

Study on the Appraisal Model of the High-tech Enterprises' Performance Based on Knowledge Production Function

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Abstract. We analyze the origin and development of knowledge production function and evaluate the application field and application space of it. Based on these, we put forward the feasibility of knowledge production function in high performance enterprise performance evaluation. On the basis of analyzing the input and output of high-tech enterprises, knowledge production function is studied and expanded, knowledge spillover is introduced the production function model. The appraisal model of the high-tech enterprises' performance is set up based on knowledge production function.

1. Introduction

Knowledge is increasing with of the explosive rate at the era of knowledge economy now, and knowledge has become the main support of social development. Knowledge has replaced the status of traditional capital. This epoch-making change will bring the economic revolution, and knowledge is so on for production. Because the main driving force of economic growth comes from the growth of knowledge, it does not meet the needs of the development of the times that the labor and capital are discussed as the two basic elements of the production function, in particular, considering the traditional capital as the subject of discussion does not conform knowledge economy spirit. Compared with knowledge, capital has been degraded the production factor similar to land and labor force to some extent. In the era of knowledge explosion the rate of capital growth has lagged behind the growth of knowledge. The capital has been degraded to fixed assets. This change has influenced the knowledge production: the production is no longer dependent on the number of capital; capital-intensive production is no longer able to make the more contributions. Knowledge-intensive production has been given a new mission; the combination of production factors must take into account the knowledge of the "bubble" role, that is, self-breeding function. The knowledge production function as an economic concept was proposed before about twenty years. The study about the nature of the knowledge production process is based on the effective measurement of the input and output of the knowledge production process. The classical knowledge production function is essentially a two-factor CD function. Next, the scholars analyzed and expanded it, and applied it to test and analyze the influence of the knowledge spillover effect on the regional innovation. Now the knowledge production function has become a powerful empirical model, it is widely used in regional innovation research, which is the study focus of developing countries, such as China.

2. The origin of knowledge production function

In 1979, Griliches proposed the concept of knowledge production function when he measured the impact of R&D and knowledge spillovers on productivity growth. He took the output of the innovation process as a function of R & D capital or personnel input in the knowledge production function model (1). Griliches's knowledge production function is:

$$Y = F(X, K, u) \quad (1)$$

Let Y = the output of macro or micro level

X = the normal production input vector, mainly including labor and capital
 K = the level of technical knowledge, partly decided by the current and past R&D costs
 u = a random interference.

The level of technical knowledge is determined by current and past R&D investment, namely:

$$K = G[W(B)R, v] \quad (2)$$

$W(B)$ Is a lag polynomial, B is the hysteresis operator; R is the R&D cost; v is a random error term. Along with this idea, Griliches used the Cobb-Douglas function (C-D function) to describe the knowledge production function as follows:

$$Y = DC^\alpha L^\alpha k^\gamma e^{\lambda t + \mu} \quad (3)$$

In 1989 Jaffe defined the knowledge production function as a powerful empirical model tool for analyzing regional knowledge flow (spill) and examining its impact on regional innovation [2]. He considered the application of new knowledge as output, and considered the R&D of the enterprises and the research input of the higher institutions as input. So the C-D knowledge production by introducing the R&D input is:

$$P_i = AK_i^\alpha I_i^\beta \varepsilon \quad (4)$$

i : the unit observed (Such as the province); P : new knowledge used by economic, with the number of patents applied by the company; I is the enterprise's R&D investment; K is the R&D investment of the higher institutions; A is the region's existing knowledge; α, β representing output elasticity of R&D investment about the higher institutions and enterprises respectively; ε is a random error item. Model (4) is a technical relationship about R&D between enterprises and higher institutions.

3. The development of knowledge production function

In 2000, Anselin expanded the knowledge production function using the space econometric model. In the model Anselin introduced a spatial lag model [3]; In 2001, Fischer separated completely the intraregional and interregional spillover effects, and took into account the latency of knowledge production [4]. In 2003, Greunz combined the spillovers of the geographical media and technology media, incorporated into the technical adjacency index while considering the geographical spillovers. He established the mixed knowledge production function model [5]. Greunz pointed out the selection criteria of the enterprise's location: First, Adjacent to the area possessing advanced technology, second, close to the area owning similar technical level. In the mixed knowledge production function model, Greunz weighted technical adjacency index and geography adjacency index. The results showed that the regional innovation is not only dependent on its own R&D investment, influenced by the R&D spillovers of several adjacent geographical areas, and also common influenced by the spillover because of geographically adjacent and the technology adjacent.

4. Application of Knowledge Production Function in Performance Evaluation of High-tech Enterprises

The differences among individuals were ignored during studying the object of knowledge production function. The measurement method and case study method of knowledge production function only concerned on the "average enterprise". The specific differences of the enterprises did not considered, such as the specific size of enterprises, human capital, physical capital and industrial types.

Knowledge production function more and more refined. Griliches, Jaffe models pointed out that the new economic knowledge is the most important output, the enterprises pursued new economic knowledge and put it into the production process, and investment variables included R&D and

human resources, so the impact of knowledge spillovers on innovation output is ignored. Romer model thought that the new knowledge output at any given moment was a function of the existing knowledge stock and the input number of R&D personnel, and he did not take into account the impact of R&D investment.

Fischer has refined the KPF, and Greunz proposed the mixed KPF, they widened the future way for the development of knowledge production functions. Next scholars used the economic zone instead of the administrative area in the aspect of regional division of the sample, and used the industry distance instead of space distance when measuring the geographical distance. Scholars pointed out the lag of input and output. The spillovers existing in industry interior, different industries, interregional, different regions can be finely analyzed in order to expand the application of KPF.

It is a complex and unstructured phenomenon when knowledge production is discussed in the fields of social sciences, management science, and organizational sciences. However, the research based on knowledge production function requires to construct a measure system for these phenomena and to measure them. In fact, only some specific aspects of the phenomenon are seized by the measure system and its subordinate indexes, and how much it can actually measure the concept depends on the definition of the concept, the completeness of the selected dimension, and how to use the indexes to measure the related questions. In this paper, it is necessary to formulate the general model of knowledge production function by redefining the hypothesis and the reasonable explanation of the parameters on the basis of deeply analyzing the characteristics of multiple inputs and multiple outputs of the innovation process and their relevance. To do so is to better reveal the inherent law between input and output of science and technology. In order to better study the impact of knowledge capital and knowledge spillovers on firm performance, we will expand the production function and redefine the input and output of micro enterprises.

5. The Development of Knowledge Production Function in the Performance Evaluation of High-tech Enterprises

From the essence of innovation, the enterprises or institutions, region, nation and industry as the knowledge production system is no essential difference, they all can be seen as the complex multiple input-output system. For the micro-enterprises, the enterprises put a variety of resources into the production system; these resources are processed, produced, absorbed and converted. The resources are formed productions finally, and the productions are sold, the enterprises achieve income and generate profits, and then the resources are put into production again. This is not only the production cycle process of the enterprise, but also is the process of value added. It is necessary to establish a scientific and reasonable measurement system for the input and output of the enterprises so that the accurate assessment to the specific phenomena of the input and output of all kinds of resources in the production system can be possible. The scientific and reasonable measurement system can further expand the application scope of the knowledge production function. This paper studies the impact of enterprise's knowledge capital and regional knowledge spillovers on firm performance. Therefore, the indicators of knowledge production function are determined to stand on the firm's position.

5.1 The Input Resources of High - tech Enterprise Production System

In the study of scholars, they put knowledge as an important input into the production function model. In the micro-enterprises, knowledge is the important capital for enterprises, especially high-tech enterprises. According to the source of knowledge, one is from the internal enterprise, that is, the enterprise's knowledge capital; the second is derived from the external enterprise, that is, regional knowledge spillovers. Therefore, the inputs of enterprise production system mainly include material capital, labor capital, knowledge capital, and regional knowledge spillovers.

5.2 The output of high - tech enterprise production system

The goals of the enterprise are to survive, develop and profit. The enterprises strive to maintain

the ability to use of revenue to finance expense and repay the debts due to reduce the risk of bankruptcy, so that enterprises can survive long-term stably, this is the survival requirements; to raise the necessary funds for enterprise development is the second requirement - the development; the rational and effective use of funds to enable enterprises to profit, is the third requirement – profit. The measurement of the output level of the enterprise cannot be measured by the production of the enterprise, because the production capacity can only represent the production capacity of the enterprise and cannot represent the profit level of the enterprise. Therefore, we consider the final goal of the enterprise as the starting point, the performance of the final output will be the final output of the enterprise.

6. Knowledge Production Model of High-tech Enterprises Introduced Knowledge Spillover

Improve the production function model of Cobb- Douglas, and introduce the knowledge stock and the knowledge spillover into the model. The expression of the production function is:

$$P = AM^\alpha L^\beta K^\gamma S^\sigma e \quad (5)$$

P : Corporate performance; M : material capital, expressed by total assets; L : labor capital, expressed by annual average wage, K : technical level (knowledge capital); S : regional knowledge spillover level; e : random perturbation term, error term; A : constant; $\alpha, \beta, \gamma, \sigma$: the corresponding input -output elasticity.

In the knowledge production function model, for any kind of input, for example K , the bias of its output is:

$$E_K = \lim_{\Delta T \rightarrow 0} \frac{\frac{\Delta P}{P}}{\frac{\Delta K}{K}} = \frac{K}{P} \lim_{\Delta T \rightarrow 0} \frac{\Delta P}{\Delta K} = \frac{K}{P} \frac{\partial P}{\partial K} = \frac{K}{P} \frac{\partial P}{\partial K}$$

Take the logarithm on both sides of the Equation (5)

$$\ln P = \alpha \ln M + \beta \ln L + \gamma \ln K + \sigma \ln S + e \quad (6)$$

Take partial derivative of P with respect to K .

$$\frac{1}{P} \frac{\partial P}{\partial K} = \gamma \frac{1}{K} \Rightarrow \frac{K}{P} \frac{\partial P}{\partial K} = \gamma = E_K$$

The meaning of the parameter γ is the output elasticity of the input K , which means that the input amount of resources K increases 1%, there will be γ % incremental output.

When applying the regression equation, we will utilize the method used by Kokko (1994) when he analyzed the influencing factors of the FDI spillover effect in Mexico—to multiply the FDI and the indicator of spillover factors, then the result as an explanatory variable was introduced to the regression equation [6]. With reference to the similar approach, we consider that knowledge capital and knowledge spillovers can act on certain carriers to play a role. Therefore, the performance, technical level and regional knowledge spillovers are multiplied by the total assets of the enterprise, the results as the explanatory variables will be introduced to the regression equation.

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