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# A Promotion Mode for the Development of Advanced Manufacture with Legislation in USA

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**Abstract.** Advanced manufacture has played an increasingly critical role in industry and academic areas. To accelerate the development of advanced manufacture, many countries and researchers focus on enacting different policies and laws. As the country that leads the innovation on advanced industrial, the unit states of America (USA), thanks to the insight into the advanced manufacture, has issued a serial of laws to establish a prefect mechanism to ensure the development for advanced manufacture. By introducing and taking advantage of the practical experience on development of advanced manufacturing with the legislation approach in the USA, we can adjust and implement guiding policies and laws for Chinese enterprises and governments to promote the development of advanced manufacture. In particular, the promoting process involves the track and research on the laws and policies, the practise of the laws and policies, and the industrialization according to these laws and policies. Furthermore, by presenting the laws and regulations in the USA on advanced manufacturing, we analyze the legislation framework and law layout, as such we can summarize an overall structure on the legislation on the advanced manufacture.

## 1. Introduction

The advanced manufacture has plays an increasingly critical role in industry areas in recent years. As a results, the development of the advanced manufacture become an important issue for governments and enterprises. Especially, how to enact a series of guidelines, policies, and plans to ensure the development of advanced manufacture forms a great challenge [1-2]. However, the unit states of America (USA), as an advanced industrial country leading in the area of manufacture, has established a comparatively perfect mechanism for planning and practice the policies and laws. However, how to use knowledge on implementation of advanced manufacturing in the US for china road to develop the advanced manufacture is still not reported. In addition, how to follow the experiences in advanced manufacturing and implements its strategies of the USA is another important research topic for Chinese government and enterprises.

In the context of China's strategic system, the national advanced manufacturing strategy. Furthermore, manufacturing strategy is carried out with the support of the national innovation strategy, the consensus that the society, and the competitiveness with the USA.

The strategic plan begins with a major problem that needs to be addressed amid the advanced manufacturing innovation in the US, which is why basic R&D results in advanced manufacturing failed in the market. The same issue is also indicated in the national innovation strategy, saying that in advanced manufacturing, despite the necessity of further improvement, basic innovative activities in the US are still powerful, and the main problem, however, is the mismatch in social and economic benefits resulted from basic R&D activities, which have been negatively affected in return. The reasons behind are certainly complex, including the complexity of private and public factors in modern manufacturing technologies; these factors keep changing throughout the life cycle of a technology; the cultivation of talents is not responsive to technological development and demand; the advanced manufacturing industry fails to make the best use of

 

basic investments from the government; And so on. How could this main problem be solved on the basis of these reasons? This answer is the core of the advanced manufacturing strategy [5][6].


Fig.1 Reports on Advanced Manufacturing.

The Executive Office of the President of the US released the report on Revitalizing American Manufacturing in December 2009. It is how the US thinks about and sums up the recession in its manufacturing foundation after the economic crisis and since a long time ago. The continuous decline of employment in manufacturing in the US since 1991 and the constant enhancement of strength of competing countries highlight the strategic role of advanced manufacturing, and the shaken manufacturing foundation affects its national economy, innovation and security. Consequently, the then Obama administration was so determined that it made clear to revitalize the US manufacturing industry with relevant strategies and measures to be implemented. But revitalizing the US manufacturing is not simply a revival in traditional manufacturing, while the key is to take a lead in advanced manufacturing. Clarifying the leading position of advanced manufacturing is the guarantee of national security and economic prosperity: which is a leadership from strategic guarantee. 2. On the basis of nine prominent factors, three major goals were set: first, to develop new manufacturing technologies and do well in their transformation; second, to educate and train manufacturing workforce to facilitate their interconnection; third, to expand the capacity of the domestic manufacturing supply chain.

Based on innovative strategies and competitiveness initiatives of the US, as well as its latest national strategy in advanced manufacturing, this paper conducts a systemic study in this sequence, including some important reports and relevant legislation, to reveal the Systematization, to which China may refer when developing relevant policies and guidelines.

## 2. The Model of Improving Development Through Legislation

The then the US President Bush officially signed The US Competitiveness Initiative-Leading the World in Innovation at the White House on February 2, 2006, initiating the development model of using legislation to promote development. The initiative converts the recommendations and proposals stated in consulting reports to federal plans. The US Competitiveness Initiative is a massive program involving a budget of USD136 billion, and proposes that a company, if increasing its research budget, can enjoy a permanent tax cut, which is the most costly part of the plan, with the tax cut anticipated to reach USD4.6 billion in 2007 and to amount to USD86 billion in a decade; its plan to double the funding for basic research in physical sciences will cost USD50 billion over the decade; subsidies worth USD380 million will be provided for the Ministry of Education each year to improve math and science education in primary and secondary schools. The competitiveness initiative is an implementation program, which requires the authorization of the Congress, and its drastic funding plans will inevitably lead to fierce conflicts of interest, thus making it almost impossible to be passed by the Congress. As a matter of fact, it was stranded on the congressional discussion of the government budget in January 2007. But it serves as a practical design of the recommendations mentioned in related reports, thus acting as the basis of various relevant bills [7][8].

Above all, it puts forward three major strategic objectives: including (1) to create high-quality jobs and sustained economic growth; (2) to expedite breakthroughs in areas given national priority; and (3) to bring about an innovative government for the people. They are followed by three major strategic measures: (1) to invest in the cornerstone of innovation; (2) to improve the vitality of innovators nationwide; and (3) to "refuel" the innovation engine driving forward private economy.

### 2.1 Establish The America COMPETES Act to promote fair competition among enterprises

The two heavyweight reports and American Competitiveness Initiative being implemented eventually led to the birth of America COMPETES Act. America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science Act or America COMPETES Act [9] was signed by the then President George W. Bush on August 9, 2007.

America COMPETES Act consists of four parts: Part I involves trade and science, almost a republication of America Innovation and Competitiveness Act; Part II deals with the Department of Energy, exactly the same as the Protecting America Competitive Edge Act; Part III focuses on education, an adjusted version of America Competitiveness Investment Act; and Part IV concerns the NSF, which is based on Article 3 of America Innovation and Competitiveness Act. It can be seen that America COMPETES Act actually integrates lots of the contents of relevant bills not passed by the Congress, which exposes a side of the US legislation, exerting every possible effort to have various bills passed by the Congress by making changes in them one after another. America COMPETES Act places emphasis on three main areas: 1 increasing research investments; 2 giving citizens more opportunities to be educated in the fields of science and technology, engineering, mathematics and key foreign languages; and 3 developing the basis for innovation. America COMPETES Act was re-authorized in 2010, marking as a significant milestone along the path that the US follows to build an innovative economy in the 21st century. America COMPETES Reauthorization Act authorizes the federal government to further increase its investments in R&D budgets for the three major research institutions of the US, i.e. the Department of Energy's Office of Science, the National Institute of Standards and Technology, and the NSF. In addition, it can help to strengthen the efforts in increasing education for the US students in science, technology, engineering, and mathematics, which were first brought up by the Obama administration. It also authorizes multiple federal departments to offer bonus incentives as a competitive way to continually seek talents from the society, thus solving technical problems. The Reauthorization act is divided into 10 parts, basically concerning the same governmental agencies and related fields mentioned in the bill of 2007, still the six major government departments, as well as re-authorization in the fields of education, STEM, and innovation. It also clarifies that the country should make strategic plans for the development of advanced manufacturing. As for the basis for development and innovation, in fact, it refers to both material basis and institutional basis. Material basis can be interpreted as infrastructure construction, such as broadband access and shared infrastructure; while institutional basis is a national policy that benefits the promotion of innovation activities [10].

The US national competitiveness strategies advance gradually and share the same origin. The aforementioned overview of the US national strategies has unfolded every detail one by one: the US national strategic thinking is inherited and systemic to a great extent, and is far from a principle of issuing national guidelines for one single incident at one time. In the process of setting a national strategy, the national think tank, gathering senior talents in every field who can make scientific and far-sighted judgments from all over the US, plays an important and fundamental role. On this basis, the country formulates a strategy and drafts a corresponding bill. Throughout the process, in the case that the government and the Congress, both with advice from the national think tank, reach an agreement on a bill, the bill will be enacted into law to ensure that the strategy can be legally implemented and supervised. Subsequently, in accordance with the law, the government can make strategic deployments and investments, which will be overseen by the Congress [11].

### 2.2 Regulate the labor market through the Workforce Innovation and Opportunity Act

The Workforce Innovation and Opportunity Act or WIOA for short, as a replacement of the previous Workforce Investment Act of 1998, is the current major labor development law in the US. The Act was signed by President Obama and went public on July 22, 2014, winning broad support from the majority of both parties in the Congress. It is the first comprehensive legislation reform in the workforce development and vocational education system in the US over the past 15 years, leading to a profound impact on the development of the US vocational education system. The Act, designed to coordinate workforce development, education and economic growth, features that: it is task-driven; it faces all sorts of people, especially supporting vulnerable groups; it seeks to build an operating management system with multi-layer monitoring and multi-agent coordination; and it underlines the accountability of project operation performance [12].

### 2.3 Advance vocational education through the Carl D. Perkins Career and Technical Education Act

It is called the Perkins Act for short, a fundamental law concerning the vocational education of the US. Since it was formulated in 1984, it has been revised four times in 1990, 1998, 2006 and 2018, respectively. The Strengthening Career and Technical Education (CTE) for the 21st Century Act mentioned in our list is the fifth reauthorization act of the Perkins Act [13].

It mainly touches on (1) modernization, (2) further improving the education for learners seeking for a bachelor's degree, (3) maintaining the consistency with WIOA, (4) enhancing the emphasis on industry and commerce, (5) providing support for states and local community leaders, (6) increasing the consistency with on-demand work, (7) improving transparency and accountability, and (8) ensuring the limited role the federal government plays [14].

### 2.4 The US Manufacturing and Innovation Act encourages manufacturing innovation

The bill, referred to as RAMI, has been passed by the House of Representatives, but not approved by the Senate or signed by the President yet, which thus is not a law. Nevertheless, it's closely associated with the planning and establishment of the National Network for Manufacturing Innovation (NNMI or Manufacturing USA), an important part of the US advanced manufacturing layout [15].

The essence of the RAMI Act is that the government requests an approval from the Congress, thus allowing the establishment of a national manufacturing innovation network under the name of the National Institute of Standards and Technology (NIST), Department of Commerce, and granting appropriate fiscal appropriation. This move aims to make the US advanced manufacturing industry more competitive. Therefore, it is an appropriation bill, specifically an amendment to the previous NIST funding. According to the Act, the National Network for Manufacturing Innovation (NNMI) will serve to: (1) enhance the competitiveness of the US manufacturing industry; (2) promote the US to keep a leading role in research, innovation and technology concerning advanced manufacturing; and (3) accelerate the development of workforce for advanced manufacturing [16].

## 3. Enlightenment for China's Development in Manufacturing

Manufacturing innovation in the US forms a gigantic structure. It affects the manufacturing industry, from horizontal and vertical perspectives: the horizontal perspective refers to the innovation framework, guaranteed by reports, bills, laws, etc. from the point of macroscopic view; while the vertical perspective is the vertical realization of different strategic initiatives, projects and so on. Main enlightenments are as follows:

### 3.1 Progressive top-level designs

Top-level designs cover the organization, guarantee mechanism, evaluation approach, funding method and so on. It is a long-term process to be constantly improved. The US innovative nation project, initiated under the leadership of think tanks, will perfect its details and continue to evolve amid the insurance and

improvement of the act. To follow up an influential bill of the US, you'll find there must be numerous early reports for pioneering popularization and groundwork. It can be said that numbers of social debates and popularization work will come up "after think tanks but before legislation". And in this process, various top-level designs will be done, including a variety of think tanks, NIST under the Department of Commerce, research and development institutes funded by the federal, and different ideas from other ministries, as well as third-party consulting companies. It's a process, abundant in workshops, discussions and pilot projects, for agreeing on a consensus, which plays a good role in popularization. NIST believes that the essence of innovation process is to extend the inventions resulted from federal technological investments to the private sector, while attracting private capital to further invest in these inventions for them to be successfully commercialized in practical applications. Achieving excellence at every stage of R&D, from discovery to transformation, until innovation, is critical to the US global competitiveness [17].

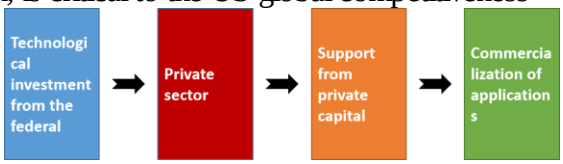


Figure 2 Innovation is a Chain

The national think tanks of the US consist of three major forms: advocacy committees existing in the form of NGO (in great numbers), United States National Academies, and the national committee in the field concerned. Among them, the United States National Academies, including academies of Sciences, Engineering, and Medicine, plays an important leading role. Top-level designs, often focusing on initiatives of these think tanks, offer different support at the different stages of the innovation chain. Think tanks in the US are also organized in a hierarchical manner. Focusing on priority technologies, PCAST mainly works on those of far-reaching significance; while think tanks at "lower" levels, which are concrete and excel in execution, are responsible for realizing more feasible and practical databases. For example, the MForesight think tank, in which the National Science Foundation (NSF) invested USD5.8 million, places emphasis on relatively mesoscopic technologies, and researches priority technologies, most of which are sourced from the sharing platform of NSF, apart from the coordination with the Department of Energy and the Department of National Defense; on the other hand, Mitre advances research and management based more on technical details that can be executed. In China, strategies and initiatives, as well as all sorts of relevant organizations are abundant. The US method can be used for reference, organizing thorough reports and discussions, especially forward-looking ones, before the implementation. Giving full play to all think tanks, non-governmental organizations, expert discussions and studies can allow each party to find a top-level system with sufficient top-down understanding and feasibility as support, on the basis of the greatest consensus. It involves both leadership departments at the macro level, technical trends and talent guarantee at the meso level, and finally front-line actuators at the grassroots level. It is necessary to integrate these three different think tanks and consulting agencies on one common thread. Confronted with the challenges in advanced manufacturing that the US may run into in the future, NSF has earmarked funds to set up a think tank, with the focus on "thinking about and acting in manufacturing" behavior", so as to provide detailed responding strategies around issues arising from advanced manufacturing in the US for the Congress. China, in the journey of advancing its manufacturing into the mid-to-high-end value chain, has been prepared to form a manufacturing-specific think tank that is both forward-looking, feasible and capable of "harmonizing knowledge and practice" [18].

### 3.2 Measurement mechanism for innovation systems in manufacturing

Among various strategic initiatives and policies, the US government has paid much attention to measurement mechanism. Due to innovation as a driving force for economic productivity and growth, understanding the nature, decisive factors and impact of innovation is becoming increasingly important for decision makers. To achieve a result, investments in innovation require in-depth understanding, so that basic inputs into the innovation process and subsequent outcomes should be measured. The US has done a lot on

"quantitative assessment". For instance, with regard to the US manufacturing innovation network newly constructed in recent years, the 2017 US annual report didn't give definite indicators for evaluating manufacturing innovation institutes, but by the 2018 report, a well clarified indicator system was shaped. The earlier national MEP system, a partnership program for manufacturing, designed to support innovations in small and medium-sized enterprises (SMEs), has been constantly improving and revising its evaluation system. In May 2016, at the request of the NSF and NCSES, the Committee on National Statistics, National Academies of Sciences, Engineering, and Medicine (CNSTAT) organized a workshop, gathering academic researchers and experts from private and public sectors to conclude the development strategies for expanding and modernizing innovative information systems. The workshop was concentrated on conceptualizing the elements of innovation, including inputs, dynamics, outputs and consequences. In 2018, the National Institute of Standards and Technology (NIST) also launched the Lab-to-Market (L2M) initiative, proposing different approaches to innovation measurement. Every policy and every action plan for innovation tends to be wide-ranging, long-term, and often crosses lots of different departments. This means that a re-evaluated innovation system should be set up, while taking into account the entire cycle of manufacturing innovation, in order to establish reasonable evaluation organizations at different stages, thus quantifying the effectiveness of a mechanism. China's current standard evaluation system tends to focus its attention on technologies and products. In terms of these soft sciences, especially large-span soft systems in manufacturing innovation, how to design a set of measurement mechanisms from the perspective of "high quality manufacturing" is of great significance to China's current manufacturing innovation. For intelligent manufacturing, currently the major direction of China's manufacturing, it is necessary to build a set of comprehensive level evaluation and measurement systems, by referring to the US classification systems, such as technology readiness levels and the manufacturing readiness level (MRL) [19].

### 3.3 Continuity of the US innovation policies

Many projects relating to innovative manufacturing in the US are relatively long-lasting, and some may have even been part of the responsibilities of government ministries. For example, the SBIR program for SMEs innovation was approved by the US Congress as early as in 1982. It was originally designed to be effective for 8 years, but continuous extensions allow it to function for a history of 37 years. The MEP program for SMEs began to be piloted by the US in the 1970s, before it became a law in 1988, so that each state has to establish a service network, providing uninterrupted services for SMEs. ManTech, the most important program of the United States Department of Defense, designed to commercialize technological achievements for manufacturing, has passed through 63 years. These policies and plans for manufacturing innovation and commercialization, in spite of changing assessment mechanisms, due to their stable, long-term existence, allow implementers and practitioners to pick up long-term strategic thinking and formulate sustained implementation programs. The important thing is that they are backed up by laws. Regarding both SBIR/STTR (Innovation and Technology Diffusion Program) for SMEs innovation that share similarities, the prerequisite is the Bayh-Dole Act, which was passed by the US to encourage the flow and transfer of intellectual property .

### 3.4 Complementarity between policies

A national strategy is surely a complex system. However, during its implementation, it will inevitably be deployed by different ministries. In the process, numerous initiatives and deployments, including the policy systems at different ministries, will emerge. As regards how to think over the relationship between these strategies and policies, how to strengthen the focus of uses of funds, and how to complement each other, it is required to plan the use and coordination of funds from an overall point of view [22].

## 4. Conclusion

The mode for developing advanced manufacture through via legislation in US adopts is a good inspiration for China to launch the technology-based enterprise innovation project in these years. That is, the best

solution to discontinuity in policies for manufacturing innovation is to toughen up legislation. Furthermore, the implementation of laws and administration of regulations provide a long-term based technology transfer scheme, such as property right protection and investment in manufacturing innovation. This scheme improves the efficiency for technology innovation.

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