Available online at www.sciencedirect.com
SciVerse ScienceDirect
Procedia Engineering 29 (2012) 2826 – 2831
Procedia Engineering
www.elsevier.com/locate/procedia

2012 International Workshop on Information and Electronics Engineering (IWIEE)

Do Imports of Technology Facilitate Technological Progress? Evidence from China

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Abstract

This paper empirically investigates the impact of imports of technology on total factor productivity for a cross sectional sample of large and medium-sized industrial enterprises by 30 major provinces or regions in China. The possible determinants of total factor productivity are sought with special focus on imports of technology. An endogeneity test is performed in order to examine whether inconsistent results exist or not. Empirical results indicate that imports of technology, the level of R&D and human capital are the most significant factors enhancing total factor productivity in Chinese industries. The findings in this paper support the argument that accelerating imports of technology is an effective way of facilitating technology progress in China.

Keywords: Imports of technology; Total factor productivity; Technological progress; China

1. Introduction

Ample theories and practices provide the evidence that R&D is notable positive factor during the innovation activities (Rosenberg, 1990)[1]. With the establishment of formal R&D operations, many enterprise are making the transition from imitation to innovation, including the creation of patentable knowledge (Kim, 1997)[2]. With the rapid development of economic globalization, as far as enterprises be concerned, imports of technology has promoted the productivity as well (Katrak, 1990)[3]. It is essential for the enterprises to accomplish advanced imports of technology, some countries, such as Japan, Korea, fulfilled technology transition through the successful imports of technology and technology

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doi:10.1016/j.proeng.2012.01.398

learning, and they have set up the excellent examples for China. In addition, it is noted that in the course of imports of technology, governments and enterprises will not lose independent knowledge property and core technology information until they pay enough attentions to strengthening the technology learning and R&D capability. Based on the current comprehensive economic strength and industrial technology foundation, China has made an important development strategy whose essence is strengthening the innovation capacity for indigenous enterprises and striving to be an innovation-oriented country. At present, as for the practice for technology strategy in China, does R&D take the first place for promoting the innovation performance? Do imports of technology take the second place for increasing the innovation performance? It is essential for Chinese governments and enterprises to answer these questions above in order to understand the meanings of the current Chinese economic policy and select the appropriate innovation paths.

In the studies abroad related imports of technology, a large number of empirical research results confirm that imports of technology has positive effects on the innovation performance. In recent years, some scholars put forward some issues that the developing countries and the indigenous enterprises will decrease the demand of independent innovation and weaken the incentives for independent innovation if they only pay attention to imports of technology, and the typical phenomenon is that imports of technology piles out R&D input. It is widely notable that technological progress is facilitated through FDI, ample empirical results provide the evidence that technological progress is positively related to FDI. As for technological progress and imports of technology, little research has been found for this topic. Imports of technology above may generate a continuous flow of new technology which may have a competitive impact on innovation performance in developing countries. As noted in some studies, the analysis sample of developing countries is exciting for scholars because a technological learning process is crucial for latecomers seeking to upgrade their technology base and climb the development ladder (Hu et al., 2005)[4]. It is reported that multinational enterprises established around 700 R&D centres in China by the end of 2004 as a part of their global R&D strategies (China Daily, 2005)[5]. So exploring the relationship between imports of technology and technological progress in China is, undeniably, meaningful to make rational economic policy.

This paper is organized as follows: This introduction is followed by a discussion of the theory of imports of technology and technological progress. In section 2 the methodology is provided. In section 3 the empirical analysis procedures are presented. In section 4 some conclusions are given.

2. Methodology

In this section, in the light of the method in the previous study, this paper specifies the following production of domestic firms in sector i in order to obtain the variable of TFP, then the determinants of TFP are tested.

$$Y_i = AK_i^{\alpha} L_i^{\beta} \tag{1}$$

where Y denotes gross output value of domestic firms in a sector, K and L are physical capital and labour inputs of domestic firms, respectively, and A equals an indicator that picks up changes in technology and represents technological progress, defined as total factor productivity. And in the equation above, α and β represent the elasticity of the factors of production in the equation.

Transforming Eq. (1) in natural logarithms, total factor productivity can be calculated as the following:

$$\ln A = \ln Y - \alpha \ln K - \beta \ln L \tag{2}$$

TFP is defined as a measure of the efficiency with which factor inputs are combined to produce output. An increase in the amount of output can be produced for given inputs reflecting an increase in TFP, which represents technological progress. Hall and Jones (1999) have found that in 1988 output per worker in the US was 35 times higher than that of Niger[6]. The differences in output per worker between these two economies are mainly attributed to the efficiency or TFP with which the two economies use these factor inputs. In this sense, an increase in TFP is assumed to be synonymous with technological progress.

It should be noted that estimating production function has imposed the assumption that all the sectors share the same production function. This paper will test whether the assumption holds in the current study by applying the Chow test. If there are deviations from the assumptions imposed by the adopted methodology, the estimate of TFP may be biased.

Following Coe and Helpman (1995), Miller and Upadhyay (2000), Hu and Jefferson (2005), R&D and imports of technology are viewed as important sources for increasing total factor productivity[4, 7-8]. The level of human capital, representing the ability to absorb advanced technology of host countries, particularly in developing countries, is also included. Firm size in a sector also affect total factor productivity in that production efficiency can be increased, and it is justified to consider this variable as one of the determinants of total factor productivity. Therefore, total factor productivity is endogenized as a function of the level of R&D expenditure, imports of technology, human capital and firm size. All of the variables are expected to have a positive sign and contribute to an increase in total factor productivity.

Total factor productivity (TFP) in sector i can be expressed as follows:

$$\mathrm{TFP}_i = f(\mathrm{R\&D}_i, \mathrm{IT}_i, \mathrm{HC}_i, \mathrm{FS}_i) \quad (3)$$

Equation (3) express the notion that TFP is affected by the factors, such as the level of R&D (R&D), imports of technology (IT), the level of human capital (HC), and firm size (FS). And other factors such as different levels of competition between sectors which may also influence TFP are not included due to the unavailability of data.

Equation (3) express a log-linear functional form is adopted to reduce the possibility or severity of heteroscedasticity and directly obtain TFP elasticity with respect to explanatory variables. The form of the model is as follows:

$$\ln\mathrm{TFP}_i = a_1+a_2\ln\mathrm{R\&D}_i+a_3\ln\mathrm{IT}_i+a_4\ln\mathrm{HC}_i+a_5\ln\mathrm{FS}_i+\varepsilon_i \quad (4)$$

where ε represents the error term.

It is noted that it is difficult to clearly assert the relationship between imports of technology and technological progress, imports of technology is expected to have positive effect on total factor productivity. On the other hand, the level of total productivity in a sector may also be one of the important factors in influencing imports of technology, because from a theoretical point of view, a sector with a high level of total factor productivity has abundant capital to pursue the goal of promoting imports of technology. If there exists a two-way relationship between foreign presence and TFP, the estimation of a single equation for TFP using the OLS method will lead to inconsistent results, implying that the estimation fails to account for time-invariant differences in productivity across sectors. Therefore, it is important to test endogeneity between imports of technology and TFP, and determine whether an alternative estimation method should be used. The endogeneity between imports of technology and total factor productivity is tested by applying Hausman's test in equations. (4) and (5).

$$\ln\mathrm{IT}_i = \gamma_0+\gamma_1\ln\mathrm{EX}_i+\gamma_2\ln\mathrm{DS}_i+\gamma_3\ln\mathrm{TFP}_i+u_i \quad (5)$$

Equation (5) expresses the notion that imports of technology in a sector is affected by the level of exports (EX), the level of domestic sales (DS), and the level of total factor productivity.

The equations are likely to be simultaneously determined if the residual of the reduced form of one equation has a significant impact on the dependent variable. The following procedure has been applied to detect the endogeneity between IT and TFP.

Firstly, the following equation is estimated.

$$\ln\mathrm{IT}=c_0+c_1\ln\mathrm{EX}_i+c_2\ln\mathrm{DS}_i+c_3\ln\mathrm{R\&D}_i+c_4\ln\mathrm{HC}_i+c_5\ln\mathrm{FS}_i+\eta_i \quad (6)$$

and obtain the residual named as v. Secondly, Equation (4) is estimated by including v as one of the explanatory variables. If the coefficient of v, denoted as λ, is statistically different from zero, then imports of technology is endogenous, and as a result, the OLS estimate will be inconsistent. Instead, twostage least squares (TSLS) method should be used. If λ is not statistically significant, then it is justified to employ the OLS method to estimate Equation (4).

One common problem encountered in cross-sectional studies is heteroscedasticity, because if it exists, the OLS estimators are inefficient. White's heteroscedasticity tests are carried out to tackle this problem, and the estimation procedure is then applied accordingly.

3. Data and Variables

Owing to the absence of the relevant data for Tibet, this paper employs the relevant data for 30 major provinces or regions in China from the 2009 China Statistical Yearbook on Science and Technology, 2009 China Statistical Yearbook and the website of National Statistical Bureau. In view of the limitation of data procuring, this paper mainly employs the data of large and medium-sized industrial enterprises by region in China. And owing to the limitation of the length, this paper omits the original statistical data.

The variables in this paper are defined as follows. Total factor productivity is calculated from Eq. (2); imports of technology is denoted by expenditure on imports per employee in indigenous Chinese firms in a sector by region; R&D, representing the level of R&D, is denoted by the expenditure for R&D; human capital is denoted by the ratio of scientists and technicians to total employees; firm size, representing the level of economies of scale, is measured by number of employees in Chinese firms by region; exports is denoted by the ratio of exports to gross output value of domestic firms; domestic scale, representing the market size, is denoted by the total domestic sales value of domestic firms. All the variables take the form of natural logarithms.

4. Empirical Results

In order to examine whether the sectors share the same production function or not, the entire industrial sectors by region are classified into two groups—low technological sectors and high technological sectors based on R&D intensity which is measured by the ratio of R&D expenditure to total sales value of domestic firms. The results from the Chow test for equation (1) (*F* test=1.8962 with probability 0.2036; log likelihood ratio=5.8976 with probability 0.1425) show that there are no sufficient differences in the production function across sectors, implying that there is no serious measurement error with estimated TFP.

The endogeneity test shows that λ is statistically insignificant even at the 10% level, suggesting that there is no evidence for a two-way link between TFP and the foreign presence in a sector, therefore, it is appropriate to apply the OLS method to estimate the TFP equation. The results from Eq. (4) are not affected by the differences in productivity across sectors. White's heteroscedasticity test generates a highly significant result (nR^2)=2. 3203 with probability 0.8065, indicating the absence of heteroscedasticity. Thus, the estimators form Equations (2) and (4) are valid, as for the detailed information, please refer to Table 1.

The regression results in Table 1 indicate that physical capital and labour force are all significant at the

Table 1. Regression results for the production function

Independent variables	Coefficients (*t*-statistics)
ln*K*	0.3826^{***} (2.2752)
ln*L*	0.6105^{***} (5.0986)
C	2.0233 (1.8607
Adjusted *R* squared	0.9273
F-value	165.3732^{***}

Notes: Dependent variable is total factor productivity (TFP), ***,**represents the 1% and 5% significance levels, respectively.

1% level, respectively. The contribution of labour force is to the level of gross output is highest with the value of 0.6105 to the elasticity of gross output, and the magnitude of the coefficient of physical is 0.3826, indicating that both labour force and physical capital are important factors in determining the level of gross output in Chinese industries.

The results from the total factor productivity equation shown in Table 2, show that the variance explained in each of the regression models are 68.5% and 75.6%, respectively. The variance explained indicates that the percentage of change in a dependent variable can be collectively predicted by the independent variables in a regression model. For instance, 68.5% of changes in total factor productivity can be accounted for by the four independent variables in model 1. From the results in model 1, we can come to the conclusions as follows.

The regression analysis results show that imports of technology is statistically significant at the 5% level, which implies that there is positive impact on total factor productivity. The analysis results confirm the fact that Chinese firms need to have the capable scientists and technicians to obtain the benefit from imports of technology.

R&D is statistically significant at the 1% level, which implies that there is a great positive impact on total factor productivity. Higher spending on R&D investment enables domestic firms to achieve the goal of pursuing the technological progress, which is in favour of Chinese firms to increase the international competitiveness and capture the chance from the international market.

Human capital is statistically significant even at the 5% level, which implies that there is a weak positive impact on total factor productivity, implying that Chinese firms need more human resources to promote technological progress. In addition, firm size seems to have insignificant impact on total factor productivity.

The results from the model 2 take into account impact of human capital and the interaction term between human capital, imports of technology, and R&D, respectively. The results indicate that the coefficient of the interaction term between human capital and imports of technology is positive and statistically significant at the 1% level, and the coefficient of the interaction term between human capital and R&D is positive and statistically significant at the 1% level, which indicates that a sector with higher level of human capital could obtain more benefits and hence total factor productivity.

5. Conclusions

As far as China be concerned, with entering into the WTO, more and more Chinese firms have realized the importance of international competitiveness of their own and they have struggled to improve their economic performance through technological innovation. As an important way for improving the technological innovation performance, imports of technology could provide the assistance for the

Table 2. Results of TFP function

Independent variables	Model 1	Model 2
	Coefficients (*t*-statistics)	Coefficients (*t*-statistics)
lnIT	0.0386^{**}(25895)	
lnR&D	0.0916^{***}(4.0562)	
lnHC	0.1287^{**}(3.6879)	
lnFS	-0.0965(0.5663)	-0.0879(0.4786)
ln(IT × HC)		0.0897^{***}(2.6785)
ln(R&D × HC)		0.0768^{***}(3.879)
Adjusted R^2	0.685	0.756
F-value	16.987^{***}	18.476^{***}

Notes: Dependent variable is total factor productivity (TFP), ***,**represents the 1% and 5% significance levels, respectively.

indigenous firms to increase the innovation level and performance. The research results in this paper suggest a few implications for policymakers. Firstly, it is noted that imports of technology could increase the level of total factor productivity, so Chinese governments should continue to stick to the principles on reformation and opening and should make the prior policies to promote the imports of technology. Secondly, the empirical results indicate that without a sufficient number of scientists and technicians with access to cutting-edge imports of technology, it is unlikely that Chinese ingenious firms will be able to obtain the benefits from imports of technology and increase the total factor productivity. So Chinese government departments enterprises should focus on attracting the sufficient enable scientists and technicians in order to facilitate technological progress.

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