Innovation Input, Innovation Output and Firm Competitiveness:

An Analysis of China Pharmaceutical Industry at Firm Level

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Abstract

Based on the pharmaceutical firm data from the census of National Bureau of Statistics, the relationship among innovation input, innovation output and firm competitiveness was examined using Probit, Tobin and extended Cobb-Douglas production function models. The results indicated that the relationship between innovation input and firm size acts in accord with Schumpeterian Conjecture. And there is a significantly positive effect between innovation input and innovation output as well as between innovation output and firm competitiveness. In addition, the elasticity of innovation output with respect to innovation input of Chinese firms is considerably lower than that in developed countries, so as to the elasticity of firm competitiveness measures with respect to innovation output. Furthermore, the feedback effect of innovation input on innovation output takes 1 - 4 years. The innovation input and innovation output of share-holding corporations limited is higher than that of foreign-funded firms and enterprises with funds from Hong Kong, Macao and Taiwan. Compared with the old firms, the new firms seem to have lower innovation input but higher innovation output.

Keywords: Innovation input, Innovation output, Firm competitiveness, Endogenesis
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1. Introduction

The empirical analysis of the relationship between innovation and productivity or firm performance has been the focus of attention in recent years (Griliches, 1995; Crepon, et al 1998; Loof and Heshmati, 2000, 2001; Kleinknecht and Mohnen, 2002; and others). However, the estimated results are different because of the different data sources, types of models, estimation methods and measures of firm performance or innovation. The firm that has higher productivity or performance may have stronger competitiveness to some extent. The goal of this paper is to investigate the relationship between innovation and firm competitiveness in China using different methods and different measures of firm competitiveness. New findings are showed and compared with some results of previous studies.

The specification of empirical model and the definition of variables are presented in Section 2, and the data used is described in Section 3. Estimated results from the model are presented in section 4, and the basic conclusions are drawn in section 5.

2. The Specification of Empirical Model

The empirical model used here is derived from the “chain-link model” of Kline and Rosenberg (1986) and further developed by Crepon, Duguet and Mairesse (1998). The model, referred to as CDM model for short, includes four equations. In this paper, the

innovation input equations include the equation of firm's decision to innovate and the equation of innovative investment of participated firm. The innovation output equation reveals the relationship of innovation input and innovation output. And the competitiveness equation reveals the firm's competitiveness related to the innovation output. In the model, we also exam the feedback effect of profit on innovation input and the feedback effect of innovation input on output.

2.1 Determines of Innovation Input

The Probit and Tobin models are used to estimate the following specification:

$$G_t^* = A^0 + \beta_1^0 \lg L_t + \beta_2^0 \lg MR_t + \beta_3^0 DIM_t + \beta_4^0 X_t^0 + \varepsilon_t^0 \quad (1)$$

$$I_t^* = A^1 + \beta_1^1 \lg L_t + \beta_2^1 \lg MR_t + \beta_3^1 \lg C_t + \beta_4^1 \lg P_{t-1} + \beta_5^1 DS_t + \beta_6^1 X_t^0 + \varepsilon_t^1 \quad (2)$$

The equation (1) in the model is a selectivity equation, modeled as a Probit, which describes the probability of a firm to engage in innovation. The equation (2) modeled as a Tobin expresses the innovation input, where a firm decide to participate in innovation. In equation (1) and (2), G_t^* and I_t^* are all latent variables. When $G_t^* > 0$, G=1.it indicates that the firm decide to innovate. And if G=1, the latent innovation input I_t^* equals to the amount of innovation input I_t, which defined as the ratio of R&D to the total sells revenue. The opposite is true if $G_t^* \le 0$. L_t is the firm size measured by the number of employees. MR_t is the market ratio defined as the ratio of the enterprise's revenue to that of the domestic industry. C_t represents the intensity of cash flow measured by the cash flow per employee. P_{t-1} represents the feedback effect of profit on innovation input. The equations also include some dummy variables. A dummy for international competition; A dummy for subsidy; A dummy for the status of register; A dummy for the entry of enterprises.

2.2 Relations of Innovation Input, Output and Firm Competitiveness

The innovation output and firm competitiveness equations can be summarized as:

$$N_t = A^2 + \beta_1^2 Y_{t-1} + \beta_2^2 K_t + \beta_3^2 \lg L_t + \beta_4^2 \lg I_{t-2} + \beta_5^2 \lg I_{t-3} + \beta_6^2 \lg I_t + \beta_7^2 \lg EX_t + \beta_8^2 \lg MR_t + \beta_9^2 \lg SUB_t + \beta_{10}^2 DCP_t + \beta_{11}^2 IMR + \beta_{12}^2 X_t^0 + \varepsilon_t^2 \quad (3)$$

$$Y_t = A^3 + \beta_1^3 Y_{t-1} + \beta_2^3 \lg N_t + \beta_3^3 \lg K_t + \beta_4^3 \lg L_t + \beta_5^3 X_t^0 + \varepsilon_t^3 \quad (4)$$

In equation (3), the dependent variable is the innovation output measured by the intensity of new products. And the explanatory variables include the firm size, the innovation input, the market ratio, the feedback effects of innovation input and capability of competitiveness on output, the inverse Mill's ratio (IMR), the capital per

employee (K_t), the intensity of exports (EX_t), the government subsidy (SUB_t), A dummy for cost push (DCP_t), A dummy for the status of register; A dummy for the entry of enterprises. In equation (4), the dependent variable is the capability of competitiveness measured by the profit per employee and the sales per employee.

Equations (1) and (2) are estimated using two-step regression of Heckman. And equations (3) and (4) are estimated together in a 3sls simultaneous equation model as well as in a 2sls model. I also compare the results of different models which have different incorporation of feedback effects.

3. The Data

The data set comes from the census of National Bureau of Statistics, which consists of much information including the measures of innovation, the profit of the firm, among others. Another advantage of the data set is that it contains almost all the manufacturing firms in China. In this part, I outline the procedure to select the data and compare the descriptive statistical results of the innovative firms and non-innovative firms.

4. The Estimation Results

In this section, the goal is to analyse the difference of the models mentioned in the foregoing discussion and to examine the robustness of the relationship of innovation input, innovation output and firm competitiveness.

5. Conclusions

This work investigates the estimated relationship among innovation input, innovation output and firm competitiveness based on the pharmaceutical firm data from the census of National Bureau of Statistics. The following conclusions can be drawn from our empirical test. The relationship between firm size and innovation input conform to the Schumpeterian conjecture. The participation decision to innovate and the innovation intensity are all positively influenced by the firm size. Another important finding is that there is a significant positive correlation between innovation input and innovation output as well as between innovation output and firm competitiveness after controlling for factors such as capital intensity. However, the elasticity of innovation output with respect to innovation input is 0.275 and the elasticity of firm competitiveness measures with respect to innovation output is 0.194, which are all lower than the estimated results of Loof and Heshmati (2002).

In addition, the feedback effect of innovation input on innovation output takes from 1 to 4 years. The significant positive effect decreased gradually with increasing processing time. I also find that the innovation input and innovation output of share-holding corporations limited is higher than that of foreign-funded firms and enterprises with funds from Hong Kong, Macao and Taiwan. Compared with the old firms, the new firms have lower innovation input but higher innovation output. All of the results should be helpful to improving the competitiveness of China's enterprises.

References: