A Study of Innovator Evolution in the High-tech SMEs

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\textbf{Abstract.} Innovators play a key role in the development of high-tech SMEs. Without the innovators' mental creation and reproduction development, high-tech SMEs will not be able to achieve good development. In this article, we analyze the innovation behavior of the innovators in the high-tech SMEs, and study the development and evolution of innovators, using the theory of cultural transmission and evolution. We found that only the more perfect legal system in society, the more corresponding profit will the innovators obtain to keep developing. At the same time, innovation should be publicized and promoted. Also, excellent innovation should be awarded and bad innovation should be punished and accelerating innovation reproduction ability, in order to form a continuous wave of social innovation, and promote the development of high-tech SMEs.

\textbf{Introduction}

Regional differences become gradually larger than before in China's economic development in nowadays. Some areas even have entered the post-industrialization period. According to the dislocation development between regions, it is necessary to develop the science and technology industry in some areas quickly, by the development of science and technology enterprises and raise China's own scientific and technological developing power. On the whole, it is a possible choice for the upgrading of Chinese industrial structure from low-level labor-intensive to high-level human capital intensive.\textsuperscript{[1]}

From the world experience, any country economic growth can’t rely only on the relatively few large enterprises, but on the small and medium sized enterprises, with more flexible mechanism, and a large number, and more active innovations, especially in the high-tech SMEs (small and medium-sized enterprises). Data show that high-tech SMEs realized 95% of the world's fundamental innovation, 50% of the OECD’ main technical innovation, 99% of the European Union (EU) country's advanced technology patents, 100% of U.S. steel and oil industries' technical innovation and 80% of U.S. aluminum industry’s technical innovation.\textsuperscript{[2]} U.S. business administration’s files pointed out that the innovation achievement of each employee of high-tech SMEs is about 2 times the size of large enterprises, and the scientists and engineers who engaged in R&D department in proportion of all employees is 1.6 times of large enterprises. In China, more than 60% of patents and more than 80% of new products are created by high-tech SMEs.\textsuperscript{[3]} Song Xuan-yi also believes that SMEs are the most active and positive core section of innovation chain\textsuperscript{[4]}.

High-tech SMEs provide a large number of jobs. They create a large number of national income; also have made a great contribution to the national tax at the same time. More importantly, High-tech SMEs are the main driving force and foundation of national development. They are one of the sources of technological innovation; can quickly realize the transformation of scientific and technological achievements and realize the technological innovations at the same time. The rapid growth of economy of United States since 1990s, are closely related with the formulation and implementation of policies which focus on promoting the development of SMEs in 1960s - 70s. For example, the rapid growth of the world renowned technical enterprises, Intel and IBM, and other companies, are benefited from the implementation of the U.S. small business investment plan, technology innovation plan and technology transfer plan, and so on. The reason that Japan was able to recover from the two oil crisis and the dollar crisis in 1970s, is closely linked to the economic growth promoted by SMEs' innovation. The reason why China's Taiwan province could suffer less
impact of the Asian financial turmoil in the end of last century is because of the ability to resist and digest risks of many local high-tech SMEs.

However, up to now, the academic circles have not formed a unified and standard definition for the high-tech SMEs. Luo Ya-fei and Hong Ying defined high-tech SMEs as the small and medium enterprises with strong technical innovation ability, mainly engaged in the research, development, production, sales and service of high technology and high-tech products. \[5\] Fu Bona believes that, high-tech SMEs are small and medium sized enterprises led or started by scientific and technological personnel, with self financing, voluntary combination, self management, self sustaining, taking research and development, production and transformation, sales and management of high technology and high-tech products as their main business. \[6\] In general, a consensus is followed in the discussion of high-tech SMEs, that is, the products or services with high technology should be accounted for more than a half of products or services provided by the enterprise; on the other hand, there should be considerable number and proportion Research Specialist Staff of the total number of employees in SMEs; At the same time, there should be a considerable number and proportion of capital and income devoted into scientific research. According to the “Interim Measures for the management of innovative fund projects for high-tech SMEs”, issued by Ministry of science and technology and Ministry of Finance in 2005, high-tech SMEs should be mainly engaged in research, development, production and services of high-tech products, with less than 500 employees; among them scientific and technical personnel with college degree or above is no less than 30% of all the employees; the scientific and technological personnel who directly engaged in research and development is accounted for no less than 10% of the total number of employees; have good operating performance and reasonable asset liability ratio; funds which is used for the high-tech product research and development every year, is not less than 5% of sales volume.

High-tech SMEs need to undergo a number of fierce competitions, if they want to develop into a mature large science and technology enterprises. In the growth process of high-tech SMEs, it’s important to making synchronously continuous improvement of the economic scale and innovation strength, and forming innovative culture, and then forming strong international competitiveness. That is to say, a country can get a certain area after the international industry competition or not, depends on whether it has large high-tech enterprises with strong international competitiveness, which are often related with the good economic development environment suitable for the early development of the high-tech SMEs in the beginning. In promoting “mass entrepreneurship and innovation”, domestic high-tech SMEs continue to emerge, but with lower survival rate and shorter life cycle. Data from the domestic high-tech SMEs survey shows that 8% of such enterprises will be closed in the next five years, 19% survive for 6-10 years, only more than 13% for more than ten years, the other be merged or converted business scope. \[7\] Therefore,

China should focus on how to foster SMEs into large science and technology enterprises. And the role of innovators in high-tech SMEs is very important, because innovation is mainly activated by human’s innovative labor. The development of science and technology human capital has important significance for the innovation activities. \[8\] There must be continuous innovation, which requires the continuous emergence of innovators, so that to improve the number and quality of innovation, if high-tech SMEs want to develop into a large scientific and technological enterprises.

The Literature Review

The Subject of Innovation

In technological innovation, the subject of innovation is always humans. Human being is the most creative and the most active factor in the economy, and is also the key decisive factors of social transformation. Only human being can develop innovation and turn innovation into practical productive forces, whereas the animal has only the functions of conditioned reflex or simple imitation, etc. innovation is one of the essential difference in which human differs from other organisms, as a higher intelligence and social organism. Through empirical study, Qian Xiao-ye found that there was a significant positive correlation between the proportion of higher education
and technological innovation activities. Sun Wen-jie and Shen Kun-rong also use industry data to show that the ability of technology-learning and the accumulation of human capital of technological personnel are the important factors that affect the ability of independent innovation. Furthermore, as for the specific mechanism of action, through empirical research, Lai Ming-yong found that we can directly increase the level of output by raise workers' education level, occupation skills, technical proficiency and labor productivity; we can also indirectly promote economic growth by enhance domestic technology absorption capacity and the level of R&D. Thus, innovators play an important role in the development of economy, and the role of high-tech SMEs in promoting economic development is largely depending on whether the enterprises can effectively develop and utilize the innovators.

Apparently, as for the subject of innovation, there is still a big gap between innovators and average person. But this kind of gap can be shortened, even eliminated, so that more average persons can be transformed into innovators. That is to say, innovators can be simulated and developed. Average person can be with more innovative desire and innovative capability through education and research. At the same time, the whole society can be with more innovator impetus through publicity, subtle influence and rule system. The research of Zhu Cheng-liang and others proves that the human capital of higher education has a great effect on improving the efficiency of economic growth. Ordinary people used to follow certain conventions, or certain thinking and behavior logic. There is always mental set exist. Under its influence, it is hard to change in cognition dimension; it is also difficult to find the problem from a new perspective and to solve it; it is difficult to create a new object of observation. Only when mind is free, is it easy to get rid of the mental set, to facilitate divergent observation, divergent memory, divergent imagination, divergent thinking smoothly. In one word, only when mind is free, is it easy to facilitate the process of divergent cognition smoothly. There are divergent thinking and convergent thinking in creative thinking, which is the unity of divergent thinking and convergent thinking.

The psychological freedom here is that the individual's psychological activity is in the state of being free from any restrictions, free from any limitation and comfortable. When the mind is in a state of free and relaxed, the divergent observation, thinking and imagination can be produced smoothly. After divergent observation, thinking and imagination are produced, convergent thinking can be used in this situation. People can Compare and screen out the best perspective of the problem, and find out the best way to solve problems, based on thinking of many dimensions. In this way, innovation has been produced.

**Physiological Basis**

The appearance of innovation and inspiration, is usually unexpected, usually when individual’s psychology is free and comfortable. It may be screened out through all the thought in the subconscious, and is a spark inspired through the perfect combination of “emotion” and “wisdom”. According to the study of emotional neuroscience, the amygdala is the brain’s central “emotional computer”, which analyzes the input sensory information to see what emotional meaning it contains, and to make a cognitive function assessment. Of course, the amygdala also plays a connecting role, so that various parts of the brain can complete emotional processing collaboratively. In the book “Mapping the Mind”, Rita Carter shows outside signals trigger the amygdala’s response through two paths: first, pass through the thalamic system into the cerebral cortex, then send messages to amygdala from cerebrum; second, send messages to amygdala directly through thalamic. The first path is related to what we call “rationality”, and the second path is related to what we call “sensibility”. Although they are different paths, there is still some complicated connection between them. Electrical stimulation on the amygdala leads to a dual response to attention and emotion. More importantly, they also agree with the idea that the amygdala can enhance motivation, update and integrate sensory signals. Other scholars believe that, the prefrontal cortex (PFC) has long been recognized as an important component of the neural circuits which produce cognitive so that psychological activity can be characterized. Jeremy et al using functional magnetic resonance imaging shows that prefrontal cortex may be an important place of cognitive information.
processing and emotional information processing. The study of Damasio in the patients of Ventromedial cortex of the prefrontal cortex revealed that “pure cognition” can not complete the planning and decision making solely, and only with the close cooperation between emotion and cognition can the planning and decision-making activities be completed. Stuns et al believe that the function of the anterior cingulate cortex is evaluation, emotion adjustment or consciously adjustment of emotional responses and this evaluation function is a necessary component of emotion control processing type, and also shows that the anterior cingulate cortex has cognitive function. Recent advances in the study of emotional neuroscience provide a solid physiological basis and scientific basis for that creative thinking may mostly be stimulated in a relaxed state of freedom.

**Innovators and High-tech Enterprises**

If the innovators are the ultimate intelligent subject of innovation, high-tech enterprises rich in innovators should be another subject of innovation. It is mainly composed of innovators, producing innovation or the products and services whose main value component is innovation. As for the subject of innovation, They not only have the ability to transform innovation into commercial innovative products which the innovators have not, but also have more social influences and cultural influences than innovators. This social influences and cultural influences are the strong driving force which is needed when developing the innovation economy, is also as the important characteristics of the innovation economy’s core which is needed by Chinese socialist economic development up to now.

All major innovations and major inventions are backed by social needs. Only after were these kinds of social needs transformed into individual needs, individuals will develop continuously innovative power, making individuals continue to undergo create activities, lead to innovative achievement. That is to say, only in accordance with the social needs have individual innovation results social conditions and foundation been applied to promote. There is an interactive system between the social needs and the innovation of science and technology. Social needs are the driving force of scientific and technological innovation. Without the basis of social needs, individual needs are like the water in the desert, and will soon dry up in the face of difficulties and failures.

In order to create the individual needs of innovation, we have to start from the research of social needs, making the individual get to know and understand what the society needs, letting people know the significance of these social needs, so that social needs can easily been transformed into individual needs of innovation. Once the individual needs of innovation were produced, it will form the power of innovation, creating innovative behavior, and then resulting in innovation. However, innovation needs to be tested by social development. Because the social and economic environment is complicated, not all outstanding innovations from innovators can be transformed into real productive forces, and promote the development of society. On the contrary, due to lack of system and even to the social habits of the bias, in some places and in some industries, innovation can even not get deserved respect, but being crazy duplicated and pirated, so that social innovators can not get proper paid, thus losing the power of innovation, and leading to the continuous reduction of innovators. In the end, the whole community emerges to be of the degradation of innovation groups.

**Research Model and Methodology of the Study**

**Hypothesis and Construction**

Consider a group with the social norms of behavior of “innovation” or not. All the people in the group are divided into two different groups, called A and B. People in group A are innovators, in group B are ordinary people (compared to the innovators); both do produce at the same time, facing the same market, and get back their own division of income.

Based on the dynamic adaptation of the organism, we assume that participants are randomly paired into a spouse at each period, and the number of their offspring is proportional to their fitness.
The family passed their cultural norms to their offspring, which is called “vertical transmission”. In that, the offspring of AA parents are innovators; the offspring of BB are ordinary people; the offspring of AB are half innovators, half ordinary people, on the probability. Innovators support innovation, having positive external effect obviously; ordinary people relatively may incline to duplicate the “innovation” and get the benefits of such “innovation” too. Therefore, if the fitness of ordinary people will be set to 1, compared to ordinary people, the innovator only has the fitness of 1-s, in which the range of s is 0<s <1. s is the representative of the difference of fitness, which is determined by the power of social norms, mainly composed by the copyright system. The weaker the copyright system is, the bigger the s is, and the smaller the social influence of innovator is, and the lower the fitness of innovator is.

Analysis and Result

In the first stage, we assume that there are n men and n women, in which the ratio of innovators isα(0 ≤ α ≤ 1). They paired up to form n families, in which there are nα^2 AA type family. The population in the community has a growth rate of g(α). Their nα^2 (1 - s)^2 β offspring are still innovators, in which β is a parameter, determined by g(α).

Still, there are 2nα(1 - α) AB type family. Their nα(1 - α) (1 - s) β offspring are innovators, another nα(1 - α) (1 - s) β offspring are ordinary people.

At last there are n(1 - α)^2 BB type family. They will have n(1 - α)^2 β offspring. All of them are ordinary people. So we get:

\[ nα^2 (1 - s)^2 β + 2nα(1 - α)(1 - s) β + n(1 - α)^2 β = ng(α) \]  (1)

Solve it, we get:

\[ β = \frac{g(α)}{(1-αs)^2} \]  (2)

It can be concluded that the frequencies of AA type, AB type, and BB type are present as follows:

\[ f_{AA} = \frac{α^2(1-s)^2}{(1-αs)^2}, \quad f_{AB} = \frac{2α(1-α)(1-s)}{(1-αs)^2}, \quad f_{BB} = \frac{(1-α)^2}{(1-αs)^2} \]  (3)

In the second stage, because of the social culture of promoting innovations in the community, due to the influence of “tilt transmission”, we assume that part of offspring of the ordinary people have been transformed into innovators. There is a linear relationship between these two groups. γ is the measurement of “tilt transmission”. Because the proportion of the innovators in last generation is α, the intensity of tilt transmission is αγ. That is to say, there are αγ proportion of ordinary people offspring of AB type and BB type transformed into innovators. So we can get the innovators of a new generation in overall population has been changed to:

\[ \dot{α} = f(α) = \frac{nα^2(1-s)^2β + nα(1-α)(1-s)β + nα(1-α)(1-s)βαγ + n(1-α)^2βαγ}{ng(α)} - α \]

Put (2) into this formula, we get:

\[ \dot{α} = f(α) = \frac{α(1-α)(r-s)}{1-αs} \]  (4)

In the third stage, account on the initiative of individuals, when each member observes other members of their type and fitness, the observer will consider of changing into the other's type, if he found the fitness of the object was higher.[21] However, there is incomplete information of the differences between the fitness in regarding with the two strategies. Moreover, because the existence of factors such as mental formulary and inertia, the preference function of participants is not completely follow the fitness. So it can be reasonably assumed that the greater the difference of the fitness is, i.e. the bigger the s is, the greater possibility participants observe and change into the same type following the observation. Therefore, we assume that the probability p with which

an innovator transformed into ordinary people is proportional to the difference between two types’
fitness, i.e. \( p = \sigma s \). \( \sigma \) is a constant greater than 0, representing the relative intensity of replicator dynamics. It is not conducive to the development of innovation economy.

Taking the changing of third stage into account, we get the changing of the proportion of innovators to the whole population of latest generation as follow:

\[
\dot{\alpha} = h(\alpha) = f(\alpha) - \alpha (1 - \alpha) \sigma s
\]

Expansion the formula (5), we get

\[
\dot{\alpha} = \frac{\alpha (1-\alpha)}{1-\alpha} \left[ \gamma - s - \sigma s(1 - \alpha s) \right]
\]

When \( \dot{\alpha} = 0 \), the proportion of innovators in the whole populations is not changed anymore. The whole community enters into stochastic stability equilibrium.

Make \( \dot{\alpha} = 0 \). It is easy to found there are three solutions: \( \alpha = 0, \alpha = 1, \) and \( \alpha^* = \frac{s(1 + \sigma) - \gamma}{s^2 \sigma} \).

When \( s < s_{\min} = \frac{\gamma}{1 + \sigma}, h'(0) > 0, h'(1) > 0, \alpha^* < 0 \). Thus, here, \( \alpha = 1 \) becomes a single stable equilibrium state. The whole ethnic group will be stable in the innovator group.

When \( s_{\min} < s < s_{\max} = \frac{1}{2 \sigma} \left[ 1 + \sigma - \sqrt{(1 + \sigma)^2 - 4 \gamma \sigma} \right], \alpha^* \in (0, 1) \), and because \( h'(0) < 0, h'(1) < 0 \), there are three equilibriums. \( \alpha^* \) is not a stable equilibrium, but \( \alpha = 0 \) and \( \alpha = 1 \) are all stochastic stable state. There are basins of attraction in these states. That is to say, any dynamic state point will be absorbed into these basins of attraction in this group. Unless disturbances have been accumulated to huge extent, such as the impact of natural disasters, war and other none resistant factors, the community will keep in this equilibrium forever. There is more than one attractor status, which means that the dynamic process is non ergodic. That is to say, the average action in the long term depends on the initial conditions, and the initial number of innovators affects the final equilibrium position of the ethnic group.

When \( s > s_{\max}, h'(0) < 0, h'(1) > 0, \alpha^* > 1 \). And then innovators will continue to decline in the ethnic group, at last all the people in the group will be transformed into ordinary people.

From the model above, we find out that, in order to promote the development of innovation economy, in promoting the transformation from ordinary people to innovators and maintaining the vitality of innovators, we must pay attention to the following questions:

1. we must optimize the legal environment, improve the level and intensity of copyright protection, to reduce \( s \), so that we can ensure the innovators to obtain proper profit in a certain period of time from his innovation, which can inspire the enthusiasm of innovators, besides, reducing the free riding behavior of ordinary people;

2. we must carry out activities and initiatives to promote innovation in the whole of society, in which we promote and stimulate innovation, increasing the level of \( \gamma \), and then reform the education mode in the education system, realizing the change from imparting knowledge to teaching innovation ability;

3. we must improve the level of innovation, giving reward to the innovations of high level, and giving punishment to false innovations and bad innovations, reducing \( \sigma \) to reduce \( p \), so as to form an innovation wave in the whole society, making the innovation economy to achieve its proper value.

**Discussion and Conclusion**

Researcher professor Florida showed that creative people love to live in the places and regions where the index of three factors, the so-called 3T, which means technology, talent (personal talent) and tolerance (relaxed and pleasant environment), ranked very high.\[22\] Thus, in order to create an innovative society, we must start in such cities with all these conditions, to construct the innovative cities, and then spread from point to surface. If the cities need to be transformed into an innovative city, they should take advantage of history and culture, cultivating developed soft environment and hard environment, protecting the diversity of cultures, respecting personal talent, constructing full complete developing mechanisms of innovators. To construct the enterprise innovation ecosystem,
we need to optimize the mental model and improve the organizational learning mode, in order to get rid of the constraints of cognitive rigidity originated from the rigidity of mental model. In order to eliminate the negative effects of internal rigidity, we need to adopt the measures of innovation ecosystem modularization and structural differentiation, so that we can reduce or even eliminate the contradiction and conflict between different innovation ecosystems. In addition, to protect the innovation ecosystem of the emerging industrial enterprises, we should improve the governance mechanism of stakeholders, and promote the enterprises to create greater value along with stakeholders, and enhance the dependence of stakeholders on the enterprise.\[^{23}\]

The specific methods are: first, advocate and implement the national “creative education” and entrepreneurship education policies and measures, to reinforce the talent development foundation of the innovation economy; second, focus on creating the “innovation life circles” of different themes and the market chain of innovation productions, strengthening the innovator's agglomeration effect; third, pay attention to the growth mechanism and special laws of innovators in enterprises, and create innovation environment to publicize innovators’ personality; fourth, innovate and improve the interest incentive mechanism for innovators, build an “experimental field” for the innovators to directly face the market competition; \[^{24}\] fifth, improve the industrial chain of innovations, focusing on cultivating their awareness of the market and the sensitivity of innovative products when cultivating the innovators; \[^{25}\] sixth, make up for the defects of external market through the collectivization management, and improve the efficiency of the use of innovators, and promote the investment of R&D of enterprise investment and innovation output. \[^{26}\]

In the category of innovation economy, the main body of investment is no longer the Monetized monetary capital, but the advanced form of human capital, innovative capital. To achieve the transformation from innovation to capital, is to achieve the ideal of the full integration of the spiritual ideal of the innovators and the material ideal of investors, which is the “ideal process” of Chinese economy and social sustainable development. At present, according to the development of China innovation industry, we should formulate feasible strategy to help and promote national innovators, encouraging independent innovation and the formation of social atmosphere encouraging people to do innovation, to promote the construction of independent innovation system of the whole society, so as to form a virtuous cycle of attracting talent, of industry innovation and of economic growth, thus creating a “China era” in global innovation economy.

References


