Scientific and Technological Innovation Capability Improvement: A Case Study of the Automotive Industry

Fuquan Zhao
State Key Laboratory of Automotive Safety and Energy, Tsinghua University
Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China
zhaofuquan@tsinghua.edu.cn

Chaofan Ding
State Key Laboratory of Automotive Safety and Energy, Tsinghua University
Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China
dcf18@mails.tsinghua.edu.cn

Han Hao
State Key Laboratory of Automotive Safety and Energy, Tsinghua University
Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China
hao@tsinghua.edu.cn

Zongwei Liu*
State Key Laboratory of Automotive Safety and Energy, Tsinghua University
Tsinghua Automotive Strategy Research Institute, Tsinghua University
Beijing, China
liuzongwei@tsinghua.edu.cn

***Abstract*—In the context of a new round of scientific revolutions, the complicated and austere international political environment, and the domestic economy under a difficult transformation have brought unprecedented challenges to China. The government, industries and enterprises have reached a consensus on the issue: "continuous promotion of innovation is the only way to break through". However, the practice of innovation has brought far more challenges than expected. In technological innovation, for example, the existing issues and bottlenecks are directly impacting the national scientific and technological output and transformation of achievements. This paper, based on the author's understanding of and thoughts about an enterprise's R&D, analyses innovative connotations in a new era, scientific and technological innovation concept development and analysis, and the status quo, and analyses the reasons for scientific and technological innovation development. Using cases in the Chinese automotive industry, this paper provides advice on promoting the sustainable development of scientific and technological innovation capability.**

Keywords-New round of scientific revolutions; Scientific and technological innovation capability; Conceptual development; Innovation theory; Improvement paths; Automotive industry; Case study

I. Introduction

A. Strategic Value of Innovation

Innovation is the fundamental driving force behind the sustainable development of human beings and the key factor for a country's competitiveness improvement. However, due to a complicated and changeable international political environment and a domestic economy undergoing a difficult transformation in recent years, innovation is expected to play an increasingly important role in various competitive activities.

Internationally, a new round of technological revolutions is driving the comprehensive reconstruction of the global economic structure and industrial landscape [1]. Competition between countries will rely more on innovation capability than ever before.

China's economy has developed into a "new normal" with stable growth and requires the immediate exploration of new growth points and new growth patterns [2]. Relevant new industries, enterprises, products, technologies and business models are all inextricably linked to innovation. At the same time, Chinese society is currently dedicated to solving the issue of "imbalanced and insufficient development" and expects to achieve the unprecedented grand goal of the common prosperity of its 1.3 billion people. As shown in Figure 1, only through insisting on continuous innovation can we effectively address the series of new issues we are facing 40 years after the reform and opening up, such as rising costs, pressure on energy savings, challenges to environmental protection, resource shortages and an ageing population, and more effectively address international political and economic pressures.

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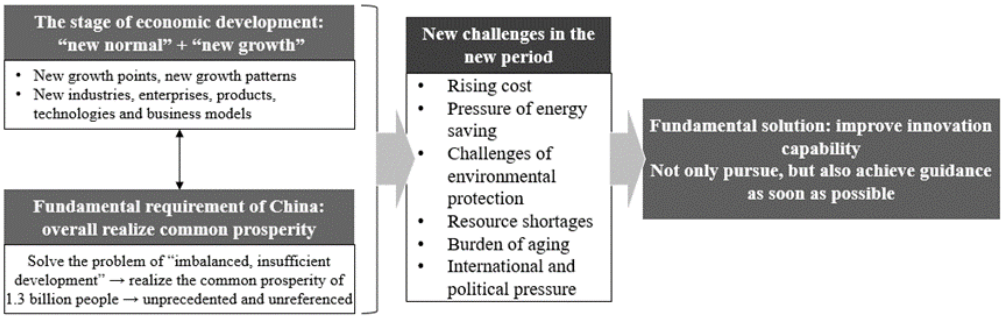

Fig.1 The strategic value of innovation to China

B. Theory of Innovation

The Theory of Innovation was proposed by Joseph Alois Schumpeter in The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle in 1917. He deemed that innovation is the introduction of a new combination of production factors and new production conditions into the production system to develop an all-new economic capability. He also believed that innovation is a process of industrial mutation that occurs incessantly from within rather from without [3].

Later, in 1960, Rostow proposed the Rostovian Take-Off Model, which further defined the position and importance of technological innovation in innovation activities. With the rapid development of technological innovation activities, innovation itself presented an increasingly intense "knowledge dependency", which built barriers between innovation activities and their application in practice[4].

Meanwhile, sociologists began to use systematic concepts to study innovation activities [5]. At this stage, the Theory of Innovation mainly followed a linear model and gradually shifted from a unidirectional linear to a bidirectional linear model, and then finally formed a multi-chain linear model. This was the basis of the "Chain-Linked Model" proposed by S. Kline and N. Rosenberg [6].

Eventually, the Organization for Economic Co-operation and Development released its research report, National Innovation Systems, based on the national innovation system, which marked the moment when the Theory of Innovation began to accept the dynamic nonlinear interactive model of innovation[7]. According to this point of view, the national innovation system comprises communication feedback among various participants (industries, enterprises, research institutes, consumers, etc.) in innovation activities. In such a system, the interaction between each participant directly impacts enterprises' innovation efficiency and the entire economic system.

However, in recent years, due to continuous changes in the positions of elements in innovation activities, subsystems appear in situations of frequent interaction, mutual adaptation and joint upgrading, which jointly foster an all-new innovation ecosystem [8]

C. Purpose of the Research

Based on the aforementioned complex innovation ecosystem scenarios, this paper will begin by elaborating the latest development of the connotation of innovation in a new era. Next, based on technological innovation, it will provide an analysis of misunderstandings, development, performance and underlying reasons based on business cases in the automotive industry. Last, it will propose specific measures to improve Chinese technological innovation capabilities.

II.The Latest Development in the Connotation of Innovation

A. Analysis of the Concept of Innovation

Innovation is always mixed with creation and entrepreneurship, but the three vary greatly in terms of connotation.

Creation is the process of growing out of nothing and inventing new things. Innovation includes creation, but creation will not necessarily become innovation. Only when creation realizes value can it be considered innovation. This is the essential difference between innovation and creation. This resembles the viewpoint of Joseph Alois Schumpeter, who believed that innovation must be applied to the market and create enough market value after being tested by the market, while there are no specific application requirements on invention [9]. For instance, X company's successful development of a new technology is called creation, but it cannot be taken as innovation until that technology successfully achieves mass production and application. Therefore, innovation can either be creation or the updating and upgrading of original objects, but the key is to realize value.

Entrepreneurship specifically means the process of creating new value and thereby starting a new career. Hence, innovation serves as the basis of and provides support for entrepreneurship and will run through the holistic process of entrepreneurship. It cannot be defined as entrepreneurship without innovation capabilities and actions.

Whether for entrepreneurship or creation, the key is to use innovation to drive and truly create new value.

B. Scope of Innovation

Since innovation involves a large number of non-technological factors, such as organizational management, mechanism, system and corporate culture, non-technological factors will play a decisive role in some specific scenarios. Take the service industry for example. According to OECD statistics,

service industry research and development (R&D) accounts for one-third of the total amount of R&D in various countries [10]. Thus, the concept of "non-technological innovation", those innovation activities first generated in non-technological links, has taken shape accordingly. Specifically, it can be divided into technological innovation, management innovation, cultural innovation, institutional innovation, theoretical innovation and so on. Take China, for example. Its "reform and opening up" is its current greatest innovation and has laid a solid foundation for the rapid growth of the Chinese economy during the last 40 years [11].

We believe that all innovation must aim at fully realizing scientific and technological value and can use the transfer efficiency of value as the evaluation standards for innovation activities. In the field of science and technology, innovation capability is equal to the capability of transforming technological achievements. If, in the end, technological innovations are not transformed into industrialization achievements to realize value, then they are not real and effective technological innovations. In other fields, innovation can be evaluated by whether or not it can help improve the capability to transform technological achievements.

C. Development of the Connotation of Innovation

In a new era of global industrial transformation and landscape restructuring, the connotation of innovation undergoes a new expansion and the complexity and integration of innovation are strengthened.

Starting from the dimension of the innovation system, technological innovation supports product and service innovation, while the latter supports industrial innovation. The innovation and integration of multiple relevant industries shape ecological innovation. In these four dimensions of innovation, especially ecological innovation, capital plays an important linking role. Last, the innovation of business models, including the innovation of internal and external management and the innovation of organization and resource combination means, will ensure a thorough connection between the aforementioned five elements and form a new innovation system, as shown in Figure 2.

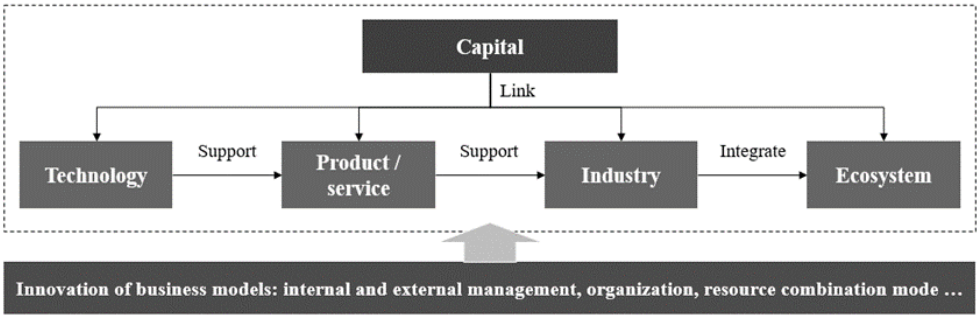

Fig.2 The innovation system in a new era

It can be seen that the innovation system in a new era must realize all-around, three-dimensional and integrated innovation at higher levels and with more dimensions. During this process, since technological innovation has played a basic and supportive role, no breakthrough has been made in core technologies. Innovation of products, services, industries, ecosystems and business models will lose its anchor and fail to realize unsustainable development. At the same time, realistic value cannot be generated using only technological innovation. Only by always ensuring the close integration of technological innovation with other innovations can we truly maximize value and better foreground its role.

At a higher dimension, a new round of technological revolutions and industrial transformations interact and impact with each other [12]. Technological innovation, from quantitative change to qualitative change, serves as the core driving force to lead industrial transformation via technological revolution, triggering social change via the transformation of multiple industries with the fundamental purpose of improving requirement-oriented social efficiency. Therefore, technological revolution is the driving force, industrial transformation is the manifestation, and social change is the result of realizing the final value.

III. Misunderstanding of Technological Innovation

As mentioned above, technological innovation is the foundation of all innovation activities. The judgement of the value of all innovation activities can be transformed into the transfer capability of technological achievements or the capacity to improve that transfer capability. Thus, technological innovation is the core of all innovation activities, and promoting the sustainable development of technological innovation is significant for boosting the development of innovation. However, there remain some differences in our understanding of technological innovation and even some misunderstandings, and these will directly affect the specific actions and practical effects of technological innovation. This paper will combine industrial and business cases to further elaborate the systematic nature and complexity of technological innovation, the new features of a new era, and the connotation, changes and importance of core technologies.

A. Technological Innovation Features High Complexity

Technological innovation is a highly complex systems engineering, especially as the automotive industry is such a significant integrator. As shown in Figure 3, from the internal perspective of enterprises, these require effective collaboration between "production, supply, research, sale and service" to form the entire process of innovation, from scientific research to technological development to engineering realization, in

order to finally realize the value of technologies. This is in line with enterprises' basic development principle of technologies and products, namely, to "produce one generation, develop the second and reserve the third". From the perspective of external resources, the original linear industrial chain is evolving into a reticular ecosphere [13]. In such a context, enterprises must closely interact with different partners. All participants should perform their own duties and give full play to their strengths to jointly complete the heavy task of industrial innovation. The precondition of each participant's performing its own duty lies in the holistic process of internal innovation, one that involves a "production-supply-research-sale-service" collaboration.

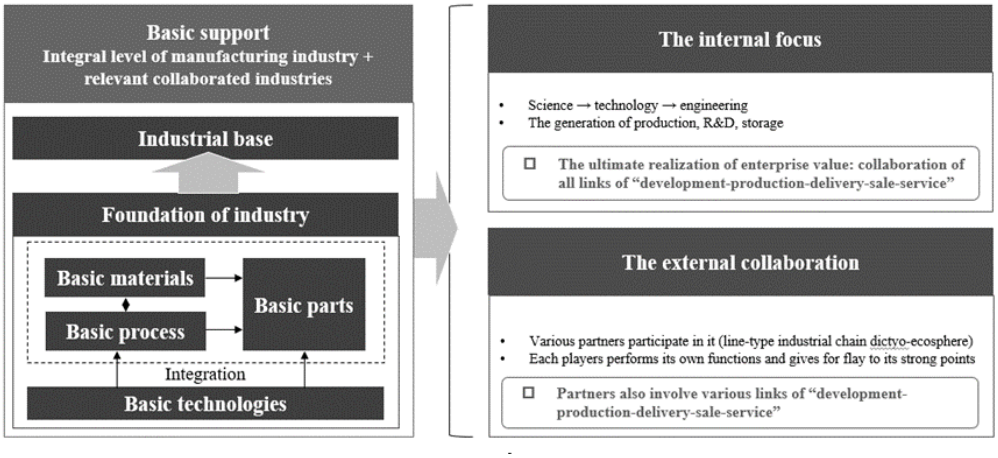

Fig.3 High complexity and systematic nature of technological innovation in the automotive industry

In addition, no industry can survive in isolation and requires support from relevant basic industries. In terms of the automotive industry [14], it cannot depend only on its own efforts to achieve industrial innovation. The overall level of the manufacturing industry is an important basis and premise for the development of the automotive industry, and many relevant industries, such as mechanical engineering, electronic engineering, transportation, energy and infrastructure, all have great impacts on the innovation development of the automotive industry. The basic technological issues and challenges facing the innovation of all automotive industry-based basic industries cannot be addressed in isolation. Actually, they are the basic industrial issues of the entire country, namely, basic parts, basic materials, basic processes and technological basis. Therefore, solving such basic industrial issues requires the nation to pay significant attention to the strategic level, allocating a large amount of public resources to actively seek solutions to facilitate the rapid improvement of the national manufacturing level.

However, many enterprises often confuse the three concepts of scientific issues, technical innovation and engineering solutions in the process of enterprise practice. They overemphasize engineering in their work while ignoring the basic supporting role of science and technology [15]. In fact, the three have their own division of labour and provide mutual support, jointly promoting industrial development and social progress. Science solves the issue of "what it is", technology for "how to do it" and engineering "what it becomes". In terms of the automobile production process, the mass production of a new vehicle model is an engineering issue, the development of turbochargers for automotive engines is a technical issue, and determining the most suitable material for turbocharger blades is a scientific issue. Obviously, it is impossible to build excellent products in engineering without sufficient scientific research and technical reserves. Therefore, during a new round of industrial transformations, where leading innovation is more urgent than ever, the industry/enterprise must pay attention to the supporting role of science and technology, strengthen basic scientific research, reserve future technology and skilfully balance and connect science, technology and engineering innovation to ensure the effective implementation of engineering innovation.

B. New Characteristics of Innovation in a New Era

Facing an all-new situation of crossover integration and ecological reconstruction, innovation also presents new characteristics, meaning that it is imperative to connect and integrate more innovation elements. This means that the competition between enterprises over innovation will depend more on the system and mechanism than ever before. As shown in Figure 4, innovation in a new era must be effectively connected with and thoroughly integrated into the internal and external, high level and grass-roots units, products and experience, technologies and modes of enterprises to form a three-dimensional structure with innovation as its core.

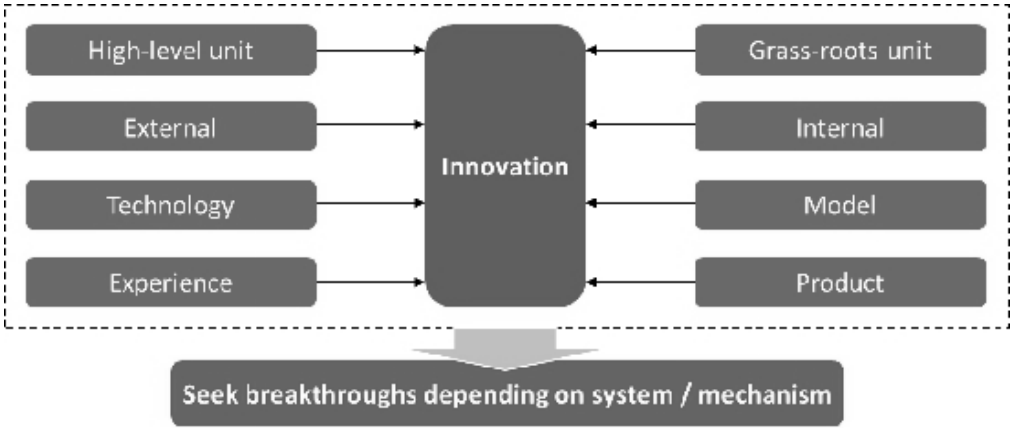

Fig.4 Multiple elements and three-dimensional structure of innovation in a new era

In the past, enterprises could concentrate their efforts on a certain field, work hard to tackle key issues, make breakthroughs to drive overall improvement with partial innovation and obtain core competitiveness. However, it will be difficult for enterprises to extend such a business model in the future. Only by effectively integrating resources (including human resources, capital resources, technical resources, partner resources, etc.) for future integrated innovation can enterprises make breakthroughs; meanwhile, resource integration is an important innovation of business models. This new characteristic of innovation poses unprecedented challenges to enterprises' decision makers, requiring them to think about innovation elements in a far more complex manner than previously when making choices.

C. Connotation and Changes of Core Technologies

During a complicated and changeable period of industry disruption, enterprises are more willing to find one specific core technology that can "win in one move". However, this is unrealistic. The fundamental cause lies in misunderstanding core technology. To be specific, the core technology of an enterprise does not mean a single or decentralized technology, but the most critical part of the technology that supports the enterprise to develop products. It is a set of advanced, complex technologies with great user value accumulated over a long period of time. In other words, core technologies are a series of technologies that can help enterprises improve their product's technical content, reduce costs, improve performance and enhance quality, all of which are difficult to master and repeat.

Therefore, the connotation of core technology can be clarified from three perspectives. First, core technology is neither exclusive nor new. Although the aforementioned unique or new technologies belong to core technologies, such a case is rare and difficult to sustain. As for developing conventional technologies shared by multiple enterprises into core technologies, it is critical for enterprises to master the recipe and quintessence, in addition to effective integration methods, to ensure they perform better than their competitors. Second, the definition of core technology is always dynamically changing. Not only do different enterprises require different core technologies, but an enterprise will also need different core technologies at various developmental stages. To be specific, any technology that enterprises need but have not mastered belongs to the core technology. Thus enterprises should master it as early as possible to obtain core advantages in market competition. Third, the current industrial restructuring period makes an enterprise's core technology change significantly. Take the automotive industry as an example. Industrial transformation has brought brand new changes to the core technologies behind automobile products, technologies that are more extensive, more important and more interconnected than ever before. Enterprises are thus required to master more core technologies than previously. At the same time, however, due to the limitations of their own resources, enterprises will master fewer and fewer core technologies. Such a new scenario will bring new challenges and opportunities to the automotive industry. Only those enterprises who truly foster their own characteristics through core technologies can win strategic opportunities.

D. Dialectical Understanding of the Importance of Technologies

On one hand, it is thought that since various resources can freely integrate in the Internet era, enterprises should shift their focus to seek partners who can provide the required technologies, which will continuously decrease the importance of technologies themselves. This point of view not only fails to promote Chinese scientific and technological innovation capability but also seriously restricts the long-term development of enterprises. On the surface, enterprises can indeed compensate for their technical shortcomings by combining resources during a short period of time. However, if all enterprises gave up scientific and technological research and relied merely on their partners to tackle key technological issues, it would be very difficult to address issues. In addition, even in resource combination, enterprises must truly understand the essence of things and possess considerable technical capabilities, because only by truly understanding technologies can they identify the core ones and do an effective job of combining resources. Take open-source innovation for example. Only by understanding technologies can leading enterprises determine and absorb the truly valuable parts and integrate them into their own technical systems for sublimation. However, if enterprises do not understand technologies, then open source will be their only choice, which means that enterprises will always have to start from scratch, and this will completely

deprive them of competitiveness. Therefore, the importance of technology in a new era increases significantly rather than decreases. Mastering the core technology of a certain aspect serves as the foundation of cooperation and the key to competition with other enterprises.

As far as the automotive industry is concerned, the energy revolution, connectivity revolution and intelligence revolution have gradually turned many new technologies in various fields into core technologies [16]. Not all technologies related to automobiles must be entirely owned by OEMs, but the automotive industry, as an integrator, must fully understand these technologies. Enterprises do not necessarily need to independently produce key components (e.g., a battery), but they must build relevant R&D capabilities and master these core technologies. It is also the basis for effectively integrating these key components and technologies and will be the core competitiveness of automobile enterprises in the future.

On the other hand, the belief that technology can solve everything is also incorrect. In the future, mastering technology alone is far from enough to meet enterprises' development demands. Companies must combine technologies and business models effectively to generate significant value. This research took the automotive industry for example. The core elements supporting the mass production of the model T invented by Ford not only included corresponding core technologies but also the assembly line production mode (i.e., business model). The optimal combination of both resulted in making the model T available to everyone.

Therefore, facing a new era of IoT and sufficient resource combination, enterprises cannot achieve sustainable development without core technologies. However, merely having technologies is far from enough. Having technology is only a necessary condition for success, while finding business models that effectively realize the value of technologies will be the sufficient condition.

IV.Realistic Performance and Cause Analysis of Chinese Scientific and Technological Innovation Capability

Since the reform and opening up, Chinese scientific and technological innovation capability has significantly improved, but there is still a wide gap between China and developed countries. According to the Global Innovation Index 2019 released by Cornell University, the World Intellectual Property Organization and other institutions, China ranked 15th among 129 countries or regions in 2019, 3 places higher than in 2018 [17]. China is also the only developing country to break into the Top 20 in the Global Innovation Index . According to the analysis of specific indicators, China was ranked first in terms of the number of researchers, patents and scientific publications but occupied a weaker position in corporate innovation, energy consumption per unit of GDP and market maturity. In general, then, Chinese innovation capacity lags far behind the rapid growth of its economic aggregate and fails to match the development demands of the era and of the country's strategic goals.

A. Specific Manifestation of China's Lesser Competitive Scientific and Technological Innovation Capability

China's insufficient scientific and technological innovation capacity is mainly reflected in the following three aspects.

First is the insufficient input in technical research and development, and the lesser competitive innovation capability. As key players in innovation, Chinese enterprises are inclined to "pay more attention to production than R&D, more attention to introduction than absorption, and imitation than innovation". Some enterprises are even trapped in a passive situation where "there is manufacturing but no creation, and property right but no knowledge". One serious phenomenon is that most universities and scientific research institutions in China excessively pursue technologies "with little investment but quick results" in scientific and technological innovation activities, resulting in low levels of comprehensiveness, interconnection, integration and internationalization. In addition, they often neglect research into basic and generic technologies. In 2018, Chinese R&D expenditure intensity was at 2.19% [18], which was the result of China's rapid growth in recent years. However, there is still a wide gap between China and countries with leading scientific and technological innovation, which indicates that China's scientific and technological innovation capacity still has enormous room for improvement.

Second is insufficient government support and inadequate system development. This is evidenced in a number of ways: First, deficient intellectual property protection, which leads to unclear intellectual property rights and a low innovation return rate. Second, an inadequate fault-tolerant mechanism and a low degree of decentralization, which causes numerous concerns about innovation and lack of motivation. Third, severely badly matched resources, which results in wasting innovation resources. Fourth, unfair market competition. It is easy to observe that government infrastructure is ineffective or absent, which may restrict innovation and lead to no unified planning. Lack of coordination between government departments leads to decentralized management and weakens the implementation of innovation activities.

Third is the extremely insufficient transformation of innovation achievements, which results from a less competitive innovation capability and inadequate innovation system. This paper has collected several quantitative indicators from officially released reports to support this conclusion. For example, the contribution rate of Chinese scientific and technological progress to economic growth was 58.5% in 2018 [19], while that of developed countries was over 70%. In addition, China displayed high dependence on imported key technologies, equipment, parts and materials. According to the findings of the Ministry of Industry and Information Technology of China [20], in terms of equipment manufacturing, more than 95% of the manufacturing and testing equipment of finished machining production lines for key component such as high-end CNC machines, high-end instrumentation, carrier rockets, large aircraft, aviation engines and automobiles currently depends on imports; for raw materials, 32% of key materials are lacking and 52% are imported. For parts and components, take chips for example: 95% of high-end dedicated chips, more than 70% of intelligent terminal processors and the vast majority of memory chips for the general processors of most servers and computers are

imported, as clearly demonstrated in the recent Sino-US trade friction [21].

In other words, China is still less competitive in R&D capacity, security mechanisms and other aspects, which results in the insufficient transformation of innovation achievements. In the future, China must strengthen "government-industry-research-application" integration, constantly enhance its innovation capability and improve its innovation system to further enhance its scientific and technological innovation capability and achieve a qualitative breakthrough as soon as possible.

B. Inherent Reasons for China's Less Competitive Scientific and Technological Innovation Capabilities

By analysing the aforementioned internal reasons for China's less competitive scientific and technological innovation capabilities, we can see that the core issue of Chinese scientific and technological innovation is that China has not yet fostered an environment conducive to scientific and technological innovation; in other words, China's innovation ecosystem is still relatively inefficient as a whole. As mentioned above, in facing innovation, such as highly complex systems engineering, China should jointly promote innovation in talents, capital, policies and regulations to make fruitful breakthroughs in the future.

As shown in Table 5, the core issue of Chinese scientific and technological innovation lies in the absence of innovation culture, which specifically involves market mechanisms, the education system, the legal environment and the policy system. These four elements influence and interact as both cause and effect. In terms of innovation culture, Chinese enterprises are still guided by traditional concepts and make slow progress in innovation concepts. First, the utilitarianism and instrumentalization of innovation concepts determine that original innovation is short of being a driving force. Original innovation is key to creative development, which is difficult yet is the precondition for leading the development of innovation [22]. At present, Chinese enterprises generally carry out innovation without original creativity and depend on scale expansion but have few truly original innovations. Second, Chinese enterprises have a profiteering attitude to success. Under the precondition that neither enterprises nor individuals can accept failure, innovation activities would either be left unfinished or be impeded by excessive development. As a matter of fact, scientific and technological innovation activities themselves are exploratory and will not necessarily deliver the expected results. Therefore, it is difficult to make breakthroughs with an attitude of being eager for quick success and instant benefits. Finally, subject to national policies, enterprises directly managed by the nation can control and mobilize most resources but are subject to a rigid assessment mechanism in terms of innovation. Therefore, large state-owned enterprises with strong innovation resources are often only willing to try short-term and follow-through innovation, which is more likely to succeed, to avoid the potential business risks caused by trial and error of innovation. They are rarely willing to take risks in long-term and original innovation.

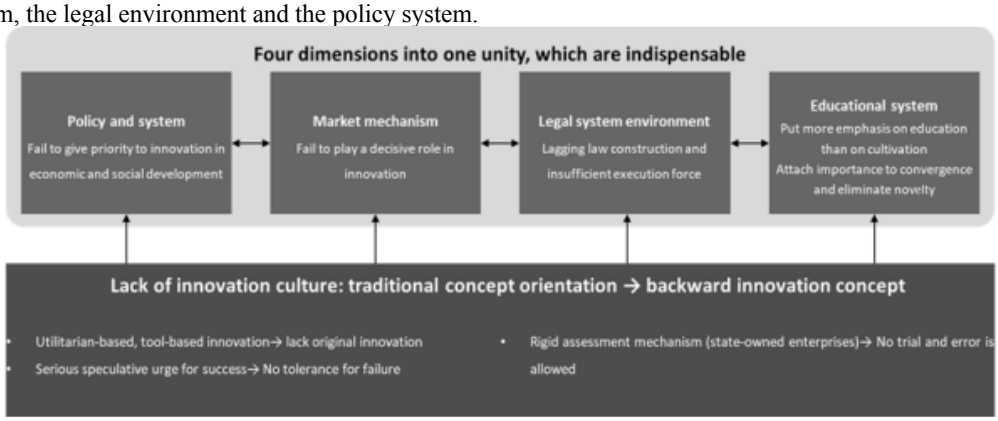

Fig.5 The core issue of Chinese scientific and technological innovation: an inefficient innovation ecosystem

In summary, China still lacks an ideal enough environment for innovation and must lay the groundwork for innovation. In addition, scientific and technological innovation activities face poor conditions and low or even zero returns. This is the fundamental reason why many enterprises and individuals are reluctant to attempt innovation.

V.Key Paths to Chinese Scientific and Technological Innovation Capability Improvement

Combined with the above viewpoints and given the status quo of China's lesser competitive scientific and technological innovation and the core issues, this paper provides three possible ways to improve Chinese technological innovation environment and enhance Chinese technological innovation capability based on practical corporate management experience.

A. Supplement Key Missing Links and Thoroughly Connect Each Link in the Technology Transfer Value Chain

Based on the above analysis, the three links of basic science, technology and engineering are separated from each other in the process of scientific and technological innovation, leading to serious shortcomings in the technological achievement transformation value chain. However, basic science, technology and engineering solve different issues. Therefore, only by simultaneously performing well in all three links and effecting their close connection relating to division of jobs and crossover

can an ideal and complete technological achievement transformation chain take shape.

At present, China is less competitive in science, technology and engineering innovation, especially in technological innovation. What's worse, basic scientific research, technology development and engineering implementation are disjointed, which makes it difficult for the basic scientific research achievements of colleges and universities to be transformed into the innovative products of enterprises. At the same time, participants in the value chain have no clear understanding of their positioning and division of labour in innovation activities, including inadequate interaction with each other and insufficient attention; this results in serious low-level and repeated investment, further increasing the harm from the separation of the links in innovation activities. In addition, due to the disconnection between scientific and technological innovation, a large number of enterprises and research institutes must perform "extra" work, which seriously affects the normal promotion of activities such as engineering development and restricts the transformation of scientific and technological innovation achievements. Moreover, many enterprises focus only on engineering in practical work and barely take into consideration technical reserve and the connection with basic scientific research institutions, which is not conducive to continuous innovation.

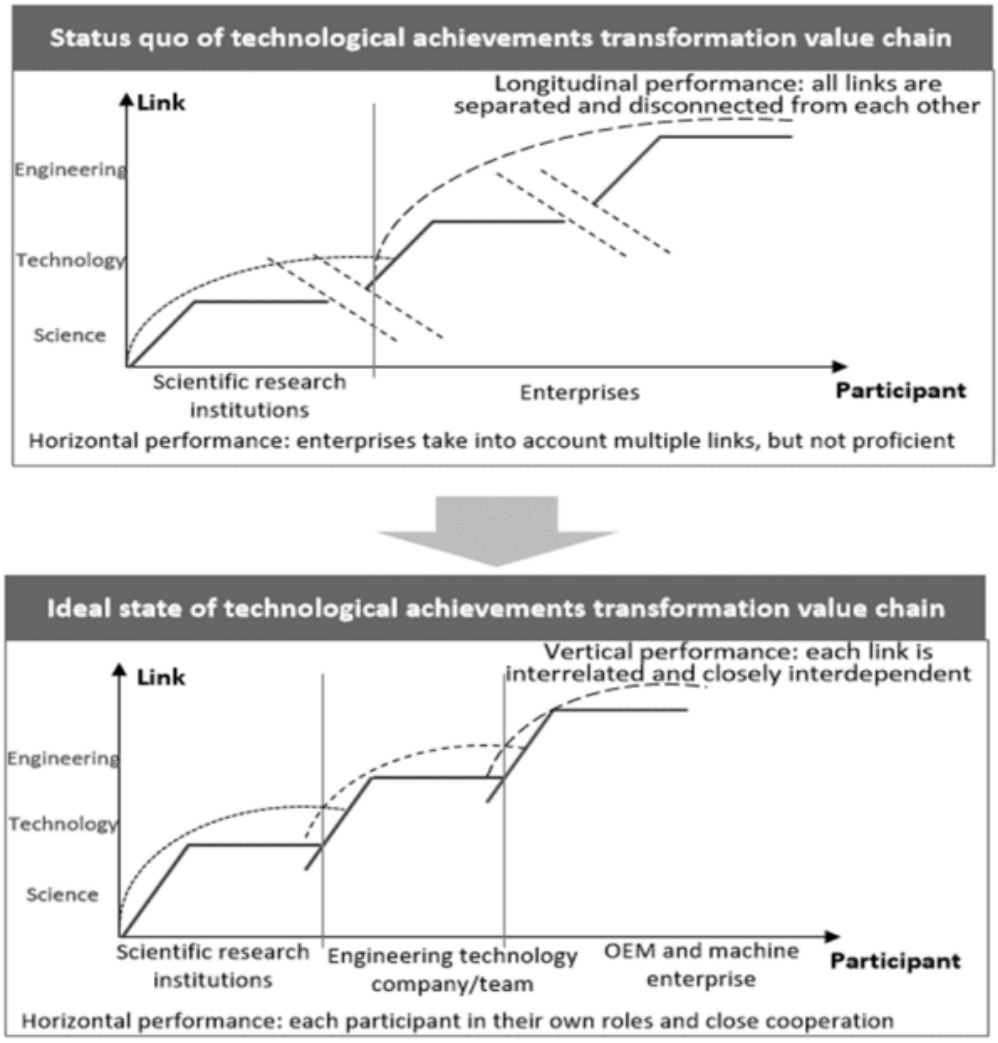

Fig.6 Status quo and ideal state of technological achievements transformation value chain

As shown in Figure 6, the key to supplementing the missing link in the innovation value chain is to build a group of highly professional and comprehensive engineering technology research and development teams and companies as soon as possible to bridge industry, universities and research institutes. These engineering technical teams and companies will not only provide engineering transfer and test verification services for the basic research of colleges and universities and scientific research institutions but also act as effective reserves of prospective technologies and engineering support for technology development of enterprises or teams which develop vehicles and engines, to build a complete technological innovation system together with colleges and universities, scientific research institutions and vehicle and machine

manufacturers; in short, they will form a technological achievements transformation chain. This kind of engineering team can be part of the R&D force within the enterprise or external professional technology companies. In fact, manufacturing powers such as the United States, Germany and Japan not only have huge advanced technology R&D teams inside their enterprises but also large numbers of excellent engineering technology companies, which guarantees the effective transformation of their technological achievements.

B. Improve Division of Labour and Make Truly Wise Choices

During the practice of innovation activities, all participants should fully focus on the main business and integrate the maximum resources to complete their own work. Whether it is an OEM or an auto parts supplier, an engineering company, a college or university, or a scientific research institution, all participants must make wise choices. In fact, this is the process of effective division of labour to create a complete innovation value chain.

In Chinese automotive industry, as far as OEM is concerned, with the development of enterprises, R&D requires continuous investment and capability improvement. However, choices must be made since it is impossible to undertake all the work. Earlier, I proposed the "Independent R&D Economics" model (as shown in Figure 7), whose core idea is that enterprises must choose what to develop. On the one hand, with an enterprise's R&D capability improves, enterprises independently complete more work, and even some difficult work through accumulation. However, when the workload reaches a specific amount, since outsourcing can deliver better cost performance, the amount of work independently completed by enterprises will not continue to increase. On the other hand, the work commissioned by the enterprise can be divided into two parts according to technical difficulty and cost. As the enterprise progresses, the part with greater technical difficulty will become increasingly smaller, but work with a particularly high cost should always be outsourced. For example, enterprises should not purchase expensive equipment with low frequency of use but try to tap others' resources through outsourcing. The other part, with low skills but large labour cost, should be outsourced as much as possible, even if the enterprise is capable of completing such work so that the enterprise can truly focus on the development of core technologies.

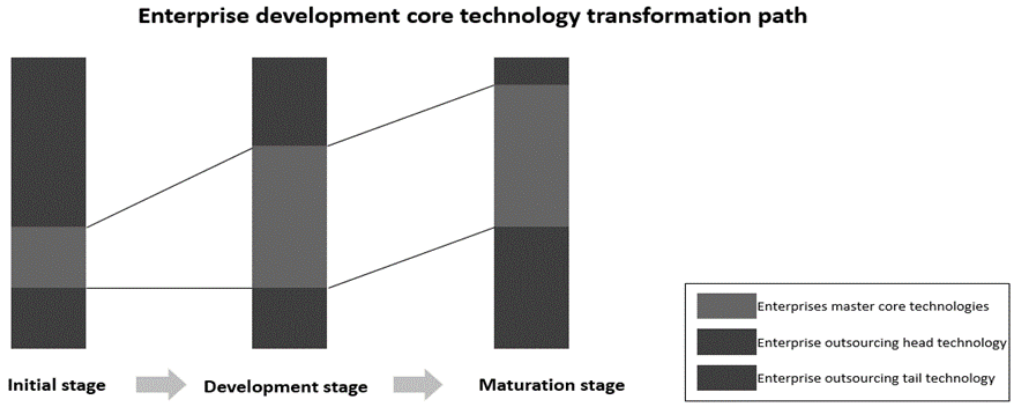

Fig.7 "Independent R&D Economics" model

C. Effectively Protect Innovation Activities and Respond to Failures with an Open and Inclusive Attitude

First, the nation should effectively protect innovation activities to address enterprises' insufficient innovation initiative. Since the essence of innovation motivation can be transformed into the input-output ratio issue and the innovation process requires constant input. If enterprises and individuals can guarantee their own survival in the process of innovation and can obtain rich returns after successful innovation, then they will have enough motivation to invest in innovation. On the other hand, if the achievements of enterprises or individuals are quickly copied by rivals, then innovation will quickly lose its initiative, and there will be substantially reduced investment in innovation. Subsequently, innovation activities will decrease. For this reason, in order to guarantee the long-term sustainable development of innovation activities, the country must focus on long-term interests and strengthen the protection of intellectual property. At the same time, in addition to the practical actions taken by the government, each individual must raise his or her awareness. Only in this way can a healthy social atmosphere, where innovation achievements and intellectual property rights are respected, take shape.

Second, the government should be more open to the shortage of innovation vitality. Under a new situation, original innovation, integrated innovation and business model innovation should be integrated and effectively coordinated to unleash the greatest innovation vitality possible. Moreover, during this process, fracturing any link will prevent an innovation breakthrough. In innovation, wholehearted efforts do not necessarily trigger success; however, without trying, success cannot be achieved. Therefore, the government should be more open and encourage various social forces to actively participate in innovation activities.

Finally, society should embrace the failure of innovation to ease the accompanying pressure. Since Chinese traditional culture advocates success and ignores failure, being less tolerant of faults will bring great psychological pressure on those participating in innovation activities. In fact, innovation activities are attempts with unknown results, whose probability of failure is much higher than that of success. Society focuses

on successful emerging enterprises in a specific field but ignores a large number of losers who have accumulated experience and lessons for later successful innovation. Therefore, society should not only encourage the success of innovation but also embrace innovation's failures, both of which are equally important. As far as the automotive industry is concerned, newcomers such as Tesla can still maintain a good business process if the American people are tolerant enough even if there are some technical issues or even serious safety accidents. Hence, a healthy environment that includes failure is important.

D. Participation of multiple entities to build a good innovation ecology for the automobile industry

Since 2014, Chinese Prime Minister Li Keqiang proposed the new concept of "mass entrepreneurship and innovation" at the Summer Davos Forum. China has begun to encourage all social entities to participate in social innovation activities with a more inclusive and open mind. As far as the automotive industry is concerned, the state, society, and industry will work together to promote the construction of an industrial innovation ecosystem; supplier companies, automotive companies, information technology companies, and post-service companies, all based on their own businesses, independently or collaboratively carry out innovative activities to promote the overall upgrading of industrial core technology and the overall improvement of the company's core competitiveness.

In this process, OEMs should give full play to their leading role, relying on their products, not only fully mobilize the internal resources to carry out innovation activities, but also can propose technological innovation requirements to related companies based on their own needs. Supplier companies should be guided by practical applications and landing practices to fully undertake and promote the product itself and technical innovation needs put forward by vehicle companies; at the same time, they can iterate on products based on their own experience in parts product design and production and force OEMs to innovate. In addition, due to the rise of intelligent networking technology, some information technology companies cross-border participate in automotive-related businesses. Because of their own stronger innovation genes and innovation power, they can use their own advantages to drive the overall improvement of the industry's innovation ecosystem; at the same time, they will Create more value and innovation possibilities in the use of automobiles, and inject more vitality into industrial development.

VI.Conclusion

Based on the limitations of the theory of innovation developed thus far and in the context of the thorough industrial transformation brought about by a new round of technological revolutions, this paper redefines and elaborates the great strategic value of innovation. Next, based on the author's thorough understanding of the automotive industry, this paper begins with scientific and technological innovation to systematically analyse why Chinese scientific and technological innovation capability improvement is trapped in a dilemma stemming from the new development of the definition of the concepts of science and technology, limitations of the status quo of understanding, poor application performance and gradual influencing factors. According to our analysis, the core reason why it is difficult to rapidly improve Chinese scientific and technological innovation capability lies in the absence of a culture-centric innovation environment, which specifically involves market mechanisms, the education system, the legal environment and the policy system.

Based on the above analysis, in order to better enhance national scientific and technological innovation capability, the government should first improve the innovation protection mechanism and enhance the protection of innovation achievements to ensure the continuous driving forces of innovation. In addition, the government should improve the technological innovation achievements transformation value chain and encourage professional engineering and technical teams to link up with the basic scientific research of scientific research institutes and the achievement development and application of vehicle and engine manufacturers to guarantee that all participants in the value chain find their proper positions, complete work accurately and efficiently and enhance the efficiency of technological innovation achievement transformation. In addition to guidance from national policies, enterprises should accurately understand development stages and properly handle internal and outsourced work to ensure the continuous improvement of enterprises' technological innovation capability while pursuing economic benefits.

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