

Analysis on Science & Technology Innovation and Its Culture in China

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***Abstract*—Innovation is the distinctive theme of our times and innovation spirit is the greatest zeitgeist. Innovation is the best generalization on human society but also the exemplification of zeitgeist and soul. Competition in current is the competition of talent and science & technology strength, and innovation is the essence of science & technology. That can be found by looking back the history of society development times focus has shifted to cultural development from politics and economy, at the same time, science & technology innovation has a rich cultural heritage. The culture in science & technology innovation is an important part of the whole social cultural system, and is the collective result of participating in science & technology innovation activities, and its evolution originates actions from science & technology innovation subjects. Based on culture, science & technology innovation regulates the innovators' behaviors and provides the most lasting and stable strong power for social economic development.**

I. INTRODUCTION

A. Science & technology and culture

Science & technology (S&T) culture is a rational crystallization of social function of S&T and is a new cultural form. It promotes S&T connotation for culture and enhances cultural meanings for science.

Science is to gradually form a complete knowledge system by subdividing and studying different knowledge. Technology is that human gradually accumulates lots of knowledge, experience, skills and methods by following the laws of nature to use and transform the nature in order to meet human's demands and aspirations. Science solves the theoretical issues and technology solves the practical problems. Culture is a symbol and sound system created, approved and used by human in the process of self-awareness and self-transformation and understanding and transforming the nature.

As the culture, S&T culture includes generalized definition and narrow definition. Generally, S&T culture is the achievements human having got and the ways of human transforming and adapting the nature and society by applying science and technology. Narrowly, S&T culture more emphasizes spirit and ideology. So, this paper defines S&T culture as following: S&T culture is the effect of human transforming nature and environment based on the accumulation of scientific theory knowledge and technological progress and also includes some institutional system and policy framework which can promote science and technology development.

S&T is a part of culture, however, in reality, separated with culture. And S&T culture belongs to the whole social culture system. There is lack of culture in S&T innovation,

vice versa. Integration between S&T innovation and culture innovation is a penetration and blend process with each other, and an inner requirement to build an innovative country and even inevitable initiatives to construct a harmonious society. The nature of S&T is the innovation. S&T innovation has a so pivotal role in national innovation system and an important significance for social innovation and constructing an innovative country.

S&T innovation is not a closed system but plays a role in innovation system all over the society together with culture innovation, which is the key of integration between S&T innovation and culture innovation, and can promote continuous culture value-added, leap and improvement for a nation or country. S&T innovation is the driving force of society development, is the cornerstone and measure of culture innovation, for which expands more space. At the same time, culture innovation provides knowledge, methods and a better environment.

B. Integration

Since the 18th century, science had been together with technology, which made technology based on experience transform into science-based technology. That science meets the social needs through technology as a medium has gradually appeared. Started from the 20th century, science guided and promoted almost all major technologies. At present, the integration between modern science and high-tech has become an inter-penetration, interdependent and interconnected network system.

The high integration between science and technology forms a S&T continuum that is from basic research to applied research and development research to practical technology and, generally, whose formation process gradually expands by technicalization of science and scientization of technology. Technicalization of science is the result caused by increasing scale of science experiment, increasing complexity of equipment and increasing widespread application of modern technology including lots of technological science research, development research and applied research as its auxiliaries in scientific activities. At the same time, technicalization of science will evolve to emerge new technology because the technical principles put forward by scientific experiment are in line with practical needs. Scientization of technology means that (i) the current technology upgrades technological science, which has formed a technological knowledge system that also improves and enhances the current technology and (ii) technology progress based on science progress. After integration between science and technology, the research methods, development speed and value orientation have

changed deeply. But technicalization of science doesn't completely convert science into technology, vice versa. Integration doesn't confuse S&T.

Modern science is composed by basic science, technical science and engineering science. Basic science is the cornerstone of modern science, is the theoretical basis of technical science and engineering science, whose development level can reflect the science level of a country or area. Technical science is like a bridge which applies knowledge of basic science to solve the practical problems and provides some new studies and methods for basic research, whose development can reflect the technical level of a country or area. Basic science and technical science can only convert to productive forces through engineering science, whose development status can reflect the productive forces level of a country or area.

Nowadays, the intertransformation process between S&T is, in fact, a process of S&T as the primary productive force achieving its function, and a process of gradual integration among science, technology, economy and society.

II. SCIENCE & TECHNOLOGY INNOVATION: MODE AND PROBLEMS

S&T innovation formed relative stable innovation modes because of inner force from itself evolution and external pressure. S&T innovation mode is an abstract of S&T phenomenon and a universality and regularity understanding and generalization.

A. Development process of innovation mode

The research on innovation began at the innovation theory firstly proposed in *The Theory of Economic Development* written by the economist Schumpeter in 1912 [1]. Until now, there is not any one theory to comprehensively explain and include innovation theory for complexity of innovation activities. Each theory has its own special value and some drawbacks when studying innovation issues but those theories are good at providing suggestions and enlightenments for S&T policies.

Since the 1950s, there have been mainly five kinds of S&T innovation modes [2].

1. Linear technology-driven mode

The linear technology-driven mode mainly existed from the 1950s to the mid 1960s. It came from the S&T development of applied research and production behavior and R&D in enterprises. But the market factor was not usually focused because of limited production capability at that time. The linear technology-driven mode is shown in Fig. 1.

For the development background, Freeman said that there are some research & development projects related with new science but uncertainty, many of which are outside the enterprises and markets, although probably influenced by some potential demands, mostly, not affected by market demands [3]. The driving-force of S&T innovation stemmed

from itself progress.



Fig. 1 Linear Technology-Driven Mode

2. Linear demand-pull mode

The linear demand-pull mode mainly existed from the mid-late 1960s to the 1970s, it was also named linear market-driven mode which emphasized the guiding role of market in innovation. During this period, enterprises more and more focused that how to innovate using existing S&T to obtain more market share. The production process gradually paid attention to promotion role of market in S&T. Shown in Fig. 2.

Demand-pull mode emphasizes clients' demand is the source of innovation thought. Research & development department activities are passive. When achievements produced by S&T are consistent with market demand, innovation possibly come true.

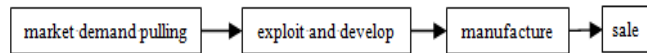


Fig. 2 Linear Demand-Pull Mode

3. Technology-market interactive mode

Technology-market interactive mode developed from the late 1970s to the mid 1980s. The related research indicated that technology-driven mode and demand-pull mode had been so simple and could not meet much higher level innovation, which directly made technology and market interactive and interconnected. Therefore, Mowery and Rosenberg put forward to the technology-market interactive innovation mode. Fig. 3 showed it.

The emergence of technology-market interactive mode means that S&T innovation on the one hand includes market demand, on the other hand, includes scientific and technological knowledge applied in research & development activities [4]. S&T innovation had changed the S&T supply-demand mode into a much more complex innovation mode which involves more innovation subjects, more function and more influence factors. The subject culture of innovation gradually appeared.

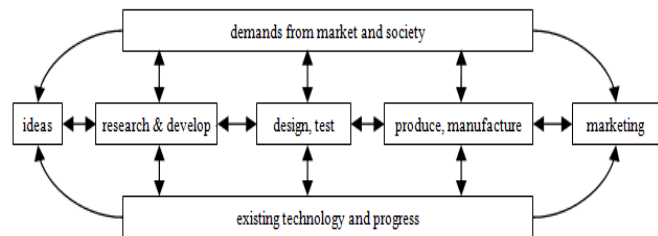


Fig. 3 Technology-Market Interactive Mode

4. Integration or parallel mode

Integration or parallel innovation mode developed from the 1980s to the early 1990s. During this period, enterprises production began to focus strategy management. Though technology-market interactive innovation mode had the information feedback, in logical, it still was a continuous process. Graves studied automobile manufacturers in Japanese and proposed the integration or parallel mode that features emphasized synchronization and integration among all kinds of functions. As the Fig. 4 shows.

Technology-market interactive mode broke the limitation of linear innovation modes, however, still didn't solve the contradiction between supply and demand of S&T. Innovation process is continuous, integral and complex, based on this background, integration or parallel innovation mode emerged. This mode focused multi-function integration of variety of different sections worked concurrently in the whole innovation process, which indicated the organization culture had formed.

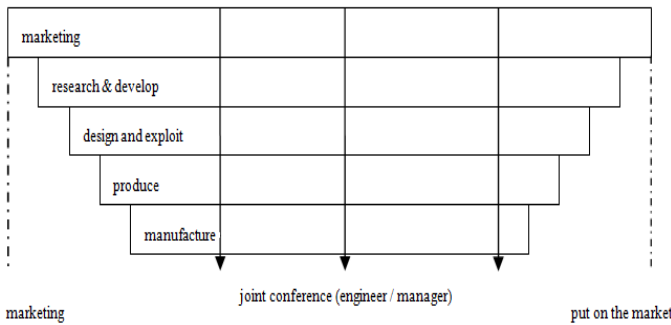


Fig. 4 Integration Or Parallel Mode

5. System integration and network mode

System integration and network mode existed from the mid 1990s to now. With the further development of technology, more and more enterprises realized that the new product R&D cycle have been a very important key to improve competitive advantage for them. Enterprises want to obtain competitive advantage on time, they must better to take advantage of modern IT technology and various kinds of electronic tools (mainly internet tools) to give assistance innovation activities. This mode emphasized close correlations among enterprises and more concentrated and strengthened internal integration within the enterprise and external network. As the Fig. 5 shows.

The rapid progress of S&T makes its innovation integrate different function of each department or organization and form a partnership with external environment and social relationship, and then finally constitute an innovation network system. System integration and network mode shows that S&T innovation more and more pays attention to the socio-cultural background.

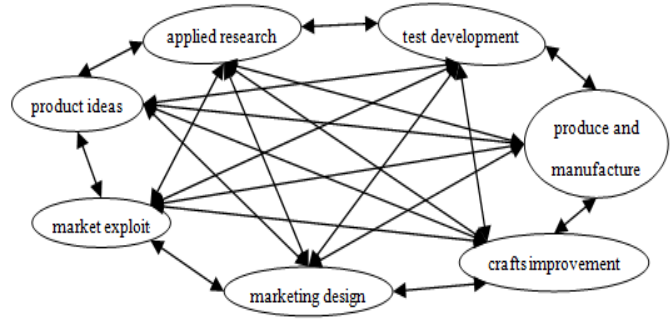


Fig. 5 System Integration And Network Mode

For above five S&T modes, the first two modes are linear modes which cannot reflect the complexity and diversity of S&T innovation and ignore interconnectedness among the each stage in innovation process, and the latter three gradually break the limitation of those linear innovation modes and strengthen interconnectedness in innovation process, especially integration or parallel mode and system integration and network mode, which more embodies the close connections with modern information technology and management techniques.

B. Current problems in China

The S&T innovation in China, especially independent innovation, still exists some problems or drawbacks which mainly as following.

Firstly, lack of original innovation. At present, the capability of Chinese S&T independent innovation is still insufficient and the major achievements of original innovation in basic fields is too few which have led to contradiction between supply and demand with modern society development. Compared with international level, infrastructures also have been existing apparent gap. In recent years, although Chinese basic scientific researches level has increasingly improved, output rate is still not high, which is reflected by a smaller number of high quality papers published each year, especially those influential papers. Only about 15% of subjects close to the advanced level in China, but large gap for others. In the long-run, only depending on technology imitate will further make the gap larger. Excessive technology dependency, compared with funds dependency and market dependency, is more dangerous. So, China must enhance and strengthen the independent innovation capability and transforms technology imitate to independent innovation as far as possible.

Secondly, the S&T innovation capability is weaker and the input of S&T funds is lower and its proportion in GDP is smaller, lagging the economic growth. The efficiency of S&T output is also lower and influence is not high. The most industry core technology still imports. A large gap between Chinese industry technology level, especially high-tech level, and world advanced level exists. Both industrialization of high-tech and high-technicalization of industry are not enough. Self-sufficiency rate of key technology is lower and

core competitiveness of enterprises is not strong. Those enterprises in China which have core technology with independent intellectual property rights only are 0.3%, which makes Chinese international technology competitiveness based on independent intellectual property rights disadvantaged. The R&D capability of enterprise is insufficient; technology transforming and technology importing are out of touch with technology innovation, which ignores the secondary innovation based on fusing and absorbing the importing technology.

Thirdly, utilitarianism tendency is so serious. Now, in China, scientific research “utilitarian” is an important factor to restrict the national S&T innovation, which is reflected in current scientific achievements evaluation system. At present, China’s economic development and scientific achievements pursue the short-term goal, the benefits for S&T personnel are directly related with evaluation indicators and assessment indicators. Some research showed that China more pursues efficient results, for example, the lag is one year when studying R&D activities, but usually two years for applied research [5]. These incentive methods or measurements are effective in the short term, but worse for scientific research in the long-run. The output of Chinese research papers increases much more rapidly, especially in engineering field, but the number of highly cited papers (high-impact papers) in all published papers is far behind the United States, and the frequency of Chinese research papers cited by foreign authors is obviously much lower than other countries, such as America and Britain [6]. So, “utilitarian” is a driving force to promote S&T development and also an obstacle or restriction, if we take academic research as a way of getting fame and fortune, it will result in a very powerful dependency relationship and restrict or hinder S&T or disciplines development [7].

Fourthly, there is still lack of innovative or creative talents and innovation subjects are vacant and mismatched. S&T resources and innovative talents cannot be effectively integrated and efficiently allocated, which is one of the causes that make Chinese S&T innovation capability weak in current. The S&T innovation talents, especially high-tech talents, are insufficient, at the same time, strategic scientists are also scarcity. In addition, the quality and accomplishment on national S&T is lower, which is not suited for rapid development of S&T, economy and society.

Fifthly, innovation system and environment have to be further improved. On the macro-management, the decision-making system and organizational mechanism are not yet formed. Segmentation system seriously affects some major S&T activities and weakens the S&T organizational capability and collaborative integration capability. A standardized and scientific decision-making consultation mechanism has not yet formed. In addition, there is a tendency which is that sector interests are instead of national interests. The S&T study platform that is beneficial to innovation for S&T personnel is also not formed. Industry policies, investment policies, trade policies and some S&T

policies do not effectively and efficiently integrate but exist contradictions and incoordination. Innovation needs a better external environment, such as social security system, financial system, Venture capital operation mechanism and so on. It is necessary to stop academic institutions to be administered and it is infeasible to administrate the original innovative and creative activities. Furthermore, S&T innovation, especially independent innovation, must have enough self-confidence, courage and ruse to break with tradition and leap-develop rapidly [8].

III. CULTURAL MEANINGS OF SCIENCE & TECHNOLOGY INNOVATION

S&T innovation has deep cultural meanings. S&T innovation culture regulates innovators behavior in an inner imperceptible way and provides a lasting continuous strong force for development of society economy.

A. Subject culture

S&T innovation culture is an important part of society culture system and a result of different subjects actions in participating in innovation activities. After accumulating and integrating the activity, creativity and self-dependence coming from different S&T innovation subjects, sense of values, way of cognitions and behavior norms will gradually take shape, and then S&T innovation subject culture will also form. The subject culture is a particular spirit quality and comprehensively reflects innovation subjects’ thought, psychology, concept and so on. Based on the spirit quality, innovation subjects can vigorously face the complex environment and form a spirit desire how to change the world and solve the problems [9].

The subject culture is reflected by science spirit, society spirit and humanity spirit. Based on cognitions from people, the science spirit is understood from the relationship between innovation subjects and nature. This spirit integrates intelligence factor and non-intelligence factor and puts scientific thoughts, methods and knowledge into innovation activities and forms a truth-seeking attitude and a rigorous, stable and creative psychological tendency. The society spirit is understood from the relationship between innovation subjects and society and is accumulated because of creativities. Individual creativity is from society and generates from society and finally serves society. Society can reveal the essence of S&T innovation and cultivate the social responsibility and morality. Humanity spirit is a reflection from innovation subjects and accumulates their self-dependence. It also is a spirit quality which S&T innovation subjects exceed themselves. What’s more, humanity spirit respects the human values and focuses the human survival and role and promotes human freedom and comprehensive development.

B. Organization culture

S&T innovation is an organized activity and not only an

economic activity but also, more importantly, a cultural activity. S&T innovation organization activities accumulate and sublimate organization culture which is a general, stable and regular content, and which makes different innovation subjects trust each other in a cultural value perspective.

S&T innovation organization culture mainly includes three meanings. The first is common values which is accumulated by S&T innovation organization adhering the spirit of S&T innovation. The value pursuit and target of organization culture is the S&T innovation whose common standpoint is the scientific spirit. Next is organization order which is a set of organization operation mode based on common values and whose function is to effectively integrate those different innovation resources, for example, information, knowledge, thought and personnel, based on innovation target. By the effective constraints and incentives of organization order and fully excavating the potential of people, it is necessary to establish a development platform to share human resource and promote the spread of innovation knowledge and innovation information in order to enhance and improve the effectiveness and efficiency of S&T innovation [10]. The third is risk apportioning which can guarantee the organization culture. Affected by uncertainty, S&T innovation has some risks. Once S&T innovation appears not good results, if failed to adjust, the negative effects will be gradually enlarged which will makes cultural phenomenon difficult to be formed. However, if S&T innovation is successful, that positive effects will bring the good, even considerable benefits and form a better cultural environment.

C. Social culture

S&T innovation subject culture and organization culture are not closed and isolated. Both of them are interactive with society activities through innovation activities. This interaction brings the interactive effects, which generates the S&T innovation social culture. S&T innovation and social culture are both excluded each other and integrated each other. First of all, innovation is the nature of S&T innovation culture, but social culture is intrinsically conservative, therefore, in the beginning, S&T innovation is difficult to integrate into society culture. Social culture is the basis of S&T innovation culture, at first, social culture is in a strong position, which makes values of S&T innovation marginalized. After all, social culture is a “soft power” and depends on a set of regulations, rules or norms though it breeds out S&T innovation culture. In fact, no matter what difficulties S&T innovation faces or suffers, some finally succeed. Experience has indicated that S&T innovation will bring great social value once it is successful. In this sense, S&T innovation and social culture are interpenetration and inter-merging, which makes social culture recognize value of S&T innovation, which can further perfect the social culture evaluation system.

All in all, constructing S&T innovation culture can unify S&T innovation activities and cultural activities, more

importantly, guide innovation culture to step into a good-cycle self-organization process.

IV. SCIENCE & TECHNOLOGY INNOVATION IN CULTURAL INNOVATION

Culture needs continuous innovation with the progress of era. Based on S&T, the S&T achievements should be applied in the process of cultural innovation.

A. Science & technology innovation affects cultural system

S&T innovation can generate a cultural effect. Looking back the development of human history, social progress and cultural development are always close with scientific & technological progress. Material culture and spiritual culture are the characteristics of S&T. As a productive force, material culture is a property; as an ideology, spiritual culture is another property, for example, scientific thoughts, scientific knowledge, scientific methods and scientific spirit.

Cultural development and progress caused by S&T innovation firstly is reflected by material culture, such as the progress of human manufacturing and using tools. And then, S&T will further affect institutional culture and spiritual culture. So the progress of S&T will stimulate the development of culture.

S&T upgrades personal cognition to cultural level in order to gain social objective knowledge. The purpose of scientific knowledge is to remove all personal factors and exerts collective human wisdom [11]. The target of science is to provide new discoveries to vouchsafe mankind [12]. S&T is the highest achievement of human wisdom development and the unique consequent of human cultural progress. The sense of values and behavior norms of S&T culture have constituted the basis of human spiritual civilization [13].

With the rapid development and changes of S&T, we must focus the newest progress and positively apply advanced S&T means to spread advanced thought and culture and continuously improve the scientific & technological quality of cultural career and industry. Occupying the key point of S&T culture must take a road of independent innovation. The national innovation system should include those high-tech researches belonging to cultural field.

Therefore, as a knowledge system of human culture, S&T is the main symbol of modern cultural progress and its theoretical function cannot be replaced by other culture. In addition, S&T also is the source of cultural innovation and a powerful driven force to promote cultural progress.

B. Cultural value of science & technology innovation

S&T knowledge system is, to greater extent, a spiritual achievement and wealth. Paying attention to cultural value of S&T knowledge is a unique sense of values of S&T community. In modern society, people find, to what extent, the cultural value such as rationality, utilitarianism, universalism, individualism, social improvement, and the social structure such as highly specialized division of labor,

open hierarchy system, non-totalitarian political system, S&T will, in what extent, prospers and thrives [14]. Therefore, S&T is a cornerstone of comprehensive national strength for a country and an important part of constructing spiritual civilization and play a fundamental role in national economy and social development strategy.

C. Advanced culture and science & technology innovation

S&T provides powerful material basis and spiritual source for other culture. Advanced culture is suitable to society and future development and surpasses itself as far as possible and provides foreknowledge, which is the supreme principle of cultural development. S&T can make people form scientific world view and methodology. The nature of S&T revolution is the thought and value revolution of people. S&T opens the way for new thought and also converts itself to social intelligence to promote the development of human thinking and the progress of spiritual civilization.

As a knowledge system and tool by which human understand and change the world, S&T is the cultural achievement of spiritual activity and spiritual production, which has been promoting development of advanced culture and construction of spiritual civilization. S&T innovation improves the level of human advanced culture by accumulating and enriching various kinds of knowledge. Scientific & technological knowledge popularization, the spread of scientific & technological thought, carrying forward scientific & technological spirit, scientific & technological methods promotion and application of S&T innovation achievements all play an important influence in constructing advanced culture.

V. CONCLUSION

This paper discussed and analyzed the relationship between S&T culture and innovation culture, the development process of S&T innovation modes, the current problems of Chinese S&T innovation, the cultural meanings

of S&T innovation and the influence and role of S&T innovation in cultural innovation. The experience and theoretical finding showed that S&T innovation and cultural innovation are not isolated but inter-integrated and inter-penetrated, what's more, is a prominent result of integration between S&T culture and humanities culture. S&T innovation ultimately is reflected in innovation of national culture. Therefore, the integration between S&T innovation and cultural innovation is an inevitable trend of promoting nation-rising, enhancing national independent innovation capability and constructing a harmonious society.

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