The Impact of Higher Education to Manufacturing -Based on Threshold Model

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Abstract. This paper examines the impact of higher education on China's manufacturing industry performance from the national and regional levels on fixed effects model. The research shows that the development of higher education has significantly promoted the improvement of China's manufacturing industry performance. If the development of higher education increases by 1%, the performance of manufacturing industry will increase by 0.239%. Through the internal mechanism test, it is found that higher education can improve the performance of manufacturing industry by increasing the R&D projects, new product projects and enterprise invention patents. Further research shows that there is a double threshold nonlinear relationship between higher education and manufacturing industry performance with per capita GDP and government financial science and technology expenditure as threshold variables based on threshold model.

Keywords: Higher Education, Manufacturing Industry, Fixed Effects Model, Threshold Model

1. Introduction
Under the background that the epidemic has not been effectively controlled, the impact of the epidemic on the international economy has exceeded expectations, and the World Bank released the world economic outlook, which will negatively increase the expected growth rate in 2020. After President Trump took office, he carried out a comprehensive contraction strategy. Put forward the plan of manufacturing industry returning to America. Under the background that the international epidemic crisis has not been completely alleviated, the domestic aging and the popularization of higher education, the development of China's manufacturing industry is facing opportunities, and there are many problems and challenges that need to be solved urgently.

2. Literature Review
1.1 literature combing higher education can train high-quality talents to directly serve as the technical backbone of the manufacturing industry and participate in the improvement of the operating performance of the manufacturing industry. Universities themselves are also innovative highlands. Invention patents and key laboratories in colleges and universities strongly promote the research and development of new products in manufacturing enterprises. The innovative human capital of
equipment manufacturing industry and the performance of manufacturing industry, and found that human capital can effectively improve the performance of manufacturing industry [1], [2]. Scientific and technological innovation can drive the transformation and upgrading of manufacturing industry and improve its performance, but it is unbalanced among regions [3].

Based on the theory of human capital, higher education can promote the formation of human capital, and improve the knowledge mastering ability, innovation ability and information collecting ability of manufacturing employees [4].

Higher education can promote innovation ability and realize sustainable economic development. Human capital can promote technological progress, thus boosting the upgrading of manufacturing industry [5].

There are many researches on the relationship between higher education and manufacturing performance, but there are few researches on whether higher education can promote the improvement of manufacturing performance and its mechanism. This paper studies and solves the following problems: Can higher education improve manufacturing performance? If it can be promoted, what is the mechanism? Is the improvement of manufacturing performance by higher education influenced by external environment, which makes the improvement of manufacturing performance by higher education present a nonlinear relationship?

3. Measurement Model, Variable Setting and Data Description

3.1. Measurement Model

\[
TP_{it} = a_0 + \alpha_i HE_{it} + \alpha_j X_{it} + \lambda_i + \varepsilon_{it}
\]  

(1)

\(TP_{it}\) representing the operating performance level of the manufacturing industry in the province in T period, \(HE_{it}\) representing the basic situation of higher education in the province in T period, \(\lambda_i\) it is the \(i\) provincial individual fixed effect, \(\varepsilon_{it}\) random disturbance term, \(a_0\) intercept term of the model, \(\alpha_i\) regression coefficient of higher education, the size and direction of which indicate the impact of the overall development level of higher education on regional manufacturing performance, and \(X_{it}\) other special control variables that may affect manufacturing performance at the provincial level. In order to study the influence mechanism of provincial manufacturing business performance, considering that there may be a nonlinear relationship between higher education development and manufacturing business performance, this paper takes per capita GDP and fiscal expenditure on science and technology as adjustment variables, constructs a nonlinear adjustment effect model, and tests the nonlinear adjustment effect of higher education under different regional economic development levels and government fiscal expenditure on science and technology. Referring to Hansen's threshold panel model in 1999, the following model is constructed:

\[
TP_{it} = a_0 + \alpha_1 HE_{it} \cdot I(q_{it} \leq \gamma_1) + \alpha_2 HE_{it} \cdot I(q_{it} > \gamma_1) + \cdots + \alpha_s HE_{it} \cdot I(q_{it} \leq \gamma_s) + \alpha_{s+1} HE_{it} \cdot I(q_{it} > \gamma_s) + \alpha_j X_{it} + \lambda_i + \varepsilon_{it}
\]  

(2)

\(TP_{it}\) representing the operating performance level of the manufacturing industry in the province in T period, \(HE_{it}\) is the core explanatory variable, threshold variable and \(\gamma_i\) threshold value, and its regression coefficient will change with different intervals delineated by the threshold, \(I(\cdot)\) which is indicator function. If it meets the conditions, take 1 or 0 \(q_{it}\) as the threshold variable, This paper takes the regional economic development level and government financial science and technology expenditure as threshold variables, and \(\varepsilon_{it}\) is the random disturbance term, \(a_0\) is the intercept term of the model, \(X_{it}\) indicating other special controls that may affect the manufacturing performance at the provincial level.
3.2. Variable Selection
Explained variable.
Referring to the research results of scholars from other scholar, the total profits of manufacturing enterprises above designated size are used to measure the operating performance of manufacturing enterprises. Considering that the Internet can improve business performance through innovation, we choose per capita GDP and government fiscal expenditure on science and technology as threshold variables. Select the number of R&D projects, new product projects and invention patents of industrial enterprises above designated size as intermediary variables.

With reference to Chen binkai's practice, the number of people with higher education/resident population (PHF) is selected to measure the development level of regional higher education, and the full-time equivalent of R&D personnel and R&D funds of industrial enterprises above designated size are selected to measure the regional r&d level, following the common practices in existing literature and referring to Zhang Xiaoxue's practice, the average years of education is used to measure the regional human capital level (ASA). Referring to Lu Fucai's practice, the market index (ML) is used to measure the local market level.

3.3. Data Sources and Their Processing
Considering that in 2011, manufacturing enterprises above designated size were adjusted to the main business income, which led to inconsistent statistical caliber of manufacturing related data before and after 2011, in order to avoid inconsistent data caliber and improve the accuracy and completeness of data, this paper selects the panel data of manufacturing provinces from 2011 to 2018. Data mainly come from China Statistical Yearbook, official website of National Bureau of Statistics, China Industrial Statistical Yearbook and other related yearbooks. Except the market-oriented index, the other index variables take natural logarithm to eliminate the influence of dimension and hetero scedasti city.

Table 1. Descriptive statistics of variables

| Variable | Symbol | Measurement method of variable index | sample number | min |
|------|------|--------------------------------------|----------------|-----|
| Interpreted variable 1 | TP | The total profit of industrial enterprises above designated size is logarithmic | 248 | 0 |
| Interpreted variable 2 | OP | The total operating profit of industrial enterprises above designated size is logarithmic | 248 | -1.514 |
| Core explanatory variable | PHF | Number of people with higher education/resident population | 248 | 6.987 |
| Mediating variable 1 | RP | The number of R&D projects (items) of industrial enterprises above designated size is logarithmic | 248 | 2.773 |
| Mediating variable 2 | NPL | The number of new product projects (items) of industrial enterprises above designated size is logarithmic | 248 | 1.946 |
| Mediating variable 3 | PGN | The number of invention patents of industrial enterprises above designated size is logarithmic | 248 | 3.466 |
| Threshold | PGDP | Take logarithm for Internet broadband access users (10,000 households) | 248 | 9.706 |
4. Result Analysis and Brief Discussion

4.1. Basic Estimation Results

| Variable 1 | Threshold variable 2 | FE | Logarithm of financial expenditure on science and technology | 248 | 1.218 | 6.942 | 4.113 | 1.090 |
|------------|----------------------|----|-----------------------------------------------------------|-----|-------|-------|-------|-------|
| Control variable 1 | ASA | | Average years of education | 248 | 4.222 | 14.18 | 9.204 | 1.265 |
| Control variable 2 | FE | | Logarithm of full-time equivalent of R&D personnel in industrial enterprises above designated size | 248 | 3.091 | 13.34 | 10.40 | 1.702 |
| Control variable 3 | RF | | R&D funds of industrial enterprises above designated size (10,000 yuan) | 248 | 7.401 | 13.34 | 10.40 | 1.702 |
| Control variable 4 | LOAN | | The balance of each loan is logarithmic | 248 | 6.004 | 11.89 | 9.923 | 0.935 |
| Control variable 5 | ML | | Market-oriented total index score | 248 | -1.140 | 10.83 | 6.421 | 2.209 |

Table 2. Basic regression results

| Variable | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) |
|----------|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| PHF      | 0.239 | 0.155 | 0.2216 | 0.4635* | 0.253 | 0.3153 | 0.397 | 0.239 | 0.258 | 0.264 | 0.413 |
| ASA      | -0.267 | -0.136 | -0.2853 | 0.0084 | -0.156 | 0.1147 | 0.188 | -0.268 | -0.288 | -0.291 | -0.314 |
| FE       | -0.268 | -0.135 | 0.2699 | 0.548** | 0.515 | 0.5982 | -0.023 | -0.268 | -0.304 | -0.298 | -0.238 |
| RF       | 0.760 | 0.943 | 0.0400 | 0.5012* | 0.269 | 0.1298 | 0.410 | 0.760 | 0.764 | 0.756 | 0.722 |
| ML       | 0.049 | 0.001 | 0.5844 | 0.0528 | 0.141 | 0.1619 | 0.174 | 0.049 | 0.044 | 0.048 | 0.019 |
| LOAN     | 0.308 | 0.308 | 0.1298 | 0.0678 | 0.2189 | 0.742 | 0.308 | 0.388 | 0.381 | 0.384 | 0.349 |
| RP2      | 0.000 | 0.0001 | 0.117 | 0.097 | 0.097 | 0.097 | 0.097 | 0.097 | 0.097 | 0.097 | 0.097 |
| NPL      | 2 | | | | | | | | | |
| PGN      | 3 | | | | | | | | | |
Table 2 reports the basic regression results of the model. In order to select a more suitable research model, referring to Professor Chen Qiang’s point of view, the auxiliary regression method is used to test. The test results show that the fixed effect model is superior to the mixed regression OLS model, and the robust standard error can solve the deficiency of heteroscedasticity of panel data. In order to improve the accuracy of the results, the fixed effect model considering robust standard error is chosen as the main model, and the following analysis is aimed at it. At the national level, higher education can improve manufacturing performance, with Table 3 Intermediary test higher education increasing by 1% and manufacturing performance increasing by 0.239%, the regression coefficients of higher education in eastern, central and western regions are 0.1559, 0.2216 and 0.4635, respectively, indicating that higher education is positively correlated with manufacturing performance and can effectively improve manufacturing can performance, but the regression coefficients in eastern and central regions are not significant, while in western regions are significant at 1%. There are many colleges and universities in the central and eastern regions, with complete disciplines, and there is a large space for integration with the manufacturing industry; higher education should be further strengthened to connect with the manufacturing industry. Considering the large performance base of the manufacturing industry in the central and eastern regions, it failed the significance test. However, there are relatively few universities in the western region, and the manufacturing industry started late. Under the western development strategy, the combination of universities and manufacturing industry is better, so the regression coefficient is larger and significant than that in the central and eastern regions. The research hypothesis (1) is verified.

4.2. Mechanism Analysis
In order to test the influence of higher education on the operating performance of manufacturing industry, this paper studies its mechanism. Taking R&D projects of industrial enterprises above designated size, new product projects of industrial enterprises above designated size and the amount of invention patents of industrial enterprises above designated size as explanatory variables, this paper studies the mechanism of higher education on manufacturing business performance, and the results are shown in Table 3(10)-(16). For every 1% increase in higher education, R&D projects in industrial enterprises increase by 0.2583%, new product projects in industrial enterprises increase by 0.3153%, and invention patents in industrial enterprises increase by 0.424%. The results show that the performance of manufacturing industry increases by 0.0001%, 0.0001% and 0.1176% for every 1% increase in R&D projects, new product projects and invention patents of industrial enterprises that lag behind the second stage. It can be seen that R&D projects and new product projects of industrial enterprises can increase the performance of manufacturing industry, but their boosting effect is obviously less than that of invention patents of industrial enterprises, which shows that R&D investment and new product development have certain risks. A lot of manpower and material resources have to be invested, and the invention patents are more targeted, which is more conducive to the improvement of manufacturing performance. Therefore, even if the data lags behind two periods, the R&D investment and the boosting effect of new product development are still significantly less than that of invention patents. The research hypotheses (2)-(4) have been verified, which is similar to the research results of other scholars.
4.3. Robustness and Endogenous Variable Test

According to the research of relevant scholars, in order to ensure the robustness of the regression results, the method of replacing explanatory variables is adopted for regression, and the operating profit is taken as an alternative indicator of the total profit. The results are shown in Table 4(12), and the results show that it is significantly positive for the operating performance of the manufacturing industry. In order to further test the robustness of the conclusion, the explanatory variable is replaced by operating profit (PR), and the regression annual interval from 2011 to 2018 is adjusted to 2011-2017 by adjusting the regression interval. The results are shown in Table (13). (12) The regression coefficient of Internet in China is 0.2291, which indicates that for every 1% increase of Internet, the profit rate of manufacturing main business will increase by 0.2291%. The regression coefficient of Internet indicators in Table 4(13) is 0.2670, which is basically consistent with the interval regression results from 2011 to 2018. Higher education can improve the operating performance of manufacturing industry. On the contrary, the development of manufacturing industry also has an impact on higher education, because of the interaction between independent variables and dependent variables, it will affect the regression results and produce deviations. In order to solve the adverse effects of endogenous problems on research, this paper tries to use authoritative data such as National Bureau of Statistics and China Industrial Statistics Yearbook in data collection. In order to avoid the endogenous problem caused by missing variables, we added the control variables such as turnover of technology market, average years of education, full-time equivalent of R&D personnel in industrial enterprises above designated size, R&D funds of industrial enterprises aboven designated size and balance of various loans, and adopted the fixed effect model.

### Table 3. Robustness and Endogenous Variable Test

| Variable | (12)     | (13)     | (14)     | (15)     |
|----------|----------|----------|----------|----------|
|          | OP       | TP(2011-2017) | TP       | TP       |
| PHF      | 0.2291** | 0.2670**  |          |          |
| ASA      | -0.2938***| -0.2904***| -0.3038***| -0.3200***|
| FE       | -0.2638* | -0.2622*  | -0.2361  | -0.2377  |
| RF       | 0.7265***| 0.7790*** | 0.7183***| 0.6674** |
| ML       | 0.0691   | 0.0559    | 0.0730   | 0.1067   |
| LOAN     | 0.2612*  | 0.2631*   | 0.3370*  | 0.4073*  |
| PHF1     |          | 0.2527*   |          |          |
| PHF2     |          |          | 0.1996*  |          |
| _cons    | -2.3237**| -3.3987***| -3.4935**| -3.1805* |
| N        | 248      | 217       | 186      | 155      |
| R2       | 0.692    | 0.752     | 0.743    | 0.728    |
| adj. R2  | 0.684    | 0.744     | 0.734    | 0.717    |
| F        | 976.9034 | 1152.8091 |          |          |
| p        | 0.0000   | 0.0000    |          |          |

Based on the understanding that the improvement of current manufacturing business performance has almost no influence on higher education lagging behind the first stage and the second stage, if higher education lags behind the first stage and the second stage, the above basic regression correspondence still exists for the current manufacturing industry, which proves that higher education is the main cause in the two-way causal relationship. To avoid endogenous problems caused by mutual causation, we can find that the results in Table 4(14)-(15) are consistent with the basic regression results in Table 2 by using the lagging first and second periods of higher education as the core test variables for regression analysis, so it can be proved that the Internet is the main cause of the bidirectional causal relationship between Internet and manufacturing performance.

4.4. Threshold Regression Analysis
It is necessary to check whether there is a threshold value for regional economic development, so that the relationship between higher education and manufacturing performance will change in structure. Referring to F statistics and LR statistics proposed by Hansen(1999), this paper tests the "threshold condition" of GDP per capita. With the software stata14.0, the Bootstrap algorithm is used to sample and estimate for 500 times, and the results of F statistic test and specific threshold estimation are shown in Table 6, and the estimated value likelihood ratio function diagram is shown in Figure 1-2.

![Figure 1. Threshold effect chart with per capita GDP as the threshold](image1)

![Figure 2. Threshold effect chart based on government financial expenditure on science and technology](image2)

According to table 5-6, it can be concluded that the f value of double thresholds rejects the zero hypothesis that there is no threshold value at the significance level of 5%, the f statistics are significant at the significance level of 1%, and the f statistics of triple thresholds are not significant. Therefore, this paper chooses double threshold regression model for model estimation. Using hansen's research method, the threshold value of sampling estimation is tested by likelihood ratio statistics LR, When LR is equal to zero, the threshold value estimated by sampling is equal to the true threshold value [6].

**Table 4. Threshold effect estimation and test results with PGDP as threshold**

| RD1 as the threshold | Threshold value | F value | P value | BS frequency | 1% critical value | 5% critical value | 10% critical value |
|----------------------|-----------------|--------|---------|--------------|------------------|------------------|-------------------|
| Single threshold     | 10.2576         | 27.77  | 0.112   | 500          | 57.1572          | 47.9736          | 28.9254           |
| Double threshold     | 10.1824 10.1716 | 38.12  | 0.0060  | 500          | 31.5370          | 20.1610          | 14.9163           |

**Table 5. Threshold effect estimation and test results based on government financial expenditure on science and technology**

| RD2 as the threshold | Threshold value | F value | P value | BS frequency | 1% critical value | 5% critical value | 10% critical value |
|----------------------|-----------------|--------|---------|--------------|------------------|------------------|-------------------|
| Single threshold     | 3.3962          | 12.18  | 0.1560  | 500          | 20.8547          | 15.9340          | 0.1560            |
| Double threshold     | 3.3962 3.3666   | 41.29  | 0.0060  | 500          | 23.7332          | 13.7572          | 11.5765           |

Figure 1 is a likelihood ratio function diagram of the first threshold value and the second threshold value obtained by fixing the first threshold variable (PGDP), and the threshold values are 10.1824 and 10.1716 respectively. Figure 2 is a likelihood ratio function diagram of the first threshold value and the second threshold value obtained by fixing the second threshold variable (government fiscal expenditure on science and technology), and the threshold values are 3.3962 and 3.3666 respectively.

It can be seen from table 6 that when PGDP is lower than 10.1716, the regression coefficient of higher education to manufacturing performance is 0.2979, ranging from 10.1716 to 10.1824, the regression coefficient of higher education to manufacturing performance is 0.0265, greater than
10.1824, and the regression coefficient of higher education to manufacturing performance is 0.3446. Higher education provides intelligence and technical support for manufacturing industry from the aspects of personnel training and innovation support, which can promote manufacturing performance. With the increase of PGDP, manufacturing upgrading has not been fully promoted. At this time, the matching degree between higher education personnel training, technological innovation and manufacturing industry has declined, and the role of higher education in boosting manufacturing performance has been significantly reduced compared with the initial stage. With the sustained economic development, manufacturing upgrading has been fully rolled out, and the matching degree between personnel training, technological innovation and manufacturing industry in higher education has been enhanced.

Table 6. Threshold effect estimation and test results

| Variable | (16) PGDP | (17) FE |
|----------|-----------|---------|
| ASA      | -0.3457***| -0.2903***|
| FE       | -0.4031** | -0.2545* |
| RF       | 0.8761*** | 0.7428***|
| ML       | 0.0539    | 0.0310  |
| LOAN     | 0.3168**  | 0.2699**|
| PHF_1    | 0.2979    | 0.3790* |
| PHF_2    | 0.0265    | 0.1009  |
| PHF_3    | 0.3446*   | 0.4071**|
| Constant | -3.8483** | -3.8818**|
| Observations | 248      | 248     |
| Number of year | eight   | eight   |
| R-squared  | 0.8145    | 0.8156  |

5. Main Conclusions
This paper studies the relationship between higher education and the improvement of manufacturing performance from the theoretical and empirical aspects by using the panel data of the province from 2011 to 2018, and selects the lagging variables of higher education for regression analysis to overcome the endogenous problem. Using substitution variables and adjustment variables to return to the annual interval for robustness test, so as to ensure the robustness of the conclusion. On this basis, PGDP and government expenditure on science and technology are selected as threshold variables to investigate the relationship between higher education and manufacturing performance.

Acknowledgment
This paper is supported by: key supported planning subject for the 13th Five-Year plan of Jiangsu education sciences (Ba/2016/01/30); the first level key construction discipline project of business administration in Jiangsu Province during the 13th Five-Year Plan Period(sjy201609); Jiangsu University Humanities and Social Sciences Out-of-school Research Base Project “Tonghu Industrial Cooperative Development Research Base”(2017ZSJQD017), Nantong, Jiangsu 226002, PR China.

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