Influence of Technology Innovation on Economic Growth Patterns from a Brain Cognition Based Approach

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ABSTRACT

In recent years, the technological innovations in China has substantial influence on the economic development. But as the market is gaining competitiveness, only with continuous innovations, can China maintain the sustainability of its economy growth. This paper, based on analysis of behavioral data and electroencephalogram (EEG) data, sets to understand the how the technological innovation can exert influence on the economic growth patterns from the perspectives of time phase, space limit and diversified approach. As for the EEG data, we test the cognition of 15 subjects on the degree of recognition, and validate the hypothesis set out beforehand. This paper adopts a new perspective that analyses technological innovation with the brain-recognition-based approach, conducts experiments on how the technological innovation can influence the economic growth patterns, and sets to provide policy recommendations to benefit future technological innovations in China.

Key Words: Brain Cognition, Technological Innovation, Economic Growth Patterns, Brain Cognition Experiment

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Introduction

Since China's reform and opening-up, its economy has enjoyed sustainable development. Now China is the second largest economy in terms of economic aggregate, with significant improvement of people's livelihood. The majority of population in China are much better off. However, with the fast economic growth, it exposes many social and economic problems and issues, such as environmental deterioration, resource shortage, unbalanced regional development, and social inequality. These issues may become the bottleneck to China's economy. In response, the Chinese leadership advocates the reform requirements on "transforming the economic growth pattern" and place it high on the agenda as a "top priority of current work".

Economic growth pattern transformation is a key strategy of China's economic plan, and also is a pre-condition for sustainable growth what provides guarantee to the realization of the Chinese dream. Among the many elements that affect the economic growth patterns, technological innovation is a key and carries vital importance. It provides comprehensive support to the transforming of economic growth patterns. Given that, the research on how technological innovation influence economic development has significant importance, both theoretical and practical, to the realization of the Chinese dream.

The world is on a fast track of technological innovation. In the 2018 National People's Congress and Chinese Political Consultative Conference, the minister of Science and Technology, Wang Zhigang, stated that the

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essential requirement of technological innovation is cultivating innovative talents. We must reward the innovators with due respect. The innovations are based on human resources, and the reform should be emphasized on development of "talents". In terms of the policy, we must award the capable, accomplished innovators with the society's acknowledgment, in terms of income, respect and honors. As for the resources, we must synergize the national strategic planning, social development demand and research interests, and properly allocate the resources. Currently, the academia has not agreed on a uniform set of standards on accessing technological innovations. Some previous research on innovation assessment standards are based on varied research methods but have considerable similarities. The Research Report on China Technological Development constructs an indicator system for evaluating China's regional technological competitiveness that incorporates over 40 indicators in 5 categories, including technological investment, technological output, balance between technologies, and social and economic development, knowledge creation, knowledge acquisition, technological potential, and social schemes. On the other hand, the Report on China's Regional Innovation Capacity sets over 100 indicators in 5 categories including innovation environment, knowledge creation, knowledge acquisition, company innovativeness, and innovation-oriented economic profits.

Adopting a new perspective of brain cognition, this paper studies the influence of technological innovation on economic growth patterns by conducting EEG experiments (Bergero *et al*., 2017; Bianco *et al*., 2017; Eimer, 1993; Franco and Värri, 2015; Ekman and Friesen, 1971; Gattuso *et al*., 2016), defines the implication factors of technological innovations, and provides advices and suggestions for future research.

Research Hypothesis

The experiments sets to address the topic of the influence of technological innovations on economic growth patterns based on brain cognition approach. Based on this topic, we set below three hypothesis:

Hypothesis 1: the influence of technological innovations on economic growth patterns is exerted in phases

Hypothesis 2: the influence of technological innovations on economic growth patterns is limited by space

Hypothesis 3: technological innovations promotes diversified economic growth patterns

EEG Experiment and Data Results

Experiment Purpose

This paper adopts the research method of event related potentials, and push-button experimental paradigm for the purpose of seeking authentic and comprehensive simulation of how brain cognition is developed when people react to the influence of technological innovation on economic growth patterns. Furthermore, we analyzed the inherent law and connections of individual subject's neuromechanism in this aspect. This experiment adopts the prime-probe experimental paradigm and selects randomly 15 city residents who volunteered for participating in the experiment. With the help of EEG analysis, we set to validate the above hypothesis.

Experiment Methods

(1) Experiment Subjects

The subjects of the experiment are randomly selected, all between the age of 18 to 50. Subject to a survey, they are free from any mental disorders and are in good health conditions. The subjects are physically and mentally fit for participating in the experiment.

(2) Research Materials

The subjects are in a quiet research environment and seated in comfortable chairs. They first read the instructions under our guidance. The monitor placed facing the subjects then displays the notice "experiment starts" to notify the subjects. Upon the notice, they will prepare themselves for the experiment.

Then, the monitor shows a case summary on how technological innovation influences economic growth patterns. After detailed reading, the subject is given some time for thinking. At last, the subjects answer to the questions shown on the monitor about the influence of technological innovation on economic growth patterns by pushing the buttons.

(3) Experiment Procedures

Through literature and market research, we select a most-up-to-date case summary on how technological innovations influence economic growth patterns in various ways so as to guarantee the adequacy of the experiment material.

Before experiment starts, the subjects must read the experiment procedures and be seated in a chair, with a computer and monitor set up before them in a distance of 90cm. They wear an electrode cap. To better prepare them for the experiment, we run a pre-test on them so they can fully adapt to the environment.

During the experiment, the subject completes three tasks, each taking up 15 minutes. They also take a brief break in between the tasks. Before the start of task, a reminder "experiment starts" is shown on the monitor to help them adjust to an experiment state of mind and stay focused for the coming up task; then the monitor display the case summery for the reading. Each subject has 15 minutes to complete the reading. Afterwards, the monitor shows some questions on the case for the subject to answer with prudence. The subject is required to follow the experiment steps and provide answers to every question based on their own understanding of the case.

During the experiment, the subjects are free to answer the questions on their own imitative on how the technological innovation affects the economic growth patterns, and press the buttons for the selection of answers, 1 for agree and 2 for disagree.

(4) EEG Data Record

Data analyzing of EEG record starts 200 millisecond before the proposing of question and 800 millisecond after proposed. Based on this, the base line of data analysis is 200 milliseconds before question is proposed.

The original EEG data includes external equipment noise such as powerline interference and physiological noise such as ocular artifacts and muscle artifacts. And these signals tend to have way large amplitude than the authentic EEG signals, making it difficult to extract the real EEG signals for the purpose of analysis. As a result, before using EEG and EPR signals for further research, we need to pre-treat the original EEG data for noise filtering.

After data treatment, we obtain the corresponding ERP gram and oscillogram. The oscillogram is selected for analysis on EEG elements that contain data needed.

EEG Data Analysis

(1) EEG Data Analysis and Steps

Utilizing the EEG record analysis system, we conduct offline analysis of the data. The process is: data merging→treatment and noise filtering→reference replacement→remove ocular artifacts→remove artifacts→data section interception→base line correction→segmentation →overlay analysis

(2) EEG Content Analysis

Based on the above-discussed, the time history of EEG data is 1000 milliseconds. Hence the EEG oscillogram in Figure 1.

Figure 1. EEG Oscillogram

Decomposition and Determination of Technological Innovation

Based on reference to existing literature and with full consideration of the obtainability of data, we construct an indicator system for evaluation of the technological innovation capacity. The system has three levels, the first level being technological innovations; the second one consisting of technology innovation, knowledge innovation, innovation environment, innovation conversion, and innovation administration efficiency; and the third level made up with 21 indicators, which are listed in Table 1.

(1) Technical Innovation

Technical innovation has 4 indicators, which are technical market turnover (X11), technical market turnover growth rate (X12), high-tech industry output value (X13) and high tech industry output value against R&D expenditure (X14).

(2) Knowledge Innovation

Knowledge innovation indicators include number of patent applications (X21), number of invention patent applications (X22), number of college/university students (X23), number of college/university students against total population (X24), and full-time equivalent of R&D personnel (X25).

Where, number of patent applications (X21) reflects the capacity of knowledge innovation;

Number of invention patent applications (X22) measures the output of knowledge innovation;

Number of college/university students (X23) reflects the investment on potential knowledge innovation population;

Number of college/university students against total population (X24) considers the support on knowledge innovation of different areas; and

Full-time equivalent of R&D personnel (X25) interprets knowledge innovation capacity from the perspective of human resources input.

(3) Innovation Environment

Innovation environment is a key factor to a region's capacity of technological innovation.

It consists of 6 indicators including allocation of technological funds of total fiscal expenditure (X31), number of computers owned per 100 households in urban area (X32), R&D input intensity (X33), local fiscal expenditure (X34), R&D expenditure (X35), and employed population against total population (X36).

Where, the allocation of technological funds of total fiscal expenditure (X31), from the perspective of fiscal input, reflects the funding support from government on knowledge innovation;

Number of computers owned per 100 households in urban area (X32) measures the environment from infrastructures;

R&D input intensity (X33) considers the support the environment has on technological innovations;

Local fiscal expenditure (X34) is the economic foundation of the region's innovation capacity; and

R&D expenditure (X35) stands for the actual support that the environment provides for technological innovations.

(4) Innovation Conversion

Innovation conversion is measured via two indicators, number of patent granted (X41) and number of invention patent granted (X42);

Number of patent granted (X41) measures the extend of conversion of technical innovation and knowledge innovation;

Number of invention patent granted (X42) measures potential realization of knowledge innovation into practical use.

(5) Innovation Administration Efficiency

Innovation administration efficiency has 4 indicators including number of technological projects (X51), growth rate of technological projects (X52), number of publications (X53) and growth rate of publications (X54).

Table 1. Technological innovation capacity measuring indicators

Technological Innovation Capacity	Technical Innovation	Technical market turnover(X11)
		Technical market turnover growth rate(X12)
		high-tech industry output value(X13)
		high tech industry output value against R&D expenditure(X14)
		Number of patent application(X21)
	Knowledge Innovation	Number of invention patent application (X22)
		Number of college/university students(X23)
		Number of college/university students against total population
		Full-time equivalent of R&D personnel
		allocation of technological funds of total fiscal expenditure
	Innovation Environment	Number of computers owned per 100 households in urban area
		R&D input intensity
		Local fiscal expenditure
		R&D expenditure
		employed population against total population
	Innovation Conversion	number of patent granted
		number of invention patent granted
	Innovation Administration Efficiency	Number of technological projects
		Growth rate of technological projects
		Number of publications
		Growth rate of publications

Table 2. Standard matrix for technological innovation indicator data

	Fp1	Fp2	F3	F4	C3	C4	P3	P4	O1
X11	0.970	0.917	1.000	0.576	0.420	0.344	0.300	0.236	0.148
X12	0.130	0.060	0.468	0.456	0.300	0.224	0.180	0.116	0.028
X13	1.000	0.841	0.745	0.615	0.278	0.206	0.166	0.158	0.123
X14	1.000	0.801	0.705	0.575	0.238	0.166	0.126	0.118	0.083
X21	0.775	0.818	1.000	0.881	0.657	0.576	0.420	0.344	0.224
X22	0.926	1.000	0.980	0.860	0.809	0.821	0.781	0.671	0.166
X23	0.882	0.947	0.927	0.807	0.680	0.692	0.652	0.542	0.432
X24	0.845	0.922	0.902	0.782	0.731	0.743	0.703	0.593	0.483
X25	0.734	1.000	0.980	0.860	0.809	0.821	0.781	0.671	0.561
X31	0.338	0.994	1.000	0.880	0.678	0.690	0.650	0.540	0.430
X32	1.000	0.943	0.923	0.793	0.742	0.754	0.418	0.308	0.198
X33	0.729	0.981	1.000	0.844	0.793	0.418	0.378	0.268	0.178
X34	1.000	1.000	0.980	0.840	0.789	0.487	0.363	0.253	0.163
X35	0.845	0.891	0.871	0.751	0.588	0.264	0.224	0.114	0.024
X36	1.000	0.620	0.600	0.480	0.429	0.441	0.312	0.192	0.102
X41	1.000	0.896	0.876	0.756	0.705	0.234	0.194	0.074	0.114
X42	0.833	0.876	0.856	0.736	0.685	0.709	0.125	0.005	0.589
X51	0.822	0.384	0.364	0.244	0.193	0.205	0.165	0.045	0.085
X52	0.862	0.632	0.612	0.492	0.573	0.585	0.827	0.707	0.312
X53	1.000	0.696	0.573	0.453	0.376	0.388	0.188	0.068	0.028
X54	0.394	0.394	0.374	0.254	0.203	0.215	0.289	0.169	0.125

Number of technological projects (X51) stands for the support on technological projects from the administrative functions;

Growth rate of technological projects (X52) reflects the floating of support;

Number of publications (X53) measures the efficiency of administrative functions on knowledge innovation results; and

Growth rate of publications (X54) reflects the floating of administrative support on knowledge innovation results.

Combining the EEG gram and results of indicators, we arrive at a standardized matrix for data on technological innovation indicators (Tang *et al*., 2016). They are listed in Table 2.

Given that there are 5 dimensions of indicators considered, we conduct a reliability check on the data to ensure its credibility.

The reliability check means a check on the reliability of data. It is conducted via repetitive tests on the same subject using the same method (Inkaew *et al.,* 2015; Epstein, 1994).

The reliability check adopts "reference value of Cronbach α" to measure the credibility of data tested. When Cronbach α result is high, the reliability requirement of this research can be met (Jeffrey *et al.,* 2016; Garbarino and Strahilevitz, 2004).

Based on exiting data and previous literature, when Cronbach α > 0.7, it is considered high reliability. The relation between Cronbach α and reliability is indicated in Table 3(Min, 2015; Ward, 2015).

Under the environment of SPSS, this paper conducts a reliability check on the indicator data reflecting the level of technological innovation capacities. The results as in Table 4.

From Table 4, we find that the overall Cronbachα value of data is 0.965. This means the indicator system has a high level of consistency that meets the requirement of reliability check.

Table 3. Relation between Cronbach α and Reliability

Cronbach α	Reliability
Cronbach α≥0.9	Highly reliable
0.7≤Cronbach α<0.9	Very reliable (the second most common)
0.5≤Cronbach α<0.7	Very reliable (the most common)
0.4≤Cronbach α<0.5	Reliable
0.3≤Cronbach α<0.4	Almost reliable
Cronbach α<0.3	Not reliable

Table 4. Reliability check results

Factor	Cronbach α	Overall Cronbach α
Technical innovation	0.720	0.965
Knowledge innovation	0.949	
Innovation environment	0.966	
Innovation conversion	0.972	
Innovation administration efficiency	0.556	

Cronbachα values for technical innovation, knowledge innovation, innovation environment, innovation conversion, and innovation administration efficiency are 0.720, 0.949, 0.966, 0.972 and 0.556. From these numbers, we see that the knowledge innovation, innovation environment, innovation conversion score higher Cronbachα values and demonstrate higher level of reliability.

Mechanism of Action

To apprehend how technological innovations affect economic growth patterns, we need to understand the mechanism of action, in addition to theoretical research and data analysis. This way we can gain a comprehensive understanding on the relations between this two. So, we conduct further analysis on the mechanism of actions of how technological innovation acts on economic growth patterns from the following 5 aspects.

(1) How technological innovation promotes economic growth

To a large extent, the economy growth is fueled by the innovation actives on the company level. Companies are the main carriers of technical innovation. With enhanced innovation capacities, they achieve higher productivity and lower costs. On the other hand, profitable companies will further lead economic growth of the region.

One typical case is Taobao of Alibaba Group. It is a leader that has transformed the way economy develops for Hangzhou and even China. With the development of internet, online shopping has made its way into our daily life. We no longer have to go to the stores for shopping and can easily shop on the online platform and buy things we want, without limitations of time and regions. Taobao not only changes our life, but has promoted fast development of the logistics industry, making it a strong drive for the economic development.

Higher capacity of technical innovations improves the innovation capacity of many small-and-medium-sized companies and lowers their production cost. Indirectly, it has provided them with opportunities of expansion and maximum profit. The benefits of economies of scale forge a clustering effect among companies and industries. Eventually, they will work together for mutual growth and economic development.

(2) How knowledge innovation promotes economic growth

Companies with similar product lines do not differ from each other substantially in terms of technical innovations. But knowledge innovation can help them gain competitiveness in the market. Knowledge innovation plays a big role in helping the companies improve and update the production techniques, lower production expenses and communication costs, enabling much improved competitive edges.

(3) How innovation environment promotes economic growth

Nowadays, economic growth call for not only growth rates numerically, but also further optimization of the economic structure. A better innovation environment helps form good momentum for industries that contributes to economy connections. It also promotes the influence of technological innovation on transformation of economic growth patterns.

As the innovation environment constantly improves, the innovation results are dissimilated among the companies and industries to further drive the sustainable economic growth for the region. In addition, innovation environment is helpful in regional economic integration, which is a driving force of connected economic growth.

(4) How innovation conversion promotes economic growth

Knowledge innovation and technical innovations, only after being converted into productivity, can realize the effect on economic growth. As a result, innovation conversion is a key component to the process. The conversion capacity directly affect the returns on technological innovation. What can we do to promote innovation conversion? The main carriers of innovation, such as companies, universities, and research institutes, should work to promote commercialization of innovation results by providing economic compensation, promoting academic exchanges, and trade exchanges.

(5) How innovation administration efficiency promotes economic growth

The technological environment vary from regions due to implications of geographic locations and policies. So with the same amount of input on technological innovation, companies often obtain different output. Sometimes, they even suffer from “high investment but low input”. The companies tend to attribute the loss and failure to objective limitations or accidents, and seldom

look for their own faults in terms of administration. In fact, sometimes, the companies just borrow directly the latest management models or schemes and implement them in their own companies. They think it is innovative management. But obviously this mindset is wrong, and this approach sometimes costs the companies administrative efficiency. So it is important for the companies to take into consideration of the innovation administration efficiency and ask themselves whether the innovation is good fit for their companies, and whether revision or adaptations need to be made. Only by finding the root cause, they can achieve economic growth.

Conclusions

This paper, based on analysis of behavioral data and EEG data, sets to understand the how the technological innovation exerts influence on the economic growth from the perspectives of time phase, space limit and diversified approach. With the help of EEG data, we test the cognition of tested subjects on the degree of recognition and validate the hypothesis from the above three dimensions. We conduct mechanism of actions analysis and concludes that technological innovation can promote economic growth.

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