Research on the Institutional Influence on the Development of the High-Tech Industry

HAICHAO LI, YILONG SHENG, AND YANQI DING

1School of Economics and Management, Harbin Engineering University, Harbin 150001, China
2College of Agriculture and Rural Development, Renmin University of China, Beijing 100872, China

Corresponding author: Haichao Li (haichaoli@hrbeu.edu.cn)

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ABSTRACT This paper measures and analyzes the institutional influence on the development of China’s high-tech industry from 1995 to 2016. The following discoveries are shown. The institutional environment on which China’s high-tech industry depends has shown an increasing trend in recent years, but its momentum is obviously weaker than that in the early stage. The calculation results are the same and comprehensive whether the institutional variable is substituted directly into the production function as the explanatory variable or if it is put into the capital stock, labor force and Total factor productivity regression equations. The institutional influences on the input-output of the high-tech industry are very clear and positive, and its influence on the TFP is the greatest. Therefore, the continuous improvement of the institutional environment of high-tech industries is conducive to promoting the high-quality development of the industry.

INDEX TERMS Contribution rate, high-tech industry, institutional factor, Solo model.

I. INTRODUCTION

In recent years, China’s high-tech industry has developed rapidly. This industry has obvious industrial advantages and has become an important driver of economic development. Currently, China has formed a high-tech industrial system with complete support facilities and perfect structure and has initially formed a batch of innovative leading enterprises. Important breakthroughs have been made in key core technologies. With a large market size and development potential and relying on strong domestic demand, the development of high-tech industries will be vigorously promoted. In the process of the continuous growth of the high-tech industry, the market-oriented economic system reform has promoted the great changes in China’s macro-institutional environment. The good institutional environment brought about by the market reform and market opening up has become the important driving forces for the gradual optimization of China’s domestic industrial structure. In the new era, China puts forward the goal of speeding up the construction of a manufacturing power and accelerating the development of advanced manufacturing industry. To speed up the construction of a manufacturing power, we need to continuously promote the continuous optimization of industrial structure, which means that the regional institutional environment can provide sufficient external environmental support for the good development of capital, knowledge and technology intensive industries. At the same time, the high-quality development of China’s high-tech industry is faced with multiple obstacles, such as slow upgrading of factors, insufficient accumulation of human capital, and low innovation ability of enterprises. New power sources must be found to promote the sound and rapid development of the high-tech industry. Especially in the era of an innovative economy, institutional innovation has great power, incentive and guarantee functions for the development of high-tech industry, and it is the power source of the development of the high-tech industry. The development of high-tech industry must turn to institutional innovation to seek new breakthroughs. Therefore, it is of vital importance to study the impact and role of institutional factors on the development of high-tech industry.

1. Research on the impact of institutional factors on economic growth

A large number of studies show that the system plays a fundamental role in economic society and is the fundamental factor that determines long-term economic performance. Noth is the representative foreign scholar who explains economic growth from an institutional perspective.
North believed that institutional factors play a role in economic growth and further notes that the property rights system has increased private benefits, which have led to economic growth [1], [2]. Flachaire et al. analyzed the role played by the system in the process of economic growth, using data from developed and developing countries from 1975 to 2005. The study found that the political system is a key determinant of the system to which an economy belongs, and the economic system has a direct impact on the economic growth rate of each government [3]. Yıldırım et al. used 23 institutional structure variables to study the relationship between the institutional structure and macroeconomics in 38 sample countries from 2000 to 2011. The analysis results show that the structural integrity of legal systems, trade barrier regulations, foreign investment restrictions, and proportion of private banks, as well as judicial independence, government spending, transfers and subsidies, and black market exchange rates, have a positive impact on the macroeconomic development of developing countries. Factors, such as collective bargaining and political stability, have a negative impact on the macroeconomics of developing countries [4]. Gurvich conducted a comparative analysis of the economies of Russia and 20 countries of similar development levels and found that Russia’s current economic development is hindered by a rigid institutional framework. If it is not changed, the economy will not achieve accelerated growth. Based on the analysis of various institutional reforms, corresponding measures were proposed to ensure the development of the Russian economy and to mitigate the economic and social risks that threaten Russia [5].

Bennett et al. confirmed the role of institutions on economic growth by using predicted genetic diversity as a tool variable and found that economic institutions have significant correlations with economic development [6]. Han and Zhu noted that the system promotes economic growth by directly affecting human, capital, and technology and other direct factors. From the perspective of the system, these authors note that Needham’s mystery is based in the lack of an effective property rights system. The mystery is based on continuous institutional innovation [7]. Fu and Wu analyzed China’s economic growth and institutional change from 1978 to 1999, calculated and evaluated the contribution of institutional change brought by reform and opening up to economic growth, and noted that institutional change and institutional innovation are the key factors of China’s economic growth, and China’s institutional reform still has a large role to play [8]. Pan and Yang described the internal mechanism of institutional change promoting economic growth by considering institutional change in endogenous growth models. Further, from the perspective of a social planning model, this paper studies the balanced growth rate and economic meaning and finds that institutional change can play a decisive role in economic growth [9]. Li, Dong, and Wang introduced the system into the endogenous growth mode, studied the relationship between economic growth and factor development, and noted that the system not only directly affects economic growth but also promotes economic growth by affecting the input and allocation efficiency of production factors [10]. Wang, Zou, and Shi through the construction of an endogenous technology macro production function, including labor force, capital and system, found that the system has a significant impact on economic growth, and we should use the regular institutional changes to promote rapid economic growth. In addition, we need to constantly update the system to prevent the outdated system from hindering economic growth [11]. Liu discussed how the land supply model with Chinese characteristics affects China’s economic growth and its transmission mechanism by establishing a multi sector dynamic overall equilibrium framework of land system [12].

In addition, scholars at home and abroad have also carried out relevant research on institutional policies and sustainable development. Greyson proposed an approach designed to prevent waste and other global impacts could be based upon the established practices of precycling, circular economic policy and recycling insurance. A new economic instrument called precycling insurance is proposed, so that decision-making can be led by the market rather than by prescriptive regulation or educational campaigns. The approach gains relevance now that China is developing a national Law on the Promotion of the Development of Circular Economy [13]. Stoever measured sustainability with an adjusted net savings (ANS) indicator, measured the quality of the system with the six average dimensions of governance. An instrumental variable is used to account for endogeneity. He demonstrated that there is a significant causal relationship between good institutions and sustainability [14]. Glass et al. conducted a comparative analysis among 41 high and upper-middle income countries. Using multiple regression, they tested the influence of different aspects of governance, namely participation, policy coherence, reflexivity, adaptation and democratic institutions on SDG achievement at the national level, controlling for the effects of additional socio-economic conditions. Of the tested factors, democratic institutions and participation as well as economic power, education and geographic location serve to explain SDG achievement [15]. Mombeuil explored the trends in worldwide governance indicators, corruption perception index, human development index, socioeconomic sustainability, gross domestic product, and environmental performance index. And the study shows that Haiti’s institutional conditions are too weak to support the achievement of the sustainable development goals [16]. In the process of reform and development of system construction Zhao provides rules of restraint, incentive and coordination for the realization of sustainable development. However, the institutional framework of sustainable development needs to be improved, and the executive power of formal system and the formation of informal system need to be improved and strengthened [17].

Li constructed a research framework of two wheels drive endogenous growth, transforming innovation driven, resource constrained, environmental constraints and sustainable
development into dynamic optimization solutions under real conditions. The research shows that two wheels drive has its inherent scientificity, rationality and inevitability [18]. Yang et al. pointed out that, with the rapid economic development of China, the increasing emission of industrial waste gas as well as its poor control efficiency have caused serious air pollution issues and put threats to human health and sustainable development [19]. We calculated the air quality scores of 26 cities in China’s most economically developed region - the Yangtze River Delta region based on their daily average concentration numbers of main air pollutants. Based on the air quality calculation result, we further studied the effectiveness of air pollution control policies of this region by using the Box-Jenkins Model with fuzzy strategy parameter adjustment [20]. Yang analyzed the development and implementation of China’s air pollution control policies, then obtained the conditions as well as policy implications of the four stable points in China’s air pollution control campaign by constructing a quadrilateral evolutionary game model involving the central government, local governments, polluting enterprises, and the public [21].

Some scholars also used decision-making model to discuss system and environmental governance, and paid attention to sustainable development. Huang and Li established the optimal timing decision model for the implementation of emission trading system, and analyzed the optimal timing decision for the implementation of sulfur dioxide emission trading system [22]. Huang and Guo pointed out that the environmental protection department is exploring the system of using emission trading to control pollutant emissions, which is a market-based environmental economic policy, giving enterprises more decision-making options. Through the establishment of the emission decision-making model under the emission right system, we can analyze the conditions for achieving the optimal decision-making and the corresponding environmental costs under different strategies, which is helpful for the design of emission right trading system. The research shows that in the relevant system design, simplifying the examination and approval procedures and enhancing the transparency of trading information will help to activate the emission trading market. In addition, we should try our best to reduce the intervention of market behavior and promote the establishment of market price mechanism. Through technological innovation, enterprises can be helped to improve the efficiency of pollution control, reduce the cost of governance, and play the role of the emission right system [23].

It should be pointed out that some of the results of the application and improvement of decision models help to advance related research. Wu et al. provided an integrated methodology to address MCGDM problems based on the best-worst method and the VIKOR technique in an interval type-2 fuzzy environment [24]. Further, under the HPFSs environment, a multiple attribute group decision making method based on the extended hesitant Pythagorean fuzzy VIKOR is presented [25]. They also proposed an approach to linguistic multiple attribute group decision making (MAGDM) problem with single-valued neutrosophic 2-tuple linguistic (SVN2TL) assessment information. These are all useful attempts [26]. Xiao et al. also pointed out that the improved supplementary regulation for HFLTS scan reserve the fidelity of original information commendably. And an approach to multiple attributes group decision making with hesitant fuzzy linguistic information is developed [27].

2. Research on the influence of institutional factors on industrial development

In the study of the impact of institutional factors on industrial development, Clarke found that by determining the level of R&D expenditure and human capital accumulation in a country or region, science and technology systems can determine the dynamic change in comparative advantage in industrial development [28]. From the perspective of evolutionary economics, Nelson and Pelikan proposed the role of institutions in promoting industrial development [29], [30]. Watanabe et al. analyzed the mechanism of the functional development of information technology, studied the interaction between technology and institutional systems, and noted that institutional flexibility is the key factor to form function and subsequent self-communication behavior of information technology [31]. Gareev summarized the existing methods to address the problem of industrial cluster identification and emphasized the key role of institutional factors in the identification and operation of industrial clusters. A comprehensive and perfect institutional environment can promote the development of clusters [32]. Mueller and Charles emphasized the importance of the impact of the basic institutional environment on agricultural policy, noting that the fiscal, monetary and political environment created by inclusive and sustainable policies has made a significant change in Brazilian agriculture [33]. Li found that the formal system can plan and guide the development of industrial clusters. To make industrial clusters have sustainable competitive advantages, the government should comprehensively consider industrial policies and the sustainable development of industrial clusters and must build a suitable institutional environment to promote the formation and evolution of industrial clusters [34]. Yuan and Feng measured the institutional change index of emerging industries, established a C-D model including human capital and institutional change, and tested the contribution of institutional change to the development of emerging industries. The research shows that institutional change has a high contribution to the development of emerging industries, but the role of institutional innovation is still large [35]. Qi and Xu found that strengthening the regional law enforcement level, standardizing the local government behavior, and improving the regional credit level can effectively improve the financial level of western China, thus promoting the upgrading of the industrial structure [36]. These authors noted that the imperfect formal system in western China can be replaced by the social capital of an informal system, and the overall optimization of the institutional environment is significant in the long run. In the short term, the positive effect is not obvious.
3. Research on the influence of institutional factors on the development of high-tech industry

Currently, relevant research has confirmed the important role of the institutional environment in the development of high-tech industry. However, there are few reports in the literature about the threshold effect of the institutional environment on the development of high-tech industry. Hansen’s threshold estimation technique can be used. Levchenko and Chor believed that as an external constraint or incentive clause, the institutional environment will affect the development of the industry in many ways, such as affecting the transaction cost, financing constraint and adjustment cost; therefore, for high-tech industry, a good external institutional environment is an important factor to determine whether it can obtain market competitiveness [37], [38].

From the perspective of the financial system environment, Chaney noted that countries with high levels of financial development should focus on developing industries with high financial demand and that promoting their exports and financial development can become an important source of comparative advantage for a country [39]. Jarunee took small- and medium-sized enterprises in China’s high-tech industry as a research object. While analyzing the financial innovation system, border trade area, increasing credit and stroke insurance capital of innovative enterprises, the research found that China’s government intervention in institutional innovation played a role in the development of China’s accession to the WTO [40].

He and Zhang noted that reasonable institutional arrangements can optimize the allocation of innovation resources, maintain the innovation power, and improve the independent innovation ability of high-tech industries. Based on the comparative analysis of the characteristic systems of high-tech industry in some developed countries, this paper proposes the institutional path to enhance the independent innovation ability of China’s high-tech industry [41]. Liu noted that there is a causal relationship between the institutional innovation and technological innovation of high-tech industry and its high-end, and the degree of order and coordination of each subsystem will affect the degree of coordination of the high-tech industry composite system. However, because institutional innovation has not met the needs of high-tech industry development, the promotion speed of the degree of coordination of its composite system is relatively slow [42]. Liu, Han and Han used the panel data of high-tech industry from 1997 to 2011 to comprehensively investigate the impact of institutional factors on the technological innovation of high-tech industry and analyze the contribution and role of various institutional sub factors in the efficiency of the three stages of technological innovation; these authors concluded that the optimization of the overall institutional environment is conducive to the improvement in innovation efficiency, and the contribution of institutional factors to innovation efficiency in different stages is heterogeneous [43]. The innovation efficiency of high-tech industry is not significantly affected by the innovation system with enterprises as the main body. Wu and Xie used the 1998-2015 provincial panel data of China, and the “threshold estimation technology” proposed by Hansen, to empirically analyze the threshold effect of the different levels of institutional environment on the development of China’s high-tech industry [44].

Based on the comprehensive analysis of the relevant literature and achievements at home and abroad, we can find the following. First, the research on the impact of institutional factors on the economy originated abroad and started relatively late at home, while the research on the impact of institutional factors on industrial development evolved from this literature. Second, scholars at home and abroad have carried out substantial relevant empirical research on the positive impact of institutional factors on economic growth and industrial development and encourage the optimization of the institutional environment to promote economic growth and industrial development. Third, the research on the impact and role of institutional factors on high-tech industry is mainly concentrated at home, and foreign research is less involved. It needs to be clear that there are still some defects in the current research results. First, the cognition and division of institutional factors are not perfect, and most of the literature is from a certain dimension of institutional factors and is less involved in a comprehensive study of institutional factors. Second, the research on how institutional factors affect the development of high-tech industry is not enough. The existing literature mainly focuses on the role of institutional factors in the innovation efficiency of high-tech industry, and the research based on the perspective of the comprehensive development of high-tech industry is relatively scarce. In light of this, from the perspective of the overall development of high-tech industry, this paper studies the impact and role of institutional factors on the development of high-tech industry. By constructing the index system of institutional factors of high-tech industry, combined with the improved critical method, the index of institutional factors of high-tech industry is synthesized. On this basis, using the Cobb Douglas production function, this paper constructs the direct regression model and the indirect regression model to study the impact of institutional factors on the development of high-tech industry, proposes the hypothesis to test the model, and obtains the perfect scientific research findings on the impact of institutional factors on the development of high-tech industry.

II. CONSTRUCTION OF INDEX OF INSTITUTIONAL FACTORS FOR HIGH-TECH INDUSTRY

A. IMPROVED CRITIC INDEX EMPOWERMENT

The CRITIC weighting method is an objective weighting method proposed by Diakoulaki to measure the conflict and variability between indicators by correlation between the indicators and standard deviation of the indicators. This method takes into account the two major factors of index conflict and index variability and has unique advantages over other objective valuation methods. Therefore, the CRITIC method is selected to give weight to the index of the high-tech
industry system factors. The CRITIC method also has some defects; for example, the correlation coefficient may be negative. When the absolute values of the positive correlation index and negative correlation index are the same, the correlation degree and conflict degree between the indexes reflected by the CRITIC method are the same, so it is unreasonable to measure the conflict between the indexes by \( \sum_{i=1}^{n} 1 - |r_{ij}| \).

In addition, by using the standard deviation to measure index variability, the calculation results will be affected by the dimensions. Therefore, it is necessary to improve the CRITIC weighting method. \( \sum_{i=1}^{n} 1 - |r_{ij}| \) is used to represent the conflict between indicators, and the coefficient of variation is used to represent the variability of indicators. The steps and methods are as follows.

Define \( a_{ij} \) to represent the dimensional data of index \( i \) in year \( j \). Select the first year as the base year with a value of 100. Equation (1) is used to standardize the original data to eliminate dimensional differences between indicators. The forward index is normally processed, and the reverse index needs to be substituted into the data in the reverse direction. That is, the year data of the maximum value and the year data of the minimum value are exchanged.

\[
b_{ij} = \frac{a_{ij}}{a_{i1}} \times 100 (i = 1, \ldots, m) \tag{1}
\]

Then, the coefficient of variation \( v_j \) corresponding to each index is calculated by using equation (2) to (4) to characterize the variability in the index.

\[
v_j = \frac{\bar{b}_j}{\bar{b}_j} \tag{2}
\]

\[
\bar{b}_j = \left( \frac{1}{n} \sum_{j=1}^{n} b_{ij} \right)^2 \tag{3}
\]

\[
\bar{b}_j = \left( \frac{1}{n} \sum_{j=1}^{n} b_{ij} \right) \tag{4}
\]

Finally, the index weight is obtained through equation (5)

\[
w_i = \frac{v_i \sum_{j=1}^{n} (1 - |c_{ij}|)}{\sum_{i=1}^{m} v_i \sum_{j=1}^{n} (1 - |c_{ij}|)} \tag{5}
\]

### B. HIGH-TECH INDUSTRY SYSTEM FACTOR INDEX SYNTHESIS

#### 1) DESIGN OF INDEX SYSTEM FOR THE INSTITUTIONAL FACTORS OF HIGH-TECH INDUSTRY

With regard to the institutional factors of high-tech industries, this paper draws lessons from the practices of the World Bank \[45\], takes into account the sample characteristics of high-tech industries, and selects a total of 12 secondary indicators from 6 primary indicators to design an indicator system. This paper obtains China’s 1995-2016 related index data from China’s 1996-2017 High-tech Industry Statistical Yearbook \[46\] and China’s Statistical Yearbook \[47\]. Some indicator data are missing, and this paper smooths them and supplements them. Before the improved CRITIC index is used to weigh, the original data are reduced by corresponding indexes to eliminate the interference of price factors. The R&D funds, the general public service expenditures of the national finance and the scale of social financing are reduced by using the consumer price index. Investment in high-tech industries is reduced by the fixed asset investment price index. The main business income of high-tech enterprises is reduced by the ex-factory price index of industrial producers. Then, using the improved CRITIC objective evaluation method, the weight results of each index calculated are shown in Table 1.

1. Degree of government intervention: The reverse indicator reflects the extent to which government agencies intervene in high-tech industries. The higher the degree of government intervention is, the more the development of high-tech industries is restricted by the government.

2. Development level of nonstate-owned economy: Positive indicators reflect the development level of nonstate-owned components in high-tech industries. The higher the
level of nonstate-owned economy development in high-tech industries is, the stronger the development of the industry.

3) Financial development level: The positive indicator reflects the possibility of high-tech industries obtaining loans from financial institutions. The higher the level of financial development is, the more likely it is that financial institutions will lend to high-tech industries to support their development.

4) Foreign investment level: The positive indicator reflects the investment level of foreign companies (including Hong Kong, Macao and Taiwan businessmen) in high-tech industries. The higher the level of foreign investment is, the higher the degree of opening up of high-tech industries, and the more likely it is to attract production factors.

5) Judicial justice: The positive indicator reflects the degree of protection of judicial institutions on the property rights of high-tech industries. The higher the level of judicial justice is, the better the judicial environment that indicates the development of high-tech industries.

6) Labor flexibility: Positive indicators reflect the flexibility of the labor market in high-tech industries. Labor flexibility means that the labor market in high-tech industries is more developed, and the level of labor input is more optimized.

2) SYSTEM FACTOR INDEX CALCULATION OF HIGH-TECH INDUSTRY

After determining the index weight, the weighted arithmetic average method is used to synthesize the index of high-tech industry system factors. From 1995 to 2016, the composite results of the high-tech industry system index are shown in Table 2 as follows:

| Year | System Index of High-tech Industry | Year | System Index of High-tech Industry |
|------|----------------------------------|------|----------------------------------|
| 1995 | 100.000                          | 2006 | 497.724                          |
| 1996 | 110.429                          | 2007 | 487.929                          |
| 1997 | 122.740                          | 2008 | 528.633                          |
| 1998 | 176.324                          | 2009 | 558.488                          |
| 1999 | 122.961                          | 2010 | 766.092                          |
| 2000 | 118.549                          | 2011 | 729.734                          |
| 2001 | 146.552                          | 2012 | 942.703                          |
| 2002 | 182.162                          | 2013 | 925.082                          |
| 2003 | 292.136                          | 2014 | 1041.070                         |
| 2004 | 417.289                          | 2015 | 1251.178                         |
| 2005 | 390.324                          | 2016 | 1505.829                         |

We can find that China’s high-tech industry system index showed an overall growth trend from 1995 to 2016 with only slight declines in 1999, 2000, 2005, 2011 and 2013. This trend shows that the institutional environment on which China’s high-tech industry depends has shown a good trend of continuous improvement between 1995 and 2016. This trend is a direct manifestation of China’s market-oriented economic system reform.

III. MODEL CONSTRUCTION OF INSTITUTIONAL FACTORS AFFECTING THE DEVELOPMENT OF HIGH-TECH INDUSTRY

A. SOLOW GROWTH MODEL OF HIGH-TECH INDUSTRY

The growth of the output of high-tech industry is recognized as the economic growth of high-tech industry, and most documents distinguish growth from the development of high-tech industry. However, at the same time, almost all viewpoints admit that continuous growth will inevitably lead to structural changes, and structural changes are the main indicators used to distinguish growth and development. Because the research interval of this article is 1995-2016, with a long time span, it is inappropriate to define the development of high-tech industry as the economic growth of high-tech industry plus the changes in the structure of high-tech industry. Considered comprehensively, this paper uses the long-term output growth of high-tech industry to represent the development of high-tech industry.

We find that the production function refers to the relationship between the quantity of various production factors used in production and the maximum output in a certain period of time under the condition of constant technical level. Cobb Douglas production function (C-D production function) is a production function created by mathematician Cobb and economist Douglas when they discuss the relationship between input and output. Its mathematical form is as follows:

\[ Y = AL^\alpha K^{1-\alpha} \]  

where \( Y \) is output, \( L \) is labor input, \( K \) is capital input, and \( A \) and \( \alpha \) are constants. The proposal of C-D production function has aroused great repercussions in western economic circles, and its application scope has been expanding. Due to the doubt of the constant technical level and other constraints, Ding Bergen improved the C-D production function by transforming \( A \) into the form of dynamic variable \( A_t \), which made the C-D production function obtain new vitality. After that, Arrow, in cooperation with Solow and others, put forward the famous CES fixed instead of elastic production function, and proved that C-D production function is a special case of CES production function.

In economic research, the basic form of Cobb Douglas production function is:

\[ Y = AL^\alpha K^{\beta} \]  

where \( Y \) is the total output value, \( A \) is the comprehensive technical level, \( L \) is the labor input, \( K \) is the capital input, \( \alpha \) is the elasticity coefficient of labor output, \( \beta \) is the elasticity coefficient of capital output.

According to the combination of \( \alpha \) and \( \beta \), there are three types:

① When \( \alpha + \beta > 1 \), the return to scale is increasing, which shows that according to the existing technology, it is advantageous to increase the output by expanding the production scale.
When $\alpha + \beta < 1$, the return to scale is decreasing, which shows that according to the existing technology, it is not worth the loss to increase the output by expanding the production scale.

When $\alpha + \beta = 1$, and the return on scale remains the same, which indicates that the production efficiency will not increase with the expansion of production scale, and only by improving the technical level can the economic benefit be improved.

In a large number of studies on the improvement of C-D production function by scholars at home and abroad, the most outstanding one is the significant improvement made by Solow, an American economist. Assuming that technology is neutral, Solow’s model contains four variables, namely output ($Y$), capital ($K$), labor ($L$), and technological progress ($A$). It amends the production technology hypothesis of Harold Domar model, and adopts the neoclassical Cobb Douglas production function that capital and labor can replace. Under the assumption of complete competition, this paper describes the growth of output caused by the growth of capital and labor input whose production function has constant returns to scale, and draws the conclusion of stable economic growth.

The analysis of economic growth factors was first proposed by Abramovitz and Solow. The analysis is usually carried out through a total production function. Later, the analysis of economic growth factors led to the development of many forms of production function method models [48], [49]. Among these models, the Cobb-Douglas production function is widely used. Therefore, this paper sets the production function of high-tech industry as $Y_t = AK_t^aL_t^b$, where $Y$, $K$, $L$ and $t$ represent output, capital, labor, and time, respectively, total factor productivity $TFP_t = A$. $a$ and $b$ are respectively capital output elasticity and labor output elasticity. If the return on scale is assumed to be constant, then $a + b = 1$.

$$\text{TEP}_t = \frac{Y_t}{K_t^aL_t^b}.$$  

**B. REGRESSION MODEL OF THE INFLUENCE OF INSTITUTIONAL FACTORS**

Currently, there are three main views on how to take the institutional factor as a factor of production into the production function to explain its influence on the output growth. A group of scholars, such as Hall and Jones, Jin believe that institutional factors should be introduced into the traditional production function as a direct factor input to study the direct impact mechanism of institutional factors on output growth [50], [51]. Another group of scholars, such as Wang, proposed that institutional factors have only an indirect impact on output growth. Therefore, in the construction of production function, institutional factors cannot appear directly as the dominant variables. Some scholars, such as Shao and Zhang, also noted that calculating the impact of institutional factors on output growth as direct or indirect variables alone is biased, so they should be added together. This article considers that on the one hand, as a standard trading rule, institutional factors can reduce the transaction cost and directly promote the improvement of output efficiency, thus stimulating the rapid growth of output; on the other hand, improving a good institutional environment can effectively promote the expansion of investment scale, from the increase in industry personnel to the progress of science and technology. Therefore, the high-quality institutional environment also has an indirect impact on economic growth by improving capital accumulation, increasing the labor force and promoting technological progress. However, from the nature of the regression model, whether the system variable is directly substituted into the production function as the explanatory variable or the capital stock, labor force and total factor productivity are indirectly calculated, the calculation results of the two models will be the same, including the direct and indirect effects of institutional factors on the output growth of high-tech industries. Therefore, this paper will use these two methods to obtain the impact of institutional factors on the output growth of high-tech industry and verify the hypothesis that the results of these two methods are the same.

Hall and Jones use cross-sectional data to study the impact of institutional factors on the different economic growth effects of different countries [50], directly regress the social infrastructure variables with the per capita output level of each country, and calculate the impact of each institutional variable on the per capita output level of each country. This method is called the direct method in this paper. Using this method for reference, we can calculate the effect of institutional factors on the output growth of high-tech industry.

$$\ln Y_t = \beta_0 + \beta_1 \ln I_t + \epsilon_t$$  

In equation (8), $I_t$ is the institutional variable of China’s high-tech industry in year $t$, and $\epsilon_t$ is the random error term.

$$C_B = \frac{(\ln I_t - \ln I_{t-1}) \cdot \beta_1}{\ln Y_t - \ln Y_{t-1}}$$

In formula (9), $C_B$ represents the contribution rate of institutional factors to the output growth of high-tech industry in year $t$.

In addition, the effect of institutional factors on the output growth of high-tech industry can also be indirectly measured by the regression of institutional variables on capital stock, labor force and total factor productivity. This method is called the indirect method in this paper. The procedure of this indirect method is as follows:

$$\ln K_t = \gamma_0 + \gamma_1 \ln I_t + \mu_t$$  

$$\ln L_t = \delta_0 + \delta_1 \ln I_t + \sigma_t$$  

$$\ln A_t = \theta_0 + \theta_1 \ln I_t + \tau_t$$  

$$C_B = \frac{(\ln I_t - \ln I_{t-1}) \cdot (\gamma_1 + \alpha + \delta_1 * b + \theta_1)}{\ln Y_t - \ln Y_{t-1}}$$

Parameters $a$ and $b$ are capital output elasticity and labor output elasticity, respectively.

It can be seen that when $\beta_1$ is equal to $\gamma_1 + \alpha + \delta_1 * b + \theta_1$, the effect of the institutional factors derived from the direct method and indirect method on the output growth of high-tech industry is equal, that is, the hypothesis holds.
IV. EMPIRICAL ANALYSIS OF THE INFLUENCE OF INSTITUTIONAL FACTORS ON THE DEVELOPMENT OF HIGH-TECH INDUSTRY

A. DATA GENERATION

(1) Due to the changes in the caliber of China’s high-tech industry statistical yearbook during the research period, the lack of output value data of high-tech industry is too serious. Therefore, considering the availability of data, this paper chooses the total main business income of high-tech industries as the output index. In addition, this paper uses the ex-factory price index of industrial producers to reduce the ex-factory price index of the industrial producers by the operating profit of high-tech industries. The calculated capital output elasticity (a) and labor output elasticity (b) are 0.567 and 0.433, respectively. Then, using the TFP calculation formula, taking 1995 as the base year and assigning a value of 100, all the subsequent years are divided by the base year value and multiplied by 100 to obtain the total factor productivity results of China’s high-tech industry from 1995 to 2016 in Table 3 as follows:

### TABLE 3. Total factor productivity of high-tech industry.

| Year | Total Factor Productivity of High-tech Industry | Year | Total Factor Productivity of High-tech Industry |
|------|-----------------------------------------------|------|-----------------------------------------------|
| 1995 | 100.000                                       | 2006 | 354.828                                       |
| 1996 | 106.498                                       | 2007 | 351.915                                       |
| 1997 | 134.474                                       | 2008 | 320.112                                       |
| 1998 | 166.723                                       | 2009 | 332.050                                       |
| 1999 | 198.567                                       | 2010 | 332.795                                       |
| 2000 | 233.339                                       | 2011 | 325.684                                       |
| 2001 | 261.884                                       | 2012 | 328.764                                       |
| 2002 | 290.400                                       | 2013 | 340.786                                       |
| 2003 | 336.152                                       | 2014 | 345.548                                       |
| 2004 | 350.706                                       | 2015 | 365.251                                       |
| 2005 | 348.521                                       | 2016 | 379.502                                       |

From Table 3, it can be seen that the total factor productivity of China’s high-tech industry increased rapidly before 2004, then fell into a period of fluctuation and was greatly reduced by the 2008 financial crisis. In recent years, there has been a growth trend, but its momentum is obviously weaker than that of the previous period. TFP is a comprehensive index to measure the operation of economic production activities and reflect the level of technological progress or efficiency. The slowdown in the growth rate of the total factor productivity undoubtedly severely limits the high-quality development of high-tech industries. Therefore, the total factor productivity of China’s high-tech industry urgently needs to be improved.

B. DIRECT METHOD REGRESSION RESULTS

First, referring to the practice of high-tech industry system variables, the output data of high-tech industry are standardized to eliminate the dimensional differences between the indicators. Then, based on the formula, substituting the high-tech industry output and system variable data, and using EVIEW software to carry out ordinary least square fitting regression, the estimated results of the model are as follows:

\[ \ln Y_t = -0.818 + 1.246 \ln I_t + \varepsilon_t \]  
\[ (21.760) \]

\[ R^2 = 0.960, F = 437.512, S.E = 0.233, DW = 0.846 \]

Equation (16) has a high goodness of fit and a small regression standard error. This equation passes the White
test at the significance level of 99%, and the estimation coefficient of $I_t$ also passes the $t$ test at the significance level of 99%. However, the $DW$ value of Equation (16) shows that the model cannot pass the sequence autocorrelation test. Therefore, the above equation is modified by the weighted least square method, and the estimated result of the model is shown as follows:

$$
LnY_t = -0.725 + 1.235LnI_t + \varepsilon_t
$$

(126.470)

$$
R^2 = 0.999, F = 15994.540, S.E = 0.051, DW = 2.306
$$

(17)

It can be seen that after the weighted least squares correction, each statistic of the model is more optimized, and the model passes the sequence autocorrelation test. The formula shows that the output of high-tech industries will rise by 1.235% for every 1% increase in system variables. This result shows that China’s high-tech industry system factors have great positive influence on the output of high-tech industry.

C. INDIRECT METHOD REGRESSION RESULTS

First, according to the practice of high-tech industry system variables, the data of capital input and labor input in high-tech industry are standardized to eliminate the dimensional differences between the indicators. Then, based on the formula, EVIEWS software is used to carry out ordinary least square fitting regression, and the estimation results of each model are shown in Table 4 as follows:

### TABLE 4. Indirect method regression results.

| Interpreted variable | Elastic coefficient | $t$ | $R^2$ | $F$ | S.E | $DW$ |
|----------------------|---------------------|-----|-------|-----|-----|------|
| Ln$\bar{K}_1$       | 1.334               | 22.259 | 0.961 | 495.478 | 0.243 | 0.932 |
| Ln$\bar{L}_1$       | 0.531               | 15.442 | 0.923 | 238.459 | 0.140 | 0.572 |
| Ln$\bar{A}_1$       | 0.367               | 5.814  | 0.628 | 33.800  | 0.256 | 0.172 |

It shows that the regression model of capital input and labor input has a high goodness of fit and a small regression standard error. The total factor productivity regression model has a small regression standard error, but its goodness of fit is not high. In addition, the estimation coefficients of $I$, $t$ of the three indirect models all passed the $t$ test at the significance level of 99%, but all failed the White test and the sequence autocorrelation test. Therefore, the equation is modified by the weighted least square method, and the estimated result of the model is shown in Table 5 as follows:

### TABLE 5. Revised “indirect method” regression results.

| Interpreted variable | Elastic coefficient | $t$ | $R^2$ | $F$ | S.E | $DW$ |
|----------------------|---------------------|-----|-------|-----|-----|------|
| Ln$\bar{K}_1$       | 1.328               | 1587.6 | 0.999 | 252075.4 | 0.000 | 2.340 |
| Ln$\bar{L}_1$       | 0.532               | 1025.6 | 0.999 | 105193.3 | 0.003 | 2.378 |
| Ln$\bar{A}_1$       | 0.247               | 14.256 | 0.910 | 203.233  | 0.051 | 1.466 |

D. ANALYSIS OF THE DEGREE OF CONTRIBUTION OF INSTITUTIONAL FACTORS

Through the regression results of the direct method and the indirect method, $\beta_1 = 1.235, \gamma_1 + \alpha + \delta_1 \ast b + \theta_1 = 1.230$ can be obtained. It is found that the values of $\beta_1$ and $\gamma_1 + \alpha + \delta_1 \ast b + \theta_1$ are very close, and their errors can be ignored. Therefore, if this hypothesis holds, the institutional factors obtained by the direct method and indirect method have the same effect on the output growth of high-tech industries. Using the calculation formula of the degree of contribution and substituting relevant data, the annual contribution of institutional factors to output growth, capital input, labor input and total factor productivity of high-tech industry is obtained in the following Table 6.

### TABLE 6. Contributions of institutional factors to the input and output of high-tech industry.

| Year | Capital input | Labor input | Total factor productivity | Output growth |
|------|---------------|-------------|---------------------------|--------------|
| 1996 | 185.031       | 190.494     | 38.921                    | 111.439      |
| 1997 | 194.644       | -81.959     | 11.193                    | 57.633       |
| 1998 | 562.572       | -209.869    | 41.625                    | 222.874      |
| 1999 | -607.196      | 907.278     | -50.957                   | -225.121     |
| 2000 | -40.246       | -136.754    | -5.594                    | -20.279      |
| 2001 | 184.086       | 527.962     | 45.092                    | 134.093      |
| 2002 | 158.347       | 187.335     | 52.307                    | 123.448      |
| 2003 | 277.708       | 211.820     | 79.743                    | 186.586      |
| 2004 | 223.372       | 91.760      | 207.785                   | 174.46       |
| 2005 | -44.491       | -29.021     | 264.019                   | -54.952      |
| 2006 | 27.637        | 20.104      | 60.063                    | 30.81        |
| 2007 | 120.297       | 76.910      | -538.168                  | -149.215     |
| 2008 | 59.406        | 37.383      | -20.894                   | 207.537      |
| 2009 | 40.564        | 217.646     | 37.059                    | 55.339       |
| 2010 | 195.033       | 127.971     | 3482.820                  | 228.779      |
| 2011 | -28.869       | -52.641     | 55.603                    | -58.001      |
| 2012 | 138.424       | 135.121     | 672.142                   | 182.115      |
| 2013 | -110.020      | -51.410     | -12.977                   | -15.957      |
| 2014 | 80.087        | 262.754     | 210.236                   | 129.435      |
| 2015 | 132.121       | 451.723     | 81.882                    | 153.051      |
| 2016 | 141.733       | -1090.549   | 119.559                   | 210.385      |

During the period 1995-2016, China’s high-tech industry system contributed 94.432%, 94.727%, 85.431% and 230.070% to output increase, capital input, labor input and total factor productivity, respectively. Institutional factors play the greatest role in promoting the total factor productivity of high-tech industries and have approximately equal and greater impact on the output and capital input of high-tech industries, while having the least impact on the labor force of high-tech industries. From the average point of view,
the impact of institutional factors on the input and output of high-tech industries is very obvious and positive. In the research area, there is a negative contribution in some years, but this does not negate the promotion effect of the improvement in the institutional environment of high-tech industry on the development of high-tech industry. Based on the fluctuating trend, the contribution of institutional factors to the input and output of high-tech industries has not shown an obvious trend. However, except for a few years, the trend of each contribution basically coincides, which shows that the impact of institutional factors on the development of high-tech industries is comprehensive and homogeneous. Empirical analysis shows that the total factor productivity of high-tech industry urgently needs to be improved. The analysis of contribution shows that the optimization of high-tech industry systems can greatly improve the total factor productivity of high-tech industry. Therefore, continuous improvement in the institutional environment of high-tech industries is conducive to the promotion of the high-quality development of high-tech industries.

V. RESEARCH FINDINGS AND LIMITATIONS

Any industry should develop under the certain institutional background and environment, and high-tech industry needs a good institutional environment and institutional arrangements. Institutional environment is accompanied by the development process of high-tech industry and is the primary factor determining its growth and development. In the development process of high-tech industry, due to the uncertainty of technological research and development, production realization, market sales, capital investment and other aspects of industrial technological innovation activities, as well as the environmental demands of improving the efficiency of resource allocation, strengthening the incentive mechanism and reducing transaction costs, there are objectively institutional demands for the development of high-tech industry. In fact, the problems in the development of China’s high-tech industry reflect the lag and defects of system construction. Compared with traditional industries, high-tech industries need to follow the laws of the market economy and play the basic role of the market mechanism. However, it is of vital importance to make up for market failure, actively guide the allocation of factors and create a good policy environment for industrial development through appropriate government macro-control intervention, especially the use of public policies and the optimization of institutional arrangements.

This paper discusses the influence and function of institutional factors on the development of high-tech industry, summarizes the research results related to the existing industrial system and considers the characteristics of high-tech industry. From six perspectives, namely, government intervention, nonstate-owned economic development, financial development, foreign investment, judicial justice and labor flexibility, and then constructs a scientific and comprehensive evaluation index system of high-tech industry. This paper uses the improved CRITIC method to determine the weight of each index, and uses the weighted arithmetic average method to synthesize the index of high-tech industry institutional factors.

There is a great controversy regarding the measurement of the influence of institutional factors, which includes the measurement models of direct and indirect influence. The factor analysis of economic growth is generally carried out by constructing a gross production function, and the Cobb Douglas production function is a very widely used method. In this paper, the Cobb Douglas production function of high-tech industry is established, the total factor productivity of China’s high-tech industry in each year is calculated by using the function. We build a regression model of the influence of institutional factors on the development of high-tech industry, and scientifically judge the influence degree of institutional factors on the development of China’s high-tech industry. Finally, based on the statistical data from 1995 to 2016, we use the EVIEWS software to fit the model, verify the assumption that the calculation results of the two model methods are the same, and quantitatively analyze the contribution of institutional factors to the input and output of high-tech industries. Empirical research shows that, the impact of institutional factors on the development of high-tech industry is comprehensive and positive. Continuous improvement in the institutional environment of high-tech industry is a breakthrough to solve the existing problems in the development of high-tech industry, which provides a new understanding for the development of the institutional environment on which China’s high-tech industry depends.

Through research we find that: (1) China’s high-tech industry system index showed an overall growth trend from 1995 to 2016. This trend shows that the institutional environment on which China’s high-tech industry depends has shown a good trend of continuous improvement between 1995 and 2016. (2) The total factor productivity of China’s high-tech industry increased rapidly before 2004 and then fell into a period of fluctuation, which was greatly reduced by the 2008 financial crisis. In recent years, there has been a growth trend, but its momentum is obviously weaker than that of the previous period, which has severely restricted the development of high-tech industries. The total factor productivity of China’s high-tech industry urgently needs to be improved. (3) Whether the system variables are directly substituted into the production function as explanatory variables or the capital stock, labor force and total factor productivity are indirectly estimated by regression, the calculation results of the two model methods will be the same, including the direct and indirect effects of the system factors on the output growth of high-tech industries. (4) Institutional factors have a significant positive impact on the input and output of high-tech industries and have the greatest contribution to the total factor productivity of high-tech industries. (5) Continuous improvement in the institutional environment of high-tech industries can significantly enhance the total factor productivity of high-tech industries, thus promoting the high-quality development of high-tech industries.
It needs to be clear that high-tech industry is a major driver of China’s economic development, but few scholars have studied the direct and indirect impacts of institutional factors on the development of high-tech industry from the perspective of the comprehensive development of high-tech industry. This paper constructs the direct regression model and the indirect regression model of the impact of institutional factors on the development of high-tech industry. However, there are some limitations in the research, which are mainly reflected in the fact that the “Statistical Yearbook of China’s High-tech Industry” is closed, and this paper can only use the relevant data of high-tech industry from 1995 to 2016. In addition, this paper does not further explore the impact of the secondary indicators of institutional factors, such as the level of government intervention, the level of nonstate-owned economic development, the level of financial development, the level of foreign investment, the level of judicial justice and the flexibility of the labor force on the development of high-tech industries. These issues deserve further in-depth discussion and valuable research findings.

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HAICHAO LI was born in February 1977. She received the Ph.D. degree in management science and engineering from Harbin Engineering University, in 2006. She was employed as an Associate Professor with the School of Economic Management, Harbin Engineering University, in 2008, and also employed as a Master’s Tutor, in 2010. She has published more than ten articles in important journals at home and abroad, presided over four provincial scientific research projects, and participated in six national projects. Her main research directions are industrial innovation and growth and technological innovation.

YILONG SHENG was born in June 1997. He is currently pursuing the master’s degree in management with the School of Agriculture and Rural Development, Renmin University of China. His main research interests are industrial organizations, futures and financial derivatives markets, and agricultural products markets.

YANQI DING was born in November 1997. She is currently pursuing the bachelor’s degree in economics with the School of Economics and Management, Harbin Engineering University.

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