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CHONGQING'S TECHNOLOGY ASSETS AND OPPORTUNITIES IN THE CONTEXT OF NATIONAL INDUSTRIAL RECONSTRUCTION

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ABSTRACT

As a fact, China is now losing its competitiveness in the global industrial chain as the labor and land cost are increasing while the its industrial structure remains backward. Thus, big efforts will need to be made for China to upgrade within global value chains so as to achieve a sustainable growth in the near future. According to the latest National 12th Five-Year Plan (from 2011 to 2015), it is urgent to tackle this problem by "Transformation and upgrading, enhancing the competitiveness of Industrial core", 1and "Foster and develop strategic emerging sectors". Chongqing is one of the four ventral government direct-controlled cities in China, which was created in 1997 and significant change has been made since that time. From 1997 to 2010, the annual average growth rate of GDP in Chongqing is more than 10% and the annual average growth rate of fixed assets is more than 20%.[2] Given the background of the new round of national industrial reconstructing and the critical role the city plays, it is essential to do an industrial targeting in Chongqing.

In this paper, I used several indicators to identify (1) the local industrial and innovation strength and (2) the local knowledge infrastructure so as to find the high-technology industrial clusters and sectors that with greatest potential to develop in the future. After a set of screening process, two industrials have been identified as the development target: (1) Medical and Pharmaceutical and (2) Transportation.

[1] China's 12th Five-Year Plan, The State Council of the People's Republic of China, Part III, Chapter 8.

[2] National Bureau of Statistics of China

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CHAPTER ONE

BACKGROUND

1.1 “Significant Concerns” of China’s Industrial Structure

Since 1978, China’s domestic economic system evolved and taken significant steps toward industrialization and global integration. Given China’s population size and the effectiveness of its Reforms and Opening-up, this transition has delivered the greatest "shock" to the international economy. However, China's GDP only expanded at an annual rate of 7.6% in the second quarter, the slowest pace of growth in almost ten years. More specifically, China’s both heavy and light industrial profits have been declining since 2010. China is losing its competitiveness as labor costs rise.

Also, the processing industry (e.g. laptop assembly), as a major component of China’s industry, has an extreme small share of profits compared to other countries engaging in more technology- and knowledge-intensive activities within global value chains (GVCs). A low-end processing industry cannot be sustainable for China’s growth. In reverse, this fact fosters China’s sticking to the low-end export-processing regime, which is a vicious circle. Although China has increased its share of world exports in high technology products such as computer equipment, “the share of imported intermediate inputs in China’s exports is 27.4%, substantially higher than that of large manufacturing exporters like the U.S. (12.3%) or Japan (15.4%)[3],” which indicates China’s indigenous technological capabilities are still at a low level. During my field survey (July, 2011) in MAZDA Motor Corporation, Hainan Province, the technical director Zhang told me that

[3] OECD (2012), China in Focus: Lessons and Challenges, OECD, Paris.

the floorboard, one of the most basic opponents of a vehicle, still could not be produced domestically. This kind of imported intermediate input costs a lot of money every year and accounts for a substantial share of the final product. Take the I-phone for example. China exports the I-Phone at a unit price of just over USD 194, but generates only about USD 6.5 of value-added. The largest portion of value-added from the production of the I-Phone is accounted for by imported intermediate inputs from countries providing key components, such as Korea. Big efforts will need to be made for China to upgrade within global value chains.

As early as the 11th Five-Year Plan (2006 to 2010), the Chinese government has realized the crisis and started to optimize and upgrade its industrial structure, targeting the problem of low value-added in the industrial sector. Industries have been encouraged to move towards high technology and greater innovative capability. In November 2010, The Ministry of Commerce designated the city of Suzhou as a pilot area for expediting the upgrading of traditional industries including (i) equipment manufacturing, (ii) shipbuilding, (iii) automobiles, (iv) iron and steel, (v) nonferrous metals, (vi) building materials, (vii) petrochemicals, (viii) light industry, and (ix) textiles. This policy for Suzhou aims to encourage enterprises to shift from processing and manufacturing to design, research and development (R&D) as well as high technology. Also, Guangdong province introduced new measures including (1) financial support and special funds; (2) tax incentives; and (3) related administrative measures in May 2011 to foster industrial restructuring through administrative and approval procedures. This policy also aims at encouraging local companies to upgrade and transform.

1.2 The 12th Five-Year Plan (2011 to 2015)

In the 12th Five-Year Plan, there are two sets of objectives associated with the industrial development strategy. The first is "Transformation and upgrading, enhancing the competitiveness of Industrial core", [4] which is to further upgrade and restructure traditional industries. These industries are identified as needing technical upgrading as well as consolidation to benefit from scale efficiencies.

To meet the goal, policies will support the technical improvement of enterprises and accelerate the application of new technologies, new materials, new techniques and new equipment to improve traditional industries and market competitiveness as well as to encourage enterprises to enhance new product development capacity, increase the technology level and value-added of products, and accelerate the upgrading of products. Lastly, the policies aim to promote IT-based improvement and upgrading of R&D and design, production circulation, and business administration, carry out advanced quality management, promote the management innovation of enterprises, and build a number of technical innovation service platforms.

The second objective is to "Foster and develop strategic emerging sectors." The goal is to bring the share of strategic emerging industries to 8 percent of its gross domestic product (GDP) by 2015 and 15 percent by 2020. The industries that the government wants to develop into future pillars of the economy have a high-tech or environmental focus, which include (i) energy conservation and environmental protection, (ii) new-generation

[4] China's 12th Five-Year Plan, The State Council of the People's Republic of China, Part III, Chapter 8.

IT, (iii) bio-tech, (iv) high-end manufacturing equipment, (v) new energy (including nuclear and renewable energy), (vi) new materials, and (vii) new-energy automobiles. These strategic industries accounted for less than 4 percent of GDP in 2010.

1.3 Push Forward a New Round of Western Development

Western China contains 71.4% of Mainland China's area, but only 28.8% of its population, as of the end of 2002, and 19.9% of its total economic output, as of 2009. To deal with the significant development imbalance between the eastern and western regions in China, the central government proposed the Western Development Strategy (WDS) in 1999 to accelerate the western regions’ development and reduce regional disparities. In the year 2000, China’s State Council released policy measures to implement the WDS. Five major policy instruments include (1) Fiscal Transfers and Tax Preference, (2) National Investment, (3) Financial and Credit Support, (4) Guiding Policy and (5) Interregional Mutual Aid Promotion Policy. The achievements of the WDS are significant from the perspective of economic growth. Between 2000 and 2010, the western economy has experienced an average annual growth rate of 13.6% and become the fastest growth region in China.

Generally, regions with higher technical level (more patents and R&D activities) indicate higher economic development level. However, when we look at the technology sector in the western region of China, even with a high-speed development in the last decade, it is still at a much lower level compared to other regions (Jefferson, Hu and Su, 2006; Li, 2009). Technology progress is the engine for long-term economic growth since it can not only improve factor productivity but also contribute to optimizing industrial structure. As a key force of promoting technology progress, the scale of research and development (R&D) expenditure in Western China increased significantly in the past decade, but even so, its shares in GDP and national total R&D expenditure are the lowest, and the share in national total expenditure fell annually after 2000 when WDS was implemented (Lu, Zheng and Deng, Xiang, 2011).

According to the 12th Five Year Plan, the central government is pushing forward a new round of western development. Priorities are given to "strengthening infrastructural construction, taking advantage of resources, implementing market-oriented advantage resources transmission strategy, arranging a number of resource development and developing advantage industries". [5]

[5] China's 12th Five-Year Plan, The State Council of the People's Republic of China, Part V, Chapter 18.

CHAPTER TWO

LITERATURE REVIEW

2.1 What is Industrial Targeting?

Generally speaking, industrial targeting is the process of identifying the industries or clusters that are most likely to prosper in a region, given the region's economic composition, work force, and resource base. To distinguish this from business recruitment, an industry targeting study can have broader applicability to land use and natural resource planning, education and work force development, utilities and infrastructure. More specifically, industrial targeting is a popular tool for improving regional economic development, especially with local officials concerned with economic development issues. As usually implemented by the local government, industrial targeting is a type of government intervention.

2.2 Why Industrial Targeting?

As Martin and David (2004) point out, from a policy perspective, "the driving force behind an industrial targeting study is the desire to identify the clusters, industries, and sectors that could potentially give a boost to the local economy."[6] Since 1960s, the practice of "picking winners" to accelerate local economic growth has been very popular among the governments of many regions, especially in the emerging economy nations like Japan and Taiwan. Basically, industrial targeting can be justified by the benefits of industrial clusters and the existence of market failures.

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[6] Martin Shields, David Barkley and Mary Emery, "Industry Clusters and Industry Targeting." Penn State University, in collaboration with Regional Project NE-1011 and the Rural Poverty Research Institute (RUPRI), 2004, P.7.

Identifying an industry cluster for targeting industrial development is founded on the perception that cluster growth will provide greater local economic development benefits than a less focused effort (Barkley and Henry, 1997). Professor Michael Porter developed the Diamond of Advantage, a model that offers insights into industry clusters and competitiveness. Porter contends that regions develop a competitive advantage based on their firms' ability to continually innovate, and that economic vitality is a direct product of the competitiveness of local industries In the Porter Diamond model, clusters advance through four dimensions (1) strong and sophisticated local demand; (2) a local base of related and supporting industries in the local economy supporting an export industry; (3) favorable factor (resource) conditions and (4) a competitive climate driving firm productivity (Douglas, 2009).

Such industrial targeting policies “can be justified by the existence of some market failure that makes government nonintervention suboptimal.”[7] For example, such targeting policies could be welfare enhancing (Pareto improvements) when industries are characterized by imperfect competition or information asymmetries. Brander and Spencer (1985) analyze models that demonstrate how government intervention in imperfectly competitive industries allows a country to extend its market share and thereby generate more taxes. Mikhail (1999) also suggests that “besides dealing with market failure, industrial targeting policy can be justified for encouraging new firms in new industries since research and development (R&D) has long-term returns with higher risks.”[3]

[7] Mikhail M. Klimenko 1999, “Industrial targeting, experimentation and long-run specialization.” Journal of Development Economics 73 (2004) 75– 105, P.76.

2.3 How it Be Done?

In practice, methods of implementing an industrial targeting program vary. However, suggested by Martin and David (2004), most targeting programs generally consists of two components.

The first is a means to identify clusters that have a high potential for locating or expanding in a particular area. In this respect, analysis includes examining existing industrial clusters, infrastructure bases, relevant knowledge assets and industry trends at national or even international levels. The location quotient (LQ) is, perhaps, the most prevalent method in use today for identifying existing and potential clusters. The LQ is usually examined over a period of time to see if the degree of specialization is increasing or decreasing. "The LQ approach is appealing in that it is both intuitive and easy to calculate from readily available data."[8]

Similarly, the input-output model generated with the use of IMPLAN (impact analysis for planning) data has been used to do a target industry analysis, for example in Clay County, Virginia (David, 2005). As a result, they decided that local processing of local natural resources (oil, coal and wood) should be encouraged. Studies targeting for high technology industries usually need to examine the innovation activities within the study area. Indicators used to identify innovative activities usually are "ratio of R&D expenditures to output value", "proportion of S&T personnel", "number of local based

[8] Martin Shields, David Barkley and Mary Emery, "Industry Clusters and Industry Targeting." Penn State University, in collaboration with Regional Project NE-1011 and the Rural Poverty Research Institute (RUPRI), 2004, P.9.

research institutions" and "out put per person". For example Kenneth Simons (Simons, 1996) used a growth model to examine innovative activities.

The growth model for regions or countries almost always fit the form:

> $y = A(t) \times f(k)$,
>
> where y is the amount produced per person, A(t) is a productivity measure that increases over time, $f()$ is a production function, and k is the amount of capital per person. It is commonly assumed that the production function $f()$ involves decreasing returns to scale as a function to time; The amount of capital per person changes over time because of (a) "depreciation" of machinery, buildings, and other goods when it wears out or breaks down; (b) investment in new capital to be used for future production; and (c) change in the number of people. Assume the number of people remains constant. An equation for the change in capital per person then might be:
> $dk/dt = (1-h)\, y - k\delta$, where h is the fraction of production that is consumed and δ is the fraction of capital that depreciates per year.

According to this model, let's consider first the case in which there is no technological improvement, so that A(t) = 1. It turns out a diminishing marginal production per person over time (see Figure 2.1). And the diminishing returns to the production process cause annual gains in production to grow less.

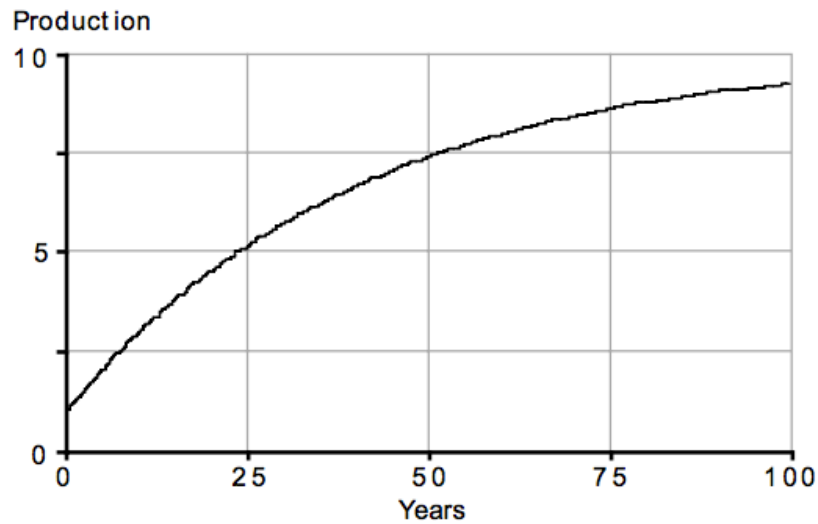

Figure 2.1 Production over Time in Growth Model with No Productivity Growth (Source: Simons, Kenneth L. "Industrial Growth and Competition." 1996, P. 37.)

Now consider another case in which the technical improvement produces a growth rate of 3% per year held every other condition constant, so that A (t) = exp (0.03×t). We can get an increasing marginal production per person over time (See Figure 2.2).

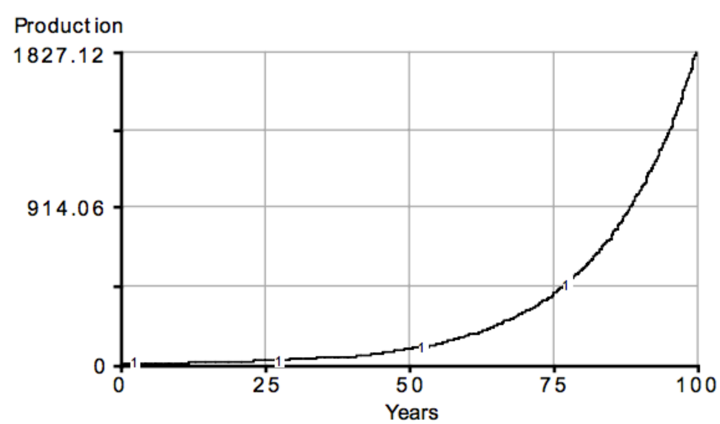

Figure 2.2 Production over Time in Growth Model with No Productivity Growth (Source: Simons, Kenneth L. "Industrial Growth and Competition." 1996, P. 38.)

The second component is narrowing candidates to sectors that provide attractive local economic development impacts, such as job growth in the future, high wages, contributions to the local tax base, and minimal negative environmental impacts. After assessing potential industries, regions decide which of these characteristics are most important and target clusters accordingly. Simply put, it is a process of evaluating the desirability of attracting or developing an industry. For example, Cox et al. (2000) used interviews with local economic development officials and the analytical hierarchy process (AHP) to evaluate the desirability of different types of industries. They argue that the AHP provides a systematic and consistent process of eliciting preferences.

An industry targeting approach developed and used by the Regional Economic Development Research Laboratory (REDRL) of Clemson University has been applied to many cases. There are three steps of conducting the REDRL targeting method:
"First, the region's industries must pass five screens to be selected as a targeted cluster: substantial local presence as indicated by number of establishments and employees, industry employment in the region is growing, the region is relatively specialized in the industry (LQ> 1.20), and local employment growth exceeds the national industry average. Next, industry value chains are identified to determine if linked industries are good prospects for targeting. Finally, the identified high potential industry clusters are rated according to workers' wages, potential future employment growth, import substitution potential, average plant size, and linkages to the local economy. Comparisons of these industry characteristics provide communities with insights regarding the potential

economic and fiscal impacts associated with the attraction of an establishment in one of the target industries.[9]"

David (2007) identified the similarity between the skill demand of an industry and the skill supply in Nebraska and the analysis provided an indicator of how closely Nebraska communities match the occupational and skills demands of post-industrial industries. The method used to measure the similarity between the skill demand of an industry and the occupational or skill supply in a region is the Labor Similarity Index (LSI). LSI is calculated using a Gini coefficient and then converting the coefficients to a standardized Z-score for easier interpretation. The greater the LSI value, the greater occupational similarity or match between industry demand and the regional supply. After calculating and ranking the LSI scores in Nebraska, the study provides a form of industry targeting that indicates which industries are best suited to the occupational and skills base in that region.

[9] David L. Barkley and Mark S. Henry, "Targeting Industry Clusters for Regional Economic Development: An Overview of the REDRL Approach." REDRL Department of Applied Economics and Statistics Clemson University, Clemson, South Carolina, 2005, P.1.

CHAPTER THREE

RESEARCH METHOD

I selected Chongqing City in China as my case. The municipality is direct-controlled by the central government, and was created in 1997 and significant change has been made since that time. From 1997 to 2010, the annual average growth rate of GDP in Chongqing is more than 10% and the annual average growth rate of fixed assets is more than 20%,[10] which makes it attractive to do an industrial targeting. The time frame of this study is from 1997 to 2010. The major source of data is the China's National Statistics Bureau (NSB). The NSB reveals annual and seasonal reports of economic indicators both on national and local levels (including the city of Chongqing). Also, CEIC China Premium Database provides useful macroeconomic, sector and regional data.

To examine technology-related assets within and near Chongqing City and decide which hi-tech industries the local government should pursue, I gathered and analyzed data from two perspectives:

The first step was a screening process to identify the concentration of the employment and production in high-technology industries (aircraft, office and computing equipment, drugs, and medicine, radio, TV and communications equipment). [11] The first indicator is employment growth in these industries, which is to identify a list of those industries that

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[10] National Bureau of Statistics of China

[11] The high technology manufacturing defined by Organization for Economic Co-operation and Development (OECD) include aircraft, office and computing equipment, drugs, and medicine, radio, TV and communications equipment.

have grown in the study area in the 10-year period of 1997-2010. The rationale is that if the employment has grown, it is likely that the individual firm and the sector in general will continue to grow. The data on employment for each industry are accessible on the website of China's National Statistics Bureau (NSB). Also, I will examine the location quotient, which indicates whether the sector is able to supply the demand on the products and services in a particular region relative to the rest of the country. Employment location quotients for the eight high technology occupation categories will be highlighted if it is significantly above 1.0 (e.g., >1.2), indicating a specialization in the given technology area. It is used to identify the region's exporting industries.

Secondly, I analyzed the region's strength from the perspective of knowledge infrastructure. Chongqing's knowledge infrastructure is defined as two major components: (1) organizations conducting scientific research and (2) applied innovation and the region's human capital base. These organizations include research universities and institutions, state-level research laboratories, state-sponsored technology agencies, and private sector businesses engaged in innovation. The measurement of innovative activity is summarized in Table 3.1. Also, I evaluated the human capital dimension of the Chongqing's colleges and universities. The literature on technology-related regional growth has long emphasized the important role that major research universities play in conducting R&D, transferring technology, and generating spin-off companies (Bozeman and Crow 1991; Chrisman, Hynes et al. 1995). The indicator I used was the number of enrolled graduate students majored in Science and Technology (S&T), the number of researchers with special allowance offered by the state.[12] At last, I will create a ranking of hi-tech industries by weighted scores of these knowledge indicators. Thus, we can get a list of hi-tech industries that are relevant to or could benefit from the region's knowledge strength.

Table 3.1 Measurement of Innovative Activity

Measurement	Source
• Rating of universities, by academic discipline	• China Education and Research Database (CERD)
• Number of R&D institutions	• CERD
• R&D expenditures by sectors	• CEIC China Premium Database
• Patents issued by sectors	• NBS
• Student enrollment, by academic discipline	• CERD

The findings from the two perspectives above can identify localized concentrations where hi-technology industrial and knowledge creation assets overlap within specific functional areas. The overlaps, which we label technology clusters, are places where a moderately to highly sophisticated knowledge infrastructure is joined with a substantial related industrial base. Indeed, numerous regions in the U.S. have identified key industry clusters to serve as cornerstones of their economic development efforts. For example, Pennsylvania has prioritized its workforce development programs to focus on 17 select industry clusters. Hence, the findings will help the local government to recognize local sectors with competitive advantages that can serve as growth engines in the future. As such, they are first candidates for the local government to pursue and development policy initiatives designed to increase the general complement of technology activity in city of

[12] Chinese Government Special Scholarship" is set up to award outstanding scholars with monthly allowance.

Chongqing. Given the context of the National 12th Five-Year Plan, recommendations will be given to local governments.

CHAPTER FOUR

DATA ANALYSIS

4.1 Part One: Identify Local Industrial and Innovation Strength

The data are mainly from the National Bureau of Statistic of China (NBS) and Chongqing Bureau of Statistics (CBS). Some of the industrial data were collected from the China High Technology Industry Statistics Yearbook, which give us important numbers on research and development (R&D) both for the city of Chongqing and nationwide. All of these data are free and open to the public.

There were two steps in this part of analysis: (1) examine the local employment pattern and (2) examine local innovation activities.

4.1.1 First Step: Examine Local Employment Pattern

One of the key components of this analysis is the use of relative local employment growth rates as a way to identify "promising" high technology industries. Given the fact that China is currently a developing country with a recently significant growth of GDP, most of industries in China experienced employment growth during the last decade. We should highlight industries with an employment growth rate higher than average. Thus, the assumption is that an industry with a comparatively high growth rate may indicate an area of competitive advantage.

The high technology manufacturing defined by Organization for Economic Co-operation and Development (OECD) include aircraft, office and computing equipment, drugs and medicine, radio, TV and communications equipment. Subjected to the data availability and based on different categorization for industries between China and International conventions, I select seven technology-intensive industries as the industrial targeting candidates. These industries are:

(1) Petroleum and nuclear fuel processing
(2) Chemical materials and products
(3) Medical and pharmaceutical
(4) Electric equipment
(5) Communication and computers
(6) Meters and office machinery
(7) Transportation.

During the period of 2005 to 2010, the total industrial employment in Chongqing has increased from 905,000 to 1.46 million, or 61.9%, while national level employment increased 2.6% during the same period. In employment terms, the largest high-tech industries in Chongqing are transportation equipment, chemical materials and electric equipment (See Table 4.1). If we look at the employment growth data, we see that four industries experienced above local average growth (61.9%) during 2005 to 2010: medical and pharmaceutical (65.5%), electric equipment (133.2%), communication and computers (184.2%) and transportation equipment (65%). The employment growth rates of these four industries in Chongqing are all higher than the national level of 2.6%.

Table 4.1 High-technology Employment and Wages: Chongqing and China (2005 and 2010)

Chongqing	Employment			Payroll	
Industries	2005 (000's)	2010 (000's)	% Change 05-10	Total Wage (Yuan) 2010	Average Wages Chines Yuan
All Industries	**905**	**1465.6**	**61.9**	**61,852,388**	**42,203**
Petroleum and Nuclear Fuel Processing	3.8	6	57.9	475,418	79,236
Chemical Materials and Products	56.8	82.1	44.5	3,107,925	37,855
Medical and Pharmaceutical	19.7	32.6	65.5	2,237,349	68,630
Electric Equipment	20.5	47.8	133.2	1,830,792	38,301
Communication and Computers	10.1	28.7	184.2	879,762	30,654
Meters and Office Machinery	20.5	25.8	25.9	873,278	33,848
Transportation Equipment	236.7	390.6	65.0	16,720,574	42,807

China	Employment			Payroll	
Industries	2005 (000's)	2010 (000's)	% Change 05-10	Total Wages 2010	Average Wages Chines Yuan
All Industries	**93039**	**95447**	**2.6**	**-**	**-**
Petroleum and Nuclear Fuel Processing	779.9	921.5	18.2	-	-
Chemical Materials and Products	4447.6	4741.4	6.6	-	-
Medical and Pharmaceutical	1324.8	1731.7	30.7	-	-
Electric Equipment	4453.8	6043	35.7	-	-
Communication and Computers	4354.8	7727.5	77.4	-	-
Meters and Office Machinery	1139.5	1248.6	9.6	-	-
Transportation Equipment	4327.7	5737.2	32.6	-	-

Source: the National Bureau of Statistic of China, Yearbook 2005, 2010. Chongqing Bureau of Statistics, Yearbook 2005, 2010.
The data for the payroll in national level is not available.

In employment terms, the largest high-tech industries in Chongqing are transportation equipment, chemical materials and electric equipment (See Table 4.1). If we look at the employment growth data, we can find that there are four industries experienced above local average growth during 2005 to 2010: medical and pharmaceutical (65.5%), electric equipment (133.2%), communication and computers (184.2%) and transportation equipment (65%). The employment growth rates of these four industries in Chongqing are all higher than the national level respectively.

The second indicator to identify the local employment pattern is the location quotient, which indicates whether the sector is able to supply the demand on the products and services in a particular region relative to the rest of the nation.

The basic formula for the location quotient is:

$$LQ = \frac{\text{Ratio of Local Employment of Industry x to Total Local Employment}}{\text{Ratio of National Employment of Industry x to Total National Employment}}$$

Employment location quotients for the eight high technology occupation categories are highlighted if it is significantly above 1.0 (e.g., >1.2)[13], indicating a specialization in the given technology area. There're three high-tech industries with a LQ that exceeds 1.2: medical and pharmaceutical (1.23), meters and office machinery (1.35) and transportation equipment (4.43), which are identified as the region's exporting industries (See Table 4.2).

[13] Shields, Martin, David Barkley, and Mary Emery. "Industry clusters and industry targeting." *Targeting Regional Economic Development* 44 (2009): 35. P.1.

Table 4.2 High-technology Location Quotient (2010)

2010	Employment				LQ
	Chongqing		China		Location
Industries	Employment	% of Total	Employment	% of Total	Quotient
All Industries	**1465.6**	**100**	**95447.1**	**100**	**-**
Petroleum and Nuclear Fuel Processing	6	0.41	921.5	0.97	0.4
Chemical Materials and Products	82.1	5.60	4741.4	4.97	1.1
Medical and Pharmaceutical	32.6	2.22	1731.7	1.81	**1.2**
Electric Equipment	47.8	3.26	6043	6.33	0.5
Communication and Computers	28.7	1.96	7727.5	8.10	0.2
Meters and Office Machinery	25.8	1.76	1248.6	1.31	**1.4**
Transportation Equipment	390.6	26.65	5737.2	6.01	**4.4**

Source: the National Bureau of Statistic of China, Yearbook 2005, 2010. Chongqing Bureau of Statistics, Yearbook 2005, 2010. *Employments are in thousand people (000's).

According to the data, the transportation equipment sector in Chongqing has a significantly high portion (26.7% of total industrial employment) of the region's industrial structure. Chongqing is China's largest center for motorcycle production and the third-largest center for auto vehicles. In the year of 2011, Chongqing produced about 60% of China's motorbikes and one million sedans, most of which are sold to domestic consumers.[14] Thanks to the strong industrial base in the local auto industry, the vehicle parts sector as well constitutes a big share of national output. A U.S. Ford auto joint venture in Chongqing has brought with it several big parts suppliers. The U.S. engine-maker Briggs & Stratton even set up a global sourcing center in Chongqing.

Now, we can summarize the results according to the indicators applied in the first step (See Table 4.3). The key findings in the first step are: (1) in employment terms, it appears to be that the Transportation, Medical and Meters and Office Machinery related

[14] China Statistics Yearbook on High Technology Industry, 2012

industries have the greatest strength within the study area, (2) employment growth rates of medical, electric and communication related industries are relatively higher and (3) medical and transportation related industries constitute relatively higher wages. As a result, there were two industries that fulfill all the terms we set in the first step: Medical and Pharmaceutical and Transportation Equipment.

Table 4.3 Local Employment Pattern Summary

Chongqing	Employment growth	Location Quotient	Annual Wage	Total Rank
	Rank	Rank	Rank	(Sum)
Petroleum and Nuclear Fuel Processing	5	6	1	12
Chemical Materials and Products	6	4	5	15
Medical and Pharmaceutical	3	3	2	8
Electric Equipment	2	5	4	11
Communication and Computers	1	7	7	15
Meters and Office Machinery	7	2	6	15
Transportation Equipment	4	1	3	8

Employment growth higher than regional average; or,
LQ larger than 1.2; or,
Annual wage higher than regional average

4.1.2 Second Step: Examine the Innovation Activities

In order to get rid of the low-end export-processing regime and upgrade within global value chains, it is essential to foster industries with relative strength in high technology. Innovation activities are more likely to cluster than manufacturing activities since knowledge spillovers, as an important engine of long-run economic growth, are the ability of economic agents to utilize a new technology or innovation without fully compensating its original source or owner. [15] To obtain these benefits, high technology

[15] Grossman, Gene M., and Elhanan Helpman. *Innovation and growth in the global economy*. the MIT Press, 1991.

industries are willing to locate their business close to each other (with similar value chains), which could further enhance benefits from sharing knowledge spillovers and reducing transaction costs.

Thus, the idea is to implement an industrial development strategy based on the local strength in innovation, R&D and production so as to enhance these clusters to achieve higher returns (wages, profits and tax base).

According to the model created by Kenneth Simons[16], the absence of technological improvement leads to a diminishing marginal production per person over time. And the diminishing returns to the production process cause annual gains in production to grow less. If a technical improvement that constitutes a growth rate of 3% per year, which every other thing held, we can get an increasing marginal production per person over time. Productivity change is enormously important to economic growth in the basic macroeconomic growth model. And technical improvement is a key component for increase in productivity according to this model.

Thus, another indicator used to examine the extent that an industry involves technical improvement was the gross output value per person (GOVPP) during the five-year span (2005 to 2010). From the results, we can see the industry of Medical and Transportation equipment has a significant higher percentage of change, 305% and 296% respectively,

[16] Simons, Kenneth L. "Industrial Growth and Competition." (1996).

than the other industries (See Table 4.4). Let's take a closer look into some indicators of innovation activities among those industries (See Table 4.5).

Table 4.4 Gross Output Value Per Person (2005 – 2010)

Chongqing	2005	2006	2007	2008	2009	2010	% of Change
Total	**186.1**	**260.8**	**403.0**	**477.9**	**551.6**	**623.9**	235.3
Petroleum and Nuclear Fuel Processing	227.6	288.2	336.2	483.5	579.7	676.8	197.4
Chemical Materials and Products	204.7	288.7	392.5	517.5	525.1	651.0	218.1
Medical and Pharmaceutical	219.7	336.6	428.6	536.6	672.8	891.1	**305.6**
Electric Equipment	430.3	476.9	703.4	758.5	701.6	870.0	102.2
Communication and Computers	284.6	277.8	430.3	534.4	526.9	714.8	151.1
Meters and Office Machinery	145.2	201.2	292.4	325.2	343.0	439.5	202.8
Transportation Equipment	213.3	316.9	461.1	595.8	699.1	845.8	**296.5**

Source: the National Bureau of Statistic of China, Yearbook 2005 - 2010. Chongqing Bureau of Statistics, Yearbook 2005 to 2010. * Output values are in thousand Chinese Yuan (000's).

Expenditure on research and development (R&D) is one of the most widely used measures of innovation inputs. R&D intensity is defined by OECD as "R&D expenditure as a percentage of GDP", which is used as an important indicator of an economy's relative degree of investment in generating new knowledge. In the year of 2010, the OECD average stands at 2.3%.[17]

From Table 4.5 we can find that all the industries have experienced a high increase on R&D expenditure from 2005 to 2010, among which Medical and Pharmaceutical, Chemical and Transportation related industries have an increasing rate that higher than the region's average (1.59%). There are three industries with the R&D intensity that higher than OECD's average (in 2010): medical and pharmaceutical, meters and office

[17] OECD Science, Technology and Industry Scoreboard, 2010

machinery and transportation.

Table 4.5 Expenditures for R&D, Chongqing (2005 to 2010)

	Expenditure		Rate of change	% of Output value
Year	2005	2010	05-10	2010
Total	475408	1457470	2.07	1.59
Petroleum and Nuclear Fuel Processing	1310	2514	0.92	0.62
Chemical Materials and Products	31968	112715	2.53	2.11
Medical and Pharmaceutical	13780	59585	3.32	**3.30**
Electric Equipment	16238	44001	1.71	0.88
Communication and Computers	10495	16677	0.59	0.74
Meters and Office Machinery	14273	26340	0.85	**2.32**
Transportation Equipment	224031	763760	2.41	**2.63**

Source: the National Bureau of Statistic of China, Yearbook 2005 - 2010. Chongqing Bureau of Statistics, Yearbook 2005 to 2010. * Expenditures are in ten thousand Chinese Yuan (0,000's).

Now, we can summarize the results according to the indicators applied in the second step (See Table 4.6). The key findings in the second step are: (1) to the extent of increasing rate of gross output per person, the leading sectors are transportation and medical and (2) these two sectors also have relatively higher R&D intensity, which indicates outstanding innovation strength. Thus, these two industries (Medical and Transportation) fulfill the all the terms we set in the second step.

Table 4.6 Innovation Activities Summery

Chongqing	Increasing rate of output per person	R&D Intensive	R&D Expenditure	Total Rank
	Rank	Rank	Rank	(Sum)
Petroleum and Nuclear Fuel Processing	3	7	7	17
Chemical Materials and Products	4	4	4	12
Medical and Pharmaceutical	1	1	1	3
Electric Equipment	6	5	5	16
Communication and Computers	5	6	6	17
Meters and Office Machinery	7	3	3	13
Transportation Equipment	2	2	2	6

Source: the National Bureau of Statistic of China, Yearbook 2005 - 2010. Chongqing Bureau of Statistics, Yearbook 2005 to 2010.

Increasing rate if output per person (Coefficient) higher than regional average; or,
R&D Intensive larger than 2.3%;

4.2 Part Two: Examine Local Knowledge Infrastructure

The knowledge infrastructure in the city of Chongqing is examined from two major sectors: (1) companies (as well as non-profit organizations) conducting scientific research and applied innovation and (2) local universities engaged in developing the region's human capital base. Companies and organizations engaged in R&D activities include state-sponsored or owned institutions (e.g. Chongqing LIFAN Group Cor.), non-profit R&D organizations (e.g. Chongqing Meters Institute), and research departments within private sector businesses. Universities are those with high concentration of academic disciplines in the sciences, applied sciences, and engineering.

4.2.1. Companies and Organizations

Data on the amount of scientific and technical personnel provide concrete and direct measurements for industry comparisons of human resources devoted to R&D. Personnel engaged in scientific and technical activities of crucial importance for industrial upgrading at the firm level. To obtain these benefits, those employees are willing to spatially gather, which could further enhance benefits from sharing knowledge spillovers according to empirical evidence. For example, Romer (1990) formulated a consistent growth model with endogenous technological progress. The assumption in that model is that knowledge is non-rival and therefore everyone engaged in R&D has free access to the entire stock of knowledge. The results show that that all R&D personnel would ultimately end up in one region and this region would have the fastest rate of economic growth.

State owned or sponsored institutions represent the highest level of research in China. As the Table 4.7 shows, there are 19 of them built in the city of Chongqing. In number terms, medical and transportation related are top ranking (both have two, or 10% of the total). This data, to some extent, indicates the local knowledge base engaged in the highest research level in different fields.

Table 4.7 State-owned or Sponsored R&D Institutions (Chongqing, 2010)

Institutions	# of institutions	Percentage of total (%)
All	**19**	**100**
Petroleum and Nuclear Fuel Processing	0	0
Chemical Materials and Products	1	5.26
Medical and Pharmaceutical	2	10.53
Electric Equipment	1	5.26
Communication and Computers	1	5.26
Meters and Office Machinery	2	10.53
Transportation Equipment	1	5.26
Other	11	57.8

Source: Chongqing Science and Technology Statistics Yearbook 2010.

We use the similar method, location quotient, which has been applied to identify the employment patterns in the first part to take a closer look into the personnel engaged in science and technical activities in the city of Chongqing. The results (See Table 4.8) show that three industries (medical and pharmaceutical, meters and office machinery and transportation equipment) have a value of LQ higher than 1.2. It is also noteworthy that the LQ of transportation related industry equals 3.51, which indicates a significant high concentration of R&D personnel.

Table 4.8 Scientific and Technical Personnel (Chongqing and China, 2010)

2010	Scientific and Technical Personnel				LQ
	Chongqing		China		Location
Industries	Employment	% of Total	Employment	% of Total	Quotient
All Industries	**58,243**	**100.00**	**1,369,908**	**100.00**	**-**
Petroleum and Nuclear Fuel Processing	155	0.27	11,560	0.84	0.31
Chemical Materials and Products	3,757	6.45	79,221	5.78	1.12
Medical and Pharmaceutical	3,636	6.24	55,234	4.03	**1.55**
Electric Equipment	1,563	2.68	137,965	10.07	0.27
Communication and Computers	2,136	3.67	278,583	20.34	0.18
Meters and Office Machinery	3,184	5.47	32,578	2.38	**2.30**
Transportation Equipment	26,433	45.38	176,921	12.91	**3.51**

Source: the National Bureau of Statistic of China, Yearbook 2010. Chongqing Bureau of Statistics Yearbook, 2010.

Another indicator used here is the number of patents granted to these selected industries. Patent is a form of intellectual property. It consists of a set of rights granted by a government to an inventor to appropriate fully and exclusively any returns derived from the innovation. An invention can be a solution to a specific technological problem or may be a product or a process. Therefore, utility patent grants by sector are another important indicator of applied innovative activity. While some patents are granted to universities and research institutions, the vast majority is secured by private industry.

We use data from State Intellectual Property Office of China to calculate the location quotients of utility patents granted by sectors within the study area. Patent grants in transportation equipment account for more of one-tenth of the total and have a LQ of 4.3 (See Table 4.9). The patent data indicates the high concentration of R&D activities in transportation related industries in the city of Chongqing. Other industries with location quotient above 1.2 are chemical materials (1.8), medical and pharmaceutical (2.8) and meters (1.8).

Table 4.9 Utility Patents Granted (Chongqing and China, 2010)

2010	Granted Patents				LQ
	Chongqing		China		Location
Industries	Patents number	% of Total	Patents number	% of Total	Quotient
All	**9111**	**100.00**	**700304**	**100.00**	**-**
Petroleum and Nuclear Fuel Processing	-	-	-	-	-
Chemical Materials and Products	98	1.0	4253	0.6	**1.8**
Medical and Pharmaceutical	220	2.4	6049	0.9	**2.8**
Electric Equipment	72	0.8	4675	0.7	1.2
Communication and Computers	89	1.0	20965	3.0	0.3
Meters and Office Machinery	69	0.8	2883	0.4	**1.8**
Transportation Equipment	983	10.8	17664	2.5	**4.3**

Source: State Intellectual Property Office of China

4.2.2. Local Based Universities and Colleges

The local based universities and colleges that offer degrees in science and technology play an important role in enhancing local human resources and are the key components of Chongqing's knowledge base. Students enrolled in these universities and colleges have great potential to participate in the region's high-technology industries in different sectors. Here we use two measures to evaluate this potential in the city of Chongqing: (1) education quality by sectors and (2) number of students enrollment by sectors.

There are four (4) research universities located within Chongqing urban area: Chongqing University, Chongqing Jiaotong University, Chongqing University of Science and Technology and Chongqing Medical University. The comparative strength of the universities is identified by the rank of teaching quality (national) in different fields.

Data are collected from China Education Statistics Yearbook.[18] Other indicators for comparative strength are the number of professors, research funding and faulty quality etc. However, subjected to the data source, the only indicator used here is the rank of teaching quality. (See Table 4.10)

Table 4.10 Teaching Quality Rankings (national) of Research Universities in Chongqing

	Chongqing U	Chongqing Jiaotong U	Chongqing U of S&T	Chongqing Medical U
Petroleum Engineering	-	-	8	-
Chemical Engineering	28	-	39	-
Medical Science	-	-	-	12
Electric Engineering	10	-	-	-
Electronic Engineering	32	-	-	-
Automotive Engineering	5	24	39	-
Thermo-motive Engineering	16	-	-	-
Instrument Engineering	8	-	-	-

Source: China Education Statistics Yearbook, 2010

Top 10

Top 20

The analysis of the rankings of the universities in the city of Chongqing reveals that the research fields of petroleum, electric, automotive and instrument engineering have relatively higher strength as they are ranked top-10 nationwide. It is also noteworthy that in auto related fields (automotive and thermo-motive engineering), there are four (4) top-50 departments in three universities. And Chemical Engineering has two top-50 departments. This fact indicates relatively strong potential of human resources in automobile and chemical related industries.

[18] The rankings are only available for top 50

The last step is to look at the student enrollment in regional universities and colleges. The student enrollment data shows that three fields (Chemical Engineering, Electric Engineering and Auto Engineering) have a LQ larger than 1. (See Table 4.11)

Table 4.11 Student Enrollment (Chongqing and China, 2010)

2010	Student Enrollment				LQ
	Chongqing		China		Location
Field	Students	% of Total	Students	% of Total	Quotient
All	**353,083**	**100**	**12,656,132**	**100**	**-**
Petroleum Engineering	13,811	3.9	518,901	4.1	1.0
Chemical Engineering	18,424	5.2	565,729	4.5	1.2
Medical Engineering	16,624	4.7	803,847	6.4	0.7
Electric Engineering	22,452	6.4	974,522	7.7	0.8
Electronic Engineering	21,773	6.2	645,463	5.1	**1.2**
Instrument Engineering	8,583	2.4	455,621	3.6	0.7
Automotive Engineering	31,424	8.9	759,368	6.0	**1.5**

Source: China Education Statistics Yearbook, 2010

The student enrollment data are available from 2005 to 2010, which makes it possible to look at the change of portion to the total enrollment for each field (See Table 4.12). In the proportion of student enrollment terms, there are three study fields (Medical, Meters and Automotive Engineering) were increasing from 2005 to 2010. Medical and Automotive Engineering have a percentage change of 39.2% and 16.1% respectively.

Table 4.12 Student Enrollment Proportion (Chongqing, 2010)

Proportion (%)							Change (%)
Year	2005	2006	2007	2008	2009	2010	05-10
Total	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	0.0
Petroleum Engineering	4.67%	4.40%	4.01%	3.90%	3.83%	3.91%	-16.2
Chemical Engineering	5.20%	5.30%	5.70%	5.60%	5.50%	5.22%	0.3
Medical Engineering	3.38%	3.57%	3.92%	4.34%	4.52%	4.71%	**39.2**
Electric Engineering	6.60%	6.40%	6.70%	6.90%	6.20%	6.36%	-3.7
Electronic Engineering	6.70%	6.90%	6.10%	6.30%	6.50%	6.17%	-8.0
Automotive Engineering	8.20%	8.00%	8.50%	8.40%	8.70%	8.90%	**8.5**
Instrument Engineering	2.10%	2.20%	23.46%	2.41%	2.45%	2.44%	**16.1**

Source: China Education Statistics Yearbook, 2005 to 2010

By far, we have examined the concentration and competitive strength of the two major components of Chongqing's knowledge infrastructure: its performers of R&D and its institutions of higher education. As we can see from the regional knowledge infrastructure summary (See Table 4.13), key findings in this section of analysis are:

- The industries of Medical, Meters and Transportation have the leading concentration of S&T personnel and the utility patent granted to these three industries have relatively larger numbers.
- As a key indicator of the potential human resources, the local student enrollment in automotive related fields appears to have the greatest strength.
- Student enrollment in medical and transportation related fields experienced a strong growth during the study period (2005 to 2010).

Thus, there are two industries that fulfill the terms we set in this section of analysis and have the greatest strength in knowledge base: Medical and Pharmaceutical and Transportation Equipment.

Table 4.13 Regional knowledge infrastructure summary

Chongqing	Number of R&D Institutions	S&T Personnel LQ	Patents LQ	Student Enrollment LQ	Student Enrollment Growth Rate	Total Rank
Industries	Rank	Rank	Rank	Rank	Rank	Sum
Petroleum and Nuclear Fuel Processing	3	6	7	4	5	25
Chemical Materials and Products	3	5	4	3	3	18
Medical and Pharmaceutical	1	3	2	6	1	13
Electric Equipment	3	7	5	5	3	23
Communication and Computers	3	4	6	2	4	19
Meters and Office Machinery	1	2	3	7	3	16
Transportation Equipment	3	1	1	1	2	8

National Key R&D Units; or,
LQ larger than 1.2; or,
Student Enrollment Proportion was increasing during 2005 to 2010

CHAPTER FIVE

FINDINDS AND POLICY IMPLICATIONS

5.1 Findings

By examining the industrial and innovative patterns within the study area, there are several findings that emerge from the analysis.

- Chongqing's pillar industry appears to be the transportation related sector (e.g. automotive, motorcycle manufacturing), which has the largest employment base and probably involves a significant technical improvement recently.
- Medical and Pharmaceutical sector is the most promising industry in the city of Chongqing as it experienced a rapid growth both in employment and productivity (measured by gross output per person).
- These two industries also show a greatest strength on their innovative activities, as the R&D intensity is relatively higher than other sectors in Chongqing.
- The analysis of local knowledge infrastructure tells the similar story. The since and technology (S&T) personnel and patents data indicate a high concentration of technical human resource relatively strong ability of innovation in medical and transportation sectors in Chongqing.
- Not surprisingly, student enrolled in automotive related fields has the largest proportion. The number of students enrolled in medical related fields was increasing rapidly during the study period (2005 to 2010).

We sum up the ranks of these seven industries according to Table 3, 6 and 12 and get the total rank of theses sectors (See Table 5.1). It is clear that two industries (Medical and Pharmaceutical and Transportation) have the highest rank (22 and 24 respectively). Thus, these two are identified as localized technology-related strengths and have the greatest potential to develop in the future.

Table 5.1 Regional Strength Summary

Industry	**Total Rank**
Petroleum and Nuclear Fuel Processing	54
Chemical Materials and Products	45
Medical and Pharmaceutical	**24**
Electric Equipment	50
Communication and Computers	51
Meters and Office Machinery	44
Transportation Equipment	**22**

5.2 Auto Industry

5.2.1 Industry Outlook

The automobile industry is considered as traditional industry both in China and United States. Auto manufacturing is in the mature stage of its life cycle. Industry value added (IVA), a measure of the industry's overall contribution to the economy, is expected to decline at an average annual rate of 0.6% in the U.S. over the ten years to 2017 according to a report by IBIS. However, China is a major emerging market for automobiles and shows a strongly increasing demand recently. Additionally, the IBIS report also states "the industry can expect a surge of demand for its most advanced products over the next five years as regulators are steadily tightening and enlarging the scope of emissions regulations".[19] This kind of new regulations is expected to create demand for the industry and opportunities for increased profitability, as automakers' work with suppliers to develop new system technologies and designs in order to meet the new standard.

5.2.2 Policy Recommendations

According this trend, the local government should guide and encourage the automakers to upgrade their technology and products toward "higher efficiency" and "eco-friendly". For example:

1. Give tax abatements for the high efficient products (e.g. fuel-efficient vehicles, hybrid power engines and electrical vehicles), which will stimulate the market and increase the investor's confidence in the new trend of this industry.
2. Improve the infrastructure (roads, railways and ports). The shipment cost of auto parts or final products account for a significant portion of the total costs. Thus, the improvement of the infrastructure will make the city more attractive to automakers.

These policies are also fit into the National Five Year Plan: "Transformation and upgrading, enhancing the competitiveness of Industrial core",[20] which is to further upgrade and restructure a group of traditional industries. These industries are identified as needing technical upgrading as well as consolidation to benefit from scale efficiencies.

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[19] Auto Parts Manufacturing, *IBISWorld Industry Report* No. 33639, P. 9
[20] China's 12th Five-Year Plan, The State Council of the People's Republic of China, Part III, Chapter 8.

Also, given the sector's strength as identified in the analysis, it would be more likely for a successful upgrading.

5.3 Medical and Pharmaceutical Industry

5.3.1 Industry Outlook

Medical and Pharmaceutical industry is considered as an emerging sector in China, which is targeted as a major sector to foster and develop according to the 12th National Five Year Plan. In the U.S., it is defined as a mature industry as the average revenue grows at same pace as the U.S. economy and company numbers are stable. The industry's profit, measured by earnings before interest and taxes, are high compared with other manufacturing industries, because firms provide high-skilled value-added services. The industry generates about a 20.1% operating profit margin [21], but this varies significantly among participants. The high profit margin reflects the considerable levels of risk associated with drug development. Pharmaceutical companies must make a profit to fund past and present R&D efforts. Prescription drugs are priced to reflect not only the costs of production, but also the significant R&D costs. Many drug firms invest heavily in R&D because it has long served as the industry's primary engine for growth in revenue and profit. R&D as a percentage of total revenue has hovered between 19.0% and 20.5% since 2008.

5.3.2 Policy Recommendations

As discovering and developing new drugs is often a time-consuming, risky and costly process, an emerging industry or emerging firm is always reluctant to invest in new

[21] Brand Name Pharmaceutical Manufacturing, *IBISWorld Industry Report 32541a*

products because of a short of R&D fund.[22] Therefore, it is important for the government and public sector to provide support or subsidies for these emerging firms in order to achieve long run benefits (high profit margins). For example:

- Provide public financing tools (public debt finance with below market rate or public equity finance) to support the R&D activities in medical sector, which will mitigate the overall risk of discovering new products. Given the identified R&D strength of medical sector in Chongqing, it is promising to achieve a further enhancement of high technology in this sector if appropriate support is given.

Universities can play a powerful role in the development of industry clusters. However, a large base of research and development of universities is insufficient to leverage the relevant industries. The university must be also aligned with regional interests and industry clusters across a broad spectrum (e.g. business, workforce). Thus, the local government could provide non-financial support to enhance the spillover benefits.

The results of analysis in this paper can help the local government to further understand the regional high technology cluster. And this understanding is also helpful and essential to possibly promote or leverage productivity-enhancing spillovers and economies shared by the technology businesses at the core, for example:

- Help to establish venues or mechanisms for business collaboration and information exchange. Encourage the creation of a research association

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[22] United States. Congress. Office of Technology Assessment. Pharmaceutical R&D: costs, risks, and rewards. DIANE Publishing, 1993.

participated by local research universities, R&D institutes and private firms to promote the shared information, technology and interests in medical sector.

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