Master Programme International Public Policy and Public Management

Cluster Policy in Promoting Regional Innovation Capacity and Competitiveness

--An Analysis of emerging industries in Xiamen, China

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Content

Chapter 1 Introduction

1.1 Background

Industry clusters and cluster studies have gained popularity throughout the world since American economist Michael Porter published his book "The competitive advantage of nations" in 1990. Porter later defined cluster as "geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition"(Porter, 1998). He also contributed cluster as an important factor in promoting national productivity, innovation and competitiveness. Since then, cluster thinking have been regarded as providing a new way of looking at the economy, and cluster policies as important instruments for policy makers to boost national or regional economy. Throughout the world, cluster policies have been adopted not only by developed nations with an aim to maintain their competitive advantage, but also by developing countries in the hope of seeking exceptional economic momentum to catch up. In some nations, for example Japan and USA, cluster studies have been carried out more systematically and cluster policies have been adopted rather maturely. While some other countries haven't specifically adopted policies in the name of "cluster policy", yet certain policies in effect have contributed to the development of clusters. In the European Union, efforts have been made to promote the study and use of cluster policy to boost innovation and competitiveness of its member states. The European Trend Chart on Innovation launched in 2000, serving as a platform to facilitate "open policy coordination approach" laid down by the Lisbon Council, has initiated programmes such as seminars and workshops for cross-border lesson learning and exchange of best practices in cluster policies.

It has been observed that even though different countries have adopted cluster policies in different ways according to their local context, trans-national learning has been popular. Examples include cluster mapping using Porter's theory in different places, or cluster studies using international cluster models to define or redefine national policy. European Union, OECD etc. are among the international organizations that actively engage in promoting and spreading best practices in cluster policy.

China has acquired and maintained fast economic growth since it adopted economic reform and opening up policy in the late 1970s. Since then, various policies at national and regional level have been implemented to boost economic development. These include policies to foster innovation and industrial restructuring and upgrading. In the industrial area, even though systematic and thorough studies of cluster policy seem to be at the early stage and there is not nationwide campaign to promote the use of cluster policy, the importance of industrial clusters has been recognized. This is partly reflected in the promotion of rising industries in many places of the country.

1.2 Aim of the study and research questions

This paper chooses to study cluster development in Xiamen, China. Two emerging industries, the photonics and biotechnology industries, are chosen for case study. By comparing Xiamen case with chosen international best practices in photonics and biotech clusters development, this paper seeks to answer the question of how Xiamen can learn from international experiences by using cluster policy to promote its emerging industries. Thus focus will be on the government's role in promoting cluster development.

Central question

How can Xiamen learn from international best practice in using cluster policy to promote its emerging industries?

Subquestions

1. What is cluster and why to promote cluster?
2. What is the role of government in cluster development?
3. What are the important factors that affect cluster development?
4. What kind of policy instruments can be used to promote cluster development?
5. What and how cluster policies have been used in international best practices?
6. What's Xiamen's weak links in cluster development?
7. What conclusion can be made comparing Xiamen with international best practices?
8. What recommendations can be made based on the conclusions?

1.3 Methodology, pitfalls and countermeasure

This research project encompasses both theoretical and empirical study. The theoretical part draws on cluster theory and innovation theory to explore the relationship between cluster, innovation and competitiveness, more importantly, to identify factors that are critical to cluster development. These factors are further elaborated into independent variables for the study. On the other hand, a set of policy instruments are drawn from policy theory, which will be used as interfering variables. From the theoretical part, an analytical framework is formulated for empirical study. Considering that the effectiveness of cluster to innovation and national or regional economic development and competitiveness has been widely recognized, and the focus of cluster studies in the recent years has been shifting from whether cluster policy works or not to "which policies can be applied at a given time and place", as revealed by EU cluster study seminar (EC,2003c), the paper will not discuss whether cluster policy is effective to achieve the goal. Rather, the focus in the empirical part will be narrowed down to discuss what kinds of policy instruments are used to improve factors critical to cluster development. Thus the paper presumes that cluster policies aiming at addressing policy problems in the identified factors areas will improve cluster development as well as innovation capacity and competitiveness.

For the empirical part, data mainly come from statistical or observational analysis on selected biotech and photonics cluster. For example, in the San Diego biotech cluster case, an appraisal report on San Diego's life science clusters conducted by Milken Institute, an independent economic think tank, is used, plus other documents available on the internet. Policies adopted are mainly searched from website. The EU website also provides a handful of useful documents on cluster policy study. In the Xiamen case, some additional documents, for example, the Development Plans for biotech and photonics industries etc. are obtained from relevant governmental departments in Xiamen.

Pitfalls

1. Clusters of different industries and in different places can have quite different characteristics. In addition, clustering is a dynamic process. Thus cluster policy analysis should be case-specific. Simply comparing cluster policies adopted in different places runs the risk of over generalized context specific clusters. To mitigate this problem, more background information is provided in the annex to provide a more holistic view of selected clusters.
2. Clustering is a complex issue and has intertwining multi-dimension determinants, making it difficult to correctly judge government's role. Adding to the difficulty is that most of the documents available for biotech and photonics clusters are not written from the angle of cluster policy and government's role. Therefore there is a risk of misinterpretation. Thus in drawing conclusions and recommendations, the writer tries to follow the guideline of more observation and less speculation.

1.4 Structure of the paper

After this introduction chapter, chapter 2 is divided into two parts, the first part deal with theoretical aspects of cluster and cluster policies, which aims to address sub-question 1,2 and 4. The second part tries to develop a scheme based on the above theoretical discussion, which helps to answer sub-question 3. In the second part of this chapter, an analytical framework and a checklist is produced as a framework for the later case study.

Chapter 3 analyzes several chosen best cluster practices in photonics and biotech industry using the analytical framework and the checklist developed in Chapter 2. Chapter 4 analyzes Xiamen case using the same checklist.

Chapter 5 compares Xiamen case with international best practices. Conclusions and recommendations are drawn after the comparison.

The paper ends with a Summary and reflection chapter, which summarize answers to research questions. This chapter also gives a reflection on the analytical framework. At the end, suggestions for future study are given.

Four appendixes provide more information on the cases and cluster learning.

Chapter 2 Theoretical framework

This chapter starts with Michael Porter's competition theory as an introduction. The first half of the chapter draws on cluster studies, innovation theory and policy theory to addresses the question of what is cluster and, what are important factors that contribute to cluster development, as well as what policy instruments can be used etc. In the second half of this chapter, the writer tires to construct an analytical framework based on the previous theoretical analysis to provide a lens to look at and examine international best practice. This framework also prepares for the later Xiamen case analysis.

2.1 From national competitive advantage to national innovation system

The main theme of American economist Michael Porter's 1990 book "The competitive advantage of nations" is that competitiveness advantage lies in each particular industry and that the productivity of individual industries and firms are the prime determinant of a nation's or a region's economic prosperity. Firms acquire and maintain their competitive advantage through "improvement, innovation and upgrading"(Porter, 1990,p70). From this industry-and-firm-focused view, Porter brought forth a diamond theory that studied the determinants of national competitive advantage.

The diamond theory highlighted four determinants of national competitive advantage (Porter, 1990):

1. Factor conditions: including factors of production, such as resources (natural, skilled labor, capital etc.) and infrastructure (physical, administrative, scientific and technological, information etc.). The role of factors to a nation's competitiveness depends on the efficient and effective deployment of them. In the dynamic and interacting diamond system, factors can be upgraded or may be declined. Disadvantage in some factors may spur the improvement of other factors through innovation and strategy planning and thus help the industry to achieve competitive success (Porter, 1990).
2. Demand conditions: home demand of an industry's product or service is emphasized. Despite the globalization trend, local firms closer to home buyers are more able to respond and cater to customers need in a faster and less costly way, and be more innovative under pressures from nearby.
3. Related and supporting industries: "Related industries are those in which firms can coordinate or share activities in the value chain when competing, or those which involve products that are complementary"(Porter, 1990, p105). Information exchange and technical interchange are among the benefits gained from the presence of competitive related industries.
4. Firm strategy, structure, and rivalry: Porter emphasized the importance of domestic competition in creating and sustaining competitiveness advantage. He believed that the most advantage management practices and organizational modes are those that fit the industry and favored by national

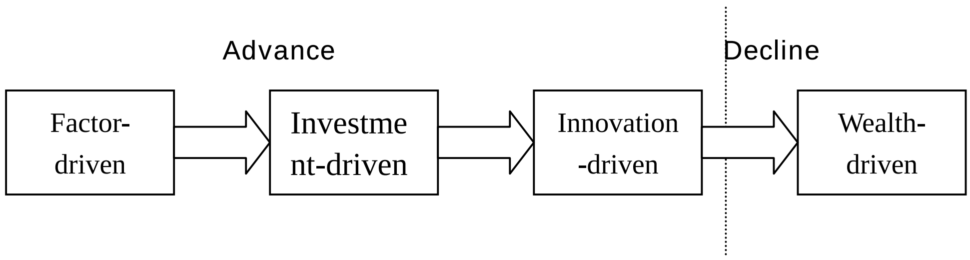
environment. Legal system, competition environment are among the factors that can influences this group of determinants.

The four determinants interact and work as a dynamic system to determine a nation's competitiveness advantage. Besides these determinants, Porter also identified two additional variables that could affect the national competitiveness system. These two variables are chance and government.

According to Porter, government exerts its impact on national competitive advantage through its influence on the four determinants. Government's influence on national advantage can be positive or negative. What's more, its effect is partial. Government can only influence the national competitive advantage but not control it (Porter, 1990).

The effect of globalization and internationalization of world trade to innovation and competitiveness should not be ignored. Some local conditions that used to be important factors, such as labor, technology etc. can now be drew from elsewhere if the local strength is good enough to attract these movable factors. On the other hand, how to retain local advantage factors and prevent them from draining to other places has posed great challenges to the government.

Another important theory of Porter is the four development stages of national competitiveness. Porter argued that government's role in different stages maybe different.



Four stages of National Competitive Development (Porter, 1990,p546)

In the initial factor-driven stage, national competitiveness depends largely on factor conditions. Technology content is usually low and mostly acquired from other countries rather than created by its own. Domestic firms have little contact with foreign market or have to access the foreign markets via foreign firms.

The investment-driven stage is characterized with the ability and willingness of a nation and its firms to invest. An essential criterion of this stage is a nation's ability to absorb and upgrade foreign technology, even though firms may only able to do that in certain industries. Another critical driving force to this stage is the presence of fierce competition. On the other hand, home demand at this stage is still unsophisticated. The government's role in this stage, as Porter suggested, can be substantial. Government is an important player in factor creation by allocating scale capital or certain resources to specific industries, encouraging the introduction and absorption of foreign technology, or providing certain protection to encourage market entry. However, Porter also emphasized that the protection should be temporary and should not restrain competition (Porter,1990).

In the innovation-driven stage, all four determinants in the diamond are playing active role in improving and upgrading national competitive advantages. Indigenous innovation takes place, encouraging more new industries to grow. Industry clusters further develop and become self-reinforcing. There is also a deepening and widening of industry clusters. As Porter (1990,p554) concluded, deep clusters "are a sign that the economy has achieved a moderate level of innovative capacity." Government's role in this stage is best when it is indirect and geared to upgrading sophisticated factors.

2.2 Industry cluster and its characteristics

2.2.1 What is industry cluster

Industry cluster is not something new. Study of industrial concentration can be dated back to 1890 in Marshall's study of industrial districts (Roelandt, 1997). However, it has been widely held that it was Porter who popularized the concept of industrial cluster with his 1990 book "The competitive advantage of nations". One interesting finding of Porter is that "the enduring competitive advantages in a global economy lie increasingly in local things- knowledge, relationship, and motivation that distant rival cannot match"(Porter, 1998). Porter in his study of national competitive advantage found that clustering tended to occur in a nation's competitive industries because of the systematic character of the diamond. Geographic proximity heightens the mutual reinforcement of each determinant. What is more important for geographic proximity is that it affects an industry's innovation and improvement, which are crucial to competitiveness. Thus "successful industries are usually linked through vertical (buyer/supplier) or horizontal (common customers, technology, channels, etc) relationships" (Porter, 1990, p149).

Since Porter, there have been many studies on clusters. For example, there have been cluster studies concentrating on the role of SMEs (Muizer & Hospers,1998; Lankkuizen & Woolthuis,2003), or on the production chain (Roelandt, 1997) etc. As Muizer& Hospers (1998) pointed out, the different cluster approaches enable people to take into account the multi-dimensional character of clusters in economic reality.

But what is exactly cluster? Porter elaborated the concept of cluster as a "geographic concentrations of interconnected companies and institutions in a particular field. Clusters encompass an array of linked industries and other entities important to competition"(Porter, 1998). However, the concept of cluster is not unitary. International organizations, academics and even countries may have different definitions of cluster for different purposes of studies and decision-making.

European commission in its 2003 Thematic Report on cluster policies used the following definition: “The cluster is a mode of organization of the productive system, characterized by a geographical concentration of economic actors and other organizations, specialized in a common field of activity, developing inter-relations of a market and non-market nature, and contributing to the innovation and competitiveness of its members and the territory” (24European Commission, 2003, p3).

Another example of cluster definition from cluster study in the netherlands goes like this: “ Clusters can be characterized as being economic networks of strongly interdependent firms, knowledge producing agents and (demanding) customers, linked to one another in a value-adding production chain” (Roelandt, 1997). This reflects that cluster studies in the Netherlands focused on the “value chain approach”

In viewing different definitions of cluster, one can see that they mostly derived from Porter’s definition. Most of them also contain what are regarded as general features of clusters, for example:

1) Geographic concentration: The Geographic proximity in a cluster should be close enough to facilitate meeting and networking, or even personal contact to encourage information flow. Size and range is an important element to consider in cluster mapping.
2) Systematic interconnection and interaction between actors (both from industry and from other institutions). It encompasses both the horizontal relations between competitors and the vertical relations from suppliers to downstream users. Other actors such as public sector organizations and brokers etc. also play an important role. Thus a cluster is a systematic network.
3) Industrial specialization: clustering helps the industry reach external economies of scale, meaning, “firms are economies that depend not on the size of the firm, but upon the size of the industry” (DeVol et al, 2004, p42). It further paves the way for specialization. This process enables the sharing of cost and increase in production efficiency, in turn benefits the whole cluster.

According to Porter, “A cluster’s boundaries are defined by the linkages and complementarities across industries and institutions that are most important to competition” (Porter, 1998, p79). Thus a cluster does not necessary fit into political boundaries. Cross-border clusters may also exist.

There are many factors that can induce the creation of industrial clusters. These include favorable location, easy accessibility of knowledge and technologies (for example close to a university or research center), skill labor pool, special local demand etc. Clusters can also grow from the existing supporting industries (photonicsclusters.com).

Rosenfeld (2002) identified three critical factors that propel cluster development. There are innovation, imitation and entrepreneurship.

2.2.2 Why to promote cluster - linking cluster with innovation and competitiveness

Porter's competitiveness diamond theory sets innovation at the core of improving productivity thus the competitive advantage of a nation or a region. The advancing of "knowledge based economies" further emphasizes the crucial role of innovation, as has been recognized by OECD (OECD, 1996) and European Union. While in literature, there have been studies aiming at reveal the close linkage between innovation and cluster development.

The traditional linear innovation theory that considers science as the driver of innovation has been believed to fail in explaining the real innovation processes. In modern innovation theory, "the strategic behaviour and alliances of firms, as well as the interaction and knowledge exchange between firms, research institutes, universities and other institutions, are at the heart of the analysis of innovation processes" (Roelandt, 1997, p4).

Modern innovation theory stresses that firms do not innovate separately. They need to form strategic alliance with other firms and institutions for complementary knowledge and technology. The specialization and globalization provide the pressure and drive for firms to innovate in coalition with others (Roelandt, 1997).

The innovation policy studies initiated by DG Enterprises of European Commission in 2002 also revealed that "Proximity is an important feature of most innovation systems, and policy-makers rightly devote resources to attempts to create self-sustaining local and regional innovative initiatives, often in science parks centred around universities or large multinational technology firms." (EC, 2002, p3)

The new economic growth theory tries to link economic growth with R&D decisions. Thus "productivity depends therefore on the amount of knowledge generated by innovation activities, and productivity increases depend on current R&D efforts which translate into increased technical knowledge." (Gumprecht et al, 2005, p51). Here innovation acts as the key word.

The growing interest in cluster analysis is thought to be a respond to the market development leading to globalization, liberalization and specialization, and that firms are increasingly more dependent on each other and knowledge institutions to get complementary knowledge and technology. Seeking synergy to cope with this market development is the driving force of clustering phenomenon (Roelandt, 1997).

In recent years, innovation and knowledge spillovers have also been widely studied. Current mainstream economic theory maintains that "technology-related activity often agglomerates in specific regions because knowledge spillovers are localized"(Gunther Maier & Sabine Sedlacek, 2005, Glaeser, 2000). Empirical studies also suggested that close geographic proximity increases the change of knowledge spillover and promote innovation activities such as R&D. Encouraged by succeed stories of high-tech regions such as Silicon Valley, the concept of innovation milieus, learning regions etc. have been used in regional development policies to foster innovation (Gunther Maier & Sabine Sedlacek, 2005).

Feser (2005) summarized that new growth theory coincides with Michael Porter's theory on national competitive advantage and cluster in that both emphasized "the tendency toward localization of economic activity and the critical role of knowledge spillovers. He also considered that these concurrent theoretical developments offer different perspectives on a similar story, leading to the concept of industrial clusters for policy deployment.

Thus we can seen that either innovation theory or new economic growth theory or the older Porter theory start from different perspectives while leading to almost the same conclusion, though they may have different emphasis. In all of them, innovation is at the core as a main driver for economic performance and competitive advantage. It has also been widely acknowledged that clusters promote innovation and competitiveness, while innovation performs better in a clustering environment. Thus cluster is closely linked with innovation and competitiveness, which are important to economic development. Since 1990s, cluster as a phenomenon has caused much world attention, clustering has also been used as a means to foster innovation and further enhance competitiveness and economic performance.

2.2.3 Exploring the inter-relationship among actors

As the inter-relationships among actors in an innovation system or cluster network are of salient important, cluster studies have been trying to reveal the interrelationship between different actors and the importance of networking to innovation and competitiveness, which offer the policy-maker new approaches to address new economic issues.

National Innovation System approach and networking

The National Innovation System (NIS) approach has been widely used as a theoretical framework to analysis innovation policy since the second half of the 1980s (Roelandt, 2000). There are many definitions of NIS. The early one is defined by Freeman (1987) as a "network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies". Metcalfe (1995) later defined NIS as a "set of distinct institutions which jointly and individually framework within which governments form and implement policies to influence the innovation process. As such it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artifacts which define new technologies".

From the NIS approach one can see that networking and interaction between different actors, especially the interaction between industry and research, are of critical important. One can also notice that the role of government has been brought to the very front for discussion. As Oreland (2000) concluded, NIS approach has a systemic character. Implying that innovation involves a wide array of agents including universities, research institutions, intermediate agencies, financial institutions etc. What is more, the system encompasses institutions in a broad sense, for example norms and rule, laws etc.

Double Helix university-industry relation model and its extension

In the NIS approach, the interaction between industry and research are of salient important. To further highlight the relationship, a Double Helix model of university-industry relation has been developed to reflect its salient important. This helix spiral model is a development from the former linear model to reflect the multiple reciprocal linkages and co-evolution of technology and institutions in the innovation system (Etzkowitz, 1995).

Metamorphosing from the university-industry double helix thinking, the innovation Triple Helix theory was first developed in 1996. It has tried to readdress the academic-industry-government, or more specifically, university-industry-government relationship. The Triple Helix study considers the role of government as an essential part in innovation. It also argues that university is increasingly becoming the center and the primary source of innovation in the knowledge-based societies, overtaking the role of the firms. In the Triple Helix, the three actors interact and share the common goal of achieving innovation, though each of them may have different means. In this process, anyone of them can be the leading organizer of innovation (Etzkowitz & Zhou, 2006). While there is still controversy about the role of university, the writer holds that the prominent role of university more often happens in the innovation stage of competitiveness development, or the knowledge-based economy. In many developing countries, the role of university is yet to bring into full play.

The arrival of the knowledge-based economy, as Etzkowitz (1995) put it, "bring the knowledge, productive and regulatory spheres of society into new configurations". Etzkowitz also observed that international organizations such as OECD, World Bank, European Union, the UN etc., have been relying on academic-industry-government relations in many of their international programmes to promote economic development.

Yet the Triple Helix thesis is not the end of the study. The importance of other factors such as the informal sector, labor, civil society, venture capital etc. have also caught much academic attention. In the fourth Triple Helix conference in Copenhagen in 2002, some suggested the expansion of the Triple Helix into a fourth helix to include one or the other important actors (Leydesdorff and Etzkowitz, 2003). Etzkowitz & Zhou(2006) argue that the Triple Helix provides an analytical framework which anyone can modify it to fix the local circumstances. This thinking is also reflected in their study. For example, to take into account the public pressure on sustainable innovation and development, they suggest a parallel twinning university-public-government Triple Helix to complement the university-industry-government Triple Helix.

Public and private relationship is another focus of studying cluster relations. As EU recognized, "the relevance of collaboration in fostering innovative performance reflects the importance of the interconnections between public and private agents in driving innovation." (EC, 2004, p13) Public sector is a key financial supporter in stimulating R&D cooperation. The EU 2004 Competitive Report revealed that, "the largest impact is achieved when collaboration among firms and public funding are present simultaneously."

Inter-firm relations

As to the inter-firm relations, one view from Porter (1990) is his cautious attitude towards inter-firm cooperation. In his view, direct inter-firm cooperation can be detrimental to competitive advantage. Thus public policy aiming at fostering direct inter-firm cooperation should be avoided. On the other hand, indirect cooperation through independent entities can be beneficial. For example cooperative R&D programs organized by trade associations and opened to most of firms. Thus shows the importance of independent entities such as trade associations. Porter (1990) also holds that vertical cooperation between supplier and buyer of the value chain will benefit national competitive advantage, provided that this cooperation does not disadvantage others.

Muizer & Hospers (1998) however argue that in an innovating economy, competition and inter-firm cooperation coexist. Firms co-operate to seek complementary competence and remain competitive in the increasingly globalized and specialized market.

Roelandt (2000) summarized cluster studies aiming at three different levels of relations. The national (macro) level cluster analysis focuses on linkage of industry groups in the economic structure; the industry (meso) level cluster analysis addresses inter-industry and intra-industry relationship at different production chain stages; while the third micro level analysis is at firm level that targeting at inter-firm linkages. As he put it "economic clusters can be characterized as being networks of production of strongly interdependent firms (including specialized suppliers) linked to each other in a value-adding production chain" (Roelandt, 2000, p8). But he also points out that clusters can also encompass links with research communities, knowledge intensive business services, brokers, consultants and other bridging institutions, as well as customers. Clusters in this sense can also be seen as “innovation systems at a reduced scale level”. He also points out that clusters can also encompass links with research communities, knowledge intensive business services, brokers, consultants and other bridging institutions, as well as customers. Clusters in this sense can be seen as “innovation systems at a reduced scale level”.

Networking approach and intermediaries

The interrelationship of actors can be reflected in a networks system. The EU experts Group on Enterprise Clusters and Networks in 2002 defined network as the following: “Networks are formal and informal organizations that facilitate the exchange of information and technology and foster various kinds of co-ordination and collaboration in a cluster.” (EC, 2003b, p16) These organizations could be trade association, chamber of commerce etc.

The EU innovation policy studies also emphasis the importance of networking and knowledge transfer mechanisms to tapping the potential benefits of science-industry linkage. Networking should facilitate the free information flow among all actors involved, including firms, research circles, investors, intermediaries, government and others. This networking ensures a well function innovation system (EC, 2002).

Intermediaries such as industry associations have been playing an important role in facilitating networking and sharing of resources in a cluster. As Rosenfeld (2002) observed, “A variety of entities that work with clusters, including technology centres, NGOs, or skills councils, serve as gateways to information, knowledge, and labour and as linking agents.”

Porter observed and summarized the roles industry associations can play. Many of these roles can been seen as extension of government function, especially in factor creation:

- Provide industry-specific training. When firms are small, trade associations have the advantage of achieving a critical mass.
- Funding or even creating specialized research institutions that aimed at industry clusters as well as crosscutting technologies.
- Facilitate inter-firm cooperation, such as cooperative R&D
- Create infrastructure for marketing of the whole industry. For example, organizing trade exhibitions and fairs etc.

(Porter, 1990)

The network governance studies also suggests that there are “more or less centralised forms of organisation connecting formally distinct firms through associations, industrial districts, consortia, franchises, equity joint ventures and so on. (Kersbergen, 2004).

2.3 Government's role and the use of cluster policy

2.3.1 The role of government

In a broader sense, the role of government in economic development has been discussed and induced different views in literature for quite a long time. In history, the way the role of government viewed by practitioners has also changed over time. In the USA for example, it is believed that there are three phases of viewing government's role. In the first phase between 1940s and 1970s, government was regarded as the prime mover of the economy. The second phase from 1979 to 1996 was the time when government's intervention was viewed by many as problem and distortion of market incentives. In the third phase since the 1980s, the optimal role of government in economic has been reevaluated. The development economics believed that government must play an active, strategic role in economic development. While governments in different countries of different development stages have different attitudes of their roles too. Also, a large variety of instruments have been used by the government to promote the economic, for example subsidies, incentives, grants, restrictions, licensing etc.(Adelman, 1999).

Like the role of government in economic development, the role of government in cluster development has been discussed in the literature with different views.

Porter (1990) argued that market force is the driving force in the creation and development of industrial clusters. He emphasized the critical role of firms in innovation and that government should act directly only when firms "are unable to act or where externalities cause firms to underinvest" (Porter, 1990, p620). Government's roles can best be played in factor creation and upgrading. Yet this government function is most appropriate to be applied in generalized area. In particular industries, the most important mechanism in factor creation still lies in the involvement of firms. Trade association activities, collaboration of universities with the industry are also among the mechanisms that affect factor creation.

Porter (1990) also contended that clusters are more likely to form by their own. While government can purposely support and reinforce a cluster when it takes shape. Government intervention at this stage is more likely to succeed than trying to create a new one. Porter held that in advanced countries, the most potent influences of government are often "slow and indirect". In viewing the role of different level government, Porter maintained that the role of state and local government could be as great or even greater than the national government. He also argued that the rational for government's direct role is greater in the initial factor-driven or investment-driven stages then in the innovation-driven stage (Porter, 1990).

Porter(1990) mentioned that policies government can deploy include creation of specialized infrastructures. In view of regional policy, Porter concluded that regional policies seldom succeed if it involved subsidies to persuaded firms to locate their activities in the less developed region because it did not really foster competitive advantage. Regional policy focusing on cluster reinforcement is more likely to succeed, thus regional policy should try to identify the strength of industries and build on them to promotion geographical concentration of the industries.

Another view from Roelandt (2000) contested the classical thinking that the role of government should be confined in "facilitating the dynamic functioning of market". He followed the modern innovation theory that takes into account the changing feature of market-based innovation system and believed that the role of government should be redefined. Roelandt further gave four rationales for the changing role of government (Roelandt, 2000, p15-16):

1) Also recognized that clustering is a market-induced and market-led process, Roelandt suggested that "the primary task of government would be facilitating the dynamic functioning of markets";
2) The externalities derived from R&D investment and knowledge creation justifies government action in funding R&D where social rate of return on R&D and knowledge creation investment is greater then private gain;
3) Government can also be a player in the market. Government should take this opportunity to foster innovation. For example, by using public procurement policy to exert pressure on firms to innovate.
4) Government should act to remove systemic imperfections and enhance the efficient functioning of the innovation system.

On the other hand, the governance studies suggest that governments are facing a shift in their governance capacities both horizontally and vertically. The horizontal shift "provides the displacement of powers and capabilities traditionally controlled by the state to institutions and organisations operating at arm's length from the political elite" (Jon Pierre and B. Guy Peters, 2000, P89), while intermediaries are at the pivotal position of this shift.

Cluster provides a new way for firms and governments to look at the economy, thus adds new perspectives for policy-making. Clusters also suggest new priorities for the government to address (Porter, 2001). The paper takes the view that government itself is an actor in a cluster system. Government can also play the special role of facilitating the market function and compensating for market failure.

2.3.2 Cluster policy studies

Policy theory

Nagel(1990) defined public policy analysis or policy study as "determining which of various alternative public or governmental policies will most achieve a given set of goals in light of the relations between the policies and the goals". Among the many directions of policy studies, there has been an increasing interest in studying the tools and instruments government can employ to address public problems.

In the early tools and instrument literature, very broad categories are used to classify policy instruments. For example, the reflexive and purposive instrument by Mohr (1973), the expenditure and non-expenditure instruments by Mosher (1980), or McDonnel and Elmore's (1986) fourfold scheme: mandates, inducements, capacity-building and system-changing etc. There classifications are in general too broad. There are also academics that advocate more attention between the matching of instrument with context (Mayntz, 1981, Elmore,1985).

In empirical studies, the classification of policy instruments may largely depend on the investigator's analytical perspective. For example, Linder & Peters (1990) in their empirical study developed a sample of public policy instruments as follow:

Direct Provision: Public investment, govn't provision, govn't-sponsored enterprises.
Regulation: quota, quality standard, price control, prohibition
Authority: certification/screening, license/permit, procedural guideline
Subsidy: cash grant, in-kind transfer, loan guarantee, loan
Tax: tax break, fee/charge, fine
Contract: administered contract, franchise, insurance
Exhortation: jawboning, public promotion, information/demonstration

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(Linder & Peters, 1990, P113)

Nagel(1990) also examined the incentives approach of public policy. As he defined, "the essence of the incentives approach is manipulating the benefits and costs of rightdoing and wrongdoing in order to encourage socially desired behavior"(Nagel, 1990, p179), though he recognized that incentives approach should be complemented by structures approach.

Cluster policy
Cluster policy is a nebulous concept. As EU's cluster policy studies suggested, "the concept of cluster encompasses many meanings. The same is therefore true when dealing with cluster policy. In essence, cluster policy is not an isolated, independent and well-defined discipline. It embraces all policies that affect the development of clusters, taking into account the synergies and interchanges between these policies" (EC, 2003c).

The EU Trend Chart on Innovation has included cluster policy into its policy study. The study focuses on national cluster policy, especially the use of industrial policy, innovation policy and regional policy. For example, the European Thematic Report on Cluster Policies (EC, 2003b) reveals that cluster policies can be embedded in science & technology policy, especially when it involved the emerging high-tech industries. In this case, governments usually take a more top-down approach. Cluster policies can also be embedded in industrial policy or regional policy, particularly in the case of existing traditional cluster where strategic planning is usually taken from bottom-up to strengthen cluster development.

The EU promoted cluster policy study also focuses on cluster in promoting productivities, innovation and competitiveness of SME, as the European Charter for Small Enterprises in June 2000 stated “Europe’s competitiveness depends on its small enterprises: these are the main drivers for innovation, employment as well as social and local integration”(EC,2003c). Thus in order to “foster the involvement of small enterprises in inter-firm co-operation, at local, national, European and international level as well as the co-operation between small enterprises and higher education and research institutions”, the DG Enterprise of the European Commission launched in 2002 a research project on enterprise clusters and networks in recognition of the importance of clusters to improving SMEs’ productivity, innovation capacity, and to the commercialization of innovation and employment(EC,2003b).

Cluster policy can also be studied from different angles. For example, Roelandt (2000) studied cluster policies that targeted at different areas of application, by which he summarized 12 areas of cluster policy practices. These areas may be categorized into two groups. The first one aims at fostering market function by creating favorable framework and addressing market imperfection problems. The underlying rational is that cluster is market-induced process and that government should act only as facilitator and moderator. The second type of cluster policy involves government with setting national priorities and launching clustering dialogues. Roelandt argued that after these initial priority setting and communication promoting actions, government should let market lead the clustering process and should not exert too much intervention (Roelandt, 2000).

As nations strive to compete with each other in the “knowledge-base economy”, high-tech industries are often seen as at the fort front of a nation’s competitive advantage and thus the focus of cluster promotion initiatives. The EU research on clusters revealed that national or regional governments in the EU are still mainly focus on high-tech or knowledge-based clusters (EC, 2003b). Initiatives to promote clustering in high-tech areas include the creation of industrial zones, software parks etc. This world zeal in developing high-tech cluster not only occurs in the advanced nations but also in developing countries such as China. However, there are debates over the notion of high-tech and low-tech industries. According to Porter (1990), both high-tech and low-tech industries can compete in a sophisticated way. Thus a nation or a region should not only look to high-tech areas but also should look to traditional industrial for sharpening its competitiveness. European Union’s innovation policy studies also reveal that the pervasiveness and diversity of innovation exist not just in “high-tech” sectors but also in every sector and every region. Moreover, knowledge creation not only comes from R&D, but also from "investment in plant and machinery" (source: Innobarometer) as well as from human resources development and the others (EU, 2002).

2.4 International learning and policy implication in less developed areas

Porter (1999) holds that national competitive advantage lies in the match between competitiveness of particular industries and the national's unique context. Thus a nation should not simple cope other nation's economic model. Rather, what the government should do is to "understand the underlying principles of national advantage and translate them into policy initiatives that reflect the nation's particular circumstances."(Porter, 1990, p624)

Porter's diamond theory can also be used to analysis the developing countries. Porter (1990) pointed out that the central quest for developing countries is to upgrade its economy from factor-driven advantage that relies heavily on basic factor conditions such land, labor, location etc. All four determinants in the developing nations are in need of upgrading, while resources are often limited, thus it is important for government to set priorities. However, Priorities should not be given to industries where there is only basic factor advantage. The principle of clustering can be of great help for government to set development priorities. The advantage of using clustering approach is that all determinants will be considered.

Less favored regions may face many difficulties in cluster development, these include (Rosenfeld, 2002)

- Backward physical infrastructure
- Lack of access to capital market
- Lack of technology support, especially cluster specific institutions for technology, training and service.
- Isolation
- Lack of attraction to talents. Low salary is just one factor that may affect attractiveness. Talents also look for choices of job opportunity, exchange with peers, and most importantly opportunities for professional development. Many of these factors are lack in less favored regions.
- Cluster hierarchies

Rosenfeld in his study provided an A to G menu of actions for less favored regions to choose when developing their industry clusters (Rosenfeld, 2002). Different regions should adopted actions that best fit the local condition.

Understanding current local conditions is the precondition for taking actions. Cluster approach helps to identify market imperfection and system failure, mapping relationships among actors, and pinpoint local strength and potential priorities for development.

Successful clusters derive much from engagement of different actors. Rosenfeld (2002) suggested a "three courses" menu for encouraging engagement. The first one is to recognize or create cluster organization. Cluster organizations act in a pivotal position of linking different cluster actors together. A functioning cluster organization should be able to build recognition, organize networking activities, and sometime undertake government-delegated responsibilities. The other two "courses" include maintaining a formal channel for communication promoting inter-firm collaboration. In both of them, cluster association can also play an important role as facilitator.

In less favored regions, government services may need to be reorganized and deliveries be improved in order to development cluster. Changes can be made through broker, one-stop cluster service hub, or creating cross-agency teams to coordinate synergic actions. As Rosenfeld (2002) suggested, new cluster agencies can also be created if necessary.

Specialized workforce needs to be built and strengthen in less-favored regions. In these places, governments often turn out to be the biggest investor. Innovative ideas include creating cluster skill centers that are linked to existing institutions and association, and partnership between existing educational institutions and clusters for the benefit of the whole cluster. Again, cluster associations can play an important role in it.

Innovation and entrepreneurship are deemed critical in cluster development. Less developed regions can invest in innovation and support business start-ups by providing seed capital, venture capital or product development funds. Cluster-based incubator is another form of government support. However, even though technology centers or technology transfer centers play an important role in promoting innovation, they are sometime faced the problem of underutilization. Rosenfeld suggested solving this problem by tightening their linkage with industry and associations, enhancing marketing capacity.

An important way of government involvement is in the resource allocation and investment. Public funds can be used in different ways to spur cluster development, for example invest in industrial park and R&D. Wise allocation of resource will achieve better result. Recommendations by Rosenfeld (2002) include re-channeling funds for collective or consortia activities in training, technical services etc; Financing cluster-oriented R&D and supporting fundamental factor creation are also useful ways for cluster development. Cluster organizations in many cases need government's financial support. Multi-channel funding from national, regional or international organizations such as EU could be sought to help them establish themselves in the cluster.

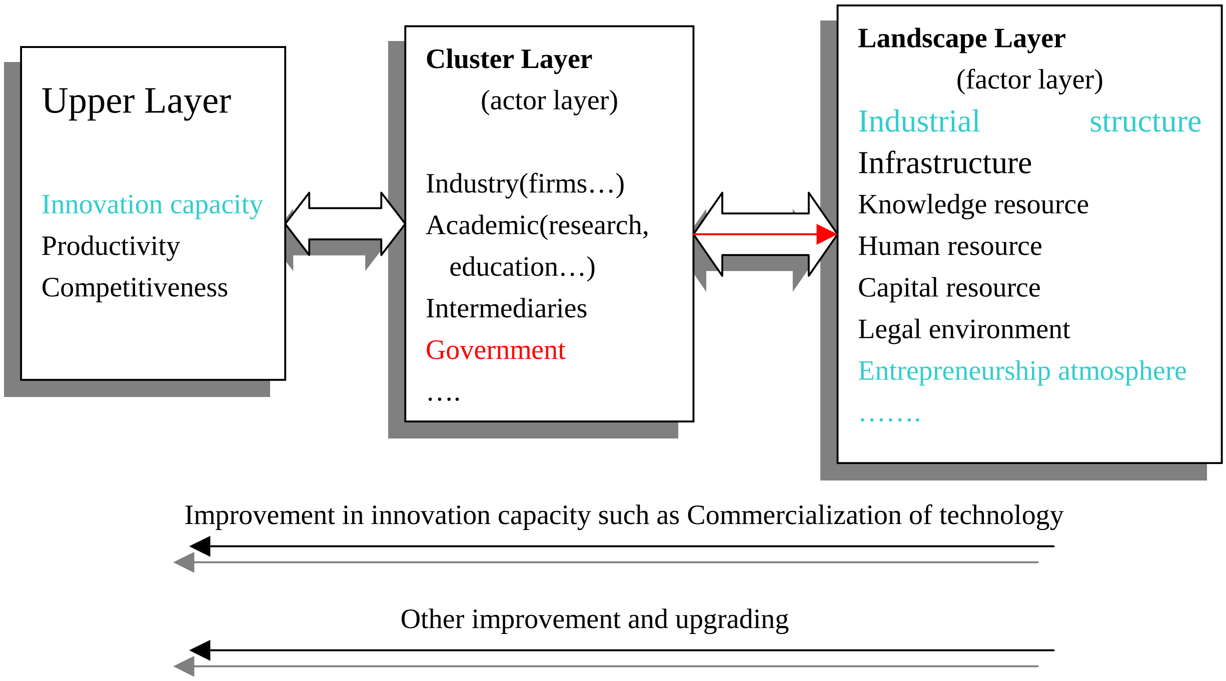
Other actions include the promotion of cluster bland and marketing etc.

2.5 Analytical framework

2.5.1 Analyzing key issues in cluster development

Three-layer cluster

Drawn on the above theories, the writer will try to analyze important factors for cluster development. First, a cluster is singled out and stratified into three layers



The lowest layer consists of factors that are important to cluster and innovation system. It provides a landscape for clustering and innovation activities. Entrepreneurship environment is more abstract thus can be seen as atmosphere. Here it is put also in the landscape layer. To describe the landscape of a cluster, one can't avoid mentioning about the industrial structure, thus it is also put in this category though it may not be considered as a factor condition. The different factors listed here may sometimes be overlapping.

The mid layer consists of different actors in a cluster, including firms, university, research institutes, educational institutions, intermediaries, government etc. The interrelationships among these actors are the core of a cluster system.

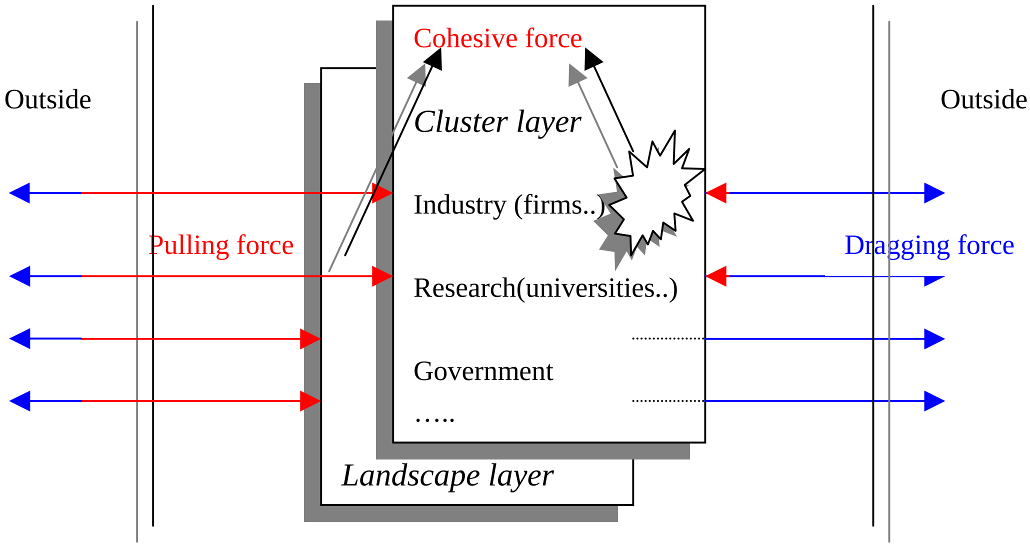
The aims such as productivity, competitiveness are extracted as the upper layer. Innovation capacity can be regarded as an aim or as an element in the process to achieve the aims.

The process of improvement in innovation capacity, for example the capacity to commercialize technology, and the process of improvement and upgrading of other aspects lead to the achievement of the aim. This happens with factor supports from the first layer and the concerted efforts of actors in the second layer.

The three layers are integrated parts of a cluster and they interact with each other. In this paper, one focus will be on the government's role in factor creation, which occurs at the interface between actor layer and factor layer and is more of a one-way route, as indicated by red arrow in the scheme.

Three forces

Secondly, Three forces that affect a cluster are identified. The Cohesive force is the force that helps with the formation and stabilization of a cluster. It mainly comes from the linkages among actors in the cluster layer. The support from the landscape layer can enhance the cohesive force.

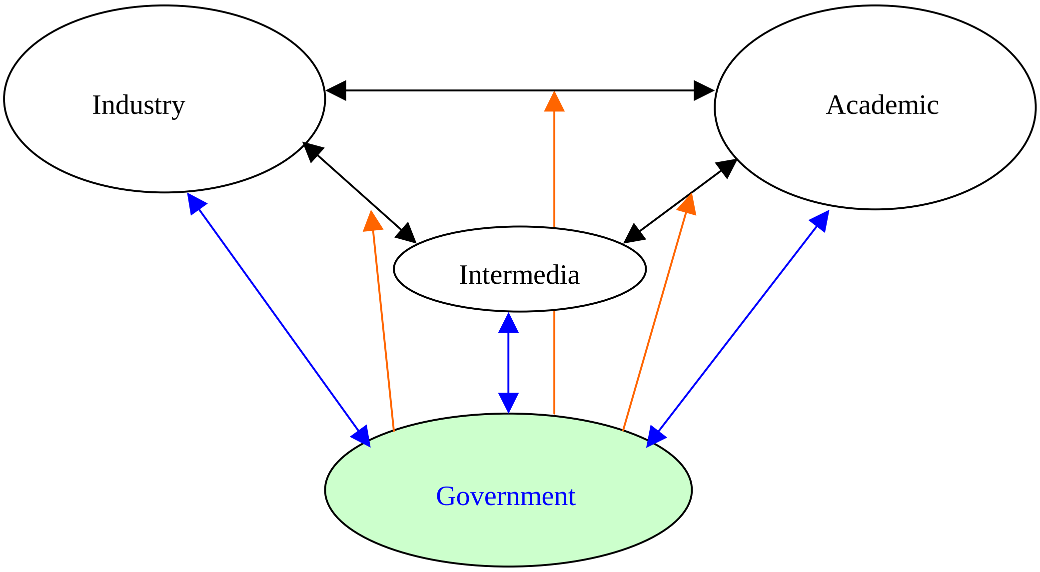


On the cluster side, there is a pulling force (indicated by red arrow) trying to draw elements from outside: mobile factors such as technology, talent, labor, and capital etc. Firms, intermediaries, even research institutions can also be attracted from outside. But it is not necessary that the pulling force lead to the relocation of external firms or agencies in the cluster. Government can strengthen this pull force by using proper policy instruments. On the other hand, there is also an external dragging force (indicated by blue arrow) that tries to drag these movable elements out of the cluster.

Topographic view of interrelationships

Cluster network reveals the interrelationship among actors. The interrelations can be viewed from different angles. Below is one view focusing on the role of government. To simplify, only four groups of actors are discussed, academic here includes research and education.

Cluster analysis focusing on government



Government's role is the focus of this paper. From this angle intermediaries take a special position as go-betweens. Here the study not only includes government's relations with industry, academic and intermediaries (blue arrow), but also includes government's role in promoting the linkages among other actors, as indicated by orange arrow.

Actors in a cluster not only interact with each other, but also reach out, expand the linkages or form alliance with external actors. The significance of reaching out is to seek complementarities, which may be seen as an attempt to enhance the cohesive force of a cluster.

2.5.2 Variables

A variable chart is developed based on the above analysis.

Independent variables **interfering variables** **dependent variables**

Infrastructure
Knowledge resources Public policy Cluster development
Human resources ⇨ Government's role ⇨ Innovation capacity
Capital resources Competitiveness
Firms and industries
Entrepreneurial environment and networking

For empirical study in this paper, the interfering variables is broken down into a sample set of commonly used policy instruments, these sample instruments draw on Linder and Nagel's policy studies but changed slightly in order to reflect the case circumstances.

Public policy instruments:

1. Planning

Financial means

2. Public investment
3. Grant/ fund
4. Loan
5. Subsidy
6. Tax incentive
7. Public procurement

Regulation and authority

8. Guideline
9. Quality standard
10. Certification/screening
11. Delegation (here refers to government's delegation of public function to other public agencies or intermediaries)

Exhortation

12. Public promotion
13. Information and service (can be seen as an incentive means to decrease the cost of right-doing)
14. Demonstration

To reflect more closely the application of policies in real world, these policy instruments are measured by intensity and diversity in the cases. However, due to the availability of information, this paper has to use broad qualitative measure to scale intensity and diversity:

Intensity: intense, moderate, weak,

Diversity: diverse, moderate, narrow.

For example, "diverse" indicates that there are more than three policy means or application areas. It should be noted that the intensity and diversity measure are subjective and mostly based on observation of policy application, thus is not very accurate and should be used cautiously as reference.

Even though dependent variables can also be broken down into more detailed variables, for example, European Innovation Scoreboard 2004 uses 20 indicators to measure innovation performances (www.cordis.europa.eu), to make the research project manageable for a master's program, the paper will not discuss the effectiveness of policy instruments in achieving the goals. Instead, the paper will concentrate on the discussion of what kinds of policy instruments are used in the policy areas that are identified as important to cluster development.

The independent variables are also broken down into more detailed policies areas, and are further developed into a checklist to provide a structure of writing for the following chapters in analyzing international best practice and Xiamen case, as well as a structure for comparison.

2.5.3 Checklist

1. Government in infrastructure creation
    a. Physical infrastructure
    b. Science & technology infrastructure (public R&D facilities, technology centers etc.)
    c. Industrial infrastructure (industrial parks, business areas etc).
2. Government in knowledge creation
    a. R&D activities
    b. Technology transfer
    c. Research-industry cooperation
3. Government in human resources creation
    a. Workforce attraction & retention
    b. Industry oriented education and training programs
4. Government in capital resources creation
    a. Different stage financial needs
    b. Venture capital
5. Firm and industry oriented support
    a. SME support
    b. Attracting firms from outside
    c. Industry oriented support
6. Promoting entrepreneurial environment and networking
    a. Cluster organizations and supporting intermediaries
    b. Business and legal environment

It should be mentioned that the scheme is not all-inclusive. The intention of constructing the scheme is to highlight the factors that the writer considers most important to examine cluster policy. Moreover, in analyzing international best practice, the whole checklist may not be run through for a single case. But with the experiences from different cases, the writer hope that at the end a comparatively holistic picture will be drawn, which will be useful for diagnosing Xiamen situation and for the comparison.

Chapter 3 Best practices analysis

Since 1990s, industry clusters have gained much popularity with the increasing globalization and liberalization of world economy and with the arrival of knowledge-based economy. Many countries have tried to adopt cluster approach to analysis the economy and applied cluster policies to promote the industry development.

Encouraged by success cluster stories in many places of the world, international learning has been popular. International organizations such as OECD, the World Bank, UNIDO and UNCTAD etc. have been active in sponsoring worldwide cluster studies in the forms of workshop, seminars etc. (Feser, 2005). These organizations are also enthusiastic in identifying and spreading best practices in cluster development. For example, the OECD has included cluster studies in its National Innovation Systems study since 1996(Roelandt and den Hertog, 1999). UNIDO also encompasses cluster in its SME programmes (UNIDO, 2001).

This chapter will analyze some international best practices in promoting photonics and biotech clusters in order to draw lessons for Xiamen. Before the analysis, some criteria are set for selecting proper international best practice:

1. Successful or recognized: The word successful could be tricky. For emerging industries such as photonics and biotech industries, longer time span may be needed to test the effectiveness of policies. On the other hand, "best practices" doesn't necessary mean the "best" ones. Some areas may be naturally endowed with better conditions to success, while other areas may not enjoy exceptional advantage at the beginning however manage to gain a niche. Their experiences are also valuable. Though the paper doesn't deliberately look for the best cases in the world, the cases chosen should be somewhat recognized.
2. Obvious government effort: The emergence of some industrial cluster may be mainly induced by market force. However, theoretical and empirical studies also suggest that governments can play an important role in cluster promotion. Thus this paper would especially look for cases where governments have been actively involved.
3. Regional or local: As Xiamen case is a local case, for comparative study, this criterion is necessary. However, it should be mentioned that not locals can avoid national influences, either from policy or environmental and other conditions, thus some national efforts are also discussed during the analysis.
4. Available of information: In combination with point one, this paper would consider cases which not only have available general information from the website, but also have existing reviews or summaries. As these documents can provide more comprehensive information about the cluster.

With the above guidelines, the paper chooses three cases for best practice study. San Diego biotech cluster is chosen for its reputation and rapid growth momentum.

Colorado in the USA and Ottawa in Canada are chosen because both regions have listed photonics and biotech/biomed as emerging industrial clusters. Besides these three cases, a description of solid state lighting industry in the USA, and a description of OECD's policy learning for venture capital are attached as appendixes as they may provide relevant information for learning. It should be acknowledged that even though many countries and international organizations have been enthusiastic in promoting clusters and spreading best practices, there is still not much summarized information concerning regional or local cases in photonics and biotech, thus limits the choice.

Each case will start with a brief description of the cluster, followed by analysis of government's effort according to the checklist produced in the previous chapter. Photonic and biotech industries are combined in the analysis as they may share some common policies, while specific policy instrument for peculiar industries will be indicated. More overall information regarding each cluster can be found in appendix 2.

3.1 San Diego biotechnology cluster

3.1.1 Descript of San Diego biotech cluster

The early nationwide cluster-mapping project in the USA identified San Diego biotechnology-pharmaceutical cluster as one of the top ten biggest clusters of its kind in the USA (Lennihan, 2003). E&Y listed San Diego as the fastest growing biotech region in the USA (Panetta, 2005). In 2004, the Milken Institute, a nonprofit economic think tank, conducted a study using different methodology to measure biotech clusters (exclusive of medical device and pharmaceutical companies). The result listed San Diego at the top of American biotech clusters (DeVol et al, 2004).

The cluster-mapping project identified San Diego's research and cluster organization as leading in the nation. San Diego also has very good professional training, specialized venture capital, angel networks and specialized service support (Lennihan, 2003).

Compared with other biotech cluster areas such as Boston, which has long history of tradition, San Diego is regarded as overnight succeed. Its experience is therefore valuable for other regional craving for biotech cluster succeed. Success stories show that government promotion helps cluster development. As Beh Swan Gin, director of biomedical sciences for the Singapore Economic Development Board (EDB) pointed out, only two biotech clusters (namely San Francisco and the Cambridge-Boston clusters) in the USA grew "naturally", the others all involved government commitment for a long period of time (Panetta, 2005).

3.1.2 Government in infrastructure creation

a. Physical infrastructure

The Regional Economic Prosperity Strategic emphasized the importance of physical infrastructure to industrial cluster development and defined physical infrastructure as "physical items that an economy depends upon to produce and distribute its goods and services" plus the support of five means of accessing international and domestic markets. Substantial financial resources have been allocated to the construction of physical infrastructure. Cooperation programs within the region or across border were also carried out. For example the San Diego Unified Port Authority has worked with member cities to customize its development programs to the region's economic and civic needs (SANDAG, 1998).

b. Science & technology infrastructure

The Center for Applied Competitive Technologies (CACT) is a technology center designated and sponsored by the state of California to help manufacturers improve their technologies. It operates under San Diego Community College District. It also has an incubator facility funded by Department of Commerce's Economic Development Administration (www.sandiego.gov).

San Diego Technology Incubator is created in conjunction with the city government to provide space and services for emerging high-tech companies (www.sandiego.gov)..

c. Industrial infrastructure

The city of San Diego has created a number of business development and incentive zones, including eighteen business improvement districts, fifteen redevelopment project areas, three enterprise zones, several recycling market development zones, a foreign trade zone and a renewal community. Various kinds of business incentives such as tax credits are offered to companies within the zones (www.sandiego.gov).

3.1.3 Government in knowledge creation

a. R&D activities

As is estimated, the biotech or biopharmaceutical approval process normally takes "12-15 years to go from initial—or preclinical—development to commercial approval" (DeVol et al, 2004 ,p28). Public funding thus is an important source besides industrial R&D. San Diego ranks high in drawing R&D fundings from NSF and NIH for basic and advance research, and the Small Business Technology Transfer (STTR) program and Small Business Innovation Research (SBIR) program for more applied R&D. Metropolitan also invests heavily in supporting academic R&D. These efforts have helped the industry keep a long-term commitment to R&D and technology innovation. Many of the companies in San Diego have been investing in R&D for over 10 to 15 years, a time long enough for biotechnology to reach the stage of commercialization.

b. Technology transfer

The Southwest Regional Technology Transfer Center: The center is supported by a technology transfer grant from NASA to help businesses commercialized technologies from defense and space programs(www.sandiego.gov).

CACT, Technology Incubator and other organizations also involved in technology transfer activities.

c. Research-industry cooperation

In San Diego, flexible policies have been developed to encourage the integration of research with commercial applications. The leading biotech research institute Salk Institute, for example, allows its researchers to work off-site one day a week.

Many government programs involved the participation of public-private, industry-research cooperation, as described in other sections.

3.1.4 Government in human resources creation

a. Workforce attraction & retention

The city and the county of San Diego have signed a Joint Powers Agreement to create a Workforce Partnership program dedicated to job training and employment. Workforce partnership provides funds for various initiative projects (www.workforce.org).

b. Industry oriented education and training programs

The Southern California Biotechnology Center (SCBC) located in San Diego is funded by California Community Colleges Economic and Workforce Development Program and in partnership with biotech firms, educational organizations, public agencies and associations to provide life-long workforce training needs for biotech industry (www.miramar.sdccd.net).

3.1.5 Government in capital resources creation

a. Different stage financial needs

San Diego government has made efforts to address various financial needs of both large and small local business. Below are some of the programs:

- Industrial Development Bonds for manufacturer or nonprofit organizations. These bonds are offered with low interest rate and long-term amortization period. Eligibility requirements include creation of public-benefits, and prove of credit worthiness etc.
- San Diego Regional Revolving Loan Fund (SDRRLF): Aims to improve economically distressed areas in cities of San Diego and Chula Vista by assisting expanding and start-up businesses financially. This fund is provided by both city governments (as matching fund) and Economic Development Administration (EDA) (as grant).
- Metro Revolving Loan Fund (Metro RLF): Similar to SDRRLF, while the matching fund is provided by the city of San Diego and used to improve targeted distressed areas in San Diego.
- San Diego Technology Fund: This public revolving loan fund focuses on

financing promising early-stage small companies who may not yet possess enough size or history credit record or show market potential necessary to attract venture capital or obtain conventional loans. The fund is used as working capital and normally requires matching fund from the companies and the participation of angle partner equity etc.

- San Diego Regional Technology Alliance: is a grant-founded non-profit organization the provides information to high-tech companies regarding competitive grant and contracting opportunities
- Other business financing programs, including SBA (Small Business Administration) loans, SBA International Trade Loan Program, funds from Export Import Bank of the United States to encourage export and purchase of US goods etc.

(www.sandiego.gov)

b. Venture capital

Venture capital investment in Southern California has increased rapidly in the past years, and San Diego ranks just behind Silicon Valley in attracting venture investment.

In the side of government, efforts are mainly made by cooperating with nonprofit organizations such as UCSD Connect, San Diego Regional Technology Alliance etc. to provide information for companies to get access to venture capital, government technology grants and other means of financial sources. (www.sandiegometro.com)

3.1.6 Firm and industry oriented support

a. SME support

Small businesses represent about 92% of the city's businesses. In recognition of small businesses as driving force of the economy, the city of San Diego has created the Office of Small Business. Efforts include:

- Help with the creation of Business Improvement Districts (BID), which collect accessed fee from business owners as a pool of private resource for the improvement of the business area. The city allocates matching funds to many of BID activities. Government also renders supports to BID in many other means such as providing information, assisting in planning etc.
- Seed Capital Grant Program is designed by the city of San Diego geared to the needs small businesses. Grants are normally channeled to non-profit organizations as matching grants (1/3 city, 2/3 applicant) to leverage the funds and volunteer efforts presented by these organizations.
- Small Business Enhancement Program (SBEP) funds and Community Development Block Grant (CDBG) support a wide spectrum of business support programs. These programs are usually contracted out to agencies. In this way, government forms a partnership with small business assistance organizations and nonprofits to support the growth of small business.

(www.sandiego.gov)

b. Attracting firms from outside

The city of San Diego has taken proactive actions towards business expansion, attraction and retention (BEAR) through a BEAR team under the City's Economic Development Division. Main programs include:

- Business & Industry Incentive Program: Establish in 1993 by the San Diego City Council, the program provides certain financial incentives, and permit assistance to various business investors.
- Business Cooperation Program: This program aims to lower the cost of doing business in San Diego. Financial incentives are offered to business and non-profit corporations for equipment expenditure etc.
- Guaranteed Water for Industry Program: This program ensures industrial water use in time of drought provided that participating firms observe certain norms such as "Best Management Practices for Potable Water Conservation."

(www.sandiego.gov)

c. Industry oriented support

San Diego Association of Governments (SANDAG) is a joint power governmental agency consists of 18 cities and county government. SANDAG serves for the comprehensive strategic planning in a broad range of economic areas. Among the many plans produced by SANDAG, the 1998 Regional Economic Prosperity Strategic is an important one. This report pointed out that cluster industries are “emerging as the engines of economic activities” and that biotechnology/pharmaceuticals industry, an emerging industry in the 1990s had expanded rapidly, contributing to San Diego’s “modern export-driven economy” (SANDAG, 1998, p20).

3.1.7 Promoting entrepreneurial environment and networking

a. Cluster organizations and supporting intermediaries

In San Diego, government has co-sponsored the establishment of a number of public-private jointed organizations, which include:

- San Diego World Trade Center
- San Diego Regional Economic Corporation
- Center for Allied Competitive Technologies

(Porter, 2001)

Non-profit organizations are eligible to Industrial Development Bonds. Seed Capital Grants are normally channeled to non-profit organizations to leverage the funds and volunteer efforts presented by these organizations (www.sandiego.gov).

Government also forms partnership with many cluster organizations and intermediaries such as BIOCOM, UCSD CONNECT, San Diego Dialogue etc. Through these connections, government actively participates in business promotion and information/service providing activities.

b. Business and legal environment

3.2 Colorado Case

3.2.1 Brief description of Colorado’s photonics and biotech industries

Colorado has strong research capacity in related photonics and bioscience areas. It also has one of the most educated populations in the USA. In Colorado, telecom, oil and gas, energy management, aerospace and storage devices are distinguished as established industry clusters, while bioscience (including medical devices), photonics, satellite imaging and telecom are identified as emerging clusters (Serapio,2005).

Photonics industry

As of mid 2004, there were 260 photonics related organizations, of which 204 are companies directly engaged in production or service (134 manufacturing) and 44 professional, scientific, and technical companies. Seven of the 204 companies had over 1000 employees, 29 over 100, while most of the companies (49.3%) were relatively small, with less than 10 employee. The report also showed that over half of photonics companies were established less than 15 years, 18.4% were set up in 2000 and later.

Biotech industry

According to Battelle 2004 report, bioscience industry can be grouped into 4 sub-sectors including Agriculture Chemicals and Feedstocks, Drugs and Pharmaceuticals, Medical Devices and Equipment, and Research and Testing. Statistics shows that Colorado has comparative strength in medical devices and research and testing sub-sector (Bioplan2004).

The Battelle report revealed that 40 states in the USA had targeted bioscience industry, while Colorado was still not known as having special bioscience strength by the time of the report. Much still need to be done to turn the bioscience industry into a key driver of Colorado’s economy.

3.2.2 Government in infrastructure creation

a. Physical infrastructure

There is not statewide capital plan for Colorado, each agency prepares it own five-year plan. A Capital Development Committee and a committee of the legislature coordinate the efforts. On the other hand, the Taxpayers Bill of Rights has restricted the available spending on state’s infrastructure. Maintenance also constitutes a large portion of the spending. The Capital construction fund and Capital Maintenance Fund supports Infrastructure construction in Colorado (www.results.gpponline.org).

b. Science & technology infrastructure

For photonics industry, government support includes funding for Center of Excellent at CU and CSU by grants from Colorado state and National Science Foundation. For example, the Optoelectronics Computing Systems Center, a colloaboration between CU and CSU was launched in 1985 and lasted for eleven years, resulting in more than 15 spin-off companies using university-developed photonics technology. Besides these, state and local governmental agencies also support various forms of cluster promoting programmes(www.coloradophotonics.org).

In 1999, the state also supports the creation of Colorado Advanced Photonics Technology Center (CAPT) with a $4.5 million fund. CAPT operates as a non-for-profit organization providing research support and rental equipments to companies. Some facilities are the only resource in Colorado. It also offers technical training courses to the photonics industry.

In bioscience, government efforts to enhance research capability include the construction of Regional Biocontainment Laboratory in 2004 with a grant from National Institute of Allergy and Infectious Diseases (NIAID), part of the National Institutes of Health (NIH). A public Centers for Disease Control was also built on the campus of CSU (Serapio,2005).

c. Industrial infrastructure

Dozens of business incubators have been set up in Colorado to provide shared space, facilities, services as well as management assistance to emerging businesses.

For biotech industry, local governments have been dedicated to supporting the industry through infrastructure construction. An example is the creation of a new Bioscience Park by Forest City in 2003 (Bioplan2004). According to Battelle Health and Life Sciences State Bioscience Initiatives 2004, Colorado was specially known for Its “university related research parks” in the nation (Bioplan 2004). Other biotech incubators include Bioscience Park Center in Aurora, Rose Biomedical Development Program in Denver etc. (www.gjincubator.org).

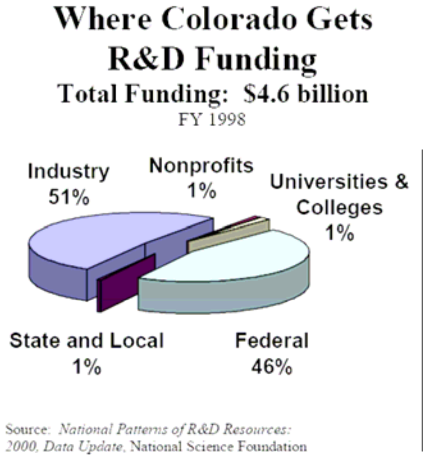
Colorado government also worked with other stakeholders of the bioscience industry such as CBSA through a Management Team to identify the gaps or duplications of entrepreneurial infrastructure and services. At more local level, many business incubators learned from Fort Collins Business Incubator’s experience in establishing bioscience planning groups to develop local implementation plan for the industry. Colrado’s biotech implementation plans emphasized mobilizing efforts from local government and the industry (Bioplan2004).

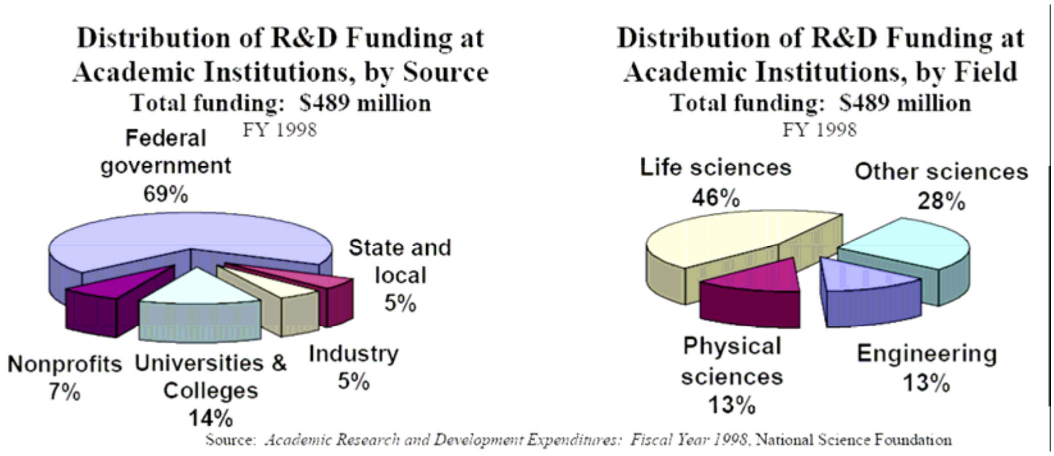
3.2.3 Government in knowledge creation

a. R&D activities

There are a number of government R&D funds available and Colorado universities are very competitive in receiving federal R&D investment.

Colorado has the access to many sources of R&D funding. Among them, government funding is an important one.





(http://www.ccrhq.org/states/Colorado.pdf)

b. Technology transfer

There are several mechanisms to encourage technology transfer. For example, the CU Technology Transfer Office created in 2004 a Proof of Concept (POC) program to encourage inventions having commercial potential. In CSU, a Commercial Opportunity Fund was created in 2003 to support the commercialization of university research results (Bioplan2004).

Public technology transfer institutions and nonprofit organization have been organizing different kinds of activities to set up successful role models for the industry. For example, the Technology Transfer Showcase at BioWest 2004.

c. Research-industry cooperation

Compared with other leading biotech regions, Colorado has a weak record of collaboration between higher education and industry. Public efforts to overcome this weakness have been focused on technology transfer and commercialization (Serapio, 2005).

3.2.4 Government in human resources creation

a. Workforce attraction & retention

The government of Colorado co-sponsored and co-financed the creation of Colorado Institute of Technology, a public-private partnership with some big organizations in ICT fields. The institution was originally aimed to enhance the workforce training in the technical field. CIT have been offering grants and successfully supported many programs. However, due to the recent over expansion that exceed its financial sustainability, CIT have to be close in 2006 (www.coloradoit.org).

For bioscience industry, Colorado BioScience Association has been working with public universities and the industry to identify workforce training and education needs to design training courses tailored made to the industry. Other initiatives include internship programs etc. OED coordinates these efforts as well as bioscience recruitment efforts etc. (Bioplan2004).

b. Industry oriented education and training programs

The Colorado First and Existing Industries Job Training Programs is a government effort to improve workforce skills of new and existing businesses by supporting customized job training programs. (Guide9)

Government doesn't offer direct financial supports to photonics and biotech industries' training programs. Industry specific training programs are mainly organized by government supported cluster organizations and other non-profit organizations such Colorado Advanced Photonics Technology(CAPT) center, which was founded by a state grant.

3.2.5 Government in capital resources creation

a. Different stage financial needs

Each Local Economic Development Office (EDO) in Colorado offers various services to businesses of different sizes and businesses at different stages. Some EDOs also provide small loans. Some loans are managed through independent, nonprofit organizations (Guide9).

b. Venture capital

In 2004, the Colorado Venture Capital Authority, a new state venture capital program was created, which will provide $50 million venture fund for Colorado's small and growing businesses as seed and early-stage investments (Bioplan2004).

3.2.6 Firm and industry oriented support

a. SME support

Colorado has set up a Small Business Development Center (SBDC) Network, which was partially financed by US Small Business Administration. It dedicated to help the growth, innovation and productivity of small businesses. SBDC links government with other stakeholders, for instance educational system and the private sectors, to provide information and services customized to the needs of small business community in areas such as financing, management, marketing, regulation etc. Partnership of SBDC includes the State of Colorado, Colorado International Trade Office, chambers of commerce, institutions of higher education, local economic development organizations, SBIR Colorado, US Small Business Administration etc.

Colorado Alliance of Microbusiness Initiatives was founded in 1999 with contributions from government (OEDIT), nonprofit organizations and banking sector etc. The mission is to pool resources from different sectors to help with the development of microenterprises and facilitate networking. CAMI also manages Colorado Capital Access Program, which provides business capital to small and micro businesses that are unable to draw traditional financial sources (www.coloradoalliance.org).

b. Attracting firms from outside

Different areas in Colorado can have slight different plans for business retention and attraction. For example, in Colorado Springs, an Urban Enterprise Zone and a Foreign Trade Zone has been established. Tax incentives are offered to company relocation and expansion (www.city-data.com).

c. Industry oriented support

For biotech industry, the Colorado Office of Economic Development and International Trade (OEDIT) released in March 2003 an Action Plan to Grow Colorado's Bioscience Cluster, which encompasses three strategies and eighteen action items. The three strategies include creation of business climate and bioscience entrepreneurial culture that encourage commercialization of technology, and expansion of research base and construction of research excellent. Implementation progress was tracked regularly during 2003-2004 and resulted in an updated Action Plan (Bioplan2004).

Government's focus on bioscience industry was strengthened by the appointment of a Director for Biosciences and Emerging Technologies Initiative under the Governor's Office of Economic Development and International Trade (OEDIT).

The government also offers Biotechnology Sales and Use-tax refunds to purchasing of equipments for research and development of biotechnology (www.advancecolorado.com).

3.2.7 Promoting entrepreneurial environment and networking

a. Cluster organizations and supporting intermediaries

In order to maximized business supports from different actors such as government, chamber of commerce, trade associations, economic development organizations etc., the Colorado Economic Development Commission (EDC), the Office of Economic Development and International Trade (OEDIT) and the University of

Colorado at Denver and Health Science Center (UCDHSC) jointly established the Advance Colorado Center (ACC) as a means to support non-profit organizations that serve and support industrial in Colorado. ACC provides common headquarter and logistic support for industry supporting non-profit organizations. Colorado BioScience Association and Colorado Photonics Industry Association are among the nine organizations presently settled in ACC. Tenants in ACC not only share space and meeting facilities but also share some common partnership and linkage. What is more important is the atmosphere that bolsters all kinds of initiatives (www.advancecoloradocenter.com).

OED also works with CBSA and other industrial organizations to promote Colorado's bioscience industry to the nation as well as to the world. Through these events, OED has tried to increase government's visibility in many important industrial events. (Bioplan2004).

b. Business and legal environment

Government together with the industry representatives such as CBSA reviewed state Medicaid policies relating to pharmaceuticals to ensure that these policies don't discourage the growth of bioscience industry in Colorado. Efforts were also made to strengthen intellectual property law enforcement (Bioplan2004).

3.3 Ottawa Case

3.3.1 Brief Description of Ottawa photonics and biotech industries

Ottawa, the capital city Canada's, is the country's technology and business center. Ottawa has a high concentration of research institutes and is well known for its highly educated talents. It is also competitive in attracting venture capital. Photonics and biotech industries have been regarded as emerging industries in Ottawa.

Photonics industry

Significant photonics clusters have formed in Canada. Ottawa is recognized as the most active one among the top fives photonics clusters. (www.nrc-cnrc.gc.ca). Ottawa's photonics cluster is led by two large anchor companies, JDS Uniphase and Nortel Networks(www.nrc-cnrc.gc.ca). The cluster has over 60 firms plus a number of start-ups (www.ottawaregion.com).

Biotech industry

Diosi & Dalpe(2002) conducted a study about Montreal and Ottawa's biotech industry. The study compared these two regions' biotech industry in number and size of firms, venture capital available etc. and concluded that Ottawa was not yet a national system of innovation either in biotech or pharmaceuticals. Only one year later, According to Ottawa Life Sciences Council (OLSC), by May 2003,Ottawa life science industry was already the third largest in Canada. The industry had double its biotech companies in the last 6 years to over 110, with more than 4,000 employee

(BioNes Ottawa,May 2003). By now, Ottawa has over 140 life sciences companies, and more than 40 research institutions and centers. Eight to ten spin-offs emerged every year,(http://www.olsc.ca/ottawa/ottawa.html).

3.3.2 Government in infrastructure creation

a. Physical infrastructure

The city of Ottawa identified infrastructure priorities such as rapid transit etc. in its plan. Ottawa also try to draw investment from different level of government for its physical infrastructure construction. For example, in 2003, the city successfully drew $12 billion investment from the federal government, alone with contributions from the province of Ontario for the expansion project of Ottawa Congress Center. After the expansion, Ottawa Congress Center became the fourth largest convention center in Canada, greatly improving Ottawa's business environment (www.greaterottawachamber.com).

b. Science & technology infrastructure

Canadian government has been actively engaged in science and technology infrastructure creation. The Canada Foundation for Innovation (CFI) founded by the federal government is the main actor in infrastructure construction. The Foundation adopts a flexible multi-channel financing mechanism to incorporate efforts from different stakeholders. To be specific, for each project, CFI normally contributes 40% of the budget, while the remainder comes from provincial agencies and industry. In photonics, CFI has contributed to the construction of many research facilities. At regional level, Ontario Research and Development Challenge Fund (ORDCF) carried out similar activities as OEDCF do and actively engaged in the creation of research facilities (Smy,2002).

For photonics industry, Centers of Excellent created include:

- Canadian Institute for Photonic Innovations (CIPI): a national Centres of Excellence.
- Canadian Institute for Telecommunications Research (CITR) and Micronet
- Photonics Research Ontario(PRO): one of the five Ontario Centres of Excellence
- Communications and Information Technology Ontario (CITO): also one of Ontario's Centres of Excellence that include photonics industry into its supporting scope.

For biotech industry, science & technology infrastructure is combined with industrial infrastructure, as will describe below.

c. Industrial infrastructure

In biotech industry, one effort of government in industrial infrastructure construction is the consistent supports to the development of Ottawa Biotechnology Incubation Centre(OBIC),an spin-off of Ottawa Life Science Centre (OLSC). These include a grant of $5.4 million under the Biotechnology Commercialization Centres

Fund (BCCF) offered by the Province of Ontario in 2003 for the construction of a Biotechnology Commercialization Centre. The rest of the total $12 million investment came from bank loan and other sources. OBIC focuses on providing commercialization guidance and business services to startups. (http://www.obic.ca)

3.3.3 Government in knowledge creation

a. R&D activities

In Canada, research is regarded as the propeller for industry advancement and receives strong government support. Main government actors include National Science and Engineering Research Council (NSERC) etc. Government support not only goes to basic science but also to applied research. National Research Council's Industrial Research Assistance Program (IRAP) supports innovation of SMEs, and PRO's research support program (www.ottawa.ca).

The federal Scientific Research and Experimental Development Tax Credits (SR&ED) provide tax break to companies undertaking R&D activities (www.ottawacapitalnetwork.com). Besides this, the province of Ontario offers a number of additional tax incentives and R&D support programs. For example, Ontario Research Employee Stock Option Credit. Another tax incentive is that for the SR&ED federal investment tax credits earned in Ontario, the province also exempt its regional income tax. For more information about Ontario's R&D tax incentives, see Ontario's government website (http://www.2ontario.com/facts/fact11.asp).

Other government research funds include Industrial Research Assistant Program, Technology Partnership Program etc.

b. Technology transfer

The Research Partnership Program is launched to promote industry-research connection. Co-financing mechanism is adopted to draw investments from the industry (Smy, 2002).

Many Centers of Excellent, for example the Communications Research Center, have undergone technology transfer activities and created relevant office to promote technology transfer.

c. Research-industry cooperation

Industry-focused Center of Excellences or laboratories at national and provincial level have played an important role in promoting research-cooperation. In photonics, industry-focused Center of Excellences or laboratories at national and provincial level have been created, mostly with the technical support from universities. NCEs mainly conduct industry-focused research, training of highly qualified personnel and transfer of technologies. Their financial sources mainly come from provincial government, industrial contribution and incomes from commercialization of intellectual properties. Funds are provided to encourage interdisciplinary research with the collaboration of industry and research circles (Smy, 2002).

Tax incentives are provided to encourage industry-research collaboration. For example, Ontario Business-Research Institute Tax Credit (OBRITC) rewards contract R&D performed by eligible research institutes in Ontario (www.2ontario.com).

3.3.4 Government in human resources creation

a. Workforce attraction & retention

The city support OCRI and other non-profit organization's effort to promote Ottawa as an ideal place for business, talent and investment (www.ottawa.ca).

Ottawa has also worked a 2020 Talent Plan to create a workforce infrastructure that is regarded as important as physical infrastructure to the city's development (www.ottawa.ca).

b. Industry oriented education and training programs

The Canada Millennium Scholarship Foundation was founded in 1998 with a $2.5 billion fund aiming at providing 100,000 scholarships each year for post-secondary studies. Each province has also similar initiatives to help expend university and college enrollments in disciplines relevant to promising and growing industries such as photonics industry (Smy, 2002).

Government and public sector support different kinds of industrial training programs. For example, The Ontario Ministry of Economic Development and Trade (MEDT) jointed hands with private sector to co-financed the Photonics Technicians and Technologist Diploma program operated by Photonics Research Ontario(PRO) in cooperation with Ontario communicy colleges. This pilot project started in 2001 with the collaboration of Algonquin College and Niagara College. Industrial partners such as Photonics Industry Advisory Group (PIAG) and Joint Photonics Project Team (JPPT) help to guide the design of curriculum to meet industrial need. Furthermore, the Ontario Photonics Education and Training Association (OPETA) was formed in 2001 to bring together various stakeholders in photonics to better coordinate the overall efforts for photonics education in Ontario (Nantel & Beda, 2001)

The city's Economic Development Office also supports the efforts of Ottawa Center of Research and Innovation, Ottawa Life Science Council etc. in delivering entrepreneurship and industry oriented training and education programs and initiatives (www.ottawa.ca).

3.3.5 Government in capital resources creation

a. Different stage financial needs

An Ottawa Capital Network was created by OCRI (Ottawa Centre of Research and Innovation), a government supported nonprofit organization, to promote the efficiency of Ottawa's capital market by linking investment communities and providing support to business communities. The network offers business consultation including financing, accounting, legal consultations etc. It also organizes events such as venture capital fairs etc.(www.ottawacapitalnetwork.com). Other cluster organizations also provide networking or information service to enterprises regarding capital sources for different stage development. Government's role is mainly in offering information or service assistant to these activities.

Government's financing sources for enterprises' different stage needs include:

- Business Development Bank of Canada is a federal vehicle in providing financial support for SMEs, including venture loans, venture capital, working capital etc.
- Canadian Small Business Financing Program
- Enterprises can also apply to Funds for R&D, export and other purposes.

For biotech industry, the Ottawa Biotechnology Innovation Fund is a community investment fund jointly sponsored by the University of Ottawa and venture capital firm Genesys Capital Partners Inc. It provides early-stage funding for biotech companies in Ottawa region.

b. Venture capital

Research shows that Ottawa is a favorite place for venture capital. The government's role in it seems to be indirect. For example, the public-private partnership organization Ottawa Center for Research and Innovation monitors venture capital activities in several clusters and provide information for enterprises. The annual Ottawa Venture Capital Fair is a collaboration activities with the participation of public and private stakeholders.

3.3.6 Firm and industry oriented support

a. SME support

National Research Council's Industrial Research Assistance Program (IRAP) supports innovation of SMEs. Other government's support of SME seems to be through other indirect programs, for example, the business support from OCRI's entrepreneurship Center etc. or the financing programs for small business, as mentioned in 3.3.5

b. Attracting firms from outside

Not special policy is observed to attract firms from outside. However, the government has endeavored to promote the business environment in Ottawa. For example, government has co-sponsored the creation of Entrepreneur Center, which provides various kinds of services to enterprises. These efforts also contribute to the attraction of Ottawa as a business place.

c. Industry oriented support

Ottawa released in 2003 the Economic Strategic aiming at boosting the city's economy and competitiveness through synergies of public and private efforts. The Economic Strategic defined industry cluster as "an export-oriented group of businesses and their supply chain, including research and development. Industry clusters generate most of a city's wealth". The Strategic classified four types of clusters in Ottawa, namely expanding, transforming, emerging, and seed clusters. Photonics and life science are identified as emerging clusters, which feature high growth yet low employment concentration for the moment (www.ottawa.ca).

3.3.7 Promoting entrepreneurial environment and networking

a. Cluster organizations and supporting intermediaries

The provincial cluster organization Ontoria Photonics Consortium is partly financed by Ontario Research and Development Challenge Fund (ORDCF) and its industrial partners. ORC has close partnership with Ontario's universities for research in photonics.

In photonics industry, government also forms close partnership with cluster organizations such as Canadian Photonics Consortium (CPC), Ontario Photonics Technologies Industry Cluster, Ottawa Photonics Cluster etc. in strategic planning and industry promotion activities. One example is the initiative launched by the Canadian Photonics Consortium (CPC) in collaboration with government, industry, research circles and other stakeholders to develop a Photonics Technology Roadmap (PTRM) that aimed at guiding the way for Canadian photonics industry to succeed in the world market (Smy,2002).

b. Business and legal environment

3.4 Policy instruments used in best practices

Policy areas	Policy instruments (+ estimated intensity and diversity)		
	San Diego	**Colorado**	**Ottawa**
1. Infrastructure:			
a. Physical infrastructure	-Direct investment Intensity: moderate Diversity: diverse	-Fund Intensity: moderate Diversity: moderate	-Planning -Fund Intensity: intense Diverse: diverse (national, regional)
b. Science & technology infrastructure	-Fund/grant (some are co-financing) Intensity: moderate Diversity: moderate	(For both **photonics and biotech**) -Fund/grant Intensity: intense Diversity: diverse	(For both **photonics & biotech**) -Fund/Grant Intensity: intense Diversity: diverse (national, regional)
c. Industrial infrastructure	-Guideline Intensity: moderate Diversity: diverse	**General:** -Direct investment Intensity: moderate **Biotech** industry**:** -Planning -Direct investment Intensity: intense Diversity: diverse	**Biotech** industry: -Grant Intensity: moderate
2. Knowledge:			
a. R&D activities	-Fund/grant Intensity: intense Diversity: diverse (national, local)	-Fund Intensity: intense Diversity: diverse (national, regional)	-Fund -Tax incentive Intensity: intense Diversity: diverse (national, local)
b. Technology transfer	-Grant -Delegation Intensity: moderate Diversity: moderate	-Fund -Demonstration Intensity: intense Diversity: diverse	-Fund -Service (indirect) Intensity: moderate Diverse: diverse
c. Research Industry cooperation	-Fund -Information/service Intensity: moderate Diversity: diverse	(Efforts focus on technology transfer)	-Fund -Tax incentive Intensity: intense Diversity: diverse
3. Human resources			
a. Workforce	-Fund Intensity: moderate Diversity: moderate	-Fund Intensity: moderate Diversity: moderate (More on biotech industry)	-Planning -Information/service Intensity: moderate Diversity: moderate

b. Industry specific training programs	-Fund Intensity: moderate Diversity: moderate	-Grant Intensity: moderate Diversity: moderate (some indirect)	-Fund (some are co-financing) Intensity: intense Diversity: diverse (national, provincial)
4. Capital resources:			
a. Available of funds for different stage needs.	-Loan -Fund Intensity: intense Diverse: diverse	-Loan -Information/service Intensity: moderate Diverse: moderate	-Fund (though public organizations) -Information/service Intensity: intense Diversity: diverse
b. Venture capital	-Information/service Indirect	-Fund Intensity: moderate	Indirect
5. Firm and industry oriented support			
a. SME support	-Fund/Grant -Information/service -Delegation Intensity: intense Diversity: diverse	-Fund (co-financing) -Information/service Intensity: intense Diversity: diverse	-Fund -Information/service Intensity: moderate Diverse: mostly indirect
b. Attracting firms from outside	-Financial incentive -Information/Service Intensity: moderate Diversity: diverse	-Tax incentive etc. Intensity: moderate Diversity: diverse	Indirect
c. Industry oriented support	-Planning -Promotion Intensity: moderate Diversity: diverse	For **biotech** industry -Planning -Tax incentive -Promotion Intensity: moderate Diversity: diverse	-Planning (general)
6. Entrepreneurial environment and networking			
a. Cluster organizations and supporting intermediaries	-Fund Intensity: moderate -Information/service Intensity: intense Diversity: diverse	-Fund -Information Intensity: intense Diversity: diverse	-Information/service For **photonics** -Fund/grant Intensity: moderate Diversity: diverse
c. Business and legal environment		Regulation	

The table shows that in all the best practices studied, governments have taken proactive attitude toward promoting ideal environment for cluster growth. However, different places may have different emphases according to local context. For example, San Diego has been prominent in supporting SME. Colorado and Ottawa are keen at creating science & technology facilities. Ottawa is also distinct in supporting industry oriented secondary education and training etc.

Below lists some general observations of best practices:

a. Direct targeting policies are seldom used for selected industries. Government's efforts are more concentrated on improving the general factor conditions and business environment.
b. Information/service is widely used as policy means in best practices. This may reflect governments' close relationship with other stakeholders in successful clusters. Government's participation in various forms of cluster activities also promotes information exchange and sharing, which is of special importance in cluster development.
c. Funds as a policy instrument is widely used in areas where there is great public benefit or market failure exist, for example, in support R&D, or supporting early-stage enterprises' financial needs. In areas where market can play its role, government funding is not necessary, for example, in matured venture capital market.
d. Best practices synthesize government efforts from different level to promote cluster development. Besides local effort, national support is also important for cluster development, especially in supporting knowledge creation.
e. In places where both photonics and biotech industries are identified as emerging clusters, governments don't take the same actions for both industries, but apply different policy instruments according to different industry's development need.

From the best practice, we can also see that in well-established clusters, such as San Diego biotech cluster, other actors grow and take initiative to play important roles in the cluster, overshadowing governments' role. But this doesn't mean that governments withdraw their support.

More detail comparison of government efforts between best practices as well as Xiamen situation will be given in Chapter 5

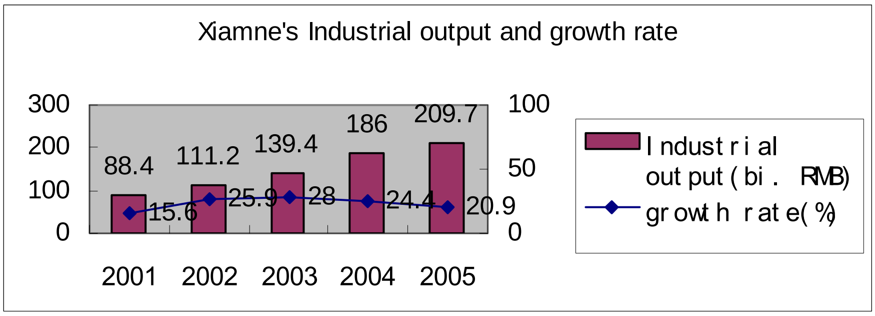
Chapter 4. An analysis of Xiamen case

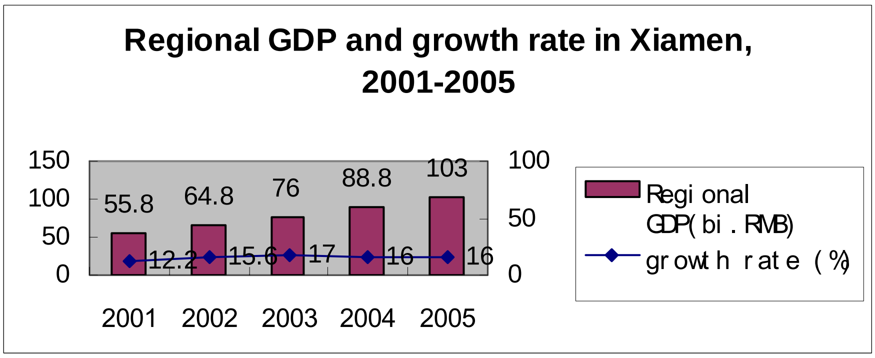
Xiamen, a coastal city in the southeastern part of China, is one of the five Special Economic Zones (SEZs) in China. Since the establishment of Xiamen SEZ in 1980, Xiamen has been a pioneer and leader in the province' s economic development. Its economic momentum radiates to and influences the neighboring regions. Over the years, Xiamen has taken the advantage of SEZ status to adopt preferential policies to attract foreign investment. The top three pillar industries, electronics, machinery and chemicals have sustained fast growth rate in the past years. In spite of this progress, Xiamen also recognizes the importance of innovation and seeks to cultivate new economic drivers to maintain its sustainable economic growth and improve its comprehensive competitiveness. Three emerging industries in the high-tech area have been identified and given special priority. These three emerging industries are: photoelectronic, biotech-pharmaceutical, and software industry. Initiatives had been made by the government to promote the growth of these industries. This chapter will analyze government's effort in promoting two of the emerging industries, the photonics and biotech industries. The writing will follow the checklist. But different from best practice analysis, in this chapter for each checklist points, a brief account of local situation may be added before describing government's role and policies. The purpose is to take into account local context in the policy analysis. Appendix 3 provides background information about China's innovation system and more information about Xiamen case.

4.1 Industrial structure and the emerging industries in Xiamen

4.1.1 Economy and industrial structure

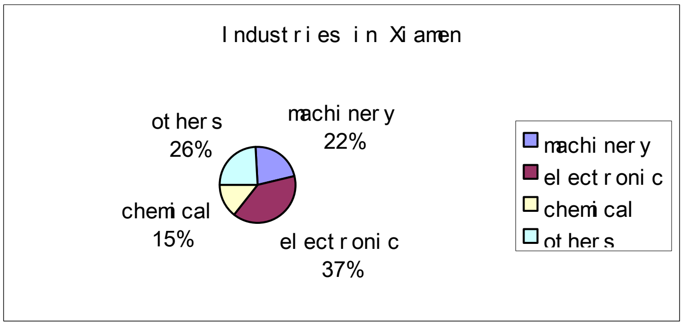
Like the province, Xiamen had fairly backward industrial foundation during the 1950s-1970s. The inflow of foreign direct investment (FDI) since the establishment of Xiamen SEZ in 1980 has greatly spurred the local economic development. By the end of 2004, industrial output from foreign invested enterprises had accounted for about 85% of the city's total. Thirty-five Fortune 500 companies have set up operations in Xiamen, including high-tech companies such as Dell, Kodak, ABB, Panasonic, Phillips etc. The city's economic is also highly export-oriented. According to Xiamen's Statistical Communiqués on Regional Economy and Social develop in 2005, the three pillar industries, namely machinery, electronics and chemical industry, have a total output of 153.49 billion RMB, contributing to 75.7% of the city's scaled industrial output. Industrial output from 72 key high-tech enterprises reached 112 billion RMB, accounting for 55.3% of the total output, a 24.7% increase compared with previous year.





(source: Xiamen statistical communiqués on national economy and social develop, 2005)

The three pillar industries have significantly propelled Xiamen' s economic development. Their contribution to the city' the s total industrial output in 2004 is shown below, data came from Xiamen Economic Development Bureau:



Centered on these three pillar industries, the city's Economic Development Bureau identified 11 industry clusters. Besides these 11 clusters, five traditional industry clusters and two emerging high-tech industry clusters were also identified. The below table shows these 18 clusters:

Industry clusters	**Percentage of industrial output(%)**
Machinery and metallurgy (6)	
1. Engineering machinery	2.79
2. Switch gear and controlling equipment	5.16
3. Automobile manufacturing	3.85
4. Ship building and repair, and supporting	0.43

service	
5. Aircraft maintenance	0.64
6. Tungsten and deep processing	1.72
Information and Communications (3)	
1. Mobile communications	6.22
2. Computer and its peripherals	18.23
3. Digital audio and video products	6.05
Petrol and chemical (2)	
Fine chemical	3.16
Chemical and chemical fiber	11.97
High-tech	
Biotech and new pharmaceutical	0.64
Photonics	0.73
Traditional industry (5)	
Food processing	5.16
Printing and packaging	3.64
Textile and garment	4.25
Shoe leather & products	1.52
Construction materials	1.7

These 18 industry clusters realized a total industrial output of 128.3 billion RMB, accounting for 74.2% of the city' s total.

(source: Xiamen Economic Development Bureau, www.xmjfj.gov.cn)

Emerging high-tech industry clusters

Xiamen' s economic is to a large extent driven by its three pillar industries. To look for new economic drivers and innovation poles, the municipality has identified several emerging high-tech industries in its Implementation Outline for Accelerating the Development of Big Xiamen Area. These emerging high-tech industries include photonics, biotech and new pharmacy, software, scientific instruments and apparatus. Priorities will be given to these areas. An office for the emerging industries was set up in 2003. The office was attached to Xiamen Science & Technology Bureau and mainly responsible for attracting investments from outside. Surveys of these industries were conducted in order to understand the current situation and discover the potential of these industries. Relevant experts groups were also set up to draft long-term development plans and give guidance to the implementation of the plan. An Investment Guide to the Emerging Industries in Xiamen was also compiled. Since then, some government initiatives have been launched to foster the growth of these emerging clusters.

4.1.2 Photonics industry

International and national context

It has been widely recognized that photonics industry holds great promises for the future. As an emerging industry, the gap between developed countries and some developing countries is narrower. Even though the United State, EU and Japan are currently the world leader and most of the core technologies and patents are in the hands of these countries, the fast evolving technologies and the emergence of new breakthroughs offer new opportunities for other countries to catch up. For example Taiwan and Korea has made great progress in photonics industry in the recent years and became big producers in the world. Due to the above reasons, China has attached strategic importance to the development of photonics industry, especially in the development of solid-state lighting industry. The central government has orchestrated and coordinated the national efforts to develop the photonics industry. The National support of the photonics industry includes general R&D programs such as National Basic Research Program and the Torch High- tech Industry Program. Industry specific programs include National Photonics Industrialization Plan, Photonics Key Project and Key Products Program etc. In 2001, the first photonics valley was set up in Wuhan. Almost at the same time, some other regions with comparative photonics research and industrial strength established similar photonics industrial base or science parks. The Central government' s effort to promote the industry includes selecting demonstration projects and bases. As the result of the launching of Solid-state Lighting Engineering Programme by the Ministry of Science & Technology in 2003, Xiamen became one of the four cities in China that have been entitled as" the National Solid- state Lighting Industrialization Base" thanks to its fairly good photonics industry foundation (Xiamen Industrial Plan for Solid State Lighting).

Industry conditions and the industrial sturcture

In Xiamen, there are currently over 60 enterprises engaging in the manufacturing, R&D and related service of the photonics industry (news.xinhuanet.com). These enterprises were mostly established after 2000. They produce a wide range of products covering from optical display, optical storage, optical communication, input and output device, optical component and other photonics products (Xiamen Photonics Plan). Among them, optical display accounts for the largest proportion and maintains a strong growth momentum.

In solid state lighting, the industry covers the whole range of production chain ranging from epitaxial wafer and chip manufacturing, to packaging and application (www.fjtv.net).

Table: Distribution of Solid State Lighting Production Chain in Xiamen (source: www.china-led.net)

Upstream	Midstream	Downstream and application		
Epitaxial wafer	Chip	packaging	application	
AlGaInP	Red light Yellow light	Digit tube LED tube	Digital display	Electric appliances, automobile, light industry, tourism
			Backlight source	IT (mobile phone, computer）

		Chip LED	Landscape light	Landscape lighting project
			Digital microscope light	
GaN	Blue light Green light		Special working light Army light	
			display	

Though the production chain of solid state lighting industry in Xiamen ranges from upstream to midstream to downstream. There are still weaker links, mainly in the lack of application companies, despite the presence of dozens of LED application companies in the neighboring regions such as Zhangzhou. For example, Xiamen San-an Electronics, a market leader in upstream epitaxy and chip production, finds it difficult to find local packaging companies. 90% of its products are sold to midstream companies located along the Yangzi River Delta region and Pearl River Delta region. The general manager of Hualian Electronics, a large electronic packaging company in Xiamen, also expressed his opinion that more local application companies will provide larger market demand and thus will be beneficial to upstream and midstream companies in the region (www.fj.xinhuanet.com).

Photonics enterprises in Xiamen also show diversified ownerships. About one third of them are Taiwanese enterprises (news.xinhuanet.com). Foreign investment also accounts for a large portion. Among the world's three largest lighting groups, GE, Philips and Orsam, two have set up operations in Xiamen. One is Philips Lighting Electronics (Xiamen) Co., Ltd, which is a wholly owned subsidiary of Philips Group in China. Another is Xiamen Topstar Lighting Co. Ltd., a joint venture between GE, and two former SOEs and a Chinese research institute. There are also a considerable number of private-owned enterprises, some have grown into leading companies in the industry. For example, Xiamen Sanan Electronics Co.Ltd, a joint venture between SOE and POE, is now the biggest epitaxy and chip producer in China for high-end Ultra-bright LED.

The present of foreign investment in Xiamen is conducive in upgrading the industrial structure. Some joint ventures have helped transform SOEs into modern enterprises. Foreign investment also brought with it new technology and managerial experience to the local industry. For example, Philips has set up the Lighting Asia Pacific business center for electromagnetic ballasts in the Xiamen in 2003, which transformed its Xiamen company from pure manufacturing to an integration of manufacturing, R&D, marketing and logistic. Philips also planned to co-sponsor "Philips University" with Xiamen University and provide internship opportunities for related majors of Xiamen University (www.china.philips.com).

4.1.3 Biotech and Pharmaceutical industry

Industrial conditions

According the 2003 Development Plan, there are dozens of pharmaceutical companies in Xiamen, most of them are of small and medium sizes and scatter in different production categories. There is not much evident of supplier or customer relationship between the local companies, and formal alliance are difficult to form despite some occasional contact between companies. Among the companies there are about 10-20 biotech companies that have captured certain share in domestic or international market. These companies have diversified forms of ownership. The table below shows the ownership and products of the leading companies listed in the Development Plan.

Company	Ownership	products
Amoytop Biotech	Joint-stock company	Gene engineering drugs
Bioway Biotech	Corporation	Biotech drugs
InTec PRODUCTS	Foreign founded enterprise	Medical diagnostic products
Amplly Biotech	Private-owned enterprise	Gene diagnostic reagent
MCHEM Pharma Group	Private-owned group	Pharmaceutical ingredients and intermediates
Doingcom Chemical	Private-owned enterprise	Crude drugs, intermediates
Xingsha Pharmacy Group	Joint-stock company through M&A of SOE	Chemical drugs
Xiamen Chinese Mecicine	Joint venture through merger& acquision of SOE	Chinese medicine and biotech drug
Kingerway Vitamine	Joint-stock company	Vitamine
Top-point Pharma	Foreign founded Company	Health care products
Tianan Pharma	Private-owned enterprise	Health care products

4.2 Examining government's role and public policies in cluster promotion

4.2.1 Government in infrastructure creation.

a. Physical infrastructure

Before China's reform and opening up, Xiamen was a city with rather backward industry and poor infrastructure due to its location (see appendix 3). Since the establishment of SEZ, the government of Xiamen has realized the importance of good infrastructure to attracting investment and has strived hard to improve it. Significant improvement has been made, to name a few, Xiamen international airport links Xiamen to most of cities in China and 7 Asian cities. Xiamen Port is among the top ten seaports in China. Its container harbor ranked 7th in China and 23th in the world in 2005 (www.gx.xinhuanet.com). The city also strives to make it an attractive livable city in China. Over the years, Xiamen has won honors such as "National Sanitary City", "National Garden City", "National Model City for Environmental Protection" and "Excellent National Tourist City" and "one of the coziest cities in China"(www.xm.gov.cn).

b. Science & Technology infrastructure

Xiamen government has financially support local and state universities in Xiamen in the construction of their science & technology infrastructure. Take Xiamen University for example, in 2001, the university received 150 million RMB from local government as a support to its construction of University of Excellent. In 2006, the municipal government again will invest another 120 million RMB, mainly to help the construction of university’s Science Park, public technical and innovation platforms, as well as support of start-ups by university faculties and students etc.

For photonics industry, a public technical platform for solid state lighting has passed feasibility study and will be constructed in 2006. This technical platform aims to provide scientific testing facilities and other technical assistance services to enterprises, especially SMEs with the help of research institutes and universities from home and abroad. Joint marketing will be another emphasis of this platform (www.china-led.net).

Another public platform in biotechnology to be constructed in 2006 is the Xiamen Bio-medical Incubator. This platform’s operation and technical support will based on a government founded investment company and two biotech companies. Public research facilities, open laboratory, testing center as well as a mid-term trial workshop will be set up to serve biotech companies in Xiamen.

c. Industrial infrastructure

In Xiamen, government' s efforts to promote industry cluster and economic development include the creation of a number of science parks, incubators, high-tech parks and specialized industry zones. There are currently 14 industrial zones. Among them Xiamen Torch High- tech Industrial Zone is the most important one in promoting the city' s high- tech industries. Created in 1990 and benefited from both preferential policies entitle by the nation to National High-Tech Zones and to the Special Economic Zones, Xiamen High-Tech Zone has successfully attracted many international high-tech companies such as Dell, ABB, Panasonic etc. On the other hand, though Xiamen high tech zone has achieved the highest per square kilometer industrial output among the 53 national level high tech zones, it is the smallest one in terms of land area. To overcome the limited space constraint, the municipal government implemented in 1998 a strategy of constructing multiple parks under the Torch High-tech Zone umbrella. These "multiple parks" include a Software Park, a Biotech Park, an electronics Park, an incubator (Business Startup Park for Returned Chinese Scholars), and another general high-tech park. A photonics park is also under construction recently. Companies in these parks can enjoy the same preferential policies entitled to the Torch High-tech Zone.

For photonics industry, the government has recently founded some specialized industrial parks along side with the existing science parks, incubators and industrial zones to facilitate photonics industry development. There are Siming Photonics Park, Torch Photonics Park and the future Xiang'an Lighting Park.

4.2.2. Government in knowledge creation:

Current situation

Xiamen historically has a fairly solid science and technology foundation in the province. Xiamen University is the only national key university in the five Special Economic Zones. The university has a complete range of disciplines and is one of the best universities in China in the research of chemistry and oceanography. At present, the city has 120 scientific research institutes, two national-level key laboratories (three in the entire province), and five specialized ministerial-level key laboratories. This good number of scientific research institutes and higher- learning institutions has provided strong technical support to the city' s innovation system.

Like many places in China, Xiamen traditional is weak in technology commercialization.

Photonics

Xiamen has a fairly good research support for photonics. This support to a certain degree comes from Xiamen University which contains School of physics and mechanical and electrical engineering, the school of computer and the information engineering, etc. Other public research centers include Xiamen Photonics Engineering and Technology Research Center, Xiamen Engineering and Technology Center for Scientific Instruments. There are also a few research centers set up by enterprises, including San-U Optical, Mechanical and Electrical Technology Center etc. However, compared with some northern areas in China that are regarded as the centers for photonics research, Xiamen R&D capacity in photonics is insufficient (Xiamen Photonics Plan).

Biotech

Xiamen has fairly good basic research in biotechnology. It is one of the pioneering cities in China that launched marine biology research in the very early years. Leading universities and research institutions include:

1. Xiamen University: includes School of Life Science, Medical School, and School of Oceanography. Key laboratories include:
   - State key laboratory of Marine environmental science (one of the two state key laboratories in Xiamen)
   - Laboratory of Cell Biology and Tumor Cell Engineering, a key laboratory of the Ministry of Education
   - Fujian Provincial Key Laboratory for Chemical Biology
   - Fujian Provincial Research Center for Medical Molecular Virology
2. Jimei University: School of Bioengineering.
3. Third Oceanography Research Institute of State Oceanic Administration: include 2 key laboratories of SOA, one is China Ocean Bio-gene R&D and Marine

high-tech industrialization Base, the other one is the key laboratory of MarineBio Heredity Resources, led by an academician of CAE

4. There are also three marine and fisheries research institutes, two of provincial level and one of municipal level. Besides these, there is also one Municipal level medical research institute.

There is a group of biotech and pharma related top scientists in Xiamen. Among the 11 academicians in Xiamen, 7 of them are in chemistry, 3 in biology and biotechnology. They mostly lead key laboratories and aggregate around them research teams with strong research capability.

In contrast to Xiamen' strong research capacity in biotech, the commercialization rate for scientific achievements is still low (Xiamen Biotech Plan).

a. R&D activities

There are a number of scientific funds provided for R&D activities. State funds include National High-tech R&D Programme Fund (also name as “863” Fund), Basic Research Project Fund (so called “973” Fund), Scientific and Technological Innovation Fund for SMEs etc. These funds are important financial source for emerging technologies. According to statistics, by 2003, 16 out of the 21 bioengineering drugs that had been approved in China’s market had been supported by “863”Fund. Among them, all of the first-grade drugs were supported by “863” Fund (source: Xiamen Biotech Industry Development Plan). Due to its stronger research capacity, biotech industry in Xiamen receives more R&D funds then photonics industry

The city’s Science and Technology fund aims at supporting research and technological development.

To encourage R&D activities by enterprise, governments at national, provincial level and city level have certified and allocated special fund to support the establishment of technical centers or engineering centers by enterprises. Tax incentives are also offered to R&D activities in these certified technical centers.

In solid state lighting, certified provincial level enterprises technical centers include:

1. Topstar new technology center: An in-house laboratory is to be built in collobaration with National Quality Supervision and Testing Center for Electric Light Sources.
2. Hualian Electronics technology center: The R&D expenditure in 2004 accounted for 5.07% of the company’s sales revenue. A joint laboratory has been set up with Motorola for R&D of microcomputer controller.
3. San-an Electronics technology center: Set up by a non-state-run company San-an Electronics from the neighboring city Quanzhou. (www.china-led.net)

In biotech industry, there are 2 provincial level technical center and 4 municipal level technical centers. They also received government's finance support for the construction of these centers.

b. Technology transfer

There are relevant state, provincial and municipal policies on promoting science and technology transfer. These policies include allocating special funds for technology transfer, supporting the construction of local productivity center, high-tech incubator and other public agencies as well as nonprofit intermediaries to facilitate technology transfer. Tax incentives are also offered to qualified technology transfer projects.

The municipal Technology Innovation Fund supports enterprise's new product development and technology commercialization. It is open to universities, research institutions and all forms of companies, including foreign founded companies.

Technology transfer is also enhanced through various research-industry cooperation programs.

c. Research-industry cooperation

A special fund for industry-research cooperation projects has been set up in Xiamen. This special fund aims to promote the cooperation between enterprises, universities and research institutes, as well as the commercialization of technological achievements. The Fund is appropriated in the form of project fund or subsidize for loan interest. Projects should go in line with the city's preferential industrial structure.

Even though Xiamen's universities and research institutes have provided generous technological support to the local industry development. The local knowledge resources are still not sufficient to meet industrial needs, especially for the pillar industries and emerging high-tech industries. To address this problem, the city has strived to draw science and technology support from outside. In 2003, XIamen launched the Municipality-University Cooperation Program and Municipality-CAS Cooperation Program (CAS refers to Chinese Academy of Science, under which there are 108 research institutes, covering different disciplines and scatter across the country). These two programs aim at promoting cooperation between Xiamen's enterprises and outside universities or research institutes affiliated to CAS. Selected projects have the priority to win the support from the city's Science & Technology Innovation Fund. Whether a special fund should be set up for this purpose is still under government's consideration.

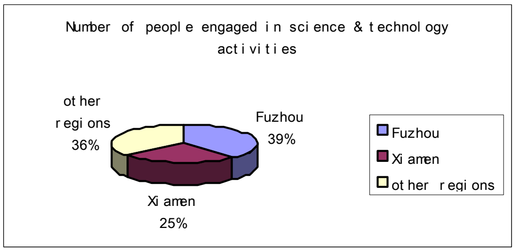
Another government effort to draw outside support is the construction of Xirmen CAS High-tech Industrialization Base in 2004. The base will serve as an incubator and industrial park that provide public facilities for the industrialization of high-tech projects.

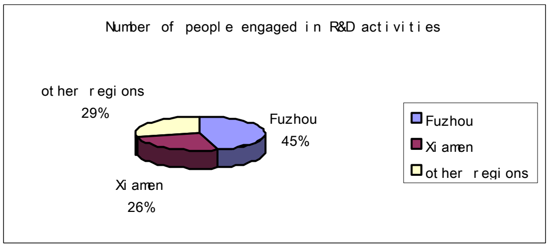
The Xiamen government also tries to promote industry and research linkage through cooperation projects. Co-financing of industry-research cooperation projects are especially encouraged. An example of government-university-industry cooperation is the Laboratory of Cell Biology and Tumor Cell Engineering of Xiamen University, which is entitled as Bioengineering Technical Center by the municipal government. The laboratory has successfully set up a joint laboratory with the investment from Yangshengtang Group, a biotech company from other province. The recent joint project with the local government is the construction of Public New Drug Research Platform for Virus Disease. Derived from the public platform, a Diagnose Agent and Vaccine Engineering Center was upgraded to national level Engineering Center in January 2006 (www.med66.com).

4.2.3 Government in human resources creation

Current situation

By the end of 2005, Xiamen has 12 general higher-learning institutions, 33 vocational schools, 6 technical school and 158 adult higher-education institutions. Among them, Xiamen University is a key university under the Ministry of Education, while Jimei University is a provincial University. In terms of the number of people engaged in science and technology related activities, Xiamen has a high concentration of talent in the province. Together with Fuzhou, the number of people engaged in science & technology activities in these two areas account for over 60% of the province' s total.





(www.stats-fj.gov.cn)

Xiamen has good biotech education foundation. The discipline of biology and the discipline of life science of Xiamen University are two of the five disciplines in the university that have been designated by the state as “national educational centers for talents” (the other three are chemistry, economics and history). Xiamen University and Jimei University offer the city with higher education in biotechnology. In addition, the Third Institute of Oceanology, SOA also confer master and PhD degree in biotechnology and marine science.

The table below shows Xiamen’s demand and supply of newly graduates in 2005 (source: Xiamen Personnel Bureau).

	total	Masters graduate	Bachelors graduate	College graduate	Secondary specialized school graduate
Graduates originally from Xiamen*	10217	470	2072	3995	3680
Local demand	10599	1310	5496	2267	1526

*Graduates originally from Xiamen means that they can come back to work in Xiamen freely even if they study elsewhere, as they already have Xiamen's residence permit. This is an indicator used in China for talent demand and supply.

The table indicates that for bachelors and above degree, graduates originally from Xiamen of the year couldn't meet local demand, while there was a surplus of college and secondary specialized school graduates. This surplus may be explained by the job preference of these local graduates. Traditionally they are reluctant to work in SMEs located in the outskirt of the city (www.gisforum.net).

According to data from Xiamen Personnel Bureau, Demand of masters and above degree fell short of especially in areas such as computer, electronic, automation, machinery, construction, communication engineering, biology, chemical, clinical medical science. While demand for bachelors degree fell short of in materials, machinery, electric, electronic, photonics, logistic, communication engineering, civil engineering, accounting, trade, marketing, tourism, clinical medical science, computer etc. (www.gisforum.net).

Another challenge is the labor shortage that occurred and accelerated in the recent years. With the upgrading of industrial structure in China, coastal regions face increasing competition in attracting skilled labor. The Yangtze River Delta region around Shanghai has advantage over others, while SMEs were generally affected more (MOLSS, 2004). Data from Xiamen Labor and Social Security Bureau shows that the average wage for ordinary workers in early 2006 grew by 30% compared with the same period last year. Some higher-skilled labor jobs have more problems recruiting people.

a. Workforce attraction and retention

The fast high-tech industry development exerts pressure on Xiamen for high-level talents. To tackle this problem, several measures are adopted. For example, the city government has appointed some prominent experts in China as municipal's science and technology advisors. Currently there are 39 science and technology advisors, many of them are academician or top-level scientist in the related areas.

Another source of high-level talent is overseas Chinese scholars. In 2002, the

Municipal People's Congress ratified an incentive policy to encourage returned Chinese scholars to set up business in Xiamen. More over, a special Business Incubator for returned overseas Chinese scholars was also set up. Job fairs and other forms of promotion activities are also arranged.

As talent and labor mobility in China is still not very high under the current registered residence permit system (meaning that the residence permit is linked to a person's place of origin and the welfare he can enjoy). In Xiamen, special incentive policies are formulated to attract bachelor and above degree talents from outside. Returned overseas scholars can also enjoy local treatment.

b. Industry oriented education and training programs

There is so far not special training program organized from photonics and biotech industry. Government's effort in this regard seems to be little.

4.2.4 Government in capital resources creation

a. Different stage financial needs

Current situation

According to the banks in Xiamen, capital supply in Xiamen is comparatively ample in the recent years. While large enterprises have not much problem in capital supply, SMEs still have many difficulties. One hurdle to SME financing is the credit risk brought about by the lack of credit awareness or law awareness in a number of enterprises, especially SMEs in China. On the other hand, enterprises complain about sophisticated credit rating system by banks. In general, the capital market still lack diversified financial means in Xiamen. (www.zzcredit.gov.cn).

For biotech and pharmaceutical industry, companies in Xiamen mostly draw investment from private sector or foreign sector. While most of state owned enterprises have been restructured into joint-stock companies through merger & acquisition. Even though there are not listed biotech companies in Xiamen, some companies have listed companies as shareholders, or have affiliated listed companies. This partly helps quench the industry's thirst for capital when there is lack of venture capital. This situation is coincided with the national situation. As estimated, since China's recession into WTO, Joint-stock economic style in the pharmaceutical industry has risen significantly during the Tenth-Five-Year Plan period from 2000 to 2005. Merger & acquisition help domestic enterprises to fence off competitions from foreign companies. Statistics shows that during the first three quarters in 2004, there were over 40 big M&A cases in China (market.ccidnet.com).

Government's effort

To help enterprises, especially SMEs overcome the difficulties of finding financial sources for different stage needs, Xiamen government has tried to facilitate bank-enterprise cooperation by organizing forums and other activities (ww.smexm.gov.cn). Xiamen Science & Technology Bureau also signed MOUs with banks with an aim to provide more financial services to technical companies through the government-bank-enterprise cooperation (www.xmkjcg.gov.cn)

In Xiamen there are also a few number of start-ups founded by researcher or faculty members of universities and research institutes. For these companies, they may receive seed funds from two sources. One is the Incubator within the High-tech Zone. Another one is the Science Park of Xiamen University. At the science park, there are also policies to encourage researchers and students to set up technological companies (Report on the Construction of Xiamen University Science Park).

b. Venture capital

Current situation

By 2005 there were 5 venture capital companies in Xiamen with a total venture capital of slightly over 100 million RMB(Zhou,2005). Zhou's study of Xiamen's venture capital market revealed that Xiamen's venture capital development still lags behind, especially when compared with other SEZs. He attributed Xiamen's slow VC development to the following reasons:

1. Limited amount of venture funds, lack of diversified sources;
2. Defects in old economic system increase the risk of venture investment. These defects include lacking clear ownership in enterprises, less flexible management mechanism etc.;
3. Insufficient project supply, partly due to weak enterprise R&D capability;
4. Lack of financial agencies and other intermediate service providers;
5. Lack of highly qualified talents who can manage venture capital;
6. There is still not secondary stock market, making it difficult for venture capital to exit.

Government's effort

Xiamen has issued in 2001 a Provisional Regulations for Promoting the Development of Venture Investment to encourage venture capital development, even though the growth in the market is still slow. The Xiamen government also invested in 2000 to found Xiamen High-tech Venture Capital Company with a total capital investment of 30 million RMB. Almost at the same time, another venture capital company was founded by the government of Shenzhen, another SEZ in China. The Shenzhen company had a total capital of 700 million RMB, 500 million of which was invested by the government. Three years latter, Xiamen Venture Capital Company, after investing 26 million RMB in 7 projects, had only 4 million left, barely enough for one more project. While Shenzhen Venture Capital Company had invested in over 30 projects and improved its investment capacity to almost 3 billion RMB (www.zero2ipo.com.cn). This comparison partly revealed that government's effort in Xiamen to promote venture capital is still weak.

In short, the present local policy to address capital resources problem is still limited.

This may on the one hand due to the fact that capital market is more controlled by the central government, and local government has not authority to adopt many of the policies suggested by OECD to improve venture capital investment (see appendix 4). On the other hand, the imperfect market economic conditions increase the risk of investment.

4.2.5 Firms and industry oriented support

a. SME support

Xiamen SME service center is a public organization subordinated to Xiamen Economic Development Bureau. The center has presently over 2000 members and offers a wide variety of services to SMEs, including policy consultant, financing resources etc.

Several public funds are available for SMES:

State funds:

- Special Fund for SME development: aiming at supporting SMEs' new products development and application, technology innovation, specialization and cooperation with large enterprises etc.
- Technology innovation fund for technology-based SMEs
- SME International Market Development Fund
- Loan Interest Subsidy for Technology Renovation Projects.

SMEs are also eligible to several municipal funds such as Science & Technology fund, Technology innovation fund etc.

(Source: www.smexm.gov.cn)

b. Attracting firms from outside

Foreign direct investment has been an important stream in driving Xiamen's export-oriented economy. Xiamen's development has to a large extent benefited from the many preferential policies designated to attract foreign investment, among which tax incentives are the major means. For example, foreign founded production or high-tech enterprise can enjoy 5-year exemption and 2-year half-reduction of corporate income tax which normally is 15%. Tax rebates are awarded to encourage local purchasing and export etc. Other measures to attract foreign investment include offering land or factories with low cost in industrial zones etc.

In photonics industry, special efforts have been made to attract Taiwanese photonics companies, as Taiwan has been undergoing a fourth wave of shifting manufacturing industries from Taiwan to mainland China. Taiwanese invested companies in Xiamen enjoy the same status as foreign-funded companies and thus can enjoy preferential tax policies. A special incubator for Taiwanese has been set up by the government to facilitate Taiwanese investment. Government also jointly sponsors with Taiwan side the China Xiamen Machinery & Electronics Exhibition (CXMEE), a regular annual exhibition and the largest of its kind in China, during which the China (Xiamen) International Photonics Fair and Solid State Lighting

Forum has been held twice. Besides this, the local government also organized various forms of business promotion activities to attract Taiwan investment in photonics industry. By now, two of Taiwan's five big LED panel manufacturers, the AU Optronics Corp. (AUO) and Chunghwa Picture Tubes Ltd.(CPT) have invested in Xiamen. The other three also have some linkage with Xiamen. For example, Chi Mei Cooperation is one of the main supplier of XOCECO in Xiamen(xpho4). Other big investors from outside include Intex Photonics from Taiwan, Jinboli Photonics from Kongkong etc. (www.china-led.net)

c. Industry oriented support

For photonics industry, a Development Plan for Xiamen's Photonics Industry and Development Plan for Xiamen Solid State Lighting Industrialization Base were drafted in 2004.

Since 2003, Xiamen municipal government has strived hard to foster the development of its photonics industry, especially for the solid state light industry. Efforts include the establishment of Xiamen Office for Emerging Industries, Xiamen LED Promotion Center, and LED Experts Consulting Committee.

Government also supports the photonics industry by sponsoring various exhibitions and fairs. As mention before.

There is not special preferential policy specifically for biotech industry or photonics industry. Both industries are regarded as a high-tech industry and thus are eligible to generally preferential policy for the promotion of high-tech industry. However, the industries do received favorable financial support from central, provincial and local government mainly through the form of supporting key projects. The central level support is mainly oriented to specific projects and firms showing good development prospect, such as State Key High-tech Industrialization Project. For example, Amoytop Biotech, a gene engineering biotech company, has received 10 million RMB project support from State Development and Reform Commission(SDRC) to build an international production base for gene engineering protein drugs. This seed money also induced the company to invest over 100 million RMB in four years to strengthen its R&D and expand its production. There are also other projects in Xiamen that have been listed as High-Tech Industrialization Demonstration Projects by SDRC, the former State Planning Commission(XB8).

Solid state lighting demonstration projects

The solid state lighting demonstration projects launched by the government in the recent years has been consider quite successful and worth specially mention about.

Xiamen started the LED Night View Demonstration Projects in 2005. Since then, several public demonstration projects have been implemented with a total public investment of near 120 million RMB to decorate busy districts with over 300 kinds of energy saving LED lights (www.china-led.net). In the implementation of these night view projects, a Xiamen LED Demonstration Experts Group was set up. The Experts Group was made up of 13 experts from different professionals: optic, photonics, semiconductor, lighting, architecture design, construction, inspection etc. Two technical and quality control documents were drafted, one was the Technical Specifications for Solid State Lighting Components and Devices used in Xiamen Night View Projects, another one was Technical and Quality Requirements for Acceptance of Xiamen Night View Project. Through these two documents, enterprises were stimulated to maintain or upgrade their technical standard and keep quality high. Some enterprises from the nearby Quanzhou and Zhangzhou regions also participated (www.straitsfair.org.cn). The implementation of these Night View projects has promoted the cooperation and exchange among photonics companies in Xiamen. Moreover, the demonstration project also drew the attention of Beijing 2008 Olympic Organizing Committee. In May 2006, two teams from the committee accompanied by the National Semiconductor Projects Office and National Solid State Lighting Association visited Xiamen separately. Xiamen's experience in Night View Demonstration Project has been seen as valuable and useful for the 2008 Olympic lighting project. Xiamen enterprises' technical and production capacity was also recognized, inspiring them to participated in the 2008 Beijing Olympic project (www.csnn.com.cn).

For biotech industry, a Development Plan for Biotechnology and Pharmaceutical Industry was drafted in 2003. The Development Plan analyzed the current situation of biotech and pharmaceutical industry in Xiamen. It also identified priorities areas where there were already present of considerable local strength, for example, the production of some gene diagnostic reagents, gene interferon etc.

4.2.6 Promoting entrepreneurial environment and networking

a. Cluster organizations and supporting intermediaries

Current situation

Incomplete statistics shows that by the end of 2004, Xirmen has 64 industrial associations, 149 societies and 523 other kinds of intermediate agencies. Among them there are 23 accounting firms, 12 asset appraisal services, 15 tax consulting firms and 6 patent agencies (csnn.com.cn). However, the role of these industrial associations and intermediate agencies is still far from satisfactory. This may be attributed to the following reasons: The first one is the institutional and organizational defect under the influence of planned economic. Many intermediate organizations still have very close tie with the government and lack independency. The second one has to do with weak self-discipline and lack of regulations to organizational behaviors. The third one is the insufficient of professional working for cluster organizations.

Government's effort

To encourage the development of science and technology intermediate agencies, a special fund has been set up by the government, providing subsidy to science & technology intermediate agencies. The subsidy doesn't specify the purpose of use.

Xiamen Photonics Industrial Association was founded in 2003 with the support of the government. The association currently shares the same staffs with Xiamen LED Promotion Center, which is a public organization under the supervision of Xiamen Science & Technology Bureau. Government also organized some photonics promotion activitives with the help of the association.

For biotech industry, a Chemical and Pharmaceutical Association was set up in 2001, but there are very few activities organized by the association (Xiamen Biotech Industry Development Plan). Government support for this association is indiscernible.

b. Business and legal environment

Current situation

Transformed from planned economic, China's market economic system still has some defect, especially in the lack of fair competition protection. On the other hand, there is still influence of planned economy that discouraged entrepreneurship. There are some studies about the influence of Chinese culture to entrepreneurship. Negative factors include traditionally looking down on commerce, while favoring stability etc. (www.continuinged.ku.edu).

Government's effort

China has one Anti-Unfair Competition law issued in 1993 but the law enforcement is rather questionable, leading to more and more cries for market order. An improvement is that an Anti-Monopoly law has been drafted and is expected to be ratified and released by the People's Congress this year (www.news.xinhuanet.com).

Government also offers legal help consultancy to companies involved in international trade dispute. An example is the story of Donglin Electronics, a privately owned manufacturer of energy saving lamps (compact fluorescent lamp, CFL). Donglin Electronics was established in 1995 with only 6 workers at the beginning. During the years, the industry went through three EU anti-dumping charges. The first one in 2000 led to a disastrous 66.1% anti-dumping duty on Chinese CFL companies, leaving half of them bankrupted (www.chinadaily.com). For the other two charges, the 2002 one was withdrawn by EU, while the investigation of the 2004 charge is still on. Each time Donglin Electronics was among the few Chinese CFL companies that responded to EU charges when many Chinese companies were still unfamiliar with anti-dumping issues. For each time, the local government as well as the Ministry of Commerce offer legal help and consultancy to Donglin and support its preparation for responding to the lawsuits. During the time, Donglin also won a yearlong dispute with Orsam over its trademark on illumination products after charging the German giant of bad-faith pre-emptive registration. The company also managed to grow rapidly. By 2005, Donglin had grown into a company of over 800 employees with annual sales income of over 100 million RMB. In 2006, the company invested 50 million RMB in constructing its own R&D center. By offer legal help and consultancy to companies, the local government also tried to promote the public's law and IPR protection awareness. (www.firefly-lighting.com).

4.3 Summary of Xiamen's emerging industries and government's policy instruments

Photonics and biotech industries in Xiamen are in different development stages

Data collected for Xiamen suggests that biotech industry in Xiamen is still in early infancy stage. Though biotech companies in Xiamen show little production chain interrelations, networking can help reduce enterprise's cost and risk by sharing of resources such as knowledge, talent pool etc.

Like biotech, photonics is an enabling technology that can bring about many new products and applications. However, in photonics industry there is often clear production chain relations. In Xiamen, the photonics industry has shown good signs of production chain and cluster forming.

Policy instruments adopted by the government

Policy areas	Policy instruments	Intensity	Diversity
1. Infrastructure:			
a. Physical infrastructure	Direct investment	Intense	Diverse
b. Science & technology infrastructure	Direct investment Fund	Moderate	Moderate (provincial, local)
c. Industrial infrastructure	Direct investment	Intense	Diverse
2. Knowledge:			
a. R&D activities	Fund/Grant Tax incentive Certification	Moderate (biotech receives more from nation)	Diverse (including national, provincial and municipal sources)
b. Technology transfer	Regulation Fund Tax incentive	Moderate	Diverse (national, provincial, municipal)
c. Research Industry cooperation	Fund Direct investment (in infrastructure)	Moderate	Diverse
3. Human resources			
a. Workforce attraction and retention	Subsidy Tax incentive	Intense	Diverse

	Information Promotion		
c. Industry oriented education and training programs	None in photonics and biotech industry		
4. Capital resources:			
a. Available of funds for different stage needs.	Fund Information	Moderate Moderate	Narrow
b. Venture capital	Fund Regulation	Weak	Narrow
5. Firm and industry oriented support			
a. SME support	Fund Information/service	Moderate	Diverse
b. Attracting firms from outside	Tax incentive Promotion Information/service	Intense	Diverse
c. Industry oriented support	**For phothonice industry:** Planning Promotion Demonstration Standard Public procurement *For biotech industry* Planning	Intense Weak	Diverse (national, local) Narrow
6. Entrepreneurial environment and networking			
a. Cluster organizations and supporting intermediaries	Guideline Fund *For photonics industry* Information Promotion *For biotech industry* None	 Weak Moderate Weak	 Narrow
c. Competition and legal environment	Regulation (law) *For photonics industry* Information and service	Moderate (not mature) Moderate	Narrow

Chapter 5 Comparison and learning

This chapter begins with comparing Xiamen case with the three chosen international best practice according to the checklist, then draws conclusions and identifies Xiamen's weak links in its cluster development. Finally, drawn on the comparison and conclusion, the writer proposals some recommendations for Xiamen.

5.1 Comparing Xiamen case with best practices

5.1.1 Government in infrastructure creation

Governments in the three best practice cases use direct investment or funding to support infrastructure creation. In physical infrastructure, government support usually goes to transportation or other infrastructure that can improve business environment. In science and technology infrastructure, creation of technical centers, centers of excellent or other forms of public R&D facilities are the common practices. This is especially the case for Colorado and Ottawa where there is intense government effort in supporting the creation of a number of photonics or biotech industry specific technical centers. There are also obvious synergic efforts from governments of different levels and sometime from private sector. In industrial infrastructure, business areas, industrial parks are the main areas of investment.

Compare with best practice cases, the government in Xiamen seems to be more keen on infrastructure construction. The government has invested heavy in physical infrastructure since the establishment of Xiamen SEZ, contributing greatly to Xiamen's becoming a hot attraction for foreign investment. In industrial infrastructure, Xiamen has set up a number of industrial zones and specialized industrial parks and has gained certain experience in operating them. For photonics and biotech industries, new industrial parks will be built too. Direct investment is the main instrument used by the government. Only in science and technology infrastructure is Xiamen lagged somewhat behind best practices, the construction of photonics and biotech industry specific public research platforms have just been approved and is to be constructed soon. Government many lack experience in running this kind of public facilities.

5.1.2 Government in Knowledge creation

All three best practice areas have good research capacity, yet all governments still exert intense efforts to support R&D activities, showing governments' long-term commitment to knowledge creation. Technology transfer and the promotion of research-industry relationship are closely related. In Colorado where technology commercialization was identified as a weaker link, government's effort is intense. Diverse means such as funding, demonstration are used. Ottawa also have fairly intense and diverse government effort in promoting research-industry relation, for example, the use of tax incentive. In San Diego, besides the use of grant/fund as a means to promote technology transfer and enhance research-industry relationship, government also frequently delegates the task to other public agencies or cluster organizations, thus exerting indirect influence on technology transfer. This may partly be explained by the fact that San Diego has rather strong cluster organization and supporting intermediaries that are able to facilitate technology transfer.

In Xiamen, diverse means such as funds, tax incentive etc. have been used to promote R&D activities as well as technology transfer and research-industry relationship. Efforts have also been made to encourage enterprise's R&D activities. However, government effort can be seen as moderate considering the intensity of financial support. Also should be taken into account is the traditionally weak enterprise's R&D capacity and weak research-industry cooperation, which requires more strong government efforts. On the other hand, unlike best practices, there are not many agencies in Xiamen that can assist government in promoting technology transfer.

5.1.3 Government in human resources creation

All three best practice places have good reputation for well-educated people. For workforce retention and attraction, the policy means of funding or providing information/service are moderately used by the government. Governments in all three places also provide financial support to diverse photonics and biotech industry specific education and training programs. Their efforts range from moderate to intense. Ottawa is especially prominent in consolidating efforts from national, provincial and municipal as well as from private sector to provide industry focus education and training programs.

Xiamen in general also has good educational foundation. However, the fast economic development demands more high-level talent supply. Compare with best practices, the government in Xiamen has exerted more intensive and diversified efforts to attract talents from outside, for example, to attract overseas Chinese scholars. Subsidy and tax incentives are used as policy means for talent attraction.

On the other hand, there are still not photonics or biotech industry focused educational or training programs, even thought companies may have some professional training for their own. There are also not government efforts observed to enhance training in these two industries. This is in stark contrast with best practices where there are a number of industry focus training programs and active government support.

5.1.4 Government in capital resources creation

All governments in three best practices areas are actively involved in addressing the problem of financing enterprise's different stage development. Besides the use of fund, public loan can also be used as a policy instrument. The government of San Diego and Ottawa are proactive in providing diverse programs to help enterprise of different sizes and at different stages. Colorado has slightly less intensive and diversified government programs comparing with the other two, but the government's effort is also obvious.

In places where there is ample venture capital investment, governments refrain themselves from direct intervention in venture capital market to avoid competing with private venture capitalist. This is the case for San Diego and Ottawa. Both are attractive places for venture investment. While Colorado use public fund as venture investment to help leverage the difference between demand and supply for SME's early-stage need. It is also observed that governments in best practices also actively provide information and services to help enterprises find proper financial sources.

Lack of multi-channel financial sources for enterprises is a weakness in Xiamen. However, compared with best practices, the intensity and diversity of fund and information service supports provided by the government is limited. Venture investment in Ximen is especially weak. There is also a lack of professional venture capital managers. Though the government has provided special fund as venture capital investment, the small amount of fund is not able to make significant changes.

5.1.5 Government in firms and industry oriented support

Governments in all three best practice cases have moderate to intensive, and diverse programs to support SME development, especially in the case of San Diego and Colorado. In San Diego, government not only provides fund and information/service to SMEs, but also extend the support through its partnership with public agencies, non-profit organizations etc. Compare with these two places, Ottawa's government support to SME is moderate and more indirect.

San Diego government is also more active in attracting firms from outside. Financial incentive as well as information/service are provided by the government as policy means to attract business from out side. Colorado also provides tax incentives to attract external business, while Ottawa's effort is indirect.

As to Industry oriented support, most governments in the best practices use planning and industry promotion support rather than financial instruments. Only Colorado offer limited tax incentive to its biotech industry.

Compare with best practice, Xiamen has attached much more attention to attracting firms from outside, mostly to attracting foreign investment since Xiamen became a Special Economic Zone in China. While tax incentive is the major instrument, other means such as investment promotion, information/services etc. are also intensively used. For domestic enterprises, especially SMEs, even though funds and information/service supports are provided by the government, the effort is moderate. This has put domestic enterprises in a disadvantage position when competing with foreign founded enterprises in Xiamen who can enjoy preferential tax policies.

When it comes to Industry oriented support in Xiamen, the photonics industry has received various forms of supports from different level government, for example, industry promotion, demonstration project etc., which have claimed to be successful attempts. Standard and public procurement are also used as other policy instruments. On the other hand, besides planning, government's direct support to biotech industry is still rare.

5.1.6 Government in promoting entrepreneurial environment and networking

All three best practices have fund support from the government to support the development of cluster organization. These funds either go directly to cluster organization or are used to construct an ideal environment to facilitate cluster organization's development. Efforts in this regard are generally moderate. On the other hand, all governments have provided intensive and diverse information/service to cluster organizations, mostly through forming partnerships with cluster organization. Best practices suggest that intermediaries play an important role as go-betweens in the cluster's networking system. With strong cluster organizations and intermediaries' support, governments can extend their function and avoid some direct intervention of the economy.

In Xiamen case, cluster organizations and intermediaries are much less active then in best practice cases. Thought government also provides fund to support intermediate agencies, the amount is small. Government in general has also less interaction with intermediaries and there are fewer joint collaboration programs. In photnics industry the situation may be better. Government has collaborated with industrial associations in several photonics industry promotion activities. In biotech industry, cluster organization is not forming in the real sense. Government's support in this regard is indiscernible.

Business and legal environment is important to cluster development, in Xiamen, this aspect is comparatively weak partly due to China's less experience in development market economy, also partly due to China's business culture. The improvement is to a large degree depended on national concerted effort. On the best practices side, the writer couldn't find proper lessons Xiamen can learn from, as the study of this aspect may need much broader search of information in the national context. However, the writer reserves this point in the checklist to recognize its importance.

5.2 Conclusions and Xiamen's weak links

Compare with best practices, the government in Xiamen has been more active in supporting infrastructure construction, and attracting businesses and talents from outside. Over the years, these efforts have achieved significant results, as partly reflected by Xiamen's GDP growth. This may be explained by the developing condition in China and Xiamen. As Porter's development stage theory suggested, in the factor-driven stage or early investment-driven stage, the competitiveness relies more on factor conditions, while government is an important player in factor creation.

On the other hand, Xiamen is less active in stimulating indigenous innovation and economic activities. This can be seen in the less powerful policies to support SME, and support of industrial training etc.

After analyzing Xiamen's situation in the previous chapter and comparing Xiamen case with international best practices, the writer suggests the following three areas as the weak links in Xiamen:

1. Weak technology commercialization capacity;
2. Lack of diversified financial sources for enterprise's different stage needs, especially for SMEs;
3. Weak cluster organizations and supporting intermediaries, and lack of professional in this service industry.

Besides these three weak links, even though the talent shortage in the emerging industries and some professional services areas in Xiamen is not yet a big problem, it can impede the competitiveness of the industries and hinder the industrial growth in the near future if not proactive actions are taken to improve the situation.

The weak link areas reflect Xiamen weakness in internal innovation and economic activities. As mentioned already, the government's effort toward these problem areas seems to be not sufficient enough.

5.3 Recommendations for Xiamen

Drawn on the comparison and conclusion, the writer forms the following recommendations for Xiamen:

1. For improving Xiamen's R&D and technology commercialization capacity, best practice experiences in this regard do not have special remedies, but suggest that government's long-term effort and commitment is important. For Xiamen, the government can strengthen the intensity of using incentive policies to encourage technology commercialization and enhance research-industry relations. Government can also use fund support and other measures to support R&D activities of domestic enterprises, especially SMEs, to leverage the policy difference between domestic enterprises and foreign founded companies.

2. To broaden enterprise's financing channels, Xiamen can learn from best practice exercises by using flexible forms of loans or funds to compensate for market failure in meeting enterprise's different stage financial needs. Xiamen should also examine the intensity and effectiveness of its use of public fund as venture capital. Moreover, government can strengthen information/services to advice

enterprises of government's financial sources, as suggested by best practices.

3. Xiamen still lags behind in the development of cluster organizations and supporting intermediaries. Drawn on best practice experiences, government can support the growth of cluster organizations and intermediaries by providing fund support for their early stage development, or financially support initiatives organized by intermediaries that benefit the public and cluster development. Xiamen government can also enhance its presence in cluster promotion activities organized by these organizations. Through this way, government can strengthen the interrelationships among actors in the cluster. On the other hand, government should refrain from the old plan economic legacy of trying to control industrial associations and other intermediaries, which affects their independency and healthy growth.

4. The government of Xiamen has been paying attention to attracting talents from outside, while somewhat ignores to encourage professional training and industry focus education and training. Xiamen can learn from international best practices by providing substantive government support, for example, by providing funds or grants to professional training programs that benefits the whole industry. Policies can also be stipulated to encourage cluster organizations and intermediaries to engage in industrial training programs.

5. Xiamen government's attitude toward photonics industry is proactive. Several initiatives such as demonstration projects have shown good results. Considering that the effect of some initiatives may be once off, it would be time for the government to consider using other policy measures that have constant effect. While for the biotech industry, special promotion programs may not be necessary at the infancy stage. Focus can be more on general, such as the promotion of general factor creation, and the nurturing of biotech cluster organizations etc.

Finally it should be bore in mind that different factors always interweave with each other to affect cluster development. Weakness in one factor may be the result of disadvantage in another factor. Thus before drafting any policies, government should carry out careful studies to find the real obstacles to ensure that policies made are proper.

Chapter 6 Summary and reflection

This chapter first looks back at research questions and tries to summarize main answers to those questions. In the second half of this chapter, the writer reflects on the analytical framework and case studies about the weakness and suggestions for future research.

6.1 Recapitulating main points to answer research questions

The paper used cluster approach to analyze two emerging industries in Xiamen, China, and compared it with three selected international best practice cases. The purpose is to draw lessons for Xiamen to improve its emerging industries as well as its innovation capacity and competitiveness.

Cluster and its links with innovation and competitiveness

Review of literatures suggests that there is not single definition of cluster. However, most of the cluster definitions emphasize geography proximity, interrelationships among actors, and industrial specialization. The differences in definitions reveal the multi-facet of a cluster. Theoretical and empirical studies suggest that industrial clusters contribute greatly to the national or regional innovation capacity and competitiveness and thus the economic development,

The role of government in cluster development

Cluster theories tend to believe that even thought the formation of cluster is a market induced process, government can play an important in fostering the development of clusters by facilitating market functioning and by correcting market failure. Case studies in the paper confirm this view. As The statement by Colorado Office of Economic Development and International Trade (OEDIT) illustrates, "Government can't create wealth itself, but it can provide the fundamental steps toward integration, communication, culture, policy and strategy that leverage all resources supporting industry, academia and the financial community – resources that the private sector cannot marshal on its own" (/www.advancecolorado.com).

The important factors that affect cluster development

The paper identified six main areas that are important to cluster development, namely: infrastructure, knowledge resources, human resources, capital resources, firms and industries development, as well as entrepreneurial environment and networking.

Policy instruments to promote cluster development

Cluster policies encompass many policy areas such as industrial policy, innovation policy, regional policy etc. The paper analyzes cluster policies from a different angle, that is, from the policy instruments adopted in the above identified key policy areas. From policy theories, a sample set of commonly used policy instruments was extracted. This sample set included 14 instruments under three categories: financial means, regulation and authority, exhortation etc.

Governments and policies in best practices
In best practices, governments actively interact with other players in the cluster. Governments also exert their efforts to the improvement of general conditions for cluster development, including research, human resources etc. Business and firm support is another focus of government. Many of government efforts have the support from cluster organization or other intermediaries.

Xiamen's weak links
Analysis of Xiamen situation revealed three main weak links in Xiamen's emerging cluster development. The first one is the weak technology commercialization capacity; the second one the lack of multi-channel financial sources; and the third one the weak role of cluster organizations and supporting intermediaries. In addition to this three weak links, the lack of industry focus professional training is also a concern.

What can Xiamen do?
To promote Xiamen's cluster development for the two emerging industries, the writer suggests that Xiamen enhances the use of policy instruments such as fund support, more information/service etc. to improve its weak links besides continuing its long term commitment to the improvement of factors conditions.

6.2 Constraints of the paper

The first constraint of the paper comes from data collection. Even though cluster studies have been popular, in the emerging industries, fewer case studies have been carried out, especially for photonics industry. Besides, as there is not enough time and opportunities for the writer to go to best practice places and conduct thorough study of those cases, most of the data used in this paper came from the website. The diversity of cluster policies also means that policies information have to come from diversified sources, such as different governmental departments or governments at different level, thus there is possibility of omitting some important data, which will affect the judgment of government's effort.

The second constraint is that judging government efforts with limited policy instruments may ignore some innovative government initiatives, which may be also valuable for learning. Also, as the checklist tries to cover many aspects of cluster and cluster policies that the writer thinks of as important, the conclusion drew in the paper is just a broad picture. The writer runs the risk of giving too generalized suggestions.

Another constraint of the paper is that China is a developing country, while the cases chosen in this paper are all from developed countries due to the availability of information concerning biotech and photonics cluster. If some cases can be found also in developing countries, more lessons may be learned on how to overcome the obstacles facing developing countries.

6.3 Suggestions for future study

Cluster and cluster policy is a complex issue that can be studies from different angles. With the limited time and space, this paper can only give a broad and general discussion of Xiamen's emerging cluster. For Xiamen's case, the writer suggests that further researchs can be carried out more in-depth or using different cluster approach in the following areas such as:

1. Focus on evaluation of policy implementation in the key cluster areas to study how Xiamen can improve its use of policies to promote cluster development. For example, in the area of using public fund as venture investment.
2. Use production chain approach to analyze the photonics industry. Focus can be on how government can do to improve the production chain.

References:

Adelman, Irma, (1999), "The role of government and economic development", Working paper No. 890, University of California at Berkeley, (http://are.berkeley.edu/~adelman/Finn.pdf)

Debresson, C., 2001, "Estimating gaps disparities", Seminar on the measurement of innovation activities in OECD and non-OECD countries, Pretoria, South Africa, March 29-29.

Elmore, R. (1985), "Forward and Backward Mapping: reversible logic in the analysis of public policy." In K. Hauf and T. Toonen, eds, Policy Implementation in Federal and Unitary Systems. Dodrecht, The Netherlands, Martinus Nijhoff.

Etzkowitz,H. & Leydesdorff,L.1995, "The Triple Helix: University - Industry - Government Relations", http://www.easst.net/review/march1995/leydesdorff

Etzkowitz, H. & Zhou, C., 2006, "Triple Helix twins: innovation and sustainability, Science and public Policy", volume 33, number 1, February 2006, 77-83.

Feser, E., 2005, "Industry Cluster Concepts in Innovation Policy: A Comparison of U.S. and Latin American Experience", in Gunther Maier, Sabine Sedlacek (eds.) (2005), "Spillovers and Innovations-Space, Environment, and the Economy", SpringerWienNewYork;

Glaeser, E.L.,2000, "The new economics of urban and regional growth" In: Clark, G.L.,Feldman, M.P. and Gertler, M.S.(eds) The Oxford handbook of economic geography. Oxford University Press, Oxford: 83-98

Gumprecht, D., Nicole Gumprecht, Werner G. Muller, 2005, "Some Current Issues in the Statistical Analysis of Spillover", in Gunther Maier, Sabine Sedlacek (eds.) (2005), "Spillovers and Innovations-Space, Environment, and the Economy", SpringerWienNewYork;

Ivarsson, I. 2005, "The effect of spatial proximity o technology transfer from TNCs to local suppliers in developing countries: the case of AB Volvo in Asia and Latin America", Economic Geography 81(1): 83-111,

Kersbergen, K. van & Waarden en F. van, 2004 "Governance as a bridge between disciplines; Cross-disciplinary inspiration regarding shifts in governance and problems of governability, accountability and legitimacy", European Journal of Political Research, Vol. 43, pp. 143-171.

Lankkuizen,M. & Woolthuis, R. K., 2003, "The national systems of innovation approach and innovation by SME", Zoetermeer: EIM

Lennihan, M., 2003, "Cluster mapping-a valuable tool for policy making?" EU Cluster Seminar, June 10

Leydesdorff, Loet and Henry Etzkowitz 2003. "Can 'the public' be considered as a fourth helix in university-industry-government relations?", Report on the Fourth Triple Helix Conference, 2002. Science and Public Policy, 30(1), February, 55-61.

Linder, Stephen H, and Peters, B. Guy, (1990), "The Design of Instruments for Public Policy", in Nagel, Stuart S.(ed.),1990, " Policy theory and policy evaluation-concepts, knowledge, causes, and norms", Greenwood press, New York.

Mayntz, R. (1981), "The changing conditions of effective public policy." Bielefeld, Germany: University of Bielefeld, ZiF Forschungsgruppe.

McDonnel, K. and R. Elmore. (1986), "Getting the job done: Alternative Polity Instruments". Paper presented at the Annual Research Conference of the Association of Policy Analysis and Management, Austin, Texas.

Mohr, L. (1973), "The concept of organizational goal", American Political Science Review 67:470-81

Mosher, F. (1980), "The changing responsibilities and tactics of the Federal Government", Public Administration Review 40:541-48

Muizer, A.P. & Hospers,G.J., (1998), "Industry clusters and SMEs", Zoetermeer: EIM

Nagel, Stuart S.(ed.),1990, " Policy theory and policy evaluation-concepts, knowledge, causes, and norms", Greenwood press, New York.

Pierre, J. & Peters, B. G, 2000 Governance, Politics and the State, St. Martin's Press Inc., New York.

Porter, M. E., 1990, "The competitive advantage of nations", The Free Press, New York;

Porter, M. E., 1998, "Clusters and the new economics of competition", Harvard Business Review, November-December,

Porter,M. 2001, ' Clusters and Competitiveness: Findings from the Cluster Mapping Project', (http://web.mit.edu/ipc/www/pubs/articles/porter.pdf) (2006-04-13)

Roelandt, T. & Pim den Hertog, Jarig van Sinderen and Ben Vollaard, 1997 "Cluster analysis and cluster policy in the Netherlands", paper presented at the OECD on Cluster analysis and cluster policy. Amsterdam, October

Roelandt, T.J.A and den Hertog, P. (eds.) (1999) "Boosting innovation-- the cluster approach". Organisation for Economic Co-operation and Development, Paris

Roelandt, Th.J.A.& V.A.Gilsing, J.van Sinderen, 2000, "Cluster-base Innovation Policy: Internaitonal Experiences", paper presented at the 4th Annual EUNIP Conference, Tilburg, The Netherlans, 7-9 December,;

Rosenfeld,S. A. ,2002, Regional Technology Strategies, "Creating Smart Systems: A guide to cluster strategies in less favoured regions-European Union-Regional Innovation Strategies",Carrboro, North Carolina, USA, www.rtsinc.org , April,

OECD (1996), The Knowledge-based Economy, Paris: OECD

Website :

European Commission (EC), 2002 "Innovation Policy Studies - Status report of latest results, and forthcoming tasks", Updated on 25.02.2002, ftp://ftp.cordis.lu/pub/innovation-policy/studies/studies_status_report.pdf

European Commission (EC), 2003a, European Trend Chart annual report 2003, http://trendchart.cordis.lu/annualreports/annual_report_en_2003.pdf

European Commission (EC), 2003b, "European Trend Chart- Thematic report, cluster policies ", http://trendchart.cordis.lu/reports/documents/TR_clusters_03_1.pdf

European Commission (EC),2003c, "Final report of the expert group on enterprise

clusters and networks ",
(http://ec.europa.eu/enterprise/entrepreneurship/support_measures/cluster/final_report_clusters_en.pdf) (2006-3-25)
European Commission (EC), 2004, "European Competitiveness Report 2004", http://ec.europa.eu/enterprise/enterprise_policy/competitiveness/doc/comprep_2004_en.pdf
European Commission (EC), 2005, " European Trend Chart- Innovation policy in Europe 2004",
http://trendchart.cordis.lu/annualreports/report2004/Innovation_policy_europe_2004.pdf
OECD,2004, "Venture capital-trends and policy", (www.oecd.org/sti/micro-policies)
OECD, (2005), "Innovation Policy and Performance, a cross-country comparison"
UNIDO, 2001, "Development of clusters and networks of SMEs", The UNIDO Programme. United Nations Industrial Development Organization, Vienna
Johnson, S. 2000, "The solid state lighting initiative, an industry-DOE collaborative effort", published in Architectural lighting, Nov/Dec Issue, (http://btech.lbl.gov/papers/47589.pdf)
http://www.photonics.com/directory//dictionary/lookup.asp?url=lookup&entrynum=3996&letter=p (2006-4-28)
http://www.genpromag.com/ShowPR.aspx?PUBCODE=018&ACCT=1800000100&ISSUE=0511&RELTYPE=PR&ORIGRELTYPE=CVS&PRODCODE=00000000&PRODLETT=W (2006-5-2)

San Diego Case:

DeVol, R. & Perry Wong, Junghoon Ki, Armen Bedroussian and Rob Koepp, 2004, "America's biotech and life science clusters- San Diego's position and economic contributions", Milken Institute
(http://www.milkeninstitute.org/pdf/biotech_clusters.pdf) (2006-4-25)
Panetta,J, President & CEO of BIOCOM, 2005, "Building a successful biotech cluster-San Diego BIOCOM", (http://epscor.unl.edu/ppts/Panetta.ppt)
San Diego Association of Governments(SDAG),(1998), "SAN DIEGO REGIONAL ECONOMIC PROSPERITY STRATEGY- Toward a Shared Economic Vision for the San Diego Region" ,
(http://www.sandag.cog.ca.us/uploads/publicationid/publicationid_604_1005.pdf)
http://www.sandiego.gov/economic-development/business-assistance/small-business/(2006-6-15)
http://www.sandiego.gov/economic-development/business-assistance/techanddev/(2006-6-15)
http://www.miramar.sdccd.net/programs/biol/biotech/about.html (2006-7-20)
http://www.sandiegometro.com/2000/nov/money.html (2006-7-20)
http://www.workforce.org/generate/html/About_Us/about_us_subhome.html
(2006-7-23)

Colorado Case:

Manuel G. Serapio, "Cluster Development and Entrepreneurship In Colorado", paper presented at International Workshop on Emerging Technologies:The Global Challenge of Convergence, Bangkok, Thailand,December 2005,
(http://www.apecforesight.org/emerging_tech/docs/M_Serapio_ClusterDevel_Entrep_14Dec05.ppt)

State of Colorado Office of Economic Development and International Trade(OEDIT), September 2004,"Colorado's Place in the Sun: A Bioscience Future, First Annual Implementation Report and Plan Amendment, An Action Plan to Grow Colorado's Bioscience Cluster", (http://www.cobioscience.com/images/2004_State_Plan.pdf)

Photonics cluster analysis & directory 2004-2005, CPIA, www.coloradophotonics.org

http://www.coloradoit.org/ (2006-6-12)

h ttp://www.coloradoalliance.org/content.asp?CID=24#overview (2006-6-14)

http://www.coloradophotonics.org/CPIAFormation.htm (2006-5-27)

http://www.coloradophotonics.org/PDF/2004/2004CPIADirectoryWebFinal.pdf

http://www.advancecoloradocenter.com/(2006-6-13)

http://www.advancecolorado.com/about.cfm (2006-6-13)

http://www.advancecolorado.com/biosciences-emerging-industries/biotech-sales-tax-refund.cfm (2006-6-14)

http://www.advancecolorado.com/business-development/rankings.cfm (2006-5-26)

http://www.gjincubator.org/cbia.html (2006-7-20)

http://www.results.gpponline.org/StateCategoryCriteria.aspx?id=98&relatedid=4 (2006-7-23)

http://www.ccrhq.org/states/Colorado.pdf (2006-7-23)

http://www.city-data.com/us-cities/The-West/Colorado-Springs-Economy.html (2006-7-23)

Ottawa Case:

Jorge Niosi, Robert Dalpe, 2003, Biotechnology clusters Montreal and Ottawa compared,
(http://www.utoronto.ca/isrn/documents/NiosiDalpe_Biotechnology.pdf)

Nantel, M. & Beda, J.,2001, "Photonics education and training in Ontario, Canada : an integrated plan", Photonics Research Ontario, Seventh International Conference on Education and Training in Optics and Photonics, Tuan-Kay Lim, Arthur H. Guenther, Editors, Proceedings of SPIE Vol. 4588 (2002), http://www.spie.org/communityServices/StudentsAndEducators/etop/2001/70_1.pdf

Rick Nordland, 2003, Comparing high tech and life science investing, http://www.ottawacapitalnetwork.com/investors.cfm?display=investors (2006-5-29)

Smy, T., 2002, "Photonics in Canada: An Outline of Current Research and Industrial

Capability"(http://www.photonics.ca/documents/final.pdf)
http://www.ottawa.ca/business/economic_profile/research_dev_en.html (2006-6-15)
http://www.ottawa.ca/business/economic_profile/ott_workforce_en.html (2006-6-15)
http://www.ottawa.ca/city_services/planningzoning/2020/es/1_5_en.shtml(2006-6-14)
http://www.ottawa.ca/city_services/planningzoning/2020/es/4_1_en.shtml (2006-6-15)
http://www.ocri.ca/about/ (2006-6-18)
http://www.ottawacapitalnetwork.com/entrepreneurs/government.cfm?display=entrepreneurs (2006-6-15)
http://www.ocri.ca/ocrireport/assets/OCRI_Report_2005_e.pdf (2006-6-17)
http://www.olsc.ca/ottawa/ottawa.html (2006-5-29)
http://www.2ontario.com/facts/fact11.asp (2006-6-17)
http://www.nrc-cnrc.gc.ca/clusters/ottawa_e.html (2006-6-1)
Ottawa: www.ottawaregion.com/media/ multimedia/ppt/New%20General.ppt (2006-5-12)
http://www.ottawa.ca/business/economic_profile/research_dev_en.html (2006-6-1)
http://www.ottawa.ca/business/economic_profile/ott_workforce_en.html (2006-6-15)
http://www.2ontario.com/facts/fact11.asp(2006-6-1)
http://www.greaterottawachamber.com/media/releases/Federal%20Govt.%20Congress%20Centre%20Press%20Release%20-%20May%208.pdf (2006-7-22)
http://www.ottawa.ca/city_services/planningzoning/2020/tal/exec_en.shtml (2006-7-23)

Xiamen Case

Xiamen office for emerging industry, Beijing Maikengqiao Consulting Co., 2004, "Development plan for Xiamen solid state lighting industrialization base"

Xiamen expert group for photonics industry development plan, 2003, "Development plan for Xiamen photonics industry"

Xiamen expert group for biotech industry development plan, 2003, "Development plan for Xiamen biotech industry"

Xiamen science & technology bureau, 2003, "The Advancement of Xiamen Science & Technology"

Fujian statistics bureau, Fujian statistical communiqués on national economy and social develop, 2004

Xiamen statistics bureau, Xiamen statistical communiqués on national economy and social develop, 2004

Fuzhou statistics bureau, Fuzhou statistical communiqués on national economy and social develop, 2004

Quanzhou statistics bureau, Quanzhou statistical communiqués on national

economy and social develop, 2004
Zhangzhou statistics bureau, Zhangzhou statistical communiqués on national economy and social develop, 2004
Liu, X.& Hu, Z., (2004), “Distribution of China’s regional innovation capacity and its cause”, http://www.sts.org.cn/fxyj/zcfx/documents/qycxnl.htm （2006-3-29）(in Chinese)
Liu, X. et al, 2006, Analytical report on China’s regional innovation capacity 2004-2005, www.softscience.gov.cn/ view_info_download.jsp?INFOID=8158 (in Chinese)
Zhou, J., 2005,”Current situation of venture capital in Xiamen and its development strategy”, (http://www.minjian.org.cn/jingjizixun/2005.12.htm) (in Chinese)
Xiamen Economic Development Bureau, http://www.xmjfw.gov.cn/xmi.nsf/index?openform&ProgramName=1A000000030183&Page=1&CSiteTemp=1 (2006-5-13)
Statistics Bureau of Fujian Province: www.stats-fj.gov.cn
http://www.stats-fj.gov.cn/tjfx/0200512230071.htm （2006-3-29）
http://www.stats-fj.gov.cn/tjfx/0200512230074.htm (2006-5-11)
http://ww.smexm.gov.cn/2005-5/2005512124021.htm项目(2006-5-18)
http://www.smexm.gov.cn/2005-1/200519225325.htm (2006-6-22)
http://www.smexm.gov.cn/list.asp?boardid=2604 (2006-6-22)
http:// www.xmkjcg.gov.cn/jsp/infor/fnewshow.jsp?inforid=2611&typeid=3 (2006-5-18)
http://www.straitsfair.org.cn/meetguide/ShowNews.asp?id=2657 (2006-4-26)
Ministry of Science & Technology: http://www.most.gov.cn/eng/pressroom/t20060310_29458.htm(2006-6-29)
Ministry of Labor and Social Security, MLSS Project team, 2004, “Survey Report on Labor Shortage” http://www.molss.gov.cn/news/2004/0908a.htm. (2006-6-7)
“An analysis of China’s LED industry investment situation” http://www.china-led.net/Html/news/scp/2006-2/22/102113388_2.htm (2006-4-26)
http://www.china-led.net/Html/zhengcefagui/gongchenggk/2006-1/8/11324844.html (2006-3-30)
http://www.china-led.net/Html/news/cyzs/2006-3/1/154637706.htm (2006-4-26)
http://www.chinatoday.com.cn/china/z2006/0604/p60.htm (2006-4-26)
http://www.chinadaily.com.cn/english/doc/2004-10/21/content_384471.htm (2006-6-4)
http://www.zero2ipo.com.cn/2003/5/21/N200352112278.html (2006-5-29)
http://www.china.philips.com/about/news/press/section-13267/article-2935.html (2006-6-5)
http://www.eceee.org/library_links/downloads/eceeedocs/cfleceeestate.doc (2006-06-05)
http://www.chinaipsmart.com/view_article.php?article_id=185&article_sortid=1&sort_superid=1 (2006-06-06)
http://search.csnn.com.cn/scripts/pws.dll/pkuir_models/rb2005/dispdoc.irm?%23

disp_doc=0&%23start_disp=0&%23disp_step=10 (2006-6-7)
http://www.csnn.com.cn/20051/ca409302.htm (2006-5-11)
http://www.csnn.com.cn/2006/ca463804.htm (2006-5-16)
http://www.zzcredit.gov.cn/Administrator/Admin_Article/Html/2005/5/20/1113-27@2005-05-20.asp (2006-5-18)
http://cj.66163.com/newsinfo.php?id=170&lanmu=cjyw (2006-5-11)
http://www.gx.xinhuanet.com/ca/2006-05/25/content_7093770.htm (2006-6-22)
http://photonics.com/content/spectra/2006/May/business/82516.aspx (2006-6-30)
Entrepreneurship in East Asia
http://www.continuinged.ku.edu/isc/previews/hist640/lesson2.html# (2006-6-29)
http://news.xinhuanet.com/legal/2006-06/08/content_4661181.htm (2006-6-29)
http://www.firefly-lighting.com/HomePage.htm (2006-6-12)
http://www.med66.com/html/2006%5C1%5Chu427414440191160022464.html(2006-5-18
http://news.xinhuanet.com/newscenter/2005-04/15/content_2834688.htm (2006-3-30)
http://www.fjtv.net/tvnews/newdisplay.asp?tp=6&id=63742 (2006-4-26)
http://www.fj.xinhuanet.com/dszx/2005-08/09/content_4841061.htm (2006-4-26)
http://market.ccidnet.com/pub/report/show_8672.html (2006-5-30)
http://www.pida.org.tw/newversion/homepage/2001new/english/overview.htm (2006-4-28)
http://www.gisforum.net/show.aspx?id=675&cid=5 （2006-5-15）

Appendix 1. Introduction of biotech industry and photonics industry

Biotechnology industry

A definition of biotechnology is that "Biotechnology is the application of knowledge about living organisms, and their components, to industrial products and processes". Under this broad definition, biotechnology is more of an enabling technology than an industrial sector. And "biotechnology companies are those whose primary business focus is the commercialisation of these new technologies"(Sainsbury et al,1999, p12).

Biotech industry is a science driven industry that needs strong research base support. Gary Pisano, professor from Harvard Business School suggests that biotech has different business model as "this is the first time that science is the actual business." He also sees a fundamental defect in the old financing model for biotech, that science involved in biotechnology and bio-pharmacy usually takes 15 to 20 years to achieve its result, while venture capitals usually look for quick returns. (The Economics, April, 2006)

As geographic proximity positively stimulates knowledge generation, transmission and knowledge sharing, industries rely heavily on new technology are likely to cluster, while cluster spurs innovation. This is especially the case for biotechnology industry whose survival relies heavily on innovation. Across the world, The USA and the UK have been considered advanced in biotechnology and biotech cluster development (Sainsbury et al,1999, p37). Other leading countries include Germany, France, etc. In the United States, dozens of biotech clusters has been formed. San-Diego biotech cluster (sometimes plus pharmaceutical) is one of the most prominent clusters among them.

Photonics industry

Generally speaking, photonics is an interdisciplinary technology that encompasses optics and electronics technology. In the narrower sense it "refers to technologies that deal with the manipulation and application of light"(Smy,2002, p7).

The last decade and onward has seen a growing industrial application of photonics technology ranging from "energy generation to detection to communications and information processing" (www.photonics.com). It can also be converged with other disciplines such as biotechnology, nanotechnology etc. It is this convergence and wide application that lead to the emergence of the so-called photonics industry, an industry that holds the promise of transforming the way we live in many ways. In the past 10 more years, photonics industry has sustained a fast growth rate and is attracting the attention of many nations. Leading countries in this area include the USA, Japan, and some EU countries. Some other countries such Korea, Canada etc. are also world leaders in some areas, while the industrial capacity is still largely dominated by developed countries.

As an emerging industry, photonics industry is also assumed to follow the pattern of cluster development. Thus governments of countries such as the USA, UK and Canada etc. and regions in these countries have taken a cluster approach when drawing up and implementing development plans for photonics industry.

Solid-state lighting industry in the United States

One promising field in photonics is the solid state lighting that is expected to bring a revolutionary change to the world of illumination in the next few decades. In stead of using conventional incandescent and fluorescent lamps as light sources, solid state lighting uses solid state materials such as Light Emitting Diodes (LEDs) and Organic Light Emitting Diodes (OLEDs) etc. as light sources. The most outstanding characteristic of Solid-state light sources is their extremely good energy conversion performance compared with traditions ones. Other advantages of solid-state light sources include durability and flexibilities etc. Yet the technology is not fully mature and the commercial application is still narrow. However, the increasing sophisticated market demands have spurred new technology development and further motivate the industry to exploit new solid state light sources applications in general purpose illumination (Johnson, 2000).

It is the promise of energy saving that brings the application of solid-state lighting to the spotlight in a nation's energy strategic development, especially for countries that have been affected by the impact of world energy shortage. The United States, for example, has attached great importance to the exploitation of solid-state lighting technology and its application.

To maintain its world leading position in photonics, the United States in 2000 drafted an initiative aiming at promoting the development of solid state lighting technology through investment in R&D in order to "overcome the technical barriers that currently limit the products to niche markets"(Johnson, 2000, P2). In the proposal, roadmaps for LED and OLED are constructed to identify technology potentials for solid-state lighting development. In parallel with the technical roadmap is the development of Industrial Performance Requirements to reflect the interest of the industry. The convergent of these two steps ensures that technological development is market-oriented, while industry development can tap the potential of technology breakthrough. Further, an energy analysis verified the plan from a different angle. The final plan of the initiative was to be used by the US Department of Energy and further for soliciting support from the Congress. The process of drafting this initiative reflects the interaction of government, industry and research from the early stage (Johnson, 2000).

Appendix 2. Extra information on three Best practice cases

1. San Diego biotechnology cluster

Strengths and weak links

The early nationwide cluster-mapping project led by Michael Porter also studied the San Diego's biotech cluster. Strengths and weak links in San Diego biotech-pharmaceutical cluster were identified.

Lead in the nation	*established position*	*weak*
research		
cluster organizations (BIOCOMM, UCSD connect etc.)		
biological goods		
	professional training	
	specialized venture capital	
	angle networks	
	specialized service (banking, accounting and legal service)	
	Instrument and equipment	
	medical device	
		consumer goods
		pharmaceutical products
		specialized containers and packaging
		specialized chemical

(Lennihan,2003)

The Milken Institute's 2004 report on San Diego's biotech cluster also identified a number of critical factors that affect the success of a biotech cluster. These factors include research and development (R&D), risk capital and entrepreneurship, infrastructure, human capital, and workforce (DeVol et al, 2004). The study shows that successful clusters such as San Diego Biotech cluster can attract movable factors such as human capital, venture capital etc. from other places to the region. However, improvement in local indigenous capital is still needed to sustain the industrial growth. Promoting the growth of diversified related industries is also important. The report also revealed that before the forming of biotech cluster, San Diego already had a good reputation of science and research capability in biotechnology. Highly educated talent could be easily found. There were also venture capitals around. (DeVol et al, 2004)

Successful factors

It is the coexistence of many success factors that creates an environment favorable to cluster growth. Among them, "high-quality science, a skilled workforce, and access to capital" are considered to be of critical importance (www.genpromag.com). Joe Panetta, President and CEO of BIOCOM in San Diego added one more factor: infrastructure, by which he meant to include local government support, supporting services and collaborative business organizations

(Panetta,2005).

While technology is important in a science-driven industry like biotech industry, management is also crucial to support the cluster development. As one of the San Diego's researcher and business innovator Ivor Royston concluded "management is far more important—significantly more important—than technology" (DeVol et al, 2004, p24).

Study also shows that San Diego's education institutions are very sensitive and responsive to biotech industry need. Special programs such as joint PHD-MBA degrees etc. cater to the industry need with curriculums designed by executives from local biotech and pharmaceutical companies "in anticipation of increasing needs or a shortage of competent science/technical business managers in San Diego" (DeVol et al, 2004, p54).

Networking has contributed greatly in creating entrepreneurial environment that encourage spin-offs. San Diego biotech cluster grew out from the first biotech company called Hybritech in the region. Founded in 1978, this "seeding company" spawned over 50 progeny biotech companies in the latter years. As Howard Birndorf, founder of Hybritech, specially mentioned "the networking here through the programs such as UCSD's Connect and BIOCOM have created a situation where starting a company is like falling off a log." (DeVol et al, 2004, p14). Network provided not only financial source but also facilities and legal support. Government's efforts are often carried out through cluster organization and other intermediate agencies.

As biotech is a heavily regulated industry, it requires a variety of expertise in the areas of for example clinical trials and FDA approval. San Diego has created a pool of expertise that can "help companies as they work their way through the whole process of product development and make sure they're in compliance with various regulatory requirements." (13DeVol et al, 2004, p50).

Cluster organizations

As recognized by the cluster mapping project, San Diego biotech-pharmaceutical cluster has rather strong cluster organizations. A wide array of sophisticated public and private, as well as joint private-public institutions facilitate collaboration in the cluster. Including:

Public organizations:

- San Diego Association of Governments
- San Diego Regional Technology Alliance (founded by defense conversion money allocated by the city)
- San Diego Science and Technology Council
- Office of Trade and Business Development
- Small Business Development and International Trade Center

General private facilitators:

- San Diego Chamber of Commerce
- UCSD CONNECT
- Corporate Director's Forum
- San Diego Dialogue
- Service Corps of Retired Executives, San Diego

While BIOCOM is a well-established biotech-pharmaceutical specialized private institutes.

There are also a number of public-private jointed organizations, which include:

- San Diego World Trade Center
- San Diego Regional Economic Corporation
- Center for Allied Competitive Technologies

In addition to these institutions, there are also supporting information networks such as Linkabit Alumni, UCSD Alumni etc.

(Source: Clusters and Competitiveness: Findings from the Cluster Mapping Project, Porter, 2001)

Cluster organizations such as BIOCOM have been playing an important role in cluster development. BIOCOM, with its over 450 members, claims to be the largest of its kind in the world. It has been actively engaged in organizing various kinds of activities to facilitate networking. BIOCOM has built a wide business network with supporting service providers such as legal firms etc. to consolidate efforts from all side for the industry. BIOCOMM also endeavors to attract venture capitals as well as other biotech firms, partnerships etc. to the regions. Job opportunity creation is another focus of BIOCOM (13 DeVol et al, 2004, p25).

2. Colorado Case

Research and education

There are four major universities in Colorado providing nine photonics related research and educational training programs, plus four federal laboratories with significant photonics activities. Colorado also has a strong knowledge resource foundation for biotech industry. In Colorado, there are four research conducting biotech related research (Serapio,2005).

In general, Colorado universities are very competitive in receiving federal R&D investment, but less successful in absorbing industry support for R&D (Serapio, 2005).

Colorado has one of the most educated populations in the USA. Morgen Quitno quoted Colorado as No. 2 in the nation for "Percent of Population with a Bachelor's Degree or More". Corporation for Economic Development listed Colorado as No.4 for "Number of Graduate Students in Science and Engineering", while the Beacon Hill State Competitiveness Report 2005 ranked Colorado No.3 in "Scientists and Engineers as a Percent of Labor Force" (www.advancecolorado.com).

Colorado Community College and Occupational Education System offer a wide variety of training and education programs including programs tailor-made to industrial needs. The system operates under Small Business Development Center and other community colleges. (Guide9)

Photonics Cluster organizations and intermediaries

Colorado Photonics Industry Association (CPIA) was founded in 1997 with an aim to promote the photonics community of Colorado. It acts as a statewide economic development agency linking different actors in the photonics cluster.

CPIA's functions include the followings:

- Represent the industry to have a voice in the government. CPIA acts as a bridge between government and the private sector.
- Provide information on venture capital, newest technology, market information etc.
- Participate or organize regional, national and international trade fair and events.
- Promote networking among member companies
- Promote international collaboration through its linkage with other international cluster organizations.
- Training and workforce promotion

(www.coloradophotonics.org)

There are also forty-one business support organizations with 500 employees provide services to the industry.

Biotech industry

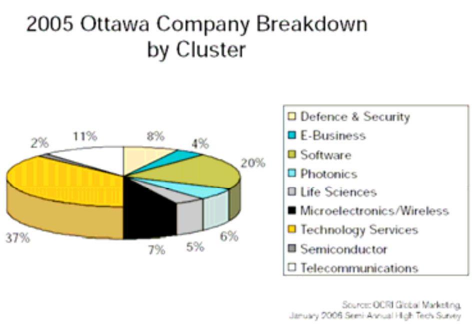
The panel on the Growth Opportunities and Challenges of Colorado's Emerging Biotechnology Industry identified university-industry relationship, technology transfer, and free flow of technology from research and universities as critical to the success of biotech industry in Colorado. However, Colorado has a weak recode of research-industry cooperation(Serapio,2005). The Biotech Action Plan also called for an executable strategic to enhance industry-research collaboration (Bioplan2004).

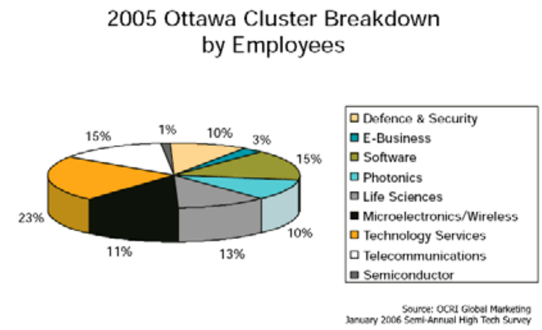
The updated Action Plan also revealed concerned from the bioscience industry about lack of angel and seed stage capital. There were also expressed needs to attract venture capital from elsewhere to set up local operations, and the needs to persuade local angle investor network to invest more in bioscience industry. Though Colorado Venture Capital Authority had been created, it did not focus on bioscience only, thus the updated Action Plan called for concerted effort to advocate for the utilization of CVCA funds for bioscience industry.

In October 2003, Colorado BioScience Association (CBSA) was formed from the former Colorado Biotechnology Association and the Colorado Medical Device Association. By spring of 2004, CBSA has over 270 memberships. It establishes a unified voice for Clolrado's bioscience cluster (Bioplan2004).

3. Ottawa case

In Ottawa, Industries such as telecommunications, software, photonics, semiconductors, defense and security, life sciences, wireless technologies etc. are either highly competitive or showing signs of fast growth.





(source: http://www.ocri.ca/ocrireport/assets/OCRI_Report_2005_e.pdf)

Research and Education

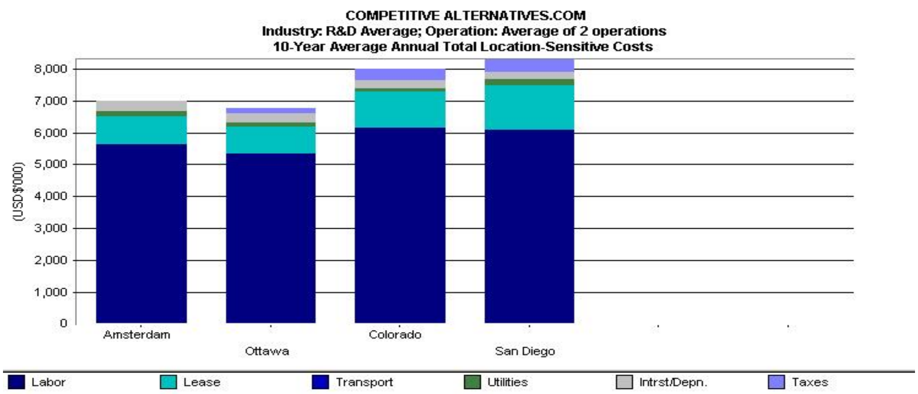
Study shows that Canada as well as Ottawa has R&D cost advantage, as shown by the charts below.

Canada's R&D costs versus Other Countries

Country	Percentage
Netherlands	-12.8%
Canada	-10.9%
France	-9.7%
United States	0% (baseline)
Japan	+4.6%
Germany	+9.1%

Source: KPMG, The Competitive Alternatives: 2006 Edition (www.competitivealternatives.com)

R&D cost comparison:



Source: KPMG, The Competitive Alternatives: 2006 Edition (www.competitivealternatives.com)

In Ottawa, there is a high concentration of public research and development organizations at national, provincial and local level, including:

- Two universities: Charleton University and Ottawa University
- National Research Council(NRC): is a governmental R&D, also home to Canadian Photonics Fabrication Centre(CPFC).
- The Natural Sciences and Engineering Research Council of Canada (NSERC): is a national instrument for strategic investment in R&D.
- Communications Research Center(CRC). Its Broadband Network Technologies division has been actively engaged in optoelectronics and photonics research.
- Canada Institute for Scientific and Technical Information (CISTI): one of NRC's service institution

The establishment of Solid State Optoelectronics Consortium (SSOC) in Canada has been praised as a good example of "significant government industry collaboration". SSOC was founded in 1988 with a government initiative to enhance the photonics capacity in Canada. (Smy,2002).

There are a number of Centres of Excellence (NCE) at different levels. The national level photonics NCEs include the Canadian Institute for Photonic Innovations (CIPI), the Canadian Institute for Telecommunications Research (CITR) and Micronet. At provincial level, there are also many NCEs that carry out similar research programs. (Smy,2002).

Research and development takes place not only in universities and research institutions but also in the industry where big companies carry out significant industry-focused R&D activities while SMEs mostly concentrate on application related R&D. This is not exceptional for Photonics industry in Ottawa.

Ottawa has the highest number of residents with a post-secondary education, and the highest per capita engineers, scientists and PhDs in Canada, contributing to its first place position in the ranking of talent in Canada. It also ranks third in the size of technology workforce. Besides, forty-four per cent of the population is bilingual (www.ottawa.ca).

Post-secondary education has contributed greatly to Canadian photonics cluster development in providing highly qualified personnel for the industry. The two-tier education system in Canada comprises of university and college. Photonics industry related disciplines offer by the University include Electrical Engineering, Engineering Science, Engineering Physics and Applied Physics. Non-degree-granting colleges usually offer more industry-oriented programmes for technical or vocational training, ensuring a steady supply of high-skilled workers (Smy,2002).

At the same time, industrial consortiums are also actively engaged in post-secondary education development by collaborating with colleges to work out training programmes tailor-made to the industry need. Industry is also encouraged to contribute financially or even participate directly to post-secondary education.

Capital resources

According to Thorington Corp., Ottawa is a favorite place for foreign venture capital. Research showed that in 2001, of the total funding to Canadian biotech firms, 37% came from Canadian venture capital, 6% from US VC, and 15% from angle capital. Government invested for 13%, while bank contributed 7% (Norland, 2003).

For 2005, Ottawa received 28% of the total Canadian VC, the largest share in the country.

Venture Capital in Ottawa-Gatineau Region

	Total (million $)	**Photonics**	**Life Sciences**
2004	**Close to 200**	**57.17**	**17.1**
2005	**About 360**	**125.55**	**58.68**

(ORCI Report 2005)

Cluster organization and intermediaries for Photonics industry

Relevant cluster organizations include:

- Canadian Photonics Consortium (CPC): a national level cluster organization that brings industry, academic and government together.
- Ontario Photonics Technologies Industry Cluster
- Ottawa Photonics Cluster: created in 1999, (Nantel & Bede, 2003)

Industrial organizations and consortia at national, provincial and local level in Canada have been playing an important role in fostering cluster development. One common goal of these organizations is to facilitate networking of the industry and enhancing government-industry-research relationship. Other main activities include providing industry-focused infrastructures and services, lobbying government policy making, especially in setting funding priorities, and secondary education etc. (Smy,2002).

Ottawa Centre of Research and Innovation(OCRI) is a nonprofit, partnership economic agency that incorporates efforts from government, research, education and industry to promote Ottawa's competitiveness. Government support is an important part along with contributions from private sector and other programs. Government support includes grants from municipal, provincial and federal level (http://www.ocri.ca/about/).

Cluster organization for life sciences

Ottawa Life Sciences Council (OLSC) is a nonprofit cluster organization founded in 1994. OLSC's board consists of representatives from industry, academia, financing and business development etc.

Appendix 3. China’s regional innovation system and more information on Xiamen case

China' s regional innovation system

Regional innovation system has been recognized as important component of national innovation system and contributes greatly to the national innovation capacity and competitive advantage. There is a growing global trend of studying regional innovation system since the mid-1990s. In China, relevant studies began from the late 1990s. In 2000, a Research Team on China's Science and Technology Development Strategic carried out the first nationwide research on China's regional innovation system, leading to the annually issuing of China Regional Innovation Capacity Report afterward (www.sts.org.cn).

The research team defined regional innovation system as the capability of a region to transfer knowledge into new products, new processes and new services. The first regional innovation report in 2001 categorized China' s regions into four tiers by regional innovation capacity. The first tier includes Shanghai, Beijing and Guangdong. Fujian belonged to the second tier, which consists of 6 coastal provinces. The result shows a clear descent of innovation capability from east to west (www.sts.org.cn).

Liu and Hu(2004) analysis the root of disparity in China’s regional innovation capacity. Before the start of economic reform, resources in China were mainly allocated to the northern, northeastern and some eastern part of China where there was relatively good industrial infrastructure. In the 1960s, for the sake of national defense, the industrial center was shifted to some western cities, while the southern coastal provinces such as Fujian and Guangdong, because of their proximity with Taiwan, were ignored of national investment. Thus these regions had less state-owned big companies and lagged behind the nation in science and technology infrastructure development.

The economic reform and opening up in China gave coastal regions new opportunities for economic development. The eastern and southern coastal regions have developed diversified regional economic models and become the most vigorous economic regions. Liu and Hu(2004) attributed the economic takeoff in the coastal regions to several reasons, including: 1) the establishment of special economic zones and open cities; 2) historically less developed heavy industries on the other hand spurred the development of light industry; 3) having fewer state-owned enterprises on the other hand encouraged the prosperity of private run and township enterprises; 4) the tradition of trade and commerce, and the many linkage with overseas in the coastal regions further boosting the economic development etc. According to a study by Debresson(2001) from Canada, three innovation poles have emerged in China. There are: the Yangzi River Delta region in the east, the Pearl River Delta region in the south, and the Beijing-Tianjin area. A fourth pole is also emerging in the middle of China' s Sichuan- Chongqing- Hubei region. Debresson further pointed out that these innovation poles draw talent, capital and other resources from their neighboring regions, leading to the hollowing out of other regions' innovation capacity.

Positioning Fujian in China

As discussed above, Fujian historically received less national investment thus had comparatively backward industrial and science & technology infrastructure and facilities before China's reform and opening up. The introduction of market economy in the early 1980s has greatly spurred Fujian's economic development. According to the first national economic survey, Fujian's GRP province in 2004 amounted to 576.3 billion RMB, ranked 9th in China. The province has resource advantage and labor-intensive industries. (www.cj.66163.com).

The 2004 China regional Innovation Capacity Report shows that Fujian ranked 9th in the nation (Liu et al, 2006). Fujian was weak in knowledge creation but performed fairly well in acquiring knowledge from other places (8th). This might partly be attributed to the province strength in attracting foreign direct investment (among the top five attractions).

Innovation indexes	Fujian' s ranking
Comprehensive innovation capacity	9
Knowledge creation	26
Knowledge acquisition	8
Enterprise' innovation	20
Innovation environment	10
Innovation efficiency	7

Positioning Xiamen in the province

Fujian province is composed of 8 regions plus Xiamen Special Economic Zone.

Xiamen, as the only SEZ and independent economic municipality in the province, enjoy much privileges than other regions, including direct economic planning under the central government, meaning that its government finance system is independent of the province. Xiamen also has sub-provincial level authority and autonomy in economic administration, and local legislative power. While the most important privilege is the power entitled to SEZ to adopt preferential policies such as tax incentives to attract foreign investment.

Below is the comparison of four most developed regions in Fujian. Data comes from each region's statistical communiqués on national economy and social develop in 2004.

Region	Province	Fuzhou	Quanzhou	*Xiamen*	%	Zhangzhou
Land area(km^2)	123800	12000	10900	**1516**	**1%**	12,900
Population (mil.)	35.35	6.6	7.6	**2.64**	**8%**	4.5
GDP(billion RMB)	605.3	154.8	160.3	**88.3**	**15%**	70.2
Industrial output	540.1	228.9	262.3	**172.9**	**32%**	81.7
Hightech output*	125.3	45.2	3	**70.3**	**56%**	2.4
Import(bi. USD)	18.2	5.1	1.09	**10.2**	**56%**	1.1
Outport(bi. USD)	29.4	7.4	2.6	**13.9**	**47%**	2.2
Revenue(bi. RMB	62.3	16.8	13.1	**16**	**26%**	3.8
Local revenue	33.3	10.7	6.28	**6.8**	**20%**	2.0
R&D/GDP**	0.74%	1.06%	0.28%	**1.74%**		0.35%

* Fujian Statistic Bureau, Fujian High tech product development status in 2004

** Fujian Statistical Bureau, Analysis of Fujian R&D input and output in 2004.

From the table, one can see that the conjuncting Xiamen- Zhangzhou-Quanzhou area lead the province in most of the economic index, consolidating this area as the most prosperous area in the province.

Regional policy, linkage with other regions

Xiamen, thought an economic heavyweight in Fujian, is the smallest region in the province in terms of land area and population. This has to a certain extent constrained Xiamen's economic development, especially when it comes to economic of scale. Several regional cooperation mechanisms have been existed for years to help address this problem:

Xia-Zhang-Quan City Alliance. Signed in 2004, This alliance composed of three most active economic regions in the province. It is a loose mechanism without strategic and implementation plan. Coordination has been done in areas such as urban planning, infrastructure, transportation, harbor development, environmental protection and tourism.

Xia-Zhang-Quan-Long-San five-region cooperation mechanism: Started from 1999,

it encompasses 2 mountainous region and three coastal regions. The original idea was to address regional disparity, aiming at helping economic development of mountainous regions through cooperation with coastal regions. However, in the recent year, the focus is shifting to achieving mutual economic complementary and integration as a win-win strategy.

Min-Yue-Gang three-province-thirteen-city economic cooperation: Is a loose cooperation mechanism. Previous cooperation was carried out especially in areas of infrastructure, tourism, environmental protection etc. (Working Report on 13-City Regional Corporation).

Xiamen Office for Regional Economic Cooperation is in charged of coordinating and implementing cooperation efforts.

Taking advantage of Taiwan's shift of manufacturing industries to the Mainland
Over the past few decades, photonics industry in Taiwan has achieved remarkable development. In 2005, the production value of photonic industry in Taiwan accounted for 16% of the world market. (photonics.com).

Taiwan's manufacturing industries have been gradually shifting to mainland China since the start of China's economic reform. This shift is on the one hand for China's huge market, on the other hand to reduce production cost and increase Taiwanese enterprises global competitiveness. A third reason can be attribute to the clustering effect. Being OEMs and suppliers to many world customers now operating in China, Taiwanese enterprises need to be proximate to production chain (www.china-led.net). According to analysis, there are four waves of industrial shift to Mainland. Fujian benefited from the first wave shift by attracting some labor-intensive industries. But the province didn't gain advantage in the second wave and third wave shifts, which are more for capital-intensive and technology-intensive industries. The fourth wave of shift is arriving in some emerging industries such as photonics, biotech, as well as services and financing etc. Statistics revealed that many Taiwanese LED enterprises has set up operations in China, mainly along the southeast coastal regions, ranging from Suzhou in the Yangzi River Delta, to Xiamen in Fujian, and Shenzhen in the Pearl River Delta (www.chinatoday.com.cn).

Xiamen has been trying to take advantage of this fourth wave shift to attract Taiwanese photonics industry. The advantages of Xiamen include:

1. Fairly good photonics industry foundation. Being one of the four " National Solid state Lighting Industrialization Base" in China, Xiamen's photonics industry has formed a comparatively completed production chain;
2. Electronics industry being the biggest industry in Xiamen, leading to an

agglomeration of many electronics application companies. For example, in mobile communications, there are big mobile phone manufacturers such as Amoi, Lenovo, VK etc. This sector contributed to 6.22% of the city's total industrial output in 2004. Another big sector is audio and video application, which accounted for 6.07% of the city's industrial output. Amoi and XOCECO are among the top 500 Chinese electronics companies. In computer and its peripherals, Dell and other companies alone took 18.23% of the city's industry share. Many of these companies are current or potential customers of Taiwanese photonics companies.

3. Years of electronics industry development have accumulated a pool of talents and technology development and research capability.

Appendix 4: OECD's Policy learning for venture capital

Venture capital has been a key driving force for innovative economic activities. This is especially the case for ICT and biotechnology. OECD Growth Project has recommended "increasing access to high-risk finance to stimulate firm creation and entrepreneurship, one of the main drivers of growth and productivity performance" (OECD, 2004,p4). (OECD,2004,p4)

In a recent study carried out by OECD on venture capital, ten OECD countries were reviewed. Based on the survey, OECD was able to analysis the recent market trend and policy framework on venture capital and drew some recommendations for OECD countries.

The study revealed that "Venture capital activity tends to be highly concentrated geographically and centred on existing areas of economic activity"(OECD,2004,p10). Many high-tech regions such as Silicon Valley in the USA etc. attract a larger share of venture capital. The study connects this concentration of venture capital to the presence of supporting infrastructure in these regions, which reduces transaction costs for start-ups and new firms. This supporting infrastructure includes pool of human resources, centers of research, legal, financial and other service etc. The study also pointed out that one shortcoming of venture capitals from corporate and individuals is their lack of long-term commitment, and that government can sometimes be a primary investor of venture capital. (OECD,2004).

OECD then gave some recommendations for venture capital policies, which cover five aspects (OECD, 2004):

1. Investment regulations: including lessening restrictions on institutional investment, and stipulating policies to encourage diversified investment, international venture capital inflow, and policies to improve investment environment and protect investors etc.
2. Taxation: including tax incentives to encourage investment, reducing taxation complexity in different types of treatments etc.
3. Equity programs: OECD suggests using public equity funds as complementary source of investment to private financing, but prefer that public equity funds be phased out when private venture market mature. OECD also recommends funding for knowledge-based clusters.
4. Business angel networks: including linking different business angel networks and their linkage with incubators etc. and offering services to improve the demand and promote investment-readiness of SMEs.
5. Second-tier stock markets: including improving merger and acquisition environment etc.

One should notice that not all OECD recommendations fit a country's specific condition. Also, some recommendations can only be implemented at central level.