

# Development Environment and Countermeasures of 3D Printing Industry Base: A Chinese Case Study

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**Abstract:** In recent years, many local governments in China scramble to build 3D printing industry base, hoping to stimulate local economic development. However, the theoretical research on development environment and countermeasures of these 3D printing industry bases are very lacking. The model analyzing development environment of 3D printing industry base was designed. The development environment and countermeasures of Anshan city's 3D printing industry base were analyzed as an example. The research results can provide valuable reference for the development and construction of 3D printing industry bases.

**Keywords:** 3D Printing, Industrial Base, SWOT Analysis, Strategy, Anshan

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## 1. Introduction

3D printing, as a representative of emerging technology, is driving the third industrial revolution [1]. Many countries in the world, such as the United States, Germany, Sweden, Japan, and Belgium all take 3D printing as an important support of the future economic development [2, 3]. Receiving great attention from governments and businesses, 3D printing has been included in the National 863 plan and science & technology support program in China [4]. Today, more and more local governments have learned the importance of the 3D printing in stimulating local economic development and building the regional characteristic industry. China 3D printing Technology Industry Alliance predicts that that Chinese 3D printing market will become the largest market in the world in 2016 which will expand to 10 billion Yuan RMB over the United States [5]. Thus, many regions of China, such as Nanjing, Wenzhou, Wuhan, Zhuhai, Qingdao, Chengdu, are rushing to build 3D printing bases (or Parks) [6, 7] to take the lead in grasping the growth opportunities and seize the large 3D printing market. However, in spite of the fast development of 3D printing industry in China, there is less research about the development environment and countermeasure of 3D printing industry. China National Knowledge Internet (CNKI)

database information shows the related scientific researches and reports on "3D printing" and "base" are totally up to 28 records. Among them, there are 22 records from China Core Newspapers Full-text Database, which are some China-related news about the 3D printing industry base. The other 6 records come from China Academic Journals Full-text Database, of which only 2 records are about how to use 3D printing to establish Lunar bases [8, 9] and the other 4 records published in academic journals are some news reports on 3D printing industry base in China. Therefore, it is badly necessary to conduct research on development environment and countermeasures of 3D printing industry base according to the time when the 3D printing industry base is expanded and constructed heavily by numerous local governments in China.

## 2. Analysis Model on Development Environment of 3D Printing Industry Base

SWOT is a structure analysis method aiming at four elements (strengths, weaknesses, opportunities and threats) and a kind of situation analysis based on the internal and external competition environment and competition conditions.

It can draw a series of conclusion by listing and comparing internal strengths and weaknesses with external opportunities and threats [10]. In view of this, combining the features of 3D printing industry, we build an analysis model on development

environment of 3D printing industry base to benefit the 3D printing industry [11, 12]. The model consists of four aspects and 10 elements, as shown in Figure 1.



Figure 1. The analysis model on development environment of 3D printing industry base.

For internal environment, “3D printing industry base” reflects the area’s core competence to develop 3D printing industry. Industry base is directly related to the development of regional 3D printing industry base. “Talents storage and research capability in 3D printing field” show the regional breakthrough ability of science and technology. 3D printing is an emerging technology. A lot of design and research work are needed during its industrializing. Therefore, the quality and quantity of regional research institutes as well as talents have much impact on long-term development potential of 3D printing industry base. Besides, “internal support policies for the development of 3D printing” are very important impetuses because better political supports will bring better development chances. “Industrial concentration of 3D printing” can reflect the regional competitiveness of 3D printing industry base. “Leading teams and core figures of 3D printing” are the key factors to lead the industry to success. “The regional economic scale” decides the long-term development potential of 3D printing industry base. Thus, these six factors can comprehensively reflect the regional inner advantages or disadvantages on building the 3D printing industry base. Also, these advantages and disadvantages sometimes can reciprocally transform into each other according to the specific situation.

For external environment, “self-development trend of 3D printing industry” will has a direct influence on the development opportunity of 3D printing industry base.

“External support policies“, such as national policies, and industrial policies can indirectly reflect the prospect and development chance. Besides, the industry competence power between existing and emerging 3D printing industry base as well as technology bottlenecks of 3D printing can all bring both chances and threats to the 3D print industry base. Therefore, the four factors—“self-development trend of 3D printing industry”, “external support policies”, “industrial competitors” and “technology bottlenecks of 3D printing” are used to analyze development opportunities and threats of 3D printing industry base.

### 3. Empirical Analysis

#### 3.1. Case Selection

Our previous researches aiming at the type of 3D printing industry base show that most 3D printing industry bases are based on manufacturing industry, such as auto industry, textile industry, medical equipment or chip industry [13]. As the main city of old industrial bases in northeast China, Anshan city in Liaoning province has outstanding industrial base of manufacture and development environment. More importantly, high quality/level and innovative area is being built in Anshan. Among the 10 major projects for science and technology development in five years, four projects-- laser technology, health manufacturing, iron reprocessing and equipment manufacturing industry all will be related to 3D printing

industry [14]. For example, laser technology is one of relying on technologies for 3D printing with significant application in steel processing, equipment manufacturing industry and health manufacturing. And this is just what Anshan city is planning to achieve—laser machining as the growing point and expansion of laser application as the focus. To sum up, Anshan city has already possessed a better development background and primary groundwork for building 3D printing industry base. It will perfectly be used as a sample city for leading the orientation of the research on development environment and countermeasures.

### 3.2. Analysis on Development Environment of Anshan City' 3D Printing Industry Base

#### 3.2.1. Advantages

##### i. Solid industrial base

Anshan City has a geographical advantage, located in the cross point of the old industrial base and coastal economic development zone in Liaoning province. Anshan City is an important production base of steel in China, honored as the "Steel City", which brings a good industrial base to 3D printing. Laser technology in Anshan is developing rapidly and there are many companies engaged in the laser industry, such as Anshan Hust laser Technology Company, Ming-hui medical laser Technology Company, Anshan Hongyuan laser technology company, Zhengya laser Technology Company, and Ziyu laser technology company. Besides, Anshan high-tech development zone has cooperatively set up Sci-tech Industrial park for laser in Liaoning with Huazhong University of Science and Technology, Harbin University of Technology, Northeastern University and University of Science and Technology Liaoning etc. It mainly focuses on developing R&D and test platform of laser applied technology, high power laser device, laser advanced manufacture technique etc., which provides a strong support for 3D printing industrial development in Anshan.

##### ii. Great scientific research strength

Anshan, as a national technological innovative trial-city and the key city of Manufacturing information engineering, has 69 research institutes, 280 scientific research institutions, 60 research and development centers, 7 industrialization bases, 80 national high-tech enterprises, and various talented people up to 240,000 [11]. With a great location and profound history of development, Anshan has been a leader in science and technology, such as steel technology, coking technology etc. Anshan city has a cooperative relationship with about dozens of universities such as Tsinghua University, Peking University, Xi'an Jiaotong University, and University of science and technology of Liaoning. Anshan city also sets up a national technology transfer center with the branch of Chinese Academy of Sciences in Shenyang. The center has reached dozens of industrialization agreements about innovative technological achievements.

##### iii. Advantages of national high tech Zones

Anshan high tech Industrial Development Zone is a national high-tech zone, and over the 20 years, it constantly has improved the environment, enhanced innovation ability and

expanded the industrial scale, which leads to the emergence of a large number of high-tech enterprises. Now it has 31 national high-tech enterprises, which accounts for the proportion of the city about 40%; it owns 39 enterprise technological centers, among which are 6 national ones and 22 provincial ones. It includes Angang Steel Company Limited, Rongxin Company Limited, Senyuan Company Limited, Anzhong Company Limited and Fuan Company Limited and other listed companies. It also includes a group of well-known research institutes and R & D centers, for example, NETC, SINOSTEEL. The University of Science and Technology Liaoning, located in the core area of high-tech Zone is the subordinate university of original Metallurgical Industry and has research highlights in machinery, metallurgy, chemical and other disciplines. At the same time, management Committee in Anshan high-tech zone has signed a long-term cooperation agreement with the vocational education of Anshan city, which tends to recommend professional technicians for high-tech enterprises in the region.

#### 3.2.2. Disadvantages

##### i. Lower concentration of industry chains

There are not many equipment suppliers of raw materials and component suppliers for the localization of 3D printing in Anshan, so it can be limited by the development of the suppliers: the downstream has not formed a long-term, stable and large scale demand. Also, customer bases are widely dispersed. Taken together, due to lower concentration of the 3D printing industry chain in Anshan, the elongating chain may reduce the industrial competitiveness of 3D printing industry base in Anshan.

##### ii. Lack of first-class leading teams and characters.

In China, first-class research teams on the study of 3D printing mainly include Yan Yongnian team in Tsinghua University, Wang Huaming team in Beihang University, Shi Yusheng team in Huazhong University of Science and Technology and Lu Bingheng team in Xi'an Jiaotong University etc. Anshan City is short of industry-leading support teams on the scientific research strength in this field, which will adversely affect the development of 3D printing industry base in Anshan.

##### iii. Lack of regional economic scale

3D printing industry development needs supporting by better economic development. The 3D industry in economically relatively developed areas tends to develop better, especially rapidly in those cities such as Beijing, Hangzhou, Nanjing and Guangzhou etc. By contrast, Anshan City has slightly economically backward development, which has a negative impact on the development of the 3D printing industry.

#### 3.2.3. Chances

##### i. Global industrial spree

In recent years, the 3D printing industry scale has expanded rapidly. It is predicted that from 2013 to 2020 year, the compound annual growth rate of the global market for 3D printing will reach 23%, reaching 8.41 billion dollars in 2020 [16]. The research from Market research firm Researchmoz shows that early 2015 in China the total was up to about 3.7 billion Yuan. By 2016, the total market will be over 3 times,

which is expected to exceed 10 billion Yuan [17]. The study of Lux Research shows that by 2018, the 3D printer market in China (excluding exports) will grow to 37800 with compound annual growth rate of 34% and the revenue of 3D printer will grow to 700 million Yuan with compound annual growth rate of 27%. Therefore, the global 3D printing market has a tremendous potential for development [18].

- ii. More development opportunities from China and its Liaoning province together

In 2013, at the national level, the government added 3D printing to the National High Technology Research and Development Program of China to upgrade it to a national strategy; Released in February 2015 national additive manufacturing industry development plan (2015-2016), China is going to establish a complete additive manufacturing (also known as "3D printing") industrial system in early 2016; May 2015, China released the plan made in China 2015, proposing to promote technological breakthroughs of many emerging fields, in which 3D printing is in the first place. At Liaoning provincial level, the laser industrial park's development in Anshan has got great support from Liaoning provincial government, which has become one of ten key industrial parks in Liaoning province. Liaoning province is in the process of construction of "Liaoning (Anshan) laser science and technology industrial park" with entire province to make Anshan laser industry as provincial strategic emerging industries. With above-mentioned national and Liaoning provincial measures, Anshan city has a better development opportunity for building the laser industry base.

### 3.2.4. Threats

- i. Industrial competitors

Moving quickly in some regions of the country exerts pressure on Anshan. Institutes of 3D printing technology industry and industry bases as well as public service platforms of the government were established in Nanjing. Also, the government is giving continuous support of policies and fund to the project related to 3D printing to promote the development of 3D printing. Wuhan was the first to set up Chinese first 3D printing factory. Dongguan added the emerging industry of 3D printing to the government work report in 2013 and it is proposed that Dongguan should have layouts in advance to early expend into the technology market of 3D printing. Harbin University of Technology established its own Engineering Center of 3D printing lab. Renze Science and Technology Development Co, Ltd in Heilongjiang has purchased Flash cast double 3D printer and cooperated with Harbin University of Technology to introduce 3D printing technology to the field on research development of mechanical equipment and large-scale construction projects. The construction and development of advanced base will become competitive threats to the construction of 3D printing industry base in Anshan City

- ii. Bottlenecks of technology development

First of all, in terms of cost, though the cost of 3D printers is constantly decreasing, it is still relatively expensive, which has a direct influence on 3D printing's widespread use; secondly, in terms of printing material, selected materials of 3D printing are mainly about chemical polymers with weak physical properties

which have unsteady hidden danger; thirdly, in terms of accuracy, speed and efficiency, the accuracy and speed of the 3D printing with consumption type are comparatively low and the efficiency of printing is not suitable for the demand for massive production; finally, in terms of intellectual property protection, it is easier to copy products resulted from 3D printing, increase risks of piracy and to some degree prevent the rapid growth of 3D printing industry.

### 3.2.5. Conclusions of Development Environment

Anshan City has developed 3D printing industry with 3D printing industry's expansion and rapid growth at home and abroad. Market requirements growing rapidly, Governments at all levels of nation, provinces and cities have gradually put forward a series of incentive measures to stimulate the development of 3D printing industry. Most importantly, Anshan has already possessed its own industrial base for developing 3D printing and it has clear development opportunities with better bases of scientific research strength and talents storage. Thus, Anshan City has greater development advantages and development opportunities. Meanwhile, Anshan has faced 5 major development disadvantages and threats existing in low industrial concentration, lack of leading teams and projects, limited regional economic scales, increasing competitors, technological bottlenecks and so on when developing 3D printing industry base. Taken together, advantages and opportunities of developing 3D printing industry base are more outstanding with better development environment in Anshan. Weaknesses and threats faced can also be overcome by taking a series of measures.

### 3.3. Development Countermeasures of 3D Printing Industry Base in Anshan

#### 3.3.1. Deepen Reforms and Strengthen Advantages

- i. Strengthen organization and coordination

Through relevant government departments taking the lead, set up regional development-leading teams of 3D printing industry to establish working mechanisms, clear division of responsibility, and strengthen cooperation with provinces and municipalities. Establish the cooperation mechanism of local superior functional departments and strive for superior authority. Strengthen supervision and inspection to ensure the realization of planning objectives.

- ii. Deepen the mechanism of talents cultivation

Talents are the core resources of developing 3D industry. Introduce high-level personnel and teams at home and abroad, carry out related policies, and encourage overseas professionals to return home and start a business to promote the aggregation of resources. In addition, encourage related universities and research institutes to accelerate the process on professional training of 3D printing. List 3D printing into related subjects in universities and take cooperative teaching methods by school-enterprises to promote the cultivation on advanced talents of 3D printing. Also, push industrial association to have related training and carry out publicity and promotion of 3D printing technology in public agencies such as science & technology museums, activity centers, which will accumulate

experiences for developing 3D printing industry.

iii. Increase more policy support

Insert 3D printing industry into development priority among local emerging industries and further implement preferential policies and supportive measures in finance, land, tax and government procurement etc. Government should give priority aid to construction of major projects on 3D printing industry, extension of demonstration and application, industrialization on research and development of key technology, standards setting as well as the cultivation and introduction of talents. Set up local development funds of 3D printing technology and increase support on introduction and cultivation of related innovative enterprises and major projects. List 3D printing equipment into the catalogue of government procurement and increase support on research and development for 3D printing technology; encourage financial institutions to innovate financial products and take diversified investment and financing ways such as, credit, guarantees, venture capital and corporate bills to speed up the development of 3D printing technology and application industry.

### 3.3.2. Take Positive Action and Transform Weaknesses

i. Optimize industrial structures and improve the degree of industrial concentration

The material, software, equipment and application services of 3D printing are key links of building 3D printing industry and each link is independent mutually and relate to each other. None of these can be excluded in building perfect industry chains of 3D printing. It is badly difficult for Anshan to achieve that every link has its own corresponding enterprises. However, the incomplete industry chain can also limit self-development. Therefore, we must consider that local industries focus on the introduction of vacant industry as well as measure its own ability when selecting incoming materials. Through combination of business and technology, perfect the structure of regional industry chains step by step. For example, through the introduction of relevant research institutions and research teams, Anshan can set up R&D sub-centers and offices, filling gaps of local industry.

ii. Enhance powers of existing corporations and create leading enterprises

Actively work out cultivation projects of 3D printing enterprises and select better bases of 3D printing enterprises. Government should provide policy support to project implementation, construction of platform and talents introduction etc. Meanwhile, give support to technology-based SMEs with higher technology and better market prospects to promote the development into high-tech enterprises. Encourage enterprises to carry out standards setting and patent applications of 3D printing technology. Also, build industrial parks of 3D printing with key enterprises-oriented and bringing incubation, application, industrial undertaking and development function together. Form the superiority of industrial agglomeration and enhance the industrial influence of local industry.

iii. Improve qualities of investment enterprises and play a leading role

The supporting enterprises of investment industry not only

enhance the local industrial popularity but also can have the development effect of industrial agglomeration. It is widely suggested that Anshan City introduce large-scale industrial equipment manufacturing enterprises of 3 D printing, desktop civil equipment manufacturing enterprises and service enterprises of 3 D printing, etc. Strive to introduce the American, German, and other famous 3 D printing companies to set up offices in An Shan and focus on leading enterprises of 3D printing industry from Beijing, Shanxi, Hubei and other developed areas to establish branch offices in Anshan and enhance the overall industrial strength. Focus on the existing land and housing resources, especially working harder on a certain volume of domestic and foreign 3D printing projects. Take much more measures just like up-down multi-linkage, cooperation among customers and so on to obtain information and promote industrial development process.

iv. Strengthen the introduction of expert talents and teams to occupy industrial commanding heights

Introduce domestic and foreign industrial experts and teams in 3D printing field through the introduction of a series of talents and increasing great support in research fund, personnel connection, tax relief, home treatment, etc. With their leadership, it will come true that Anshan City's 3D printing industry base has leapfrog development and occupies industrial commanding heights.

### 3.3.3. Gather Strength and Deal with Threats

i. Analyze opponents and make precise application strategies

Compared to other regional situation on industrial development and combined with the existing location base in Anshan, it is necessary to appropriately locate development goals and reduce blind investment and risk. The development and application of industry can promote the popularity of technologies. Also, the combination of technology and industry can effectively improve industrial competitiveness. For example, the technology combined with existing industry can be classified properly into categories such as materials, design, control, information, etc. Further, financial and policy support can be given to key enterprises to encourage the technological innovation.

ii. Integrate resources and break through bottlenecks

Due to the problem of "small and scattered", the comprehensive competitiveness and the capability to withstand risks are not strong enough. Therefore, at present, development-united is an effective way to solve this problem. In the process of developing the 3D printing industry, Anshan City can found regional Industrial Technology Association and integrate distributed resources to effectively promote the exchange and sharing of information resources, accelerating integration between industries. Also, it is achievable to build common technological research and development platforms relying on backbone enterprises, colleges and universities or professional R & D institutions. Concentrate on powerful research workforce to tackle technical breakthroughs and overcome technical bottlenecks of the regional industrial development.

### 3.3.4. Grasp the Opportunity and Accelerate the Development

#### i. Dock policies and plan development

Actively dock national, provincial, city's development plans of 3D printing. Work out development plans reasonably and scientifically. Fully consider the eruptive growth situation on the industry in the future and high-tech barriers to arrange space layouts, development paths, enterprise fostering and project constructions. Perfect industrial structures of full chain and put the stress on the key talents and core technology. Increase the input of public platform construction. Keep on sensitivity of technology and urgency of fierce competitions to promote industrial agglomeration and speed up the pace.

#### ii. Speed up development and take the preemptive opportunities

At present, many countries in the world are promoting the development of 3D printing industry, but development gap is not very great by technical bottlenecks and limits of application market. Therefore, in order to grasp the future rare opportunity, it is necessary to strengthen macro guidance, promote industrial layouts, exchange and cooperate actively with domestic and overseas developed regions. Accelerate the upgrading of Anshan City's technological and industrial advantages and seize the initiative among fierce competitions in the future.

## 4. Conclusion

In this paper, the SWOT analysis model on development environment of the 3D printing industry base has been designed, which can be as feasible analysis tools in other parts of China to build 3D printing industry base. However, the chosen analysis factors of the model are not comprehensive enough and need to be further improved. Although development strategies designed for 3D printing industry base in Anshan is not suitable to apply to all areas, the problems faced in the construction of 3D printing industry base are common. Therefore, the model is of great benefit for other associated builders and government management departments to have greatly useful reference.

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