Scitovsky identifies another type of externality, which occurs as a result of one company's new investment that enhances profitability of other companies without their paying the cost (Harrison 1992). These economies help lower the unit cost of production for companies in a cluster; these are collectively called "agglomeration economies." These theories of agglomeration economies imply that companies are competing on price, and clusters help them compete by reducing their factor costs.

(1992), Harrison, Glasmeier, and Polenske (1996), Porter (1998b), and Polenske (2001).

Although the theories of agglomeration economies offer an explanation of why companies cluster, this explanation is decisive and static by nature: the theories assume that companies cluster in places that are well-endowed by cheap immobile production factors whose condition will not change (Doeringer and Terkla 1995). In contrast to the classic explanations offered by theories of agglomeration economies, many researchers have recently noticed changes in the nature of competition as well as the factors that drive companies to cluster. Porter (1998a), one of the strong advocates of industry clusters for competitiveness, argues that competition in today's economy allows companies to source globally, which makes low factor costs less relevant to competitiveness: instead, competition is far more dynamic and productivity and innovation are critical. Similarly, through the study of the U.S. manufacturing industry that faces de-industrialization, Doeringer, Terkla, and Topakian (1987) find that "invisible factors," in addition to factor costs, are critical to competitiveness: such factors include labor quality, entrepreneurial skills, corporate strategy, labor-management environment, and effective management process. Best (1990) also notices the changing nature of competition (new competition, in his words) and points out that competitive companies are characterized by strategy-orientation, finding numerous ways to compete, and continuous learning and improvement to flexibly adjust to changing market conditions.

Due to the changing nature of competition that changed the critical factors for competition and the advancement of technology and communication, low costs, in terms of production inputs, transportation and transaction costs, are not the single determinant for clustering anymore. In particular, researchers highlight the importance of the quality of business environment that strongly influences the new factors for competition. For example, Porter (1998a) considers that competitive advantage (depending on productivity) lies in local business environment in a global economy, and argues that industry clusters promote competitiveness by offering an innovative environment due to pressures from rival companies, customer bases that also pressure companies to be innovative, specialized supplier base, and access to highly specialized labor and technology. In Piore and Sabel's (1984) view, collaboration among small specialized companies constitutes a competitive advantage because of their flexibility to specialize in niche markets (flexible specialization). Industry clusters promote such collaboration because

companies are highly interdependent and are densely networked with communication based on trust. Harrison (1992) also stresses that vibrant clusters are characterized by trust among inter-linked companies fostered by repeated interaction and face-to-face interaction. These points are also reflected in interviews conducted by Doeringer and Terkla (1995) to find the reasons for companies to cluster. They found out that major determinants of clustering are dynamic externalities that arise from collaboration economies from supply chain integration practices such as just-in-time production, labor productivity as opposed to labor cost, transfer of knowledge and technology through exchanging employees, and a local climate that has a responsive government and favorable labor-management relationships.

Collectively, I call these arguments "new theories of competition." Companies are competing on more than prices (for example, product developments, customized products, services, and quick response to customers), and industry clusters help companies compete by offering an environment with productivity, human resources, and collaboration, all of which are dynamic and can be developed over the years. Both theories of agglomeration economies and new theories of competition are not mutually exclusive but the latter highlights the complexity of new competitive situation. Table 2.1 summarizes the differences of the nature of competition and how industry clusters help companies compete.

It is worth noting that the benefits of clustering, under both theories, are *potentially* realized in industry clusters. For example, Enright differentiates what he calls "working cluster" from "latent/unrealized clusters": the former is a cluster in which a group of companies act collectively for shared vision and social infrastructure exists that encourages sharing of information and new start-ups (ex. Silicon Valley), while the latter is a cluster in which cluster potentials are not fully realized due to the lack of interaction, shared vision and collective action (i.e., pharmaceutical/biotechnology companies around Research Triangle Park) (Rosenfeld 1996, p. 182).

Table 2.1 Drivers of Competition and Clustering: Two Theories

	Theories of Agglomeration Economies	New Theories of Competition
Literature	Marshall (1890), Weber (1929), Hoover (1937), Scitovsky (1963)[7]	Piore and Sabel (1984), Doeringer, Terkla, and Topakian (1987), Best (1990) Harrison (1992), Doeringer and Terkla (1995), Porter (1998a)
Drivers of Competition (Key competitive factors)	• Price (low input costs)	• Productivity and innovation • Quick response to the market • "Invisible factors" • "Flexible specialization" • Continuous learning and improvement, flexible adjustment
Drivers of Clustering (Spatial concentration/ collaboration)	• Transportation and transaction costs savings • Economies of Scale • Externalities from common pools of production inputs and major investment	• Quality of business environment: rival companies, demanding customers, specialized supplier base, specialized labor and technology • Labor productivity • Face-to-face interaction, trust • Collaboration economies through channel integration practices • Transfer of knowledge and technology • Responsive government and favorable labor-management relationship

Source: Author's review of literature

2.3. THE ROLE OF THE PUBLIC SECTOR

Given that industry clusters can promote competitiveness, to what extent can the public sector influence the process and what should be its role? When companies compete on low prices, the cost of production factors is the most critical factor for competition as well as the determinant of location. Thus, it appears appropriate for the public sector to focus on lowering business cost (i.e., provide transportation, communication, and other physical infrastructure; offer subsidies for capital and wages or land acquisition and development). However, as the new theories of competition suggest, companies are increasingly competing on more than price. In particular, development of technology and communications has made lower inputs costs not the single determinant of location and competitive advantage anymore. Moreover,

[7] Instead of referring to original works, I used the review articles to summarize these theories of agglomeration economies: they include Harrison (1992), Doeringer and Terkla (1995), Enright (1996), and Feser (1998).

the emergence of developing countries that can compete better against the advanced countries on production factor costs suggests that the lower cost approach is not enough.

The emphasis on human resource is perhaps what differentiates new theories of competition from theories of agglomeration economies. Company productivity, innovation, and ability to flexibly respond to the changing market boil down to the productivity, skills, and learning capacity of workforces. Access to capacity specialized to company needs has become one of the most important determinants of location as well as the competitiveness of companies. Knowledge and technology can be spread further by exchanging employees within a common pool of skilled workers developed around the region's core strength (Doeringer and Terkla 1995). Thus, investment in education and vocational schools and encouragement of on-the-job training for specific skills both appear to be important.

In the current competition, companies are also strategy-oriented and competing in various ways. Thus, for the industry cluster approach to be effective, researchers stress the importance of being sensitive to the industry's economic and strategic reasons for clustering. Enright (1996) points out that depending on the industry's competitive nature and strategy, some industries do not cluster or do so for different reasons; therefore, developing policy without understanding such features will fail. Similarly, Doeringer and Terkla (1995) also express reservations about the ways industry clusters are used in policies. They argue that states that adopted the cluster approach identified clusters by mechanical criteria such as concentration of employment in a single industry, and thus lacked the understanding of functional relationships among industries and the dynamic economies of clustering. They further argue, "uncertainty about the cause of companies' geographical clustering has led to a lack of focus in state and local economic development policies involving clustering -- too little emphasis, in particular, being placed on *specific causes* of cluster relationships among companies across industries." (Doeringer and Terkla, p. 226, empahsis added.)

New theories of competition also suggest that the business environment is critical to competitiveness. Indeed, the EDA argues that developing economic infrastructure that is tailored to the needs of a region's industry clusters is the crucial source of competitive advantage (1997, p. 3). The

following lists the major categories of economic infrastructure that the EDA includes: adaptable skills, accessible technology, adequate financing, physical infrastructure, advanced communications, acceptable regulatory climate, and quality of life. Note that the concept of economic infrastructure is more inclusive than physical infrastructure as fundamentals for all industries, reflecting the position of theories of new competition. These categories do not imply that each region should be equipped with all of them to an equal degree. Rather, the successful region pays special attention to its invisible economic strengths and focuses on companies that appreciate such strengths (Doeringer, Terkla, and Topakian 1987).[8] Similarly, Enright (1996) points out that the successful cluster approach places greater attention on local economic, industrial, skill, and institutional bases than other approaches. These arguments suggest that the public sector should be aware of the strength of local economic infrastructure and should make the infrastructure responsive to industries that benefit from its strength.

The limited success of the growth-pole approach in the 1960s and the 1970s due to the lack of adequate understanding of socioeconomic prerequisites (Feser 1998) is also suggestive. In fact, Porter (1998a) claims that the public sector should not create entirely new clusters and should instead build on existing and emerging ones. In contrast to the traditional industry policy, Porter also argues that the public sector should reinforce all clusters rather than targeting a selected one: "not all clusters will succeed, of course, but market forces -- not government decisions -- should determine the outcomes" (1998a, p. 89).

2.4. CONCLUSION

This chapter showed that the industry cluster approach gained attention in 1990s as another way to achieve economic development, after the growth-pole and the industrial-complex approaches in the 1960s and 1970s, and the entrepreneurial approach in the 1980s. In spite of some similarities to the past

[8] They provide an example of Montachusett region where skilled and adaptable labor, customized production, and small scale of operation are their strength. These invisible factors not necessarily benefit high-technology companies that require scientific and technical labor for product development and more semiskilled labor for production (Doeringer, Terkla, Topakian 1987, p. 107).

approaches, the cluster approach has different focus in terms of geographical scale (region), industrial organization (interfirm relationships), economic inputs (soft and value-added factors), and local economic, industrial, skill and institutional bases, in other words, economic infrastructure. Because of its attention to the unique local context and characteristics, the industry cluster approach in practice has great variation among cases.

Drawing on two sets of theories, namely theories of agglomeration economies and new theories of competition, I suggested that the nature of competition as well as the factors that drive companies to cluster have changed (or become more complex): companies are no longer competing only on prices (e.g., new product developments, customized products, services, and quick response to customers), and industry clusters can be critical to competitiveness of companies as they offer an environment with productivity, human resources, information flow, and collaborative activities. These changes of competitive conditions suggest that the lowering business cost approach through subsidy and physical infrastructure provision is no longer sufficient for the public sector to increase the competitive position of the industries and the public sector needs to support the capacity of local economic, industrial, skill and institutional bases that enhance productivity, flexibility, and learning. More specifically, the new theories of competition appear to imply the following roles of the public sector in implementing the industry cluster approach: (1) learn the needs of industries in light of the nature of competition and industries' economic and strategic reasons to cluster; (2) learn the strength of the region's economic, industrial, skill and institutional base and match it to the needs of industry clusters; (3) invest in human resources for their capacity-building and enhanced productivity, and develop their capacity around the industries' needs; (4) support industry clusters as an enabling environment where productivity enhancement, information flow, specialization, collaborative activities, and leaning take place; and (5) learn the existing and emerging clusters in the region and support to upgrade all of them.

These findings lay the foundation for the analysis in the subsequent chapters that discuss the Industry Cluster Initiative in Connecticut, how the public sector (in this case, the state of Connecticut)

responded to the different competitive challenges of the biomedical and aerospace industries, and what roles the public sector played in building their competitive strength by utilizing industry clusters.

CHAPTER 3. CONNECTICUT'S APPROACH

Using theories of agglomeration economies and new theories of competition in the previous chapter, I examined the concept of an industry cluster from the perspective of the nature of competition, rationales for companies to cluster, and suggested possible roles of the public sector. Using this approach, in Chapters 3 and 4, I show how the Industry Cluster Initiative has been introduced and implemented in the state of Connecticut. The case of Connecticut provides an opportunity to examine how industry clusters were identified and developed into the economic development strategy (Chapter 3), what have been the economic or strategic reasons for companies within the clusters to agglomerate and work collaboratively, and how the public sector has helped to improve the performance of the clusters (Chapter 4). Therefore, this chapter focuses on the process of introducing the Industry Cluster Initiative itself, institutional arrangement for its implementation, and the roles played by both the public and the private sector.

Connecticut is a relatively new adopter of the industry cluster initiative, following Texas, Arizona, Florida, and others, as was discussed in Chapter 2. On the surface, it is a story of a state searching for a new strategy to get out of the 1989-1992 recession and to adjust to the new economy. It is also a story of building a working relationship among the governor, legislature, state departments, business leaders, educational institutions, and other related organizations to increase the competitiveness of the economy. In the process of designing the Industry Cluster Initiative, business leaders found common ground without compromising their competitive relationship with each other; the public sector found a way to support businesses, without choosing target industries and by cultivating a responsive economic infrastructure. When business leaders presented the *Partnership for Growth: Connecticut's Economic Competitiveness Strategy* report in February 1998, which reports on issues and recommends actions for key industry clusters, Governor John G. Rowland praised it as "the most important economic plan in 50 years." The key industries had existed in the state for many years and there were privately

initiated activities to promote their growth, taking advantage of industry's relative importance in the state. However, in the process of devising the *Partnership for Growth* report, the existing industries started recognizing the value of working as a cluster group. It appears that the public sector played an important role in facilitating the networking of business leaders in the key industries.

3.1. ECONOMIC CONDITIONS IN CONNECTICUT

Connecticut is one of the smallest states with 3.2 million in population in a 5,000-square-mile area, but is economically strong. Connecticut's per capita personal income was more than $39,000 in 1999, growing by nearly five percent over 1998; the state ranked first in absolute per capita income and 10th in growth rate in the nation (Northeast Utilities Systems 2000). The Connecticut population is also highly educated: 33.5 percent of the population had graduated from college in 1999, the third highest level in the nation (Northeast Utilities Systems 2000). Blessed with the convenient location between Boston and New York, Connecticut ranked third in terms of major business headquarters per million in 1991 (State Department of Labor 1998). According to the 2000 Development Report Card, an annual ranking of fifty states on their economies and potential for future growth,[9] Connecticut excelled economically, particularly with its highest average annual income in the nation, improved income distribution, improving competitiveness of existing businesses, and human resource asset in terms of college attainment and math and reading proficiency.

Although Connecticut has these assets and has shown the upward trend over the past several years, it is still recovering from the severe recession during the 1989 - 1992. The state economy had been based on the manufacturing sector. In 1978, 31 percent of the total non-farm employment was in the manufacturing sector, especially due to the defense contracts awarded to the aerospace industry: the sector also contributed 29 percent of total gross state products in 1977 (U.S. Bureau of Analysis). However, the

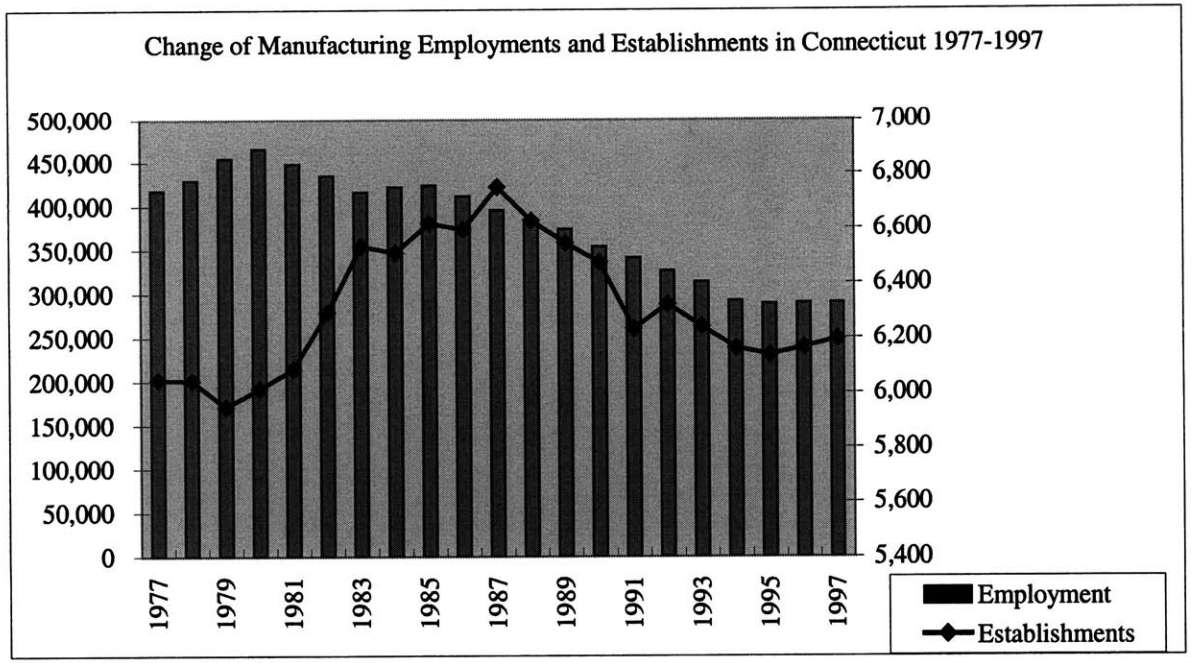
[9] This assessment is conducted annually by the Corporation for Enterprise Development (CFED), a non-profit corporation, based in Washington DC, San Francisco, and Durham. The CFED benchmarks fifty states according to performance index, business vitality index, and development capacity index, using more than 70 indicators. Information is available at: www.cfed.org

recession as well as the end of the Cold War, hit the sector severely. Connecticut lost nearly 70,000 manufacturing jobs during 1987 – 1992 (Figure 3.1) and the sector currently accounts for 17 percent of total non-firm employment (Figure 3.2): relatively high compared to the nation but significant downsizing compared to the 1970s. Simultaneously, the recession also affected the insurance industry, another important economic base of the state.[10] The collective impact was so severe that Connecticut could not recover until 1999 its employment level prior to the recession. This slow recovery of employment level may have been reflected in the 2000 Development Report Card, which pointed out that Connecticut had weakness in terms of long-term employment growth as well as in the number of jobs generated by new businesses: the state ranked last among fifty states for both indicators. Therefore, to come up with a strategy to accelerate diversification by encouraging the emerging industries as well as to upgrade and strengthen the existing industries became the important issue in the state in the early 1990s.

[10] Around 110 companies were located in the state in 1991 (Connecticut Market Data 1998).

Figure 3.1 Manufacturing Employment and Establishments in Connecticut 1977-1997

Connecticut	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Employment	417,460	429,013	454,332	464,838	447,725	434,283	415,433	421,320	422,978	411,146	394,991
Establishments	6,047	6,044	5,948	6,014	6,086	6,292	6,533	6,509	6,617	6,594	6,748
	1988	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	
	383,455	373,419	353,726	341,030	325,607	313,180	292,023	288,198	289,100	289,670	
	6,626	6,545	6,474	6,233	6,321	6,240	6,162	6,138	6,165	6,195	

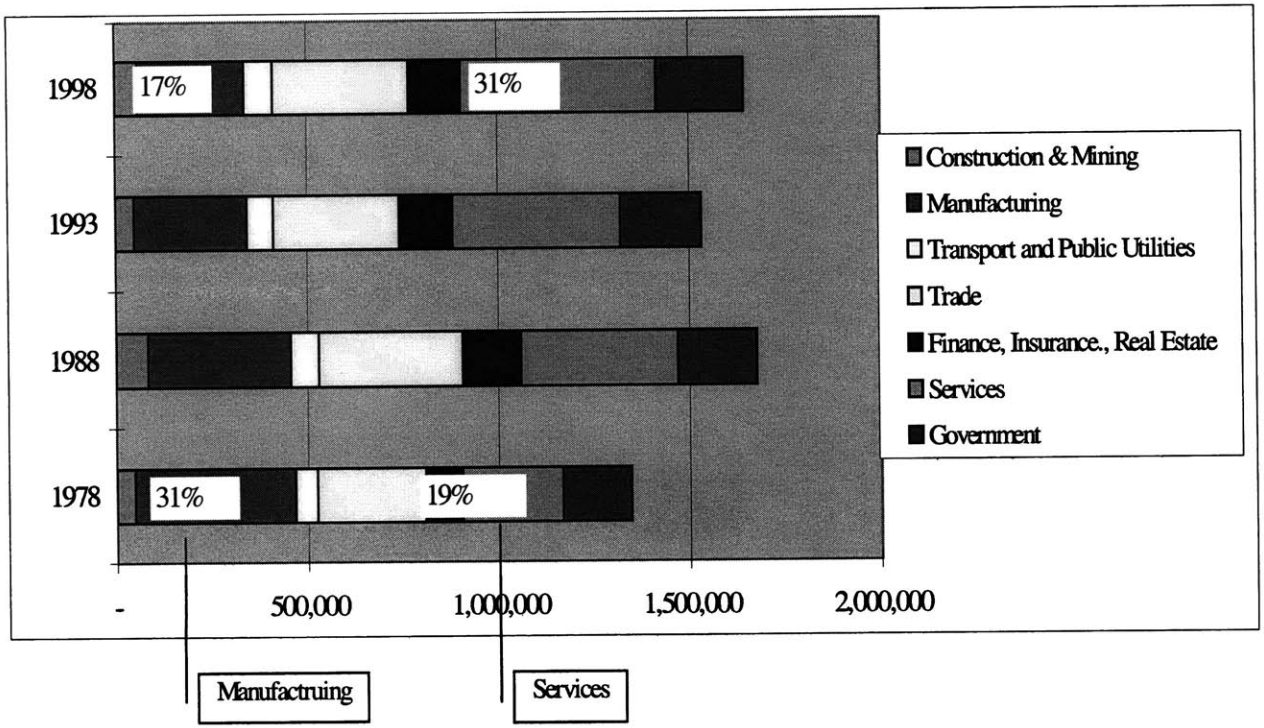


Source: "County Business Patterns, U.S Bureau of the Census

Figure 3.2 Employment by Sector in Connecticut

	1978	1988	1993	1998	Share ('78)	Share ('88)	Share ('93)	Share ('98)
Construction & Mining	47,900	82,900	48,500	59,700	4%	5%	3%	4%
Manufacturing	419,600	373,300	294,100	276,900	31%	22%	19%	17%
Transport and Public Utilities	57,800	73,100	69,500	75,700	4%	4%	5%	5%
Trade	284,200	377,700	330,300	355,800	21%	23%	22%	22%
Finance, Insurance., Real Estate	95,200	152,100	139,800	136,500	7%	9%	9%	8%
Services	262,200	409,400	438,100	511,000	19%	24%	29%	31%
Government	179,200	206,300	210,700	227,800	13%	12%	14%	14%
Total	1,346,100	1,674,800	1,531,000	1,643,400	100%	100%	100%	100%

Source: Connecticut Economic Digest based on U.S. Bureau of Labor of Statistics and Connecticut Economic Review 2000



3.2. INDUSTRY CLUSTER INITIATIVE

Since the early 1990s, the state has explored the industry cluster approach as a way to revitalize the existing industries as well as to develop new industries.[11] However, only after Governor John G. Rowland took office in 1995 did the cluster approach gain momentum. The industry cluster approach was introduced as a long-term strategy to improve the Connecticut's competitive position. This process is a problem-oriented as well as a result-oriented process, which produced outputs that lead to the next stage. The process can be divided into three stages: (1) cluster identification stage; (2) cluster analysis stage; and (3) cluster activation stage. Both the public and private sectors took part in the process, however it started as the state-led initiative.

(1) Cluster Identification Stage. Conceptually, Connecticut embraces Michael Porter's cluster definition:

> *industry cluster is a critical mass of interconnected companies and institutions in a particular field and particular location and .. .concentrations of companies, specialized suppliers, service providers, firms in related fields, and associated institutions (universities, trade associations, and standard-setting agencies) that are present in particular regions...*(Connecticut Industry Cluster Advisory Boards 1998, p. 4)

Industry clusters in Connecticut were identified based on the economic analysis especially the contribution to the economy in terms of employment and gross state products.[12] Therefore, the list of identified clusters includes (Table 3.1) industries that are not growing rapidly such as manufacturing, which had been declining for years. The purpose of cluster identification was to understand a group of industries that were dominant in the state. In other words, the state did not take the position of public sector "picking winners and losers."

In fall 1996, a newly created Department of Economic and Community Development (DECD)[13] updated the list of six industry clusters: (1) Telecommunications and Information; (2) Financial Services;

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[11] It is worth noting that the state adopted Michael Porter's cluster approach. In fact, he has been involved in Connecticut since 1991 when the state was exploring a way to revitalize its own economy. Later, when the governor established the Industry Cluster Advisory Boards in 1997, Porter became a senior advisor to the Boards.

[12] The first study was commissioned to Data Resources Inc. (DRI)/McGraw Hill in 1993-1994.

[13] The department was created in spring 1995 by the legislature as a result of merging the Department of Economic Development and the Department of Housing.

(3) Health Services; (4) High-technology; (5) Manufacturing; and (6) Tourism and Entertainment. These clusters were identified to provide a platform to begin organizing the cluster initiative and thus, they include many subcategories that later become formerly organized industry clusters (Table 3.1). For example, the manufacturing cluster includes plastics, metalworking, and aircraft parts.

The state explains the concept of industry cluster and the relationship with the Connecticut economy with three components. First, the driver industries are the driving force of the economy. The industries often represent economic base, or core export-oriented industries, thereby bringing new wealth back to the state. The six clusters above represent this category. Second, the supporting industries support the driver industries by supplying raw materials, semi-finished materials, parts and components, and other services. Increasingly, the state acknowledges that these industries also become important exporters and form clusters by themselves. Both the driver industries and the supporting industries bring new wealth to the state that supports the local industries, which primarily serve local population such as retail, real estate, construction, and others. Finally, economic infrastructure (they call economic foundations, but hereinafter I refer as economic infrastructure) represents the cross cutting issues that have major effect on the growth and competitiveness of *all* industries and defines them as the combination of: (1) skilled, adaptive and innovative human resources; (2) accessible technology; (3) available capital; (4) advanced physical infrastructure; (5) pro-competitive tax and regulatory climate; and (6) high quality of life (Connecticut's Industry Cluster Advisory Boards 2000, pp. 7-8). The state considers specialized and high-quality economic infrastructure essential to productivity and innovation driven competition, thus, regards the key role the public sector plays as shaping and developing the economic infrastructure. "Successful industry cluster growth depends upon the strength and vitality of all three components," the state remarks (Connecticut Industry Cluster Advisory Boards 1998, p. 8).

Table 3.1 Six Industry Clusters in Connecticut

SIC	Industry Clusters
	Telecommunications and Information
731	Advertising
48	Commercial, Radio and TV
82	Educational services
2721	Periodicals
2731	Book Publishing
2741	Misc. Publishing
3663	Radio & TV Communication Equipment
357	Computer and Office Equipment
	Financial Services
631	Life Insurance
633	Fire, Marine & Casualty
637	Pension & Health Funds
641	Agents, Brokers, and Services
603	Savings Institutions
602	Commercial Banks
614	Personal Credit Institutions
615	Business Credit Institutions
628	Security and Commodity Services
679	Misc. Investing
	Health Services
632	Accident and Health Insurance
806	Hospitals
805	Nursing and Personal Care
807	Medical & Dental Laboratories
809	Misc. Health Services
	High Technology
283	Drugs
384	Medical Instruments
3844/3843	X-Ray Apparatus & Tubes
3357	Fiber Optic Cables
3229	Fiber Optic Strands
3674	Laser Diodes
3699	Laser Welding & Drilling Equipment
3845	Laser Medical Systems
3827	Acousto-optic Equipment
3861	Cameras and Related
3679	Opto-electronic
737	Computer & Data Processing
873	Photonic Services

SIC	Industry Clusters
	Manufacturing
282	Plastics Materials and Synthetics
308	Misc. Plastics Products
342	Cutlery, Handtools and Hardware
343	Plumbing and Heating
345	Fabricated Structural Metal Products
346	Metal Forging and Stamping
347	Coating, Engraving and Related
348	Ordnance and Accessories
349	Misc. Metal Products
354	Metalworking Machinery
355	Special Industry Machinery
356	General Industry Machinery
359	Industrial Machinery
351	Engines and Turbines
372	Aircraft and Parts
373	Ships and Boat Building
361	Electrical Distribution Equipment
362	Electrical Industrial Apparatus
364	Electrical Lighting and Wiring
367	Electrical Components
369	Macs. Electrical Equipment
381	Search and Navigating Equipment
382	Measuring and Controlling Devices
	Tourism and Entertainment
79	Amusement, Rec. and Casino
70	Hotels and Lodging Places
78	Motion Pictures
45	Air Transportation
413	Intercity Bus
414	Charter Bus
448	Water Transportation, Passenger

Source: Modification based upon Partnership for Growth (1998) Appendix A: Cluster Profiles

(2) Cluster Analysis Stage. From the experiences of other states, Connecticut learned the importance of involving business leaders to identify problems and possible solutions of key industries. Thus, during 1997, the governor directly recruited business executives from both large and small companies, asking them to serve as members of Industry Cluster Advisory Boards and to come up with the priority recommendations for each cluster.[14] The advisory boards were formed for five clusters chosen during the cluster identification stage, except for tourism and entertainment. The tourism cluster had already been established under the Connecticut Tourism Council. The state recognized that business leaders are skeptical to work with government and that they have limited available time, thus they requested only a short-term commitment. After a few months of discussion, the advisory boards presented preliminary recommendations to the governor and key legislators, which were enthusiastically accepted. Each industry cluster advisory board made recommendations in terms of human resources, regulatory and tax climate, physical infrastructure, access to technology and capital, creation of collaborative institutions, and marketing.[15] Some of the priority recommendations were to develop a manufacturing resource center, to position Connecticut as a high-technology state with a great quality of life, to streamline regulatory requirements especially for small businesses, and to create a marketing campaign. Accordingly, the board members agreed to continue meeting with the specific tasks charged by the governor: (1) develop specific recommendations to improve competitiveness of Connecticut companies and (2) determine whether the industry cluster initiative should be launched, and if so, recommend action steps. In February 1998, the results came as a report *Partnership for Growth: Connecticut's Economic Competitiveness Strategy* (hereinafter, *Partnership for Growth*).

The report is the response by the Industry Cluster Advisory Boards. The governor gave it the compliment of "most important economic plan in 50 years," not only because of the volume of input from the private sector but because of its comprehensive coverage of recommendations with concrete action steps. In addition to the specific recommendations for each industry cluster, they gave recommendations

[14] The initiative was called "First 100 days" - 40 days to recruit business leaders and 60 days to devise recommendations.

for a number of crosscutting issues whose quality and specialization affects the productivity of all clusters. Among the broad categories the EDA defines (discussed in Chapter 2), it appears that Connecticut selected ones most relevant to their situation. Their economic infrastructure issues include: (1) workforce development, (2) transportation infrastructure, (3) regulatory environment, (4) urban development,[16] (5) marketing, and (6) capital and incentives. The attention to these issues in conjunction with the individual cluster also suggests that this cluster initiative did not target the "winner industries:" by cultivating the economic infrastructure, the state nurtures not only the "identified" clusters but also other clusters that may emerge in the future as is discussed later.

The fact that the recommendations were the result of discussion of 130 business and educational leaders provided a compelling reason for the legislature to support. Shortly after the presentation, the "cluster bill" was passed and the Industry Cluster Initiative was officially launched under the DECD. The bill also authorized the followings: $3 million fund for cluster activation and related activities; additional $20 million for the Connecticut Innovations[17] (state's venture-capital arm) bond funds to increase the available laboratory space; expanded application of 15 year carry forward provision to all tax payers who spends 20 percent on research and experiments;[18] an expansion of the full 6 percent R&D tax credit to small companies ($100 million or less in revenues); $4 million budget for cluster activities allocated from the Manufacturing Assistance Act (MAA);[19] and an increase from $1 million to $3 million for the

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[15] Summarized in the matrix by each industry cluster: Appendix A Partnership for Growth (1998), pp82-83.

[16] One of the issues under this category was the gap in prosperity between suburbs and inner cities. To provide an overall competitive strategy for inner cities, the Governor's Council launched the Connecticut Inner City Business Strategy in partnership with the Initiative for a Competitive Inner City (ICIC), for which $5 million was allocated from the Manufacturing Assistance Act (MAA). This strategy has been implemented in Hartford, New Haven, Bridgeport, Waterbury, and New Britain. It also identified key clusters for each city.

[17] It is a quasi-public organization created by the Connecticut General Assembly in 1989 to provide risk capitals to high-technology companies in the state. The focus areas are: bioscience, information technology, aerospace, advanced materials, energy and environmental systems, advanced marine applications, and photonics.

[18] Prior to this bill, the provision was applicable only to biotechnology companies.

[19] One of the most comprehensive economic development financing programs within the DECD. This act allows for the provision of financing for the projects that include planning, acquisition of real property, the purchase of machinery and equipment, construction, and/or infrastructure improvements, substantial renovation, improvement or expansion of a facility, and offset the costs related to relocation (Consolidated Audit Guide for Audit of the DECD programs).

Connecticut State Technology Extension Program (CONNSTEP)[20] to create a manufacturing resource center (The Connecticut Economic Digest, June 1998).

(3) Cluster Activation Stage. One of the characteristics of the Industry Cluster Initiative in Connecticut is that it differentiates the existence of clusters from working clusters, which is referred as activated cluster (noted in Chapter 1). In other words, after clusters are identified based on economic base analysis, the decision is left to business leaders to organize themselves to work as a cluster group and be formalized (called, activation). Only after business leaders decide to work collaboratively and develop a strategic plan as well as operational plan, can the state provide seed money. The role of the public sector in this stage is to support the activation through seed funding, organizational guidance, and devising public policy to respond to the private sector's needs for growth. In exchange, the private sector has to be responsible for leading the cluster initiative: companies have to commit the matching funds, designate or organize a formal cluster organization, and implement the agenda. Ultimately, the cluster organization is expected to be self-funding in general after three years. At present, six clusters have been activated: BioScience Cluster (1998), Aerospace Manufacturing Component Cluster (1999), Software/IT Cluster (2000), Metal Manufacturers Cluster (2000), Maritime Cluster (2001), Plastics Cluster (2001), and Agriculture Cluster (in progress). The six original clusters, which were identified prior to the *Partnership for Growth*, are so large and varied that activated clusters are usually their sub-clusters. For example, bioscience and software/information technology were a part of high-technology cluster. Similarly, aerospace, metalworking, and plastics products industries were a part of manufacturing cluster.

3.3. KEY ELEMENTS OF LAUNCHING THE INDUSTRY CLUSTER INITIATIVE

The three stages discussed in the previous section illustrate that the major initiative was taken first by the public sector and gradually shifted to the private sector (Table 3.2). The process also includes some interesting elements in each stage to launch the industry cluster initiative.

[20] It was established in 1994 and operates as the state's Manufacturing Extension Center, which is under the United States Department of Commerce, National Institute of Standards and Technology (NIST) Manufacturing Extension

During the identification stage, a list of six clusters was produced. This process was based on the quantitative analysis conducted by an outside consultant[21] and later by the DECD. It is noteworthy that the state identified only broad clusters that include a collection of sub-clusters. In essence, what was done in this stage was to identify a group of related industries that are dominant in the state and to provide a platform for further investigation, rather than choosing a winner industry to target.

In the analysis stage, the governor called for the commitment from business leaders and asked if the cluster initiative should be launched to improve competitiveness of the state's economy. This action resulted in the positive response laid out in the *Partnership for Growth.* The report is the comprehensive recommendations from the private sector to the state government, and recommendations both to develop each cluster as well as to handle crosscutting issues (economic infrastructure). This comprehensiveness made the *Partnership for Growth* the guideline for the later activities: activating clusters, designing programs to address economic infrastructure issues, and monitoring the implementation progress. Their recommendations were authorized by the passage of the cluster bill that legitimizes the implementation of the Industry Cluster Initiative with the appropriate budget. The two-step approach, to start with the preliminary recommendations and expand later to the fuller extent, appears to have succeeded in overcoming the initial skepticism of the business leaders and in having an eight-month commitment from the private sector. The fact that it was the business that decided to launch the initiative also contributed to the sustainable commitment. Another important element of this stage is that the business leaders represented all of the key industries in the state, which provided a legitimate reason for the legislature to support the bill. Had it been the initiative to support only a handful of targeted industries, it would have been difficult to receive bipartisan support.

The activation stage is ongoing, however the six cluster organizations have received formal recognition from the state as activated clusters and have been awarded seed money for their initial operation. What is critical in this stage is that the state did not offer a "free" support to key clusters.

Partnership program.

[21] The first study was commissioned to Data Resources Inc. (DRI)/McGraw Hill in 1993-1994.

Instead, the state offered the choice for business leaders to organize themselves and take an initiative to start prioritizing and handling issues that were identified in the analysis stage. Moreover, the state required a financial commitment from the business leaders in order to provide seed money. Connecticut's position appears to be ensuring business leaders' ownership in the cluster initiative as opposed to the public sector steering their actions.

In Connecticut, the public sector took the initiative, providing an opportunity for the private sector to launch the industry cluster initiative. The private sector took the opportunity because they found the merits of promoting industry clusters, which will be discussed specifically in the next chapter. Thus, the Industry Cluster Initiative in Connecticut is the demand-driven approach, whose ultimate fruit seems to be the working relationship between the public sector and the private sector, overcoming the skepticism in the past. This aspect is also reflected in the institutional arrangement, which I turn to next.

Table 3.2 The Public and Private Sectors Involvement in Launching the Industry Cluster Initiative in Connecticut

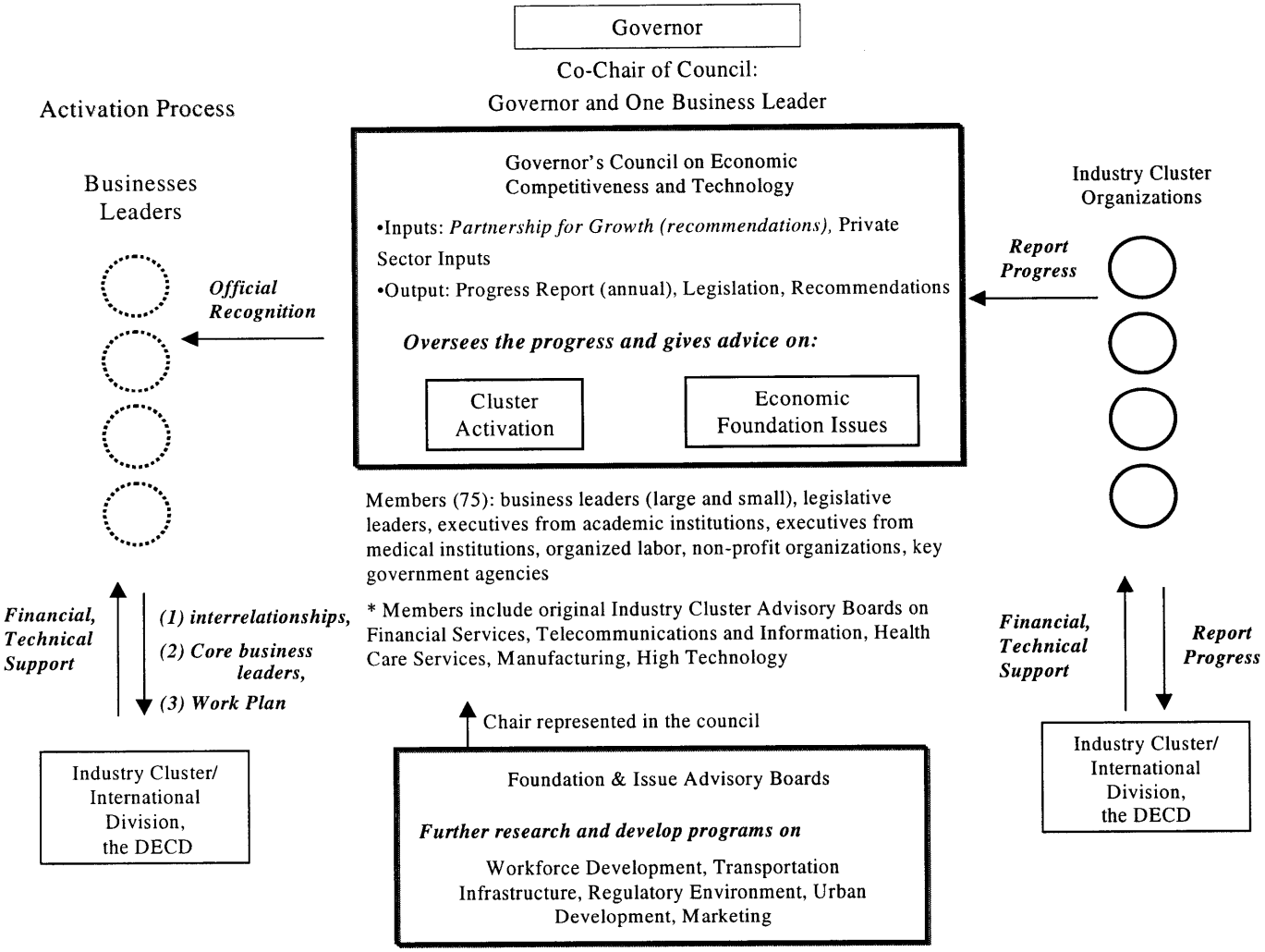
Stage	The Public Sector	The Private Sector
Cluster Identification	economic analysis	none
Cluster Analysis	recruit and convene business leaders	analyze issues, decide to launch the initiative, recommend action steps
Cluster Activation	official recognition, seed money, technical support (explain cluster concept, help develop a plan, build membership etc.)	initiate activation, build core leaders, commit financially, designate/create formal organization, devise work plan

Author's review of Connecticut experiences

3.4. KEY ELEMENTS OF IMPLEMENTATION: INSTITUTIONAL ARRANGEMENT

The Industry Cluster Initiative in Connecticut was introduced by the public sector at the governor's level with the inputs from the leaders in the private sector, which resulted in the comprehensive recommendations for the development of industry clusters as well as the economic infrastructure issues. What is impressive about the Connecticut initiative is that the state established the institutional framework to implement the recommendations to support industry clusters by addressing both (1) cluster-specific issues and (2) cross-cutting economic infrastructure issues, and to track the performance over time (Figure 3.3).

Figure 3.3 Institutional Arrangement of the Industry Cluster Initiative in Connecticut



Based on the *Partnership for Growth* recommendations, the state (by the governor's executive order) newly established the Governor's Council on Economic Competitiveness and Technology (hereinafter, the governor's council), which is co-chaired by the governor and a business leader. The governor appoints the council members, which consist of business leaders of small and large companies, legislators, executives from the academic and medical institutions, labor and non-profit organizations, and key government agencies. The members also include the chairs of the industry cluster advisory boards as well as the chairs of Economic Foundation and Issue Advisory Boards (explained later). It is under this council that the strong public and private leaderships are exercised to promote the cluster initiative and to increase competitiveness of the state economy. The missions of the council are to advise on policy matters related to clusters, to assess the progress of cluster activation, and to ensure responsiveness of government agencies. The progress of both industry cluster activation and programs related to economic infrastructure issues are monitored, measured against the original *Partnership for Growth* recommendations, and documented in progress reports that are issued annually by the governor's council. This high-level standing council is a striking feature of the Connecticut initiative to ensure that the *Growth for Partnership* recommendations are properly assessed and implemented accordingly. The council members meet twice a year prior to and after each General Assembly session. Thus, the day-to-day operation is executed by the related state agencies and the advisory boards. The principal agency for the Industry Cluster Initiative is the Industry Cluster/International Division at the DECD, officially authorized by the legislature under the cluster bill.[22]

Overseen by the governor's council with operational support from the related public agencies and non-profit organizations, two categories of activities are undertaken under the Industry Cluster Initiative: (1) cluster activation and (2) economic infrastructure issues.

(1) Cluster Activation. Cluster activation is the process of officially recognizing the existence of industry cluster in order to promote its development. The candidates of such clusters were broadly

[22] For the Industry Cluster Initiative, the DECD allocated $9 million in total: $3 million (FY1998/1999), $2 million (FY1999/2000), and $4 million (FY2000/2001) (DECD Annual Report).

identified under the six clusters discussed in the *Partnership for Growth*, which defined the priority and long-term issues as well as the recommended actions. As discussed earlier, it is up to business leaders in each cluster to take the initiative in assessing further issues and implementing the recommended actions. In order for a cluster to be activated, it has to meet the test of having: (1) interrelationships among businesses (vertical/ horizontal); (2) core business leaders to commit to the initiative; and (3) deliverables i.e. work plan. The state considers its active participation in the early stage essential, because the industry cluster concept may be in general difficult for business leaders to come to terms with and may require explanation of its practical value. Thus, the DECD helps interested business leaders refine and design the long-term plan with goals and priority activities. The department also supports building membership and forming a formal cluster organization, which can be either the new non-profit-organization or the existing one (it is usually reorganized to reflect cluster activities.[23]). After these processes, a cluster can be formally activated with the recognition from the governor's council, accompanied by the DECD awarding seed money for activation and program operation for the first few years.

The state requires each activated cluster to have a cluster organization. It is based on the state's and business leaders' belief that existing clusters must be organized to be effective (Connecticut's Industry Cluster Advisory Boards 1998). The rationale is to keep the collaborative process moving forward and to ensure that the recommended actions are properly assessed by cluster members and implemented. From the state perspective, a cluster organization is to act as a fiduciary agent in managing state funds, to provide an infrastructure and act as administrative staff for a cluster, to facilitate cluster meetings, to assist coordination and implementation of the cluster's agenda, and to represent the industry's issues.[24] During the activation stage, a cluster organization enters into a contract with the DECD and sets a milestone based on a working plan, commits the matching fund for the state's seed money, and reports the progress quarterly. The DECD meets with a cluster organization on a regular bases, including their Board of Directors meeting, to see if the milestone has been achieved. Even after

[23] For example, the BioScience Cluster used the existing organization but it reorganized the board of director members.

seed money expires, this ongoing communication channel and working relationship continues. For example, although seed money is not available after a few years, the DECD is open for the specific proposal from the cluster organization, for which the additional funding can be awarded. As an example, the cluster organization of the BioScience Cluster has recently proposed to establish the bioscince office within the DECD. During the governor's council meeting, the cluster organization makes a presentation to report the progress status as well as to propose the new activities that are debated in the meeting.

(2) Economic Infrastructure Issues. The *Partnership for Growth* recognizes that the economic infrastructure issues have major effect on growth and competitiveness of all industries and industry clusters. As discussed earlier, Connecticut focuses on economic infrastructure issues that are more relevant to their economic situation, which include workforce development, inner city business development,[25] transportation infrastructure, regulatory environment, capital formation and incentives, marketing the state, and international trade assistance.[26] The recommendations of the *Partnership for Growth* subsequently led to the creation of the Economic Foundation and Issue Advisory Boards by the governor's council. These advisory boards are established separately for each issue, whose members consist of wide stakeholders. The missions of the advisory boards are to further research the key issues and to develop programs to implement the specific recommendations of the *Partnership for Growth.* The chair of each advisory board is also a member of the governor's council.

To institutionalize economic infrastructure issues separate from the industry cluster activation but under the same Industry Cluster Initiative appears to have several implications. Workforce Development illustrates them well. First, economic infrastructure programs are demand-driven, reflecting the spirit of the *Partnership for Growth* whose fundamental recommendation for workforce development was to create demand-driven training initiatives. The Demand-driven aspect was highlighted because of

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[24] The DECD response to the author's inquiry (Response by Facsimile dated April 24, 2001).

[25] The governor's council launched the Connecticut Inner City Business Strategy in spring 1999, as a major component of urban development issues.

[26] Although the international aspect was not explicitly discussed in the *Partnership for Growth*, international trade issues have always been undertaken under the Industry Cluster and International Trade Division, DECD. After the Industry Cluster Initiative was officially launched, the international trade appeared to become a part of the initiative

the perception that the private sector in general viewed existing training and educational system as supply-driven and did not effectively tied to their needs. For example, Connecticut Business Training Networks, one of the training programs newly developed under the Workforce Development Advisory Board, is a grant program to help small and medium-sized companies define their own training. Once a group of more than five companies forms a network, it works with various training providers and develops a training program customized to their needs, for which the state award grants. Another program newly created under the initiative is the Secondary School Pilot Program, established in response to the Manufacturing Cluster Advisory Board. It is to provide young students with opportunities to receive advanced manufacturing training. The area industries help vocational technical high schools develop curriculum, provide internship opportunities, and conduct hands-on training. At present, four pilot projects are on going, one of which the member companies of the aerospace component manufacturing cluster participate in. The key is that these programs are not just for activated industry clusters: it does not preclude not-yet-organized businesses to join programs. Because these programs are organized under the umbrella of the Industry Cluster Initiative, they rather function as a platform for such companies to work around the specific programs together that may help them be organized into a new cluster. In fact, 10 metalwork companies located in the Bridgeport area formed the Business Training Network, which later became the Metals Manufacturing Cluster that was formerly activated in 2000.

Second, the system enables activated clusters to join the economic infrastructure programs according to their priorities. In other words, the economic infrastructure programs provide a menu of services from which the cluster organizations can choose, and they can customize the menu to their needs when needed. The BioScience Cluster has already been activated since 1998 and is currently considering joining the training network program. Similarly, when the Aerospace Components Manufactures were looking for technical assistance to implement lean manufacturing, they could use the services of the Manufacturing Resource Center, which was newly created in response to the recommendation of

(International section appears in the first progress report in 1999.)

Manufacturing Cluster in order to support the smaller manufactures to upgrade their manufacturing and management capacities.

The economic infrastructure programs also function as a venue for activated clusters to collaborate with other clusters for their specific needs. As a part of Marketing Program, for example, the BioScience Cluster and the Software/IT cluster are planning to launch a collaborative marketing campaign to promote Connecticut as a place to pursue career in high-technology industries.

In essence, the purpose of economic infrastructure programs is to cultivate a business environment that is responsive to the specific needs of the industries and industry clusters. By institutionalizing both activities of industry activation and the economic infrastructure issues under the same Industry Cluster Initiative, the Connecticut system has the flexibility of addressing cluster specific issues and also provides opportunities for new clusters to emerge. Having the economic infrastructure under the Industry Cluster Initiative is essentially working as a platform for companies to work collaboratively among businesses, with the service providers, and for industry clusters to work with other clusters, all of which stimulate the overall health of industry clusters and the state economy.

3.5. CONCLUSION

In this chapter, I reviewed the Industry Cluster Initiative in Connecticut in terms of the process the state used to launch and implement the initiative. The 1989-1992 recession hit the state's two major industries, defense and insurance, which prompted the state to develop a long-term strategy to accelerate diversification by encouraging the emerging industries as well as to upgrade and strengthen the existing industries. The process of launching the initiative can be characterized as demand-driven: the major initiative was taken first by the public sector, but it gradually shifted to the private sector. The ultimate outcome is the working relationship between the public sector and the private sector, overcoming the skepticism in the past. I also identified the institutional characteristics of the Connecticut approach. First, a governor's council, composed of both the public and the private sectors, was established and the council monitors the progress, measures the achievement against the *Partnership for Growth* recommendations,

and documents the achievements in progress reports. Second, the state requires each industry cluster to have a cluster organization, which is based on the Connecticut's position that clusters must be organized to be effective. The cluster organizations enter into a contract with the DECD and report the progress of achieving the set-milestone. Third, the state supports industry cluster activities by handling both (1) cluster-specific issues and (2) cross-cutting economic infrastructure issues. Having both activities under the umbrella of the cluster initiative, the system provides the three avenues for businesses to work collaboratively: (1) activated clusters, working with service providers according to their priority and needs; (2) businesses working on an economic infrastructure issue program, developing into new clusters; and (3) activated clusters, working on economic infrastructure issues common to each other.

My analysis of the Connecticut approach also highlighted the roles that the public sector can play in launching the industry cluster initiative, which are not necessarily argued explicitly in new theories of competition (see Chapter 2). These roles are: (1) disseminator of the cluster idea (analysis stage, activation stage); (2) motivator to promote businesses to work together (initial analysis stage and activation stage, and programs on economic infrastructure issues); (3) supporter to handle cluster specific issues and economic infrastructure issues (activation stage and programs on economic infrastructure issues); and (4) monitor of both activated and emerging clusters progress (activation stage).

The process and institutional features of Connecticut approach seems to conform to the public sector roles, which I developed in Chapter 2 based on the proposition that the nature of competition and the drivers of clustering has changed and become complex. New theories of competition suggest that lowering business cost approach is no longer sufficient to increase the competitiveness of industries: instead the public sector needs to focus on a business environment that enables productivity enhancement, capacity building of human resources, and supporting learning and collaborative activities. The prerequisite is to be sensitive to industry nature of competition and economic and strategic reasons to cluster, to understand the region's economic, industrial, skill and institutional base, and to match the cluster needs and its economic infrastructure. In Connecticut, the process of developing a comprehensive action plan appears to have been a learning process for both the public and the private sector to have a

shared understanding of insufficiency of lowering cost approach, priorities of a group of industries in a given unique competitive situation, and character of the state's economic infrastructure. As a result of this shared understanding, the state recognized the importance of common economic infrastructure issues especially the workforce development issues. One might argue that the economic infrastructure issues in Connecticut (namely, workforce development, transportation infrastructure, regulatory environment, urban development, marketing, and capital availability) are not new, however, institutionalizing them under the umbrella of the Industry Cluster Initiative provides the opportunity to customize the menu of the public sector services according to the priorities and needs of industries.

I examine these points in the next chapter in the specific context. By examining two activated clusters, BioSciecne Cluster and Aerospace Components Manufactures Cluster, the next chapter specifically demonstrates how clustering can be critical to the competitiveness of both industries given the specific competitive situation and what roles the state plays to increase the performance of those industries.

CHAPTER 4. IMPACT OF THE CLUSTER INITIATIVE ON COMPETITIVENESS: TWO CLUSTER IN CONNECTICUT

The previous chapter examined the process of the Industry Cluster Initiative being introduced to the state of Connecticut and analyzed the institutional arrangement that has been put into place. I argued that the inclusive and demand-driven process of launching the initiative, the institutional framework to assess, implement, and monitor the progress, and organizing economic infrastructure under the umbrella of the industry cluster initiative are key characteristics of the Connecticut approach. This system holds a possibility to keep sustainable commitment of key stakeholders. This chapter reviews the BioScience and the Aerospace Components Manufacturers clusters in Connecticut, using the framework developed in Chapter 2, namely to examine three dimensions of each industry: (1) competitive situation, (2) drivers for clustering, and (3) the need of policy supports.

The two clusters are early examples in the state that business leaders took initiative and took advantage of the state's initiative. Table 4.1 and Figure 4.1 summarize the basic facts about the two clusters. BioScience is an emerging cluster in Connecticut– it is in the middle of building a critical mass especially of biotechnology companies. In contrast, the aerospace components manufacturers have located for many years in Connecticut. Their issue is how to respond to the new competitive pressure from customers in terms of price, quality, and delivery. Thus, the Aerospace Components Manufacturers Cluster is an upgrading cluster – it is in the middle of transforming the business practices. Examining these two industry clusters provides an opportunity to present differences in issues for better performance, locational implications, and benefits of working as a cluster group. This analysis also provides useful insights about how the public sector responds to the different industry needs under the Industry Cluster Initiative. It is worth pointing out that the momentum to build and develop both industries did not only come from the top (cluster policy) but also from the bottom (private sector initiatives). Prior to or in parallel to the policy to encourage cluster development, business leaders, academic institutions, or private organizations had taken some initiatives. The Industry Cluster Initiative in Connecticut helped the

industries to move in this direction.

Table 4.1 Summary of Two Clusters in Connecticut

	BioScience Cluster	Aerospace Component Manufacturers Cluster
Related SIC	283: Pharmaceuticals 384: Medical Devices	372: Aircraft and Parts
Number of Employees*	8,880 (SIC 283), 8,386 (SIC 384)	32,825
Number of Establishments*	18 (SIC283), 112 (SIC 384)	113
Coordinating Organization	CURE (1990-)	Aerospace Components Manufacturers (ACM) (2000-)
Activated	October-98	July-99
Main Function	Research and Development	Machining suppliers of engines and other aerospace parts
Cluster Type	Horizontally related	Horizontally related
Members	Near 90 (Core: 5 Pharmaceuticals, 18 Bio-Technology Companies)	37 (As of April 2001)
Category of Members	pharmaceutical companies, biotechnology companies, education and research institutions, hospitals and health care organizations, professional societies, supporting businesses i.e., law firms, accounting firms, voluntary health organizations	Mostly machining suppliers in aerospace industry
Main Goals/Activities	1) Develop a critical mass of bioscience companies 2) Promote networking 3) Publicize the socioeconomic contributions of the cluster (Annual Economic Report) 4) Develop skilled and entrepreneurial workforce	1) Progressive Manufacturing (lean manufacturing) 2)Workforce development 3) Consolidated purchasing 4) Developing new business opportunities
Connecticut Assets	1) Yale University 2) Major pharmaceutical companies 3) Proximity to NY and Boston (venture capital sources) 4) Quality of Life	1) Major engine makers and suppliers for aircraft 2) Skilled workers (long history of precision machining) 3) High concentration of various parts makers
Large Companies in Connecticut	Alexion Pharmaceuticals, Bayer Corp., Boehringer Ingelheim Pharmaceuticals, Bristol-Myers Squibb Company, CuraGen Corp., Genaissance Pharmaceuticals, Neurogen Corp., Pfizer, Vion Pharmaceuticals	Dexter Corp., General Electric, Hamilson Sundstrand Corp., Pratt and Whitney, Sikorsky Aircraft Corp., United Technologies Corp. (not cluster organization members)
Examples of Other States with Similar Cluster	California, New Jersey, Massachusetts, North Carolina, Maryland, Arizona, Illinois, Michigan, Florida, Alabama, Oregon	Arizona, Alabama, California, Oregon, Florida, Maryland, Washington

* Based on County Business Patterns, 1997, Bureau of the Census

Figure 4.1 Location of Member Entities and Large Companies: BioScience Cluster

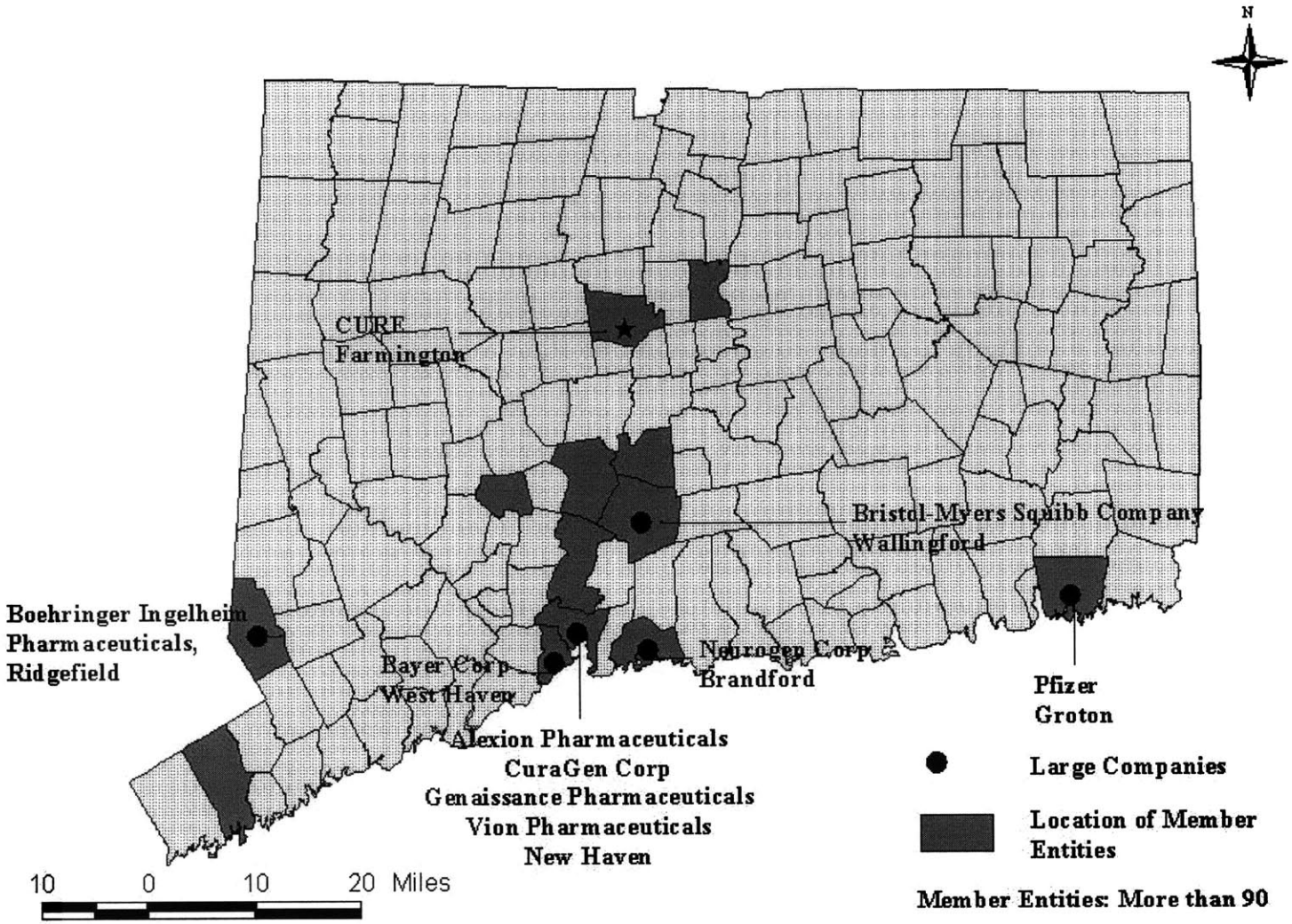
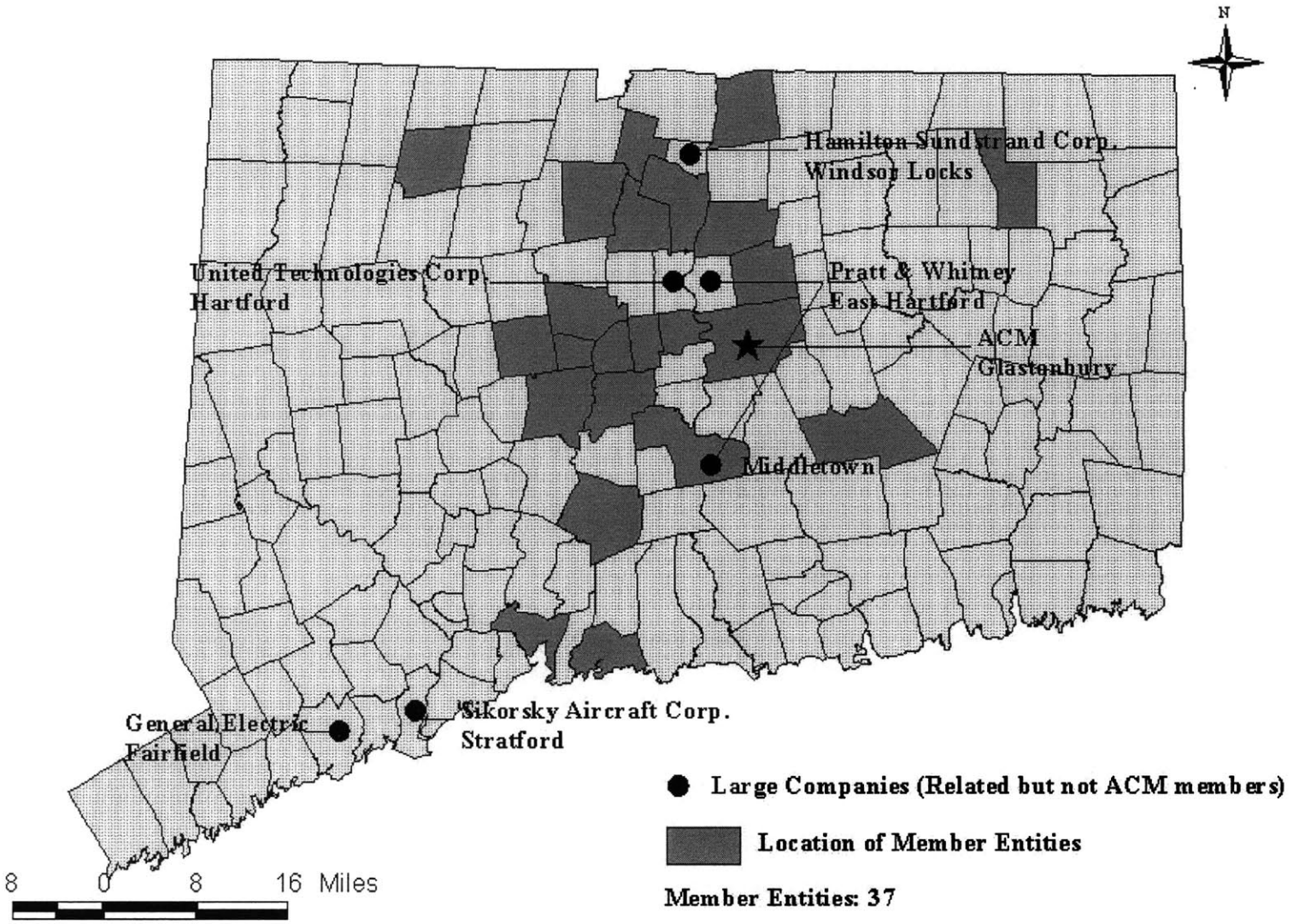


Figure 4.1 (continued) : Aerospace Components Manufactures Cluster



4.1. BIOSCIENCE CLUSTER

BioScience[27] is a relatively new and rapidly growing cluster and one of the most active clusters in Connecticut. Connecticut United for Research Excellence (CURE), a non-profit-coalition group to promote biomedical research, formed a partnership with the Department of Economic and Community Development (DECD), a principal state agency for the Industry Cluster Initiative, in October 1998 to support the growth of the BioScience Cluster. The member of the CURE has grown from 30 to nearly 90 entities, which includes 5 pharmaceutical companies and 18 biotechnology companies as the core members. The CURE also annually reports an impressive growth of biotechnology companies, pharmaceutical companies, and academic institutions in terms of R&D related employment and R&D expenses since 1995. The *Wall Street Journal* also paid attention to the "biotech boom" that is taking place around the New Haven area (September 20, 2000).

From the supply chain perspective of the biomedical industry, the main function of the cluster in Connecticut is biomedical research and development (R&D): the end products are new medicines, which are manufactured typically outside of Connecticut and distributed in a wider market nationally and internationally. In fact, the industry is very international and most of the major pharmaceutical companies are multinational corporations and produce the drugs in subsidiaries around the globe. Pharmaceutical companies in Connecticut contributed a part of $600 million export of chemicals and alighted products in 1999 (Connecticut Market Data 1999). The CURE members are mainly composed of academic research institutions, biotechnology companies, and established pharmaceutical companies. Therefore, the type of the BioScience Cluster in Connecticut is a horizontally related cluster, in which companies use common technologies and labor force skills and produce similar products.

[27] As I later explain, the function of this cluster is "Biomedical" research and development. In the early discussion prior to and during the *Partnership for Growth*, the cluster was called "biotechnology" cluster, because the initial focus was on developing a critical mass of biotechnology companies in the state. However, the state named it "BioScience" Cluster to reflect the ranges of member entities. Bioscience is defined as "any activity that substantially involves research, development or manufacture of 1) biologically active molecules, 2) devices that employ or affect biological processes or 3) devices and software for production or management of specific biological information." (CURE)

4.1.1. Industry Structure and Competitiveness

The prospect of the pharmaceutical and drug industry is promising. Increased interest in health, aging demographic trends, and public health concern in developing countries have contributed to the strong demand for this industry. In fact, the combined global pharmaceutical market (prescription and over-the-counter medications) is estimated to be over $300 billion, which grew by 7 percent in 1998 and is expected to continue to grow over the next 5 years (U.S. Industry & Trade Outlook 2000). The United States leads in terms of new drug discoveries and R&D expenditures and has maintained the competitive edge in the global market: North America accounts for 34.5 percent of total sales in the market, Europe 29.0 percent, Japan 15.9 percent, Latin America 7.7 percent, Southeast Asia and China 7.3 percent and all the other regions 5.6 percent (U.S. Industry & Trade Outlook 2000). Still, a small group of developing countries is building strong local pharmaceutical industries, taking their domestic markets away from western multinational corporations (Mourshed 1999), thereby posing a new threat to the U.S. pharmaceuticals. Introducing new products into the market is the primary force to keep the competitive advantage.

Nonetheless, biomedical research is by its very nature time-sensitive and costly. In the product discovery phase, scientists develop disease models and identify compounds to deal with it. After a compound passes the safety tests, it becomes a candidate for development. In the development stage, the drug candidate goes through extensive testing including a variety of animal experiments and eventually is tested by a few dozen volunteers. It then moves to clinical studies, in which a few hundred patients with the target diseases test the drug candidate. Only after the regulatory review by the Federal Food and Drug Administration can the drug candidate be approved as a new medicine and be introduced to the market. The entire R&D process can take from 7 to 24 years and only 7 percent of the candidates that come out of the product discovery phase become successful medicines: moreover, the entire research, discovery, development, and commercialization process can cost around $250- 500 million.[28]

[28] "The Future of the Pharmaceutical Industry" talk delivered by Dr. David McGibney, Senior Vice-President, Medicinal R&D of Pfizer, delivered to Royal Society of Arts, February 2, 1999.

Competition adds another pressure to this time-consuming, high risk, and high cost industry. Unless companies achieve the first-mover advantage, a new drug will not be worth enough to recover the initial investment cost. In addition, the patent protection will last for 20 years: after the expiration, generic drug manufacturers enter the market. Thus, this industry is extremely time-bound. To recoup the development cost, compete with established and cheaper generic products, and maintain the market share, companies have to ensure that their pipeline is full of new drug compounds. To achieve 10 percent annual growth, for example, they need to introduce two or three new products to market each year (U.S. Industry & Trade Outlook 2000).

This time aspect of the market situation is a key driver of strategic collaboration, contractual relationship, or merger worldwide in order to expand the R&D opportunity and to discover as many drug candidates as possible.[29] For example, Pfizer merged with Warner-Lambert in 2000 and became one of the largest companies in the world to pool resources to finance R&D activities effectively. Established pharmaceutical companies also seek alliances with biotechnology companies, often small start-ups, that have promising compounds but lack sufficient resources to withstand the lengthy and costly development and commercialization process. Such alliances could take several forms such as equity purchase, licensing agreements, marketing agreements, manufacturing agreements, research contracts, or joint ventures (Pagaran 1993). For example, for a drug program for anxiety and Alzheimer treatment, Pfizer paid Neurogen Corporation, a biotechnology company in Connecticut, $50 million in equity payments and research funding to become eligible for a worldwide royalty on marketed products (Neurogen website: Corporate Alliance).

Universities are another collaborating partners for research-based pharmaceutical companies and biotechnology companies because of their possible clinical candidates and technology transfer, in addition to the fact that universities are the source of prominent scientists. Especially since the passage of the Bayh- Dole Act of 1980, which allowed universities to retain property rights for federally funded research, commercialization of academic research has been accelerated. For example, Yale University

[29] "In the early 1990s, mergers were driven primarily by a desire to cut costs. In the late 1990s, R&D opportunities

received more than $46 million licensing revenue in FY2000, which accounted for 11 percent of the total research expenditure at the university (Yale OCR 2000). Thus, it is not surprising that companies locate themselves around universities with a strong reputation in science. In fact, most of the states that are known for the industry have prominent universities: Stanford University, University of California (San Diego) in California, Massachusetts Institute of Technology in Massachusetts, Princeton University in New Jersey, Johns Hopkins University in Maryland, and Yale University in Connecticut.

4.1.2. Cluster Activation

BioScience is the first activated cluster in Connecticut and the state considers it as a role model for the other industry clusters in the state. Nonetheless, this BioScience Cluster had long been what Enright calls "latent cluster" (discussed in Chapter 2). Three major cluster elements already existed prior to cluster activation in 1998. The prominent research universities, critical element for research-oriented bioscience industry, have been in Connecticut: especially Medical School of Yale University and University of Connecticut Heath Center and more. Connecticut has also been a home for the four established major global pharmaceutical companies (Pfizer Inc., Bayer Co., Boehringer Ingelheim Pharmaceuticals Inc., and Bristol-Myers Squibb Co.). Moreover, the specialized supporting institution, the CURE that later became the cluster organization, has existed since 1990.

Nonetheless, Connecticut was not necessarily known for the bioscience cluster due to the limited interaction and collective actions, and the lack of the critical mass. Yale University had been known for the "ivory tower," as a result of their position that the commercialization of academic research by faculty might damage the quality of research. Recognizing this attitude, pharmaceutical companies did not work with the universities and had long considered themselves to be "self-sufficient."[30] They were satisfied with Connecticut because the state had less tax burden than New York and Boston but was sufficiently close to both cities. Although CURE was established in 1990 by the industry including Yale

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appeared to be the driving force." (U.S. Industry & Trade Outlook)

[30] Remark in the interview with one of the pharmaceutical companies in Connecticut.

University and pharmaceutical companies, its primary mission was to serve as an information center to educate the public about the significance of the biomedical research and the rationale for the use of animals.

This situation has changed dramatically during the mid-1990s. First, CURE was going through a transitional period. Because of some cases reacting to the use of animals for research in a extreme manner, CURE members started to consider educating politicians and the media: to proactively publicize how much the biomedical industry contributes to the economy became their interest. Thus, CURE added economic development to their mission. When it conducted the economic survey of the biomedical industry, CURE found out that Connecticut had been short of biotechnology ventures despite the presence of prominent universities and pharmaceutical industries. The report by the Yale Office of Cooperative Research (OCR) confirmed this absence: Connecticut had only seven biotech companies in 1997, which employed only 329: occupying the lowest position among 12 comparable states (Table 4.2).[31] This fact demonstrates a striking contrast with the fact that Connecticut ranks the third in terms of per capita federal Health and Human Services (HHS) funding. This gap between funding and a number of employees translates into 1.72 biotechnology jobs per $1 million HHS funding, which is second from the bottom among 12 states (Yale OCR 1997). This fact may reflect that the research institutions in Connecticut were not active in commercializing their inventions.

[31] The twelve states are selected based on the amount of grants from the Department of Health and Human Services in FY 1994.

Table 4.2 Biotechnology Companies in Connecticut Compared to Other States in 1997

State	Biotech Companies	Biotech Employees
CA	186	34,650
MA	74	12,571
MD	40	5,085
NJ	37	4,878
NY	31	2,319
PA	30	2,392
NC	19	1,977
TX	18	1,020
GA	12	1,596
IL	10	715
MI	8	316
CT	7	329

Source: "Connecticut's Biotechnology Gap"
Yale Office of Cooperative Research (May, 1997)

Second, during the same period, Yale University also changed its attitude about discouraging the commercialization of academic research. It was the arrival of the new president Richard Levin, a specialist in the economics of technological change, that reversed the direction in 1992. Levin directed the Yale OCR to take a proactive position in assisting new ventures to originate at the university and to promote business links. The direction towards proactive technology transfer from Yale University was accelerated in 1995 when the OCR budget was tripled and Gregory Gardner, a former Pfizer executive and specialist in technology transfer, was hired to run the OCR. Gardner transformed the OCR from a patent application office to a one-stop center for start-up business. The OCR is engaged in identifying inventions with commercial prospects, finding venture-capital, and facilitating the establishment of companies. The office also works for industrial partnerships to license Yale inventions.

The result of these changes are a tremendous number of Yale-affiliated start-up companies, most of which are less than five years old: 14 companies including 5 publicly traded companies, and 11 in development (Yale Medicine 2001) mostly located around the New Haven area. This increase is also reflected in the CURE report, which shows that from 1995 to 1999 the number of R&D employees in

biotechnology companies grew from 295 to 780 (164 percent growth) and that the R&D expenditures grew from $52 million to $154 million (200 percent growth) (CURE 2000), outpacing the national figure of 49 percent and 39 percent respectively during the similar period.[32]

The growth of biotechnology companies in the state has also promoted their opportunities to have strategic alliances with pharmaceutical companies. One of the interviewees in the pharmaceutical company commented that they became increasingly less self-sufficient and sought alliances: to be competitive, the current market situation requires company to achieve the faster delivery of new drugs. "Time is more important than money," the person remarked. The pharmaceutical companies also started to send higher-ranking people to the CURE to represent them, which signifies that they start to see the value of working together.[33] Pfizer is one of the most active among all the CURE members.

It was during this transition period that the state's Industry Cluster Initiative was taking place. From the state's perspective, the dynamic change occurring in the biomedical industry was a positive sign and started to position industry as a key for the state economy in making the transition to a knowledge-based economy. Moreover, the state values the industry's significant employment and income multiplier effects as well as its high salary (Connecticut Industry Cluster Advisory Boards 1998). Thus, the DECD approached CURE to use it as a role model for other industry clusters: by this time, the three major cluster elements (universities, core companies, and specialized supporting organization) came together resulting in new start ups. From CURE's perspective, having official recognition and support from the state would accelerate the growth of the industry, particularly that of biotechnology companies. Consequently, as a part of the state's cluster initiative, CURE formed a partnership with DECD and became an organizational center of BioScience Cluster activities in October 1998, the first activated cluster in the state.

Accordingly, economic development became the primary mission for CURE and it currently acts on behalf of bioscience companies and related organizations and institutions to create a conducive

[32] The Connecticut figures are based on 16 biotechnology companies that existed and were members of CURE at the time of the survey. CURE used 1993-1997 data to represent the national figure as the latest comparable data.
[33] In fact, I interviewed a director of Research and Development Strategy Planning at one of the major pharmaceutical companies. He used to represent the company at CURE but later asked the Vice President to replace him, noticing the trend in other pharmaceutical companies.

environment for the industry. CURE is governed by a member-elected 29-person board of directors and is organized into five councils, each of which consists of the related member companies and institutions: they include bioethics and clinical research, business development and technology transfer, education and training, public relations, and research methodology. The council meetings are the main opportunities for members to exchange ideas and develop programs, and members meet four to six times a year. Apart from the council meetings, CURE organizes the annual membership meetings that have already established publicity and quarterly seminars on real estate, legal, accounting, and venture-capital. As of today, April 2001, CURE has more than 90 members including 5 pharmaceutical companies and 18 biotechnology companies as the core.

Partnership for Growth identified existing barriers as: (1) a lack of available laboratory space; (2) a complex permitting process for new facilities; (3) a unfavorable tax structure for new research-based companies; and (4) a lack of seed capital for new start up companies. As a long-term plan, CURE identified four major goals: (1) to develop a critical mass of bioscience companies by stimulating the growth of existing companies, facilitating new biotechnology companies, and recruiting companies to Connecticut; (2) to promote networking among cluster members; (3) to publicize the BioScience Cluster's socioeconomic contributions and potential; and (4) to collaborate to develop skilled and entrepreneurial workforce for the future needs of bioscience companies (DECD 1999). CURE also releases the Annual Economic Report that summarizes the survey results of the cluster performance.

One of the major achievements of the CURE activities is the creation of the $40 million BioScience Facilities Fund, authorized by the cluster bill. The fund is to underwrite the development of incubator and laboratory space in the state and especially helps start-up biotechnology companies to lease property or renovate existing space. In 1999, the fund provided $11.4 million in loans for seven companies to construct the space (CURE 2000). Another major activity is a five-year project called BioBus, which is a mobile state-of-the-art biotechnology laboratory that will start this summer visiting schools and communities to promote biomedical careers and making hands-on scientific opportunities available to students and teachers. It is a part of the long-term goal to develop skilled workforce in the

life sciences, and the Connecticut Innovation (a state venture-capital arm) provided half of the $3 million project cost.

4.1.3. Competition and Clustering

The rapid growth of the BioScience Cluster in Connecticut demonstrates how the industry cluster works for better performance. The research-based pharmaceutical companies and biotechnology companies are competing for time: to introduce new drug products into the market faster than the competitors constitutes the competitiveness. In this situation, pharmaceutical companies, biotechnology companies, universities, and CURE found the practical benefits of establishing critical mass and working as an industry cluster.

First, spatial proximity to universities is critical particularly for the start-up biotechnology companies. Universities are the source of prominent scientists, technology transfer opportunities, and clinical candidates: biotechnology companies locate around universities, seeking access to knowledge, human resources, technology, and the source of new products. The director of the Yale's OCR remarked, "ideally, you want to be within a five minutes walking distance from the university, if you want faculty's involvement and technology transfer." To illustrate the point, Winstanley Enterprises is developing the new 500,000 square feet laboratory space across from the Yale Medical School, and almost 85 percent of the space was already committed within a year from the announcement. Achillion Pharmaceutical, a promising start-up biotechnology company and tenant of the Winstanley's property, changed its initial plan to locate in New Jersey and moved to New Haven because they obtained the drug compound from Yale University.

Secondly, spatial concentration of bioscience companies raises visibility, which draws venture-capital investors and high skill scientists: finance and knowledge, two critical but mobile factors for competition. After the formation of the BioScience Cluster, some biotechnology companies have noticed that investors are approaching them instead of them visiting investors in New York and Boston. The Crossroads Venture Fair, an annual regional venture fair, will be held in New Haven for the first time. For

scientists, the existence of a cluster means multiple employment opportunities not only for him/herself but also for the spouse who is often a scientist as well. The cluster also suggests the existence of a safety net to switch jobs in case a company goes out of business. In fact, workforce mobility in this industry is relatively high. Connecticut has an additional advantage of having major global pharmaceuticals within the cluster. For start-up and newly moved biotechnology companies, pharmaceutical companies are the source of recruiting new high-skilled scientists. For pharmaceutical companies, multiple employment opportunities in the cluster facilitates to keep new graduates in life science in the region and to attract scientists outside Connecticut.

Third, time pressure to discover new drug offers an interesting aspect of collaboration among bioscience companies: they are potential competitors as well as potential customers/suppliers for each other. For example, for a drug program for anxiety and Alzheimer treatment, Pfizer paid Neurogen Corporation, a biotechnology company in Connecticut, $50 million in equity payments and research funding to become eligible for a worldwide royalty on marketed products (Neurogen website: Corporate Alliance). For Pfizer, it is better to work with the partners than to be on their own and lose the first mover advantage to other competitors. Because companies typically collaborate on individual drug programs, a competitive relationship does not preclude the collaboration. In fact, the president of one biotechnology company said that he would prefer to have more biotechnology companies in the cluster, even though it meant higher competitive pressure. "If they are competitors no matter where they are located, I would rather have them here. We may have a possibility to work with some drug programs." Although spatial proximity alone is not sufficient to have research collaboration among companies, it nonetheless facilitates the transaction.

Finally, the cluster provided the opportunities for members to interact, to recognize the interdependencies, and to take collective actions. Collectively, CURE members share an interest in building a critical mass and having streamline the permit process (e.g., start-up, land use, and environment regulation), as well as gaining political support for the industry. As explained in the next section, the public sector favorably responded to these issues that further promoted the growth of the

cluster.

4.1.4. Policy Responses

The state actively supports the growth of this industry, as it positions biomedical industry as being a key to make a transition to a knowledge-based economy. In particular, development of biotechnology companies was recommended strongly in *Partnership for Growth*, whose recommended actions quickly materialized. The advisory boards of the cluster identified existing barriers as: (1) a lack of available laboratory space; (2) a complex permitting process for new facilities; (3) an unfavorable tax structure for new research-based companies; and (4) a lack of seed capital for new start up companies. In response, the state provided assistance in the following areas: activities to activate the cluster, creation of laboratory space, and improvement of tax incentives. First, the state provided $300,000 as seed money to initiative cluster activation, which was matched by $700,000 pledge by the industry. Second, the cluster bill authorized a $40 million BioScinece Facilities Fund to promote the creation of laboratory space. Tax incentives include exemptions from sales, use and property taxes; 15 year carry-forward of R&D tax credits; exchange R&D tax credits for cash; and extension of the net operating loss carry-forward from 5 to 20 years.

To develop the biomedical industry is not only on the state's agenda but also on the city of New Haven's. Over the decade, the city's economy has fluctuated. Although the city has experienced modest employment growth, the level is still below that of 1990 (Connecticut Economic Digest January 2001). When the city elected a new mayor John DeStefano Jr., it positioned biotechnology as a new engine of its economy. The state supports the city's new position in a number of ways. The state committed with the city to build $9 million parking facilities near the new biotechnology building. In addition, the city receives from the state 75 percent of what it would have collected were educational institutions taxed. For example, Achillion and Molecular -- two biotechnology companies that occupy the new biotechnology building developed by Winstanely Enterprises -- received an 80 percent tax break on personal property for five years and the city is reimbursed for 40 percent of the tax break by state

payments in lieu of taxes, as their research involve significant university engagements (New Haven Register December 3, 2000).

Without these public interventions, could the "biotech boom" have occurred in the New Haven area and in the state? Although it is true that positive elements have already existed, the state intervention appears to have contributed to the momentum. In particular, the market was not ready for developing laboratory space. Given the early development stage of biotechnology in Connecticut, developers used to be reluctant to invest the $200 to $400 per square foot required for building the laboratory space (The New York Times December 31, 2000). The lack of available space has long forced young biotechnology companies to either become developers themselves or to leave the state. However, the state seems to have facilitated the growth of the space: CURE reports that the laboratory space in the state expanded by nearly 60 percent since 1996, for which the biotechnology segment alone achieved nearly 100 percent growth from 189,000 to 372,000 square feet (CURE 2000). This increase may have signaled the market: two major developers entered the New Haven area. Winstanley Enterprises invested more than $25 million into a former telephone customer service center building, which is five-minute walk from the Yale Medical School, and is converting it to 500,000 square feet of laboratory and office space. To help the development, Yale agreed to lease 50,000 square feet in the building (The Wall Street Journal September 20, 2000). Another developer, Lyme Properties LLC, is renovating the city's old science park into one million square feet of space and will invest $200 million over the next five to ten years (The Wall Street Journal September 20, 2000). As a consequence of a series of support from the state to develop the BioScience Cluster, Pfizer also decided to build a new $270 million global development facility near New London. To enable this project, the DECD, the Department of Environmental Protection, the Connecticut Development Authority, and the City of New London have committed to the preparation of the brownfield site, the restoration of the historical area, and the development nearby (DECD 2000). The facility is scheduled to open this year.

In the case of the BioScience Cluster, the dynamic change for growth and collaboration was taking place independent from the state's Industry Cluster Initiative. What the state did was to provide a

momentum to transform the cluster from a latent one to a working one, particularly by supporting the growth of biotechnology companies: it was a missing piece for the cluster to function. In fact, most of the state's support was geared to the needs of emerging start-ups (i.e., laboratory space, R&D tax credits, and tax break), for which the state also coordinated with the city of New Haven. However, by facilitating the building of a critical mass, the state effectively reinforced the cluster environment where information, knowledge, and technology flow takes place and new start-up companies emerge, all which are promoted by the face-to-face interaction.

4.2. AEROSPACE COMPONENTS MANUFACTURERS CLUSTER

Manufacturing has been one of the key sectors in Connecticut, which still represented more than 17 percent of non-farm employment in 1995 (Connecticut Market Data 1998). Among manufacturing industries, aerospace has been one of the important industries and it employed more than 35,000 (8 percent of the total manufacturing employment) (1997 Economic Census). The industry is also a part of the transportation equipment industry, a leading exporter in Connecticut, which achieved $2.8 billion exports in 1999, which is more than 35 percent of the total export value of the state (Connecticut Market Data 1999). The state has been a home for skilled precision manufactures for more than half a century especially in the Connecticut Valley region, which drew major manufactures of aerospace industry to the state. At present, Connecticut houses the headquarters of major manufactures such as Pratt & Whitney, an engine maker for commercial, military, and general aviation; Hamilton-Sundstrand, a manufacturer of aircraft systems such as environmental control systems to commercial aircraft propellers as well as to space shuttles and space suits; and Sikorsky, a commercial and military helicopter maker. From the supply chain perspective, Connecticut is particularly known as one of the key manufacturing centers of engines because of the concentration of key major engine producers, major aircraft suppliers, rich first tier machining suppliers, and sub-tier suppliers providing raw materials and supporting services such as

welding, brazing, heat-treat, x-ray, coating, and chemical testing.[34] Therefore, the aerospace cluster has naturally grown and companies in a cluster are vertically related, in which companies have buyer-seller relationships. Unlike the BioScience Cluster, the aerospace industry has already achieved a critical mass of companies engaged in the aerospace industry. The concern is rather the changing competitive situation: the prime contractors are requesting a higher performance in terms of cost, quality, and on-time delivery, which has introduced suppliers to whole new challenges. As a result, suppliers felt a need to work among themselves to collectively upgrade their manufacturing processes in order to meet the higher expectations of customers. Thus, a group of machining suppliers as well as sub-tier suppliers formed a group, which became an aerospace components manufacturers (ACM) cluster. The ACM Cluster is, thus, an upgrading cluster that is in the middle of transforming the business practices.

4.2.1. Industry Structure and Competitiveness

The aerospace industry comprises three markets: (1) the commercial, (2) the military, and (3) general aviation,[35] of which the first two segments dominate the market, generating more than $80 billion, $163 billion, and $18 billion in 1999 revenues respectively (Standard & Poor 2001). The development process of this industry is costly and lengthy. In commercial aviation, the process to design the Boeing 767 took six years with an estimated cost of $1.5 billion (Mowery and Rosenberg 1989, p. 171) and a new medium-sized airliner is in general estimated to cost over $2.0 billion to develop with another $1.5 billion for engines.[36] In addition, the output rate is not necessarily high: since the commercial jet transport was introduced in the 1950s, only 5 out of 23 aircraft have achieved more than 600 unit sales (Mowery and

[34] In Connecticut, many aerospace related manufacturers are involved in manufacturing engine and engine parts: the segment represents 44 percent of total aerospace employees and 47 percent of total aerospace establishments. According to the 1997 Economic Census, the industry (NAICS 3364) employed 35,351 in 117 establishments. The distributions are: aircraft manufacturing – 8 establishments with 25,000-49,999 employees; aircraft engine and engine parts – 55 establishments with 15,721 employees; other aircraft part and auxiliary equipment – 52 establishments with 5,000-9,999 employees; and other guided missile and space vehicle parts and auxiliary equipment – 2 establishments with 500-999 employees.

[35] This includes fixed wing aircraft and rotorcraft for business transportation, regional airline service, and recreation as well as specialized uses such as ambulance service, agricultural spraying, and training.

[36] The Economist, quoted by the Encyclopedia of American Industries (Volume One): Manufacturing Industries, p. 1143.

Rosenberg 1989, p. 173). Due to the long lifetime of aircraft and engines, they are also subject to periodic incremental modifications: they require the aerospace manufactures to have a global marketing capacity that provides information of operating experiences since the introduction of the aircraft as well as the worldwide product support organization with adequate spare parts and field service. Furthermore, the health of the commercial aviation business is tied to airline carriers whose performance hinges on passenger travel that is sensitive to the change of GDP: it is a very unpredictable and fluctuating market.

Given its high-risk and high-fixed cost nature, the aerospace industry has a high entry barrier that favors large players. After a series of mergers and acquisitions, the large commercial airframe industry is a duopoly of the Boeing Co., and Airbus Industrie Co., which controls 70 percent and 30 percent of the $55 billion industry respectively (Standard & Poor 2001). In the case of jet engines, it is dominated by General Electric (GE), Pratt & Whitney, and Rolls-Royce: in total they account for more than 84 percent of the global market (Standard & Poor 2001). The aerospace industry is characterized by these dominant players supported by a broad base of medium and small-size suppliers that contribute a range of parts, services, and raw materials.

The end of the Cold War has impacted the industry tremendously. Prior to the collapse of the Soviet Union and the declining threat to the United States, the industry enjoyed a large budget from the Department of Defense, which not only guaranteed the operation of manufactures but also enabled them to focus on the advancement of the technology through R&D and assured their technological leadership as their competitive edge (Dertouzos, Lester, and Solow 1989). As military spending shrunk, commercial aviation has increased in relative importance, which now has to cover the industry's R&D cost. In fact, the U.S. government military spending was $436 billion, which included $138 billion procurement spending in 1985: in contrast, $60 billion is proposed for procurement in 2001, less than half of the 1985 level (Table 4.3).[37] However, the shift towards the commercial sector also means that prime contractors are now subject to demand fluctuation and have to serve demanding customers (i.e., airline carriers) in terms of price, quality, and delivery. Competition has become fierce among dominant aircraft

[37] U.S. Department of Defense. The figure is in billions of constant 2001 dollars.

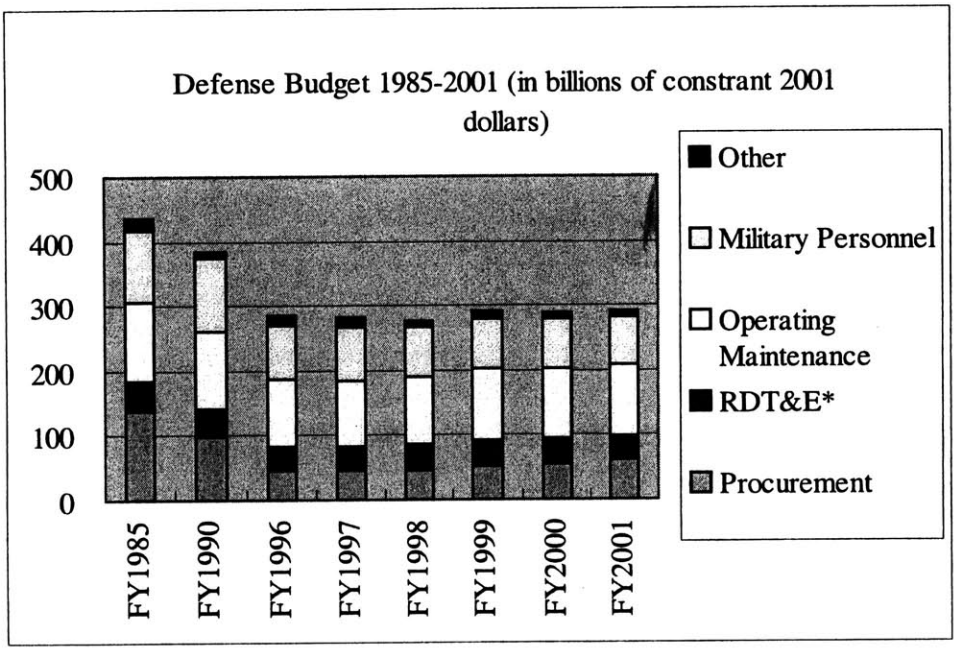
and engine manufacturers, which is felt all along the supply chain.

Table 4.3 Defense Budget 1985 - 2001 (in billions of constant 2001 dollars)

	FY1985	FY1990	FY1996	FY1997	FY1998	FY1999	FY2000	FY2001
Procurement	138.1	97.7	45.2	45.2	46.7	52.5	55.1	60.3
RDT&E*	45.9	44.9	37.5	38.4	38.7	39.6	39.0	37.9
Operating Maintenance	121.8	118.3	105.3	101.7	104.4	110.7	108.7	109.3
Military Personnel	111.5	111.9	81.9	80.3	77.2	75.8	76.1	75.8
Other	19.0	9.7	14.6	16.9	10.2	14.0	9.0	7.9
Total	436.3	382.5	284.5	282.5	277.2	292.6	287.9	291.2

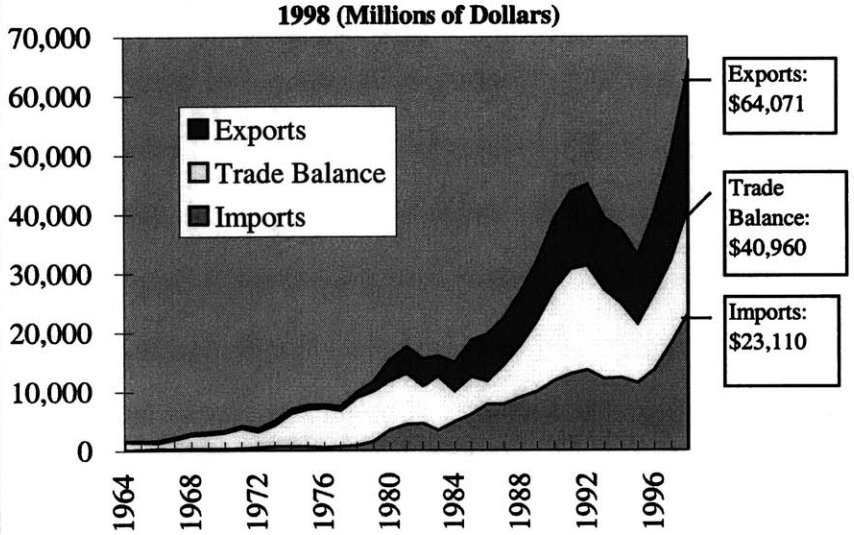
Source: U.S. Department of Defense

* Research, Development, Testing and Evaluation



The consequence of this change is a tremendous pressure on suppliers. First of all, aircraft as well as engine manufacturers are beginning to consolidate their supplier base. For example, Pratt & Whitney reduced its product related suppliers from around 1,000 to 400 and non-product related suppliers from 30,000 to 2,500.[38] For suppliers to be the preferred suppliers, they must cross the rising bar, i.e., they typically have to reduce unit cost by 5-10 percent, to improve quality by 50 percent, and to improve on time delivery performance by 25 percent.[39] The suppliers face pressure not only from buyers but also from offshore competitors. In order to share the R&D cost, to hedge the product development risk, and to penetrate the international market, aircraft and engine makers have begun to establish allies with international partners that often involve an agreement to purchase a certain portion of parts from offshore suppliers. To illustrate the point, the foreign trade of the U.S. aerospace industry has grown steadily and the trade balance of the industry was $41 billion in 1998, of which export represents $64 billion and import represents $23 billion (Figure 4.2).[40]

Figure 4.2 U.S. Aerospace Foreign Trade 1964-1998 (Millions of Dollars)



Source: Census Bureau, Foreign Trade Division and Aerospace Industries Association

[38] Interview with the Procurement Department, March 30, 2001.
[39] Michaels, L.M.F (1999), p. 139.
[40] Aerospace Industries Association of America, based on the Census Bureau, Foreign Trade Division and the Association.

4.2.2. Cluster Activation

This ever-increasing demand and competitive pressure is the situation that machining suppliers in Connecticut have faced since the mid 1990s. Although Pratt & Whitney, one of their major customers, started to adopt lean manufacturing (explained later) in the early 1990s to cope with the new situation, many suppliers were slow to react as they felt it was just another "fad" as had happened in the past. Most of the machining suppliers are run by entrepreneurial-minded owners, have been in business with major customers for twenty to forty years, and are small family-owned business with fewer than 200 employees with revenues between $2 million-$50 million (Emiliani 2000). Thus, it was conceptually and financially difficult for business owners to recognize the speed of the change and, if they do, to implement the restructuring.

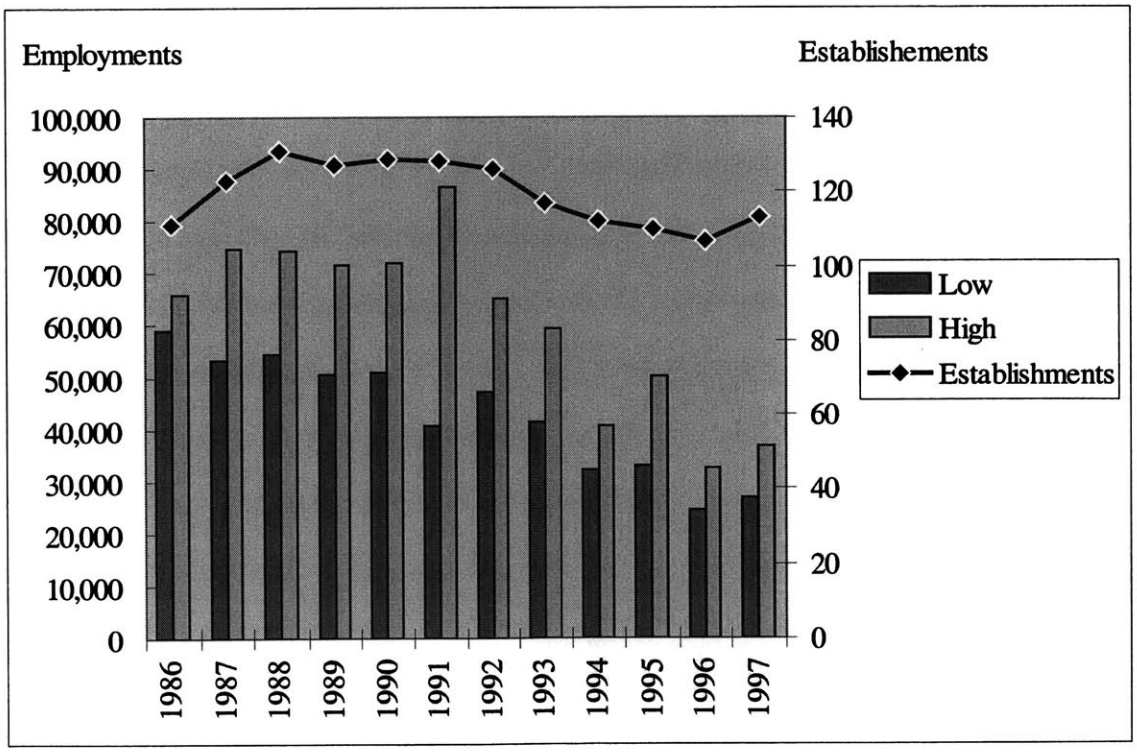
Nonetheless, some owners sensed a need to respond to the new competitive landscape: suppliers have to have a capacity to respond to the higher demand. They are not competing on price or historical ties alone anymore. They have to compete on the capacity to minimize total cost in terms of price, quality, and on-time delivery: otherwise, they will be replaced. This transformation requires organizational change and continuous improvement. Thus, some owners of machining business decided to cope with the situation by collectively upgrading their manufacturing capacity. Another impetus to collaborate came from the state's initiative to promote competitiveness through clustering. The president of one of the key companies of the cluster organization was involved in the state's Industry Cluster Initiative as a Manufacturing Cluster Advisory Board member to produce the *Partnership for Growth.* By working with other companies on workforce development issues, particularly through developing a training program to address the shortage of skilled machinists in the state, business owners of the supplier companies in the aerospace industry discovered the common issues they can work with without compromising the competitive relationship. In addition, owners have witnessed aerospace-related companies leaving Connecticut for states with cheaper labor costs. Indeed, the number of establishments declined steadily after late 1980s and the employment level is estimated to have hit the record low of 25,000 -33,000 in 1996, less than half of 55,000 - 74,000 in 1988 (Figure 4.3). The owners found a

common interest: they want to keep aerospace jobs in Connecticut and collectively upgrade their manufacturing capacity.

Figure 4.3 Employment and Establishments in Aerospace Industry in Connecticut 1986 - 1997

	Employment Low	High	Establishments
1986	58,896	65,721	111
1987	53,255	74,830	123
1988	54,559	74,203	131
1989	50,643	71,686	127
1990	50,871	71,844	129
1991	40,720	86,592	128
1992	46,964	65,110	126
1993	41,350	59,575	117
1994	32,364	40,589	112
1995	33,043	50,338	110
1996	24,461	32,756	107
1997	26,880	36,674	113

Source: County Business Patterns, Census Bureau



It started as an informal collaboration among six sub-tier suppliers, which eventually grew to twelve when they decided to organize themselves as a cluster organization. This cluster among the first tier as well as sub-tier suppliers is a subset of larger aerospace cluster and is a horizontally related cluster, in which companies are geographically concentrated and which has common or similar categories of products, suppliers, and markets. Recognizing the Industry Cluster Initiative launched by the state, the member companies saw an opportunity to seek the financial and technical support from the state and approached the DECD with a two-year start-up plan to upgrade their capacity to be a globally recognized source of aerospace components. As a result, the DECD decided to provide $125,000 each for cluster activation for two years, and the state Department of Labor (DOL) with the DECD committed $100,000 for workforce development and lean manufacturing programs, which encouraged more than $500,000 commitment from the industry. In July 1999, the aerospace components manufactures (ACM) cluster was formally activated under the direction of a six-member board of directors, the second activated cluster in the state.

The price, quality, and delivery requirements are high. However, unless suppliers excel at all three areas, they will be driven out of business. To overcome this issue, the ACM with the technical assistance from the DECD identified four areas in which they can work on collaboratively: (1) progressive manufacturing (especially lean manufacturing); (2) workforce development; (3) consolidated purchasing; and (4) special projects for new business opportunities. The ACM members have formed teams for each area to plan and manage separately, which enables each company to choose the area to participate.

(1) Progressive Manufacturing. The concept of lean manufacturing originated in the Japanese automobile industry, but it is currently applied to many different industries including aerospace throughout the world. It is a continuous improvement of material and information flow based on employee involvement that aims to enhance productivity and quality by reducing waste in terms of production volume, inventory, defects, and time. Lean manufacturing typically involves standardized work, workplace organization, visual controls, effective plan layout, quality at the source, batch reduction,

teamwork, customer demand based manufacturing, point-of-use storage, quick changeover, one-piece flow, and cellular manufacturing (CONNSTEP website). If it is implemented effectively, it can achieve the following: reduce scrap by 90 percent, reduce setup times by 90 percent, reduce lead times by 50 percent, improve inventory turns to 20 per year, reduce operating cost, improve productivity by 10 to 40 percent, and improve quality by 25 to 75 percent (CONNSTEP website). Thus, lean manufacturing is an effective means to achieving cost reduction, quality improvement, and on-time delivery without trading off against each other.

In the aerospace industry, major aircraft and engine makers started to adopt lean manufacturing but attempted to be lean internally. However, in order for lean manufacturing to function properly, experience has shown that entire supply chains have to be aligned. By 1996, one of the major engine makers, for example, turned its attention to externally supplied products that accounted for 65 percent of their total products (Michaels 1999). Accordingly, ACM members, most of which had the engine maker as a major customer, have to upgrade themselves fast enough to fall within the customers' time frame. The ACM progressive manufacturing team selected CONNSTEP,[41] a quasi-public agency, from the bid for assistance. As a part of its mission to help small manufacturing companies upgrade operations and management techniques, CONNSTEP supplied one field engineer as its representative to the team, who provided the team with guidance in the first year to select projects, to design training and workshops, and to choose appropriate lean experts. The ACM productive manufacturing team conducts both the executive level and shop staff training sessions at the member company's facilities. In the second year, the team members became confident enough to implement continuous improvement by themselves and to have regular site visits by the Japanese consultants to monitor the progress. The team has also begun conducting peer implementation such as survey visits to new member companies as well as peer-to-peer evaluation.

(2) Workforce Development. Companies have recognized that the state lacked a skilled

[41] It operates the Connecticut Manufacturing Resource Center (MRC), which was created in response to the recommendations made by the Manufacturing Cluster Committee of the *Partnership for Growth*. To make sure the activities are in line with business needs, representatives from the Manufacturing Cluster are on the CONNSTEP

workforce to fill vacancies after the industry started to recover from the major downturn in the early 1990s: many companies and employees had left the state. Thus, to retain the existing employees by raising the general manufacturing skills is the main focus of the workforce development team. The members developed a range of a core curriculum of 15 classes based on the National Tooling and Machining Association and the National Institute of Machining Standards. The team also selected instructors from a bid to offer such subjects as shop mathematics, blueprint reading, root cause analysis, geometric tolerancing, heat treating, metallurgy, cutting theory, and operator certification, all of which are offered at member company's facilities. Because of the funding from the state DOL as well as the money the members raised in the beginning, courses are available at a significantly discounted rate. Some ACM companies also participate in a secondary school technical education pilot program, which is a part of statewide workforce development efforts. With the support of the DECD, participating companies help rebuild the apprenticeship program offered by the high school in the region.

(3) Consolidated Purchasing. It is another area that members can benefit from working in as an organized cluster. By contracting with local suppliers, the ACM members in the team achieve the cost reduction based on volume-discount. As of today (April 2001), ACM members contracted for inserts, cutting tools, inspection tools and gages, abrasive materials, coolants and lubricants, general office supplies and shop supplies. In addition, agreement for liquid waste removal services, information technology service and support, and machine calibration services are in progress. Aside from the discount for some inputs, the joint purchasing enables team members to develop working relationships with local suppliers to avoid carrying inventories of inputs at each companies, and to release purchasing workforce from ordering and replenishing.[42]

(4) Special Projects. The team members hope to increase market visibility, recruiting new members, and developing new business opportunities, especially international. For example, the ACM executive director represented the members on the governor's trade mission to Germany and Ireland last

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board.

[42] For example, inserts are stocked in a vending machine that is placed in one of the team member's facility. The machine electronically tracks the reduction in inventory and the contracted supplier will visit for replenishment.

year to explore the opportunity to bid on procurement as well as to invite foreign companies to locate in Connecticut.

4.2.3. Competition and Clustering

In the aerospace industry, particularly after the commercial aviation sector increased the relative importance, machining suppliers are facing higher demand from major customers in terms of price, quality, and on-time delivery. Given the competitive pressure from the offshore suppliers, machining suppliers are increasingly facing the need to compete on total cost (i.e., product cost, higher quality, lower defects, shorter product lead time), not just on lower unit cost anymore. For this new competitive situation, to have a capacity to quickly respond to customer's need is critical.

The ACM Cluster may also fit the "latent cluster" model: the critical mass of machining suppliers has been in Connecticut for long time. Although the competitive pressure prompted machining suppliers to upgrade their capacity collectively, it was still a difficult concept to embrace. The entrepreneurial business owners have been in business for 20 to 40 years and developed their skills, business practices, and customer base independently. They had been suspicious of each other, viewed each other as competitors, and rarely shared information. However, the new competitive pressure from customers and offshore suppliers as well as the insufficient supply of skilled machinists after the recession provided compelling reasons for some business owners to work collaboratively.

The ACM Cluster is composed of horizontally-related companies who faces the common market pressure and the common agenda to respond. Given the size of companies, which are mostly family-owned small private businesses, the collectivity has enabled them to achieve scale economies in terms of accessing to their common critical resources: namely, hiring world-class (expensive) consultants in lean manufacturing, reducing input cost through bulk-purchasing, and offering a range of training. Spatial proximity adds another practical advantage. It is easier for members to visit each other for meetings and training, which are mostly offered at member companies' facilities every month.

Although the direct benefit of collaboration and clustering may be the lower costs achieved by

the common pool of inputs and services, the formation industry cluster itself appears to have possibilities of producing dynamic externalities. ACM members begin to discover the dimension they can work with without compromising the competitive relationship. As a result of working as a group, companies began to know each other, visit other companies, and conduct peer-to-peer leaning and monitoring. Most notably, some members began to contract out to other ACM members. One engine part supplier commented that his company could do this because they knew the partner company was improving in the same direction and would not trade off quality and delivery performance for reduced costs: if the partner were geographically distant, this trust may not have existed. Taking advantage of spatial proximity and the critical mass that existed, ACM might be considered to be becoming "working cluster," where information flows, productivity increase, and continuous learning occurs.

Although the three elements of an industry cluster -- namely spatial proximity, collaborative activities, and a supporting institution, -- are working well among machining suppliers, the relationship does not necessarily extend vertically. Most of the ACM members have the engine maker in the state as their major customer: it typically accounts for 50 to 80 percent of their total sale. However, spatial proximity between customers and a group of suppliers in itself is not sufficient: the new competitive situation favors speed of restructuring over proximity. Although, suppliers can in theory pursue activities with the customer, quite a few business owners in ACM prefer upgrading their capacity on their own to integration with the customer. When the original founders of ACM visited the engine maker to explain the purpose of the organization, to their surprise, the engine maker seemed to welcome the initiative because machining suppliers committed on their own to implement the lean practices to achieve lower total cost without their influence and financial support.

The major engine maker views ACM's activities as being "definitely in the right direction to go."[43] "Spatial proximity alone will not constitute the competitive advantage, but with lean manufacturing it will," commented a former employee of the major engine maker. Through the lean manufacturing practices and by redesigning the processing flow, one ACM company reduced the lead

[43] Remarks from separate but several former as well as present employees of primes (Pratt & Whitney and

time from 16 weeks to 1 week and consolidated the number of process steps from 20 to 11. Another company reduced the lead time from 60 days to 20 days and improved on-time delivery performance from less than 50 percent to 100 percent.[44] In this way, the ACM machining suppliers will increase the chance of winning not only local customers but also global customers.

It should be noted, however, this practice is not always the unanimous position of all ACM members. Instead of joining the lean manufacturing team, some companies pursue the long term agreement (LTA)[45] with the engine maker, through which it sends cross-functional teams and consultants at its own costs. Thus, ACM maintains the flexibility to work with, but keeps autonomy from the major customer depending on each company's strategic choices.

A critical mass of suppliers has existed in the state for decades, however by forming an organized cluster, ACM members found a way to effectively compete and cooperate with each other. As of today, the ACM has 37 members and it aims at reaching around 60 in the near future.

4.2.4. Policy Responses

The state recognizes that the manufacturing sector and especially the aerospace industry has been a backbone of the economy and welcomes the activation of the ACM as a forerunner of other upcoming manufacturing clusters. The direct support from the state has been in terms of technical support in the early activation stage and financing: the DECD provided funding to help arrange the organization and the state DOL also financially supported workforce development and lean manufacturing programs.

Without the state's support, would the member companies have formed the ACM? "Not a chance!" one of the original founders remarked. First, having the state's financial support has stimulated the companies to pledge their own money and commit to long-term improvement activities such as lean manufacturing and training for existing workers. The ACM estimates that the combined funding has

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Hamilton-Sandstrand).

[44] ACM Case History, Presentation Slide.

[45] Among ACM members, some have LTA with primes, others not.

enabled 50 percent reduction of the cost to implement lean manufacturing practices and existing workers training.

Second, DECD worked closely with ACM to devise the initial start-up plans. It should be noted that the relationship of ACM with the state derives from the statewide cluster initiative: the ACM was the first activated cluster among a dozen sub-clusters under the original Manufacturing Cluster. In addition, the Manufacturing Cluster Advisory Board recommended improving regulatory conditions for manufacturers, redesigning the vocational schools to train entry-level workers, and helping small manufacturing companies upgrade their manufacturing and management capacities. For the last purpose, the Manufacturing Resource Center was created within CONNSTEP with $3 million authorization from the legislature. It was from this center that the ACM progressive manufacturing team received guidance in the first year to design workshops and training and was introduced to the high profile consultants.

In case of the ACM Cluster, the demand for the collective action to upgrade the manufacturing capacity and to keep the aerospace jobs in Connecticut came from the machining suppliers. However, given the limited resources as well as the lack of history and trust in collaboration, the machining suppliers needed the support. What the state did was to respond to this need by providing technical and financial support to conceptualize the industry cluster, devise the concrete action plan, and implement lean manufacturing and training programs in the beginning. In other words, the state motivated and facilitated businesses to find common issues that are better solved collaboratively: ACM members reveal, "historically, owners have not been very trusting and have not shared anything." "We wouldn't be working together if it hadn't been for the cluster initiative."[46] By encouraging the ACM members to work as a cluster, it appears that the state facilitated a cultural shift among business owners and helped them organize. As a result, the state helped create the cluster environment where the vision is shared, information is exchanged, and continuous learning takes place.

[46] Quote from CT Business Magazine, November/December 1999, p. 55.

4.3. CONCLUSION

This chapter showed that companies are facing different competitive pressures, increasingly competing over more than prices, and competing in a more strategic manner, largely supporting what the theories of new competition suggest (discussed in Chapter 2). In spite of the different competitive pressures, my findings from both industries also demonstrate that the very competitive pressure drives companies in both industries to collaborate and work as an organized cluster, taking advantage of spatial proximity to each other.

In the biomedical industry, research-based companies compete for time to bring new drugs to the market, and this time pressure drives companies to establish the strategic alliances even though they are competitors with one another. The industry cluster further benefits them in terms of providing them with access to knowledge, technology, human resources, and sources of products as well as providing finance and human resources, and knowledge, thereby helping build a critical mass of companies (especially biotechnology companies). In the case of the aerospace industry, machining suppliers are under competitive pressure from both the customers and the offshore suppliers and face the new challenge of competing on total cost in terms of price, quality, and on-time delivery. Small machining suppliers found the common agenda of upgrading their manufacturing capacity collectively in order to cope with the challenge and to collectively keep aerospace jobs in Connecticut. The industry cluster provides them with the benefits of achieving scale economies by pooling common inputs and services they need such as hiring consultants, reducing input costs, and offering a range of training for existing workers.

Table 4.4 summarizes the attributes of two clusters in terms of what drives competition, how industry clusters are working for competition, and how the public sector (in this case, the state of Connecticut) supports the industries.

Table 4.4 Competitive Challenges, Clustering, and the Public Sector Support: Two Clusters in Connecticut

	BioScience	Aerospace Components Manufactures
Industry Character in Connecticut	Emerging	Mature
Industry Function in Connecticut	Research and Development	Manufacturing
Size of Entities in a cluster	Vary (small start-ups to established multinationals)	Mostly family-owned small companies
Relationship of core entities in a cluster	mostly horizontal (compete and cooperate)	mostly horizontal (compete and cooperate)
Competitive Situation		
Industry Structure	High-cost, high-risk, time-consuming process	High entry barrier (dominant primes and many small suppliers)
Competitive Pressure (Driver for Collaboration)	Time (to bring new drug to the market faster than the competitor)	Higher Demand (in terms of price, quality, and on-time delivery), Supplier Consolidation, Off-shore competitors
Key Competitive Factors	Highly skilled scientists	Capacity to respond quickly to customers' needs
Reasons for Clustering		
Driving Force for Spatial Concentration	Access to knowledge, technology, human resources, and source of products (locate near university), raise visibility (finance, human resources, and knowledge), knowledge spillover	Not Applicable (critical mass has already developed)
Driving Force for Collaboration/Networking	Competitive Pressure	Competitive Pressure Lower input and service costs (consultants, training, bulk purchasing), Upgrade capacity (lean manufacturing and existing workforce training), peer-to-peer learning and monitoring
Dimension of Collaboration	Research Commercialization (university and biotech), Drug Program (biotech and pharmaceutical), and Collective Voice for Common Issues (laboratory space, support start-ups)	Collective Learning (lean manufacturing), Workforce Development, Bulk Purchasing (common inputs), Marketing
The Public Sector Support		
Obstacles	Lack of laboratory space, Complex permitting process, Unfavorable tax structure, lack of seed capital for start-ups	New manufacturing process, Shortage of skilled machinists
State Support for Cluster Organization	Financing activation, Special fund for laboratory space, R&D tax credits and other tax benefits, Streamlining the permit process	Initial organization and planning, Financing for training, Financing for lean manufacturing, Technical assistance for lean manufacturing

These findings suggest that clustering is one of the possible ways for both industries to effectively respond to their competitive condition, albeit different, and thus, the industry cluster initiative can be an effective strategy for the public sector to promote the development of key industries. Given the unique competitive pressure as well as the rationale for clustering, what have been the needs of public sector supports and how the public sector (the State of Connecticut) responded? In the case of the BioScience Cluster, the priority issue was to build a critical mass especially of biotechnology companies in order to realize the cluster benefits. Thus, the state's supports were mainly geared to the needs of emerging start-ups i.e., laboratory space, R&D tax credits, tax break, and seed capital. In contrast, the priority issues for the ACM Cluster was to upgrade a manufacturing capacity and to keep existing workers and train them. Unlike the BioScience Cluster in which some forms of collaboration and the supporting organizations have been in place, the ACM members lacked the trust and history of collaboration. Thus, the state was more involved in the process of organizing the cluster organization as well as devising the cluster agenda, and provided financial (i.e., training and lean manufacturing) and technical (i.e., lean manufacturing) supports. As a result, the ACM achieved the transformation from the latent cluster to working cluster, in which the vision is shared, information is exchanged, and continuous learning takes place.

Reflecting these needs, public sector responses, and results of two clusters, how critical are they for competition compared to the analytical framework I developed based on theories of agglomeration economies and new theories of competition (Chapter 2)? Interestingly, the public sector supports provided for the BioScience cluster was largely in the form of subsidy, the lower cost approach that theories of competition suggest insufficient, while this cluster has attributes of clustering that the new theories of competition suggest is critical for today's competition (i.e., access to knowledge, technology, human resources, and source of products). Moreover, the cluster members cover key cluster elements the cluster literature suggest, namely, companies, research institutions, and supporting and related industries and organizations. This situation rather underscores that the lower cost approach is not necessarily inappropriate to cope with the current competitive challenge. There was a vital need to build the critical

mass of biotechnology companies that make the cluster a working cluster that can provide the benefits of accessing to critical competitive factors (i.e., knowledge, technology, human resources, and source of products), which the public sector effectively supported. Another related point for the situation is the institutional capacity that has already been in place. Once the cluster gained momentum thanks to the increasing scale of the cluster, CURE became proactive in pursuing the economic development agenda and organizing the necessary activities by themselves rather than turning to the state for direct involvement. Less involvement of the state in capacity-building activities does not demonstrate that the state and the BioScience cluster is not aware of the critical business environment issues that enhance productivity, as new theories of competition suggest. Rather, the BioScience cluster is self-sufficient when it comes to preparing and implementing the cluster agenda, and pursuing largely by themselves such as promoting networking, organizing to solicit the venture capital, and designing the BioBus to develop the future high-skilled workforce.

The case of the ACM Cluster also highlights some interesting aspects. In contrast to the cluster elements suggested by the cluster literature, the breadth of ACM Cluster members is limited: its members mostly consist of machining suppliers and do not include such members as major aerospace manufactures, supporting industries, and research institutions. However, the ACM's activities conform to what the theories of new competition suggest. The theories stress productivity and human resources as critical factors of competition, which were exactly the priority activities for companies in the ACM (i.e., to upgrade manufacturing capacity and train the existing workers). The public sector was directly involved in these capacity-building activities, facilitating the collaboration among machining suppliers that was historically suspicious to do so. As a result, in spite of relatively narrow scope of members, the ACM Cluster seems to have reaped the cluster benefits that are beyond the original intention (scale economies by pooling common input and services): information exchange, collective learning, and productivity increase that are enforced by shared vision, which seems to be deeper relationship than in the BioScience Cluster. This fact may suggest that there may be some trade-offs between building larger clusters that represent the entire industry or the supply chain and creating a more cohesive cluster which

is composed of a smaller set of companies within the industry. Another point is that lack of aerospace manufacturers or supporting industries as a part of cluster members does not mean there is no relationship with them. Indeed, having an upgraded capacity to meet customer demand for price, quality, and delivery, machining suppliers are more likely to be selected as preferred suppliers than before. In the case of supporting industries, the ACM has started to develop a relationship through bulk purchasing contracts with machining inputs suppliers, tools and gauge suppliers, and general office suppliers, and they also start to consider some suppliers as prospective ACM members.

One might also argue that neither cluster is focusing enough on building future human resources, which are critical for today's competition as the new theories of competition suggest. For this argument, I point to the fact that workforce development issues are the number one priority in Connecticut, which are largely dealt with under the programs on economic infrastructure issues. As I showed in Chapter 3, both the BioScience Cluster and the ACM Cluster join the programs according to their needs and priorities. CURE will soon join the Training Network Program to develop a customized training with training providers in the state, and some ACM members are involved in the Pilot Project to provide manufacturing training and internship opportunities for secondary school students.

From these findings from my study of two clusters, I can conclude that companies are competing in a new and complex competitive situation, for which the clustering offers some critical competitive elements. Given the different competitive challenge and priorities of each cluster, however, public sector support can be using either a lowering cost approach, or a capacity-building approach, or a combination of the two. In particular, the key roles of the public sector to build competitive strength of industries seems to be: (1) to encourage to create formal cluster organizations through which companies start collaboration; and (2) to provide a menu of the public sector supports that are available for activated clusters as well as industries, according to their priority needs.

CHAPTER 5. CONCLUSION: POLICY IMPLICATIONS

In this thesis, I examined whether the public sector can enhance competitiveness of industries through the cluster-led economic development policy from the perspective of industries' competitive situation, using the case of the Industry Cluster Initiative in Connecticut. I used an analytical framework based on theories of agglomeration economies and new theories of competition, which offer different explanations of why companies cluster based on the nature of competition. The theories of agglomeration economies stress economies of scale and positive externalities (agglomeration economies) as factors for clustering, assuming that companies compete on prices; and therefore, reducing input costs is the key for competition. What I call the new theories of competition highlight the different key factors of competition such as productivity (Porter 1998a), "invisible factors" i.e., labor quality, entrepreneurial skills, corporate strategy, labor-management environment (Doeringer, Terkla, and Topakian 1987), collective response to competition (Best 1990), flexible specialization (Piore and Sabel 1984), collaboration economies, transfer of knowledge, and partnership with government (Doeringer and Terkla 1995), for which the industry clusters provide an environment with productivity, human resources, and collaboration. As the new theories of competition suggest, my findings from the biomedical industry and the aerospace industry show that companies are facing different competitive pressures, increasingly competing on more issues than prices, and competing in a more strategic manner. In spite of the different competitive pressures, my findings from both industries also demonstrate that it is the competitive pressure that drives companies in both industries to collaborate and work as an organized cluster, taking advantage of their spatial proximity to each other. Therefore, clustering appears to be one of the possible ways for both industries to respond effectively, albeit differently, to their competitive condition; thus, the industry cluster initiative can be an effective strategy for the public sector to promote the development of key industries.

Given that industry cluster initiative can be an effective strategy to promote competitiveness of

industries, how did the state of Connecticut launch and implement the initiative and what are the critical elements in increasing the competitiveness of their economy? Admittedly, the Connecticut case is too recent to assess whether it is a success; nonetheless, one can still draw some lessons from the Connecticut experiences. Connecticut appears to have developed a sophisticated approach that enabled the state to effectively respond to the needs of key clusters taking account of the nature of competition and their economic or strategic reasons for clustering. Examination of two clusters, the BioScience and the ACM Clusters, demonstrated that the critical role that the state played is: (1) to encourage to create formal cluster organizations through which companies start collaboration, and (2) to provide a menu of the public sector supports that are available for activated clusters as well as industries, according to their priority needs. This menu is in the form of both (1) lowering-cost and (2) capacity building for productivity enhancement, and the state institutionalized both type of supports to activate clusters and to handle economic infrastructure issues under the umbrella of the Industry Cluster Initiative. The prerequisite seems to be that the public sector and the private sector have a shared understanding of what constitutes competitiveness and what are critical supports for the enhancing the competitiveness of industries and the state economy.

For example, in the case of the BioScience Cluster, their institutional capacity enabled them to pursue the issues mostly by themselves, and thus the direct involvement of the state that the cluster needed was rather the traditional lowering cost approach to build the critical mass especially of biotechnology companies, which resulted in the "biotech boom" in which access to knowledge, technology, human resources, and sources of products are available. In the case of the ACM Cluster, a lack of shared work history and trust necessitated the direct involvement of the state, particularly in the early activation stage, to initiate the cluster organization and formulate the action plan, which resulted in organization in which information is exchanged, collective learning takes place, and productivity is increased. One might be puzzled over the fact that the pursuit of a lower cost approach and the public-sector intervention to create cluster organizations did reap cluster benefits. However, the findings from the Connecticut experiences rather suggest first that despite the growing role of the new competitive

factors, the lowering-cost approach can be a part of the public sector support package under the industry cluster initiative, and can be effective in coping with the current competitive challenge, if it is critical for productivity increase. Second, the public sector intervention to facilitate initial organization can produce the cluster benefits through which companies collaborate. Therefore, these two approaches of lower cost and public sector intervention might seem to be the feature of the failure model, but they do work when it is a part of a large package that offers the menu of services for industries and clusters to choose from depending on their critical needs.

Other issues that are less explicit but nonetheless seem to have contributed to the state of Connecticut's effective response are to: (1) identify clusters broad enough to cover most major industries in the region, leaving the opportunity for businesses to organize themselves to become an activated cluster; (2) promote collaborative and organized activities by requesting businesses to have a cluster organization, which makes them realize the interdependencies as well as their common agenda and keeps the collaborative process moving forward; (3) have a mutual relationship with businesses in exchange for public sector supports (e.g., ask their commitments, set milestone, and require action plans), ensuring business ownership in activities; and (4) institutionalize the mechanism that keeps track of progress over the period that is based on the jointly prepared long-term strategy (in the case of Connecticut, *Partnership for Growth*).

A number of other issues emerged during my research, but I could not fully explore them in this thesis. They need to be on an agenda for future research. First, although my research demonstrated that clustering can be critical to the competitiveness of industries, I could not assess whether the activated clusters actually ease companies to competing globally (largely due to the fact that the Connecticut initiative is relatively new), and how critical clustering is to compete globally compared to other forms of competition such as supply chain management, vertical integration (e.g., acquisition, equity interest, and joint venture), and contractual relationship (e.g., sub-contrasting). In fact, the ultimate goal of clustering is to be competitive globally and any industry cluster initiative needs to take into account the international aspects of today's competition.

The international aspects of competition was evident in two industries I examined, though I only mentioned them briefly. In the biomedical industry, most of the major pharmaceutical companies are multinational corporations and produce the drugs in subsidiaries around the globe. As I discussed, the high-cost and high-risk nature of industry promotes consolidation of companies to increase their R&D budget, scientific talents, and the pool of drug candidates. These companies are global not only in production but also in sale, relying for their revenue base on the international market, In 1997, for example, the foreign sales of the top 25 U.S. based drug companies represented an average of 60 percent of total sales. (Mourshed 1999). Nonetheless, these companies are also facing a new challenge from a small but a growing group of developing countries that is increasing their presence in their domestic markets. In the case of the aerospace industry, it is one of the major export industries for the U.S. (Dertouzos, Lester, and Solow 1989). Their production also becomes global and the major aerospace manufactures increase their global sourcing, partly in relation to their strategy to penetrate into the foreign market, which often requires them to buy parts locally. As a result, U.S. machining suppliers are facing competition with foreign suppliers. Machining suppliers feel the offshore competition, especially for relatively simple parts from such countries as Poland and Singapore.[47] Therefore, the supply chain of the multinational companies is increasingly global, however companies are pursuing a strategy to meet both the decentralized organization and to ensure coordination (Amin and Thrift 1992), which has locational implications of both dispersal and concentration of activities. Where in the supply chain is the region's companies position? What are the local impacts of changes taking place along the supply chain? How does clustering contribute to the competitive position of firms? Each of these questions provide vital research for the future.

Second, in this research, I highlighted the demand-driven aspect of the Connecticut approach in terms of deciding to launch the Industry Cluster Initiative, conducting cluster analysis and making the decision to activate clusters. Although the state effectively responded to the industries' competitive condition largely due to these demand-driven aspects, one might still question if there is a trade-off. For

[47] A comment from a president of one of the ACM companies.

example, one can argue that the demand-driven process in effect created a "winner" industry, by looking at the BioScience Cluster that achieved $40 million fund; the support in this amount has not been awarded to any other cluster. Whether this kind of large investment of public resources in a particular cluster prohibits other clusters from seeking public sector supports that are vital to their competitiveness would be an important question for future research. Another possible challenge of the demand-driven aspect is the possible mismatch between economic and political boundary. In the case of Connecticut, its small size enabled the self-identified cluster by the private sector close enough to establish the working relationship and the positive cluster externalities, even if businesses are scattered around the state. In other words, had it been a large state, there might have been a mismatch between the necessary spatial proximity and a self-identified cluster. Given the fact that businesses are in fact scattered around the state, especially for the ACM Cluster, one might further argue that what the cluster organizations are doing is rather networking, which can be pursued by trade associations. As a counter to this argument, I stress that the companies in both clusters did not have a history of working together even as trade associations, and the cluster organization provided an opportunity to do so. Analysts can answer the questions of how different a cluster organization is from a trade association and whether a cluster organization is more effective than a trade association (other organizational form) in future research. Moreover, the economic activities identified by the private sector may go beyond the state boundary and extend to the neighboring state, which raises a question of how to institutionalize the public sector support for the cluster's competitiveness. In fact, the state of Connecticut has recently discovered the there is concentrated economic activity between Hartford, Connecticut and Springfield, Massachusetts (Michael Gallis & Associates 1999).

Third, in this research, I mainly referred to the governor or DECD of the state, however the DECD is only a part of several large state organizations. If the cluster initiative is really to be successful, some mechanisms to align related departments (most likely, transportation, environment, labor, education, and business development departments) would be necessary. While I am aware of the efforts that the DECD is making for this purpose (e.g., forming a project team and asking a related department to be a

team member), how to institutionalize the inter-departmental cooperation is also an interesting future research agenda.

Finally, this research focused on examining whether the public sector can promote competitiveness, assuming the industry cluster initiative has already been chosen as a strategy for economic development. I would need to conduct additional analysis to determine the merit of choosing the industry cluster initiative over other strategies that focus more on distributional aspects, human-resource capacity building, modernization of mature industries, regional disparities, and environmental impacts. Moreover, there are diseconomies of clustering, such as rising housing price, traffic congestion and air pollution, which are, in fact, observed for example in Silicon Valley. These are also the issues of economic development, which are not necessarily taken care of by the industry cluster initiative. How to mitigate such impacts while keeping the industry cluster initiative, in terms of institutional arrangement and measuring the impacts can be the topic of additional research.

As the Connecticut case -- especially the two examples of clusters -- have shown, companies are strategically competing in a global economy, taking advantage of spatial proximity; their strategy includes establishing close ties even with their competitors. Companies do simultaneously compete and cooperate; clustering can be one way for competing effectively in the complexities of this competitive situation, which the public sector can effectively support.

LIST OF INTERVIEWS

Achillion Pharmaceuticals Inc: Kevin Eastwood, Director of Business Development

Achillion Pharmaceuticals Inc: Amy Enders

Achillion Pharmaceuticals Inc: William Rice, President

Aerospace Components Manufactures: Allen Samuel, Executive Director

Aerospace Components Manufactures Member Companies: two Presidents and two employees

Boehringer Ingelheim Pharmaceutical: Director of R&D Strategic Planning

Connecticut Academy of Science and Engineering: Mike Werle

Connecticut Economic Resource Center: Jeffrey W. Blodgett, Vice President, Research

Connecticut Economic Resource Center: Dale Shannon, Senor Economist

Connecticut State Technology Extension Program: Bruce Ireland

Connecticut United for Research Excellence: Albert May, Communication and Public Policy

A Major Engine Manufacture: Large Machined Parts, Worldwide Procurement Operations

A Major Engine Manufacture: Core Procurement

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