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The Effects of Technology Import on High-Tech Industrial Structure Upgrading in China

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Abstract

Using panel data from 2004 to 2012 of five sub-industries in high technology industry, and the data of three economic regions of China, use factor analysis method to measure the degree of high technology industrial structure upgrading. Introducing cross terms of industrial and regional dummy variables to analyse the different effects of technology import, R&D capital stock on high technology industry sectors and regions of east, middle and west. Empirical Analysis shows that medical equipment and instrumentation manufacturing is most affected, but electronic and communication equipment, aviation spacecraft is little affected. From area: it significantly contributes to the middle region of high technology industry structural upgrading, while little impacts on the eastern and western regions.

Keywords: Technology import; R&D Capital Input; High Technology Industrial Structural Upgrading; Regional Innovation; Area Innovation.

1. Introduction

High technology industry is an industry using current advanced technology to produce high-tech products, its powerful innovation ability gives other related industries giant technology penetration, which can improve the overall quality and competitiveness of each industry. Compared with developed economics, China's high-tech industry started late with relatively poor technology, according to the Theory of Late-developing Advantage, after importing the advanced technology of developed economics, developing economics have faster access to gain technological progress by means of studying digesting, imitating and secondary innovation. Technology import has become the main path of Chinese technological progress.

In existing literature, whether technology import can really promote technology innovation and industrial structure upgrading or not, there is quite a lot of dissension. Some scholars think that technology import has positive influence on industrial structure upgrading and economic growth, while others questioned that, they consider there is no significant effect between the two, someone even found the negative correlation. Therefore, we from the perspective of technology spillovers to investigate the influence on high-tech industry structure upgrading by importing technology. In addition, pull-in virtual variables to demonstrate the different impacts on high-tech industry structure upgrading according to the technology import of different regions and sub-industries. Thus, to adjust the structure and scale of sub-industrial and regional technology import, achieve the goal of promoting high-tech industry structure upgrading.

2. Review of Literature

Yoshiyuki Okamoto [1] believes that there is no contradiction between the internal development and technology importing, self-development needs an external "technology seed" inflow, then absorbing, forming an independent system. For developing countries, technology transfer is necessary, ultimately still have to rely on the internal

development. Coe and Helpman [2] examined 22 OECD countries, confirmed that trade partners' R & D technology can be transferred through import, and found that less developed economics' total factor productivity (TFP) will be improved if importing intermediate goods from advanced technology countries, and this effect will be enhanced as increase their extent of openness . But in the research of Czech manufacturing enterprises, Djankov and Hoekan[3] found that FDI does not exist a positive spillover effect on Technological Innovation for tech-receiver, or this effect will happen only under certain conditions.

However, Acharya & Keller[4] investigated16 developed countries showed that for productivity, the impact of international technology transfer exceeds the impact of their domestic technological innovation, especially obvious in high-tech industries. When Independent R&D be increased 10% every unit, productivity grows 1.4%, while foreign technology R&D import contribute more.

Turning to the developing economics, Homi Katrak[5] studied Indian companies' technology options, the research has pointed out that technology import produces a substitution effect on independent research and development, it will reduce the number of scientific and technical staff who are responsible of research and development, thus generate negative effect on technological innovation capability. Unlike Homi, Aradhna Aggarwal[6] based on previous researches, came out with a different conclusion by studying Indian manufacturing enterprises. He indicated that there is an efficient gap between the companies' own technology and the technology they need to increase productivity. However, technology importing just fill in the blank, which has a positive effect on technological progress. Similarly, Andreas Savvides and Marios Zachariadis[7] examined 32 low-income developing countries found that technology import has a positive influence on domestic productivity and added value increasing , as well as capital goods import and FDI.

With the rapid development of China's high-tech industry, the problem of how technology importing effect industrial structure upgrading has also been more and more concerned by domestic scholars, such as Jiang Xiaojuan[8] discussed the important contribution-- the foreign investment has made in China's economic development. She also pointed out that multinational companies bring in creative resources which are not be replaced. Multinational companies' investments speed up the upgrading of China's industrial structure, and the rapid development of China's high-tech industry is just the product of it. Yao Jun[9] believed FDI can promote the transfer of traditional industries, help new industries' growth and development, accelerate upgrading of industry internal structure. Tang[10] pointed out that technology innovation or TFP increasing through technology import is a necessary condition for its promotion of industrial structure upgrading instead of a sufficient condition. Affected by the factors of technology transfer, the mechanism of how technology import act on economic growth pattern is much more complex.

It can be seen that how technology import affects tech-receive countries' technology progress depends on different background conditions. Well, according to the level of productive technology of China's current high-tech industry, absorptive capacity and quality of human capital conditions, is technology able to accelerate China's high-tech industrial structure upgrading? In fact, China's current technology development is still at a low level, even if high-tech industries are still largely processed intermediate goods, and expand industrial scale by manufacturing and assembling primarily. The R & D strength of China's high-tech industry is only 1.6 times of manufacturing sector, far less than 3 or 4 times than developed countries, such as Britain, Germany, France.

Therefore, China needs to lead in "technology seed" of developed countries, and then combined with the own soil and water, let it take root deep and grow up. As scholar Lin Yi fu and Zhang Peng fei[11] believe that import advanced technology from developed economic is an important part of technological innovation, in order to achieve faster upgrading, we need to balance R & D intensity and technology import degree, thus to reduce the technology gap with developed countries. Since then, scholars had further studies, proposed importing technology choice, without good choice, difficult to digest. Huang Mao xing, Li Jun jun[12] using panel data from 1991 to 2007, China's 31 provinces, analyze the problem of importing technology choice concretely. A reasonable technology import can be able to increase labor productivity through the promotion of industrial upgrading.

Hence, we propose the following hypothesis:

H1 : Technology inflows can promote high-tech industrial structure upgrading.

On the basis of the above assumption, this paper will dive deep into different industries' technology imports produce different effects. When examined Portuguese manufacturing, Varum[13] came out with the same result through by analyze different industries' detailed data. Technology import is more beneficial to higher-tech industries' labor productivity. At the same time, Xiao Hao etc[14] using 2000-2013 panel data of High-tech industry in China, introducing virtual variables, analyzing FDI, R&D and import of intermediate products, and the result show that the overall FDI, R&D and the import of intermediate products can promote the export of the product technology content. Importing intermediate products of electronic and communication equipment, computers and office equipment, and medical equipment and instrumentation can promote the export of high-tech products, while

importing intermediate products of pharmaceutical and aerial will hinder the export technology level.

Because of stronger protection consciousness of core technology in aerospace field, useful technology is difficult to obtain by technology transfer. However, at present, medical equipment and instruments are largely imported, this situation can guess the influence of technology import of medical equipment industry is bigger. The hypothesis is as follows:

H2 : Technology inflows act differently to the five sub-industries of high-tech industry. Among them, electronic and communication equipment manufacturing and aviation spacecraft industry are little affected, while medical apparatus and instruments manufacturing is most affected compared to others.

In recent years, Chinese scholars began to take a consideration of regional difference in technology transfer. Wu Yanbing [15] computed independent research and development stock and technology importing stock, has drawn a conclusion that the two factors above can both boost productivity growth and obvious. Moreover, eastern region, western region, central region regions showed different conclusions respectively. Yan Haizhou[16] through the empirical data of Yangtze river delta region confirmed: FDI effect was not obvious for eastern region to upgrade industrial structure.

Absorptive capability plays an important role in transferring the importing technology to be a diver of increasing the productivity. The low level technology of Western region, have hindered digestion of importing technology. By contrast, in eastern region, developed economy and high level technology have made them needs more independent research and development in recent years instead of imports, in other words, more and more technology import will obstruct the innovative ability. The central region has a certain technology foundation, besides there is a distance between technology needs and self-level, technology import can just fill the gap. As a result, put forward the following hypothesis:

H3: Technology inflow affects more in the central region compared with western region and eastern region.

Regard of above-mentioned three hypotheses, this paper will carry on the empirical analysis.

3. Methodology

The focus of this study is the impact of technology import on high-tech industrial structural upgrading, and sub-industry by sub-industry, region by region to comparative analyze different effects.

Firstly, use factor analysis method to calculate 2004-2012 China high-tech industrial structure upgrading comprehensive index, the results in the following table1:

Table1: 2004-2012 China High-Tech Industry Structure Upgrade Index

	2012	2011	2010	2009	2008	2007	2006	2005	2004
National	104.36	102.97	101.36	101.99	100.36	100.20	99.80	100.36	100
Eastern region	95.15	98.94	100.88	100.08	101.00	100.88	100.62	100.38	100
Central region	118.33	121.83	112.05	110.83	103.83	100.13	100.76	103.10	100
Western region	59.33	64.88	31.17	75.07	43.82	86.31	80.54	81.92	100
Pharmaceutical manufacturing	158.11	149.68	119.48	144.80	104.43	87.55	90.22	110.01	100
Aviation spacecraft equipment manufacturing	80.84	81.13	88.59	67.71	83.49	90.60	92.99	103.57	100
Electronic and communication equipment manufacturing	101.38	96.45	83.24	96.56	97.44	100.01	97.73	96.97	100
Computer and office equipment manufacturing	72.09	90.56	113.41	83.25	122.17	115.37	124.00	113.74	100
Medical instrumentation	233.54	236.22	188.22	251.16	139.88	137.62	117.68	104.04	100

3.1 Variable Selection

According to the above literature review and assumptions, we put technology import as independent variable, besides, in order to eliminate lag effect and cumulative effect of independent research and development input in the previous years, set R&D capital stock as control variable instead of R&D expenditure, calculated high-tech industrial structural upgrading comprehensive index as dependent variable. Due to the uncertain relationship between technology import and industrial structural upgrading, we introduce D_1X 、 D_2X 、 D_3X and D_4X virtual cross terms on behalf of 4 sub-industries' technology import, the reference group is medical equipment and instrumentation manufacturing; in the same way, set P_1X 、 P_2X virtual cross terms of 2 regions (eastern region and western region), the reference group is central region. Variables explanation is as follows:

Table2: Variables Explanation

Independent variable	Tech-import LnX	
	Sub-industries	Pharmaceutical manufacturing D_1LnX
		Aviation spacecraft equipment manufacturing D_2LnX
		Electronic and communication equipment manufacturing D_3LnX
		Computer and office equipment manufacturing D_4LnX
	Regions	Eastern region P_1LnX
		Western region P_2LnX
Control variable	Independent research and development input	R&D capital stock LnC
Dependent variable	High-tech industrial structural upgrading	high-tech industrial structural upgrading comprehensive index $LnUGI$

3.2 Equations

This article evaluates technology import has positive effect on industrial structural upgrading, and technology import acts different on different industries and regions, therefore, it is necessary to build two models as follows.

(a) Sub-industries comparison model:

$$LnUGI_{it} = \alpha + \sum_{k=4}^{k} \beta_k D_k \mathrm{LnX}_{it} + \beta_{(k+1)} \mathrm{LnC}_{it} + \varepsilon_{it} \quad (2.1)$$

$LnUGI$ means each sub-industrial upgrading of high-technology industry, LnX means technology import, D_kLnX is virtual variable cross term, k represents the number of industrial virtual variables. This model uses medical equipment and instrumentation manufacturing as reference, namely, if the technology import belongs to pharmaceutical manufacturing, $D_1=1$, otherwise $D_1=0$, the rest is the same, when four virtual variables are both zero, it is on behalf of the medical equipment and instrumentation manufacturing. LnC as control variable, ε_{it} for the random error term. Model's subscript i means five types of high-tech industry, and t for the year.

(b) Regions comparison model:

$$LnUGI_{it} = \alpha + \sum_{k=2}^{k} \beta_k P_k \mathrm{LnX}_{it} + \beta_{(k+1)} \mathrm{LnC}_{it} + \varepsilon_{it} \quad (2.2)$$

P_kLnX is virtual variable cross term for different regions, k represents the number of regional virtual variables. This model uses central region as reference, namely, if the technology import belongs to eastern region, $D_1=1$, otherwise $D_1=0$, another is the same, when two virtual variables are both zero, it is on behalf of the central region. Model's subscript i means two regional types of technology importing.

3.3 Data Analysis

(a) Sub-Industries Comparative Analysis

Table3: Empirical Results (1)		
Dependent Variable	**LnUGI**	
Independent Variable	**Point Fixed Effect Model**	**Time Random Effect Model**
C	-6.039358 （-3.886622）*	-0.965118 （-1.115049）
LnX	0.422876 （4.810298）*	0.516225 （5.774478）*
LnC	0.438166 （2.656358）**	-0.025959 （-0.492047）
D_1LnX	-0.083954 （-9.839267）*	-0.060959 （-8.081836）*
D_2LnX	-0.075150 （-11.81070）*	-0.064001 （-10.66335）*
D_3LnX	-0.167032 （-7.440759）*	-0.096959 （-9.187090）*
D_4LnX	-0.052440 （-3.506162）*	-0.018204 （-2.137802）**
Hausman-Test	14.51(p=0.0244) **	
Adjusted R^2	0.839793	0.738331
Durbin-Watson Stat	1.667556	1.820531
F-Statistic	17.47465	21.69184
Note: inside Brackets is the t value, * shows significant under the confidence interval 1%, * * shows significant under the confidence interval 5%		

According to the regression results of table3, it can be seen that the goodness of fit is great in a whole, after adjustment, R^2 nearly reached to 84%. And in addition to LnC is significant under 5% level, the rest variables are all significant under 1% level, it confirmed that variables are all have remarkable influence on high-tech industrial structural upgrading. Not hard to find, the coefficient of technology import is 0.42, which suggests that technology import expenditure increase every unit, the high-tech industry upgrading comprehensive index up 0.42 units. Similarly, the impact of R&D capital stock is no less than technology import, R&D stock increase every unit, the index up 0.43unit. The study indicated R&D input is as important as technology import to upgrade industry structure.

Based on result of five virtual cross terms of industries, we analyze the four virtual variable cross terms are significant under 1% level, which means they have influence on industry upgrading. Through five sub-industries effect coefficients found that medical equipment and instrumentation manufacturing is affected most (1), the impact on the electronic and communication equipment manufacturing is the minimum (1-0.167032), differs by16.7%.

Secondly, pharmaceutical manufacturing (1-0.083954), aviation spacecraft (1-0.075150) and electronic equipment manufacturing, computer and office equipment manufacturing (1-0.052440) were 8.4% 7.52% and 5.24%lower than the medical instrument industry respectively. Estimate the following equation:

$$LnUGI = 0.916046X_1 + 0.924844X_2 + 0.832968X_3 + 0.94756X_4 + X_5 + 0.4382C - 6.039 \quad (2.3)$$

(b) Regions Comparative Analysis

Table4: Empirical Results (2)		
Dependent Variable	**LnUGI**	
Independent Variable	**Point Fixed Effect Model**	**Time Random Effect Model**
C	-6.039358 （-3.886622）*	-0.965118 （-1.115049）
LnX	0.422876 （4.810298）*	0.516225 （5.774478）*
LnC	0.438166 （2.656358）**	-0.025959 （-0.492047）
D_1LnX	-0.083954 （-9.839267）*	-0.060959 （-8.081836）*
D_2LnX	-0.075150 （-11.81070）*	-0.064001 （-10.66335）*
D_3LnX	-0.167032 （-7.440759）*	-0.096959 （-9.187090）*
D_4LnX	-0.052440 （-3.506162）*	-0.018204 （-2.137802）**
Hausman-Test	14.51(p=0.0244) **	
Adjusted R^2	0.839793	0.738331
Durbin-Watson Stat	1.667556	1.820531
F-Statistic	17.47465	21.69184

Look from the coefficient, this paper takes the central region (1) as reference, the effect of technology import to the eastern region (1-0.153451) and to the western region (1-0.044167) are relatively small. When compared with the central region, the influence degree of the eastern region is 15.35% less, the western region is 4.42% smaller. Model equation is as follows:

$$LnUGI = 0.846549X_1 + 0.955833X_2 + X_3 + 0.913C - 8.003 \qquad (2.4)$$

4. Conclusions and Discussion

(a) Not only technology import to China's high-tech industrial structure upgrading has a positive role in promoting, at the same time, independent R&D input and knowledge accumulation of R&D also can promote high-tech industrial structure upgrade. Verify the hypothesis that technical flow can promote industrial structure upgrading. The result verified hypothesis $\mathbf{H_1}$ well, where gained enlightenment to insist on promoting technology import policy, strengthen the rationality of selecting.

(b) Among the five sub-industries, technology import of medical apparatus and instruments manufacturing has the largest impact on its industrial structure upgrading, while the minimum is electronic and communication equipment manufacturing reduces nearly 0.17 units, then the following is aviation and aircraft equipment manufacturing, Verified hypothesis $\mathbf{H_2}$.

Recent years, China’s government has devoted itself to develop medical and health undertakings, large number of medical equipment purchased from abroad, with the development of intelligent society, the technology requirements of precision instruments and meters is going to be reinforced, large equipment, which imported from advanced economics and knowledge spillover filled the needs of technology. However, The development of electronic communications industry has entered into matures, it has a good foundation of independent research and development, the spillover effect of imported technology began to present a tendency of diminishing marginal effect

on technology innovation, whereas independent R&D input is better to promote technological leap.

Therefore, this study tells us that we should implement different policies to different industries. For medical equipment and instrumentation manufacturing, we should continue to promote technology import, push more experts at home go abroad, invite more foreign experts to hold lectures. On the contrary, reduce electronic and communication equipment manufacturing technology import expenditure, increasing R&D input, pay more attention to training scientific research elite, enhance independent innovative capacity and strengthen the protection of intellectual property rights.

(c) Technology import is significantly contributed to the central region of high-tech industry structural upgrading, while little impact on the eastern region and western regions, especially to the eastern region. The result verified hypothesis **H_3.**

The reason is: eastern region has a better economic foundation since ancient times, and high–tech industry there started relatively early, develop fast, the pattern of promoting technology progress through technology has presented a diminishing marginal situation. The central region has a certain economic base, but there is a gap between technology needs and their own technology level. Imported technology just fills the gap. What's more, compared to the western region, central region itself has a good absorptive capability to digest.

Hence, we should increase the degree of opening to the outside world in central region, the government actively guide foreign capital into the high-tech industry, encourage local enterprises to cooperate with foreign companies, establish industrial cluster. Reduce technology import of the eastern region, enhance the technology leadership of high-tech industry in this region, strengthening independent R&D and "Industry-Academia-Research" cooperation, expand the scale of industry, building brand effect, incent enterprises "going out". In the western region, increase digestion and absorption expenditures, carry on "talent import" policy and insist on implementing "the western development strategy".

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