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# On the Relationship between Innovation Activity and Manufacturing Upgrading of Emerging Countries: Evidence from China

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**Abstract:** Most research into the relationship between innovation activity and manufacturing upgrading has been conducted in developed economies, such as the countries of North America and Europe. Due to the non-replicability of the developed countries' development modes, most emerging countries cannot directly copy the manufacturing upgrading path of the developed countries. However, knowledge about the relationship between innovation activity and manufacturing upgrading in emerging economies remains limited. This paper sheds light on the relationship between innovation activity and manufacturing upgrading in emerging countries from the following three types of innovation, namely, technical innovation, product innovation, and institutional innovation. By using data from Chinese provinces for the period 2001–2015, this paper empirically investigates the relationship between innovation activity and manufacturing upgrading in emerging countries. The results show that technical innovation, product innovation, and institutional innovation have significantly positive driving-force effects on manufacturing upgrading, which indicates that innovation is an important source of promoting manufacturing upgrading for emerging countries. Moreover, the effect above is more prominent for technical innovation. The results are resilient to the alternative indicators of innovation and the alternative indicators of manufacturing upgrading. This paper provides a theoretical and empirical reference for conducting innovation-incentive policy and promoting the optimization of manufacturing structure.

**Keywords:** innovation activity; manufacturing upgrading; emerging countries

## 1. Introduction

Economists have not paid enough attention to the relationship between innovation activity and manufacturing upgrading of emerging countries, since the existing studies focus on the topic above from the perspective of developed countries. As the global economy continues to be sluggish, countries around the world have realized that manufacturing industries play an important role in creating jobs and driving economic growth. Meanwhile, the recent rise of de-globalization and international trade protectionism has brought tremendous pressure to developing countries. In addition, the industrial powers in Europe and the United States actively formulate industrial policies to revitalize manufacturing industry, and increase the blockade of the core technology. All these facts increase the challenges for developing countries to climb up the global value chain of manufacturing industries. What interests us is whether innovation activity could be a driving force to promote manufacturing upgrading of emerging countries?

The significance of this paper lies in the following aspects. First, emerging economies are one of the most important parts of the global economy, which is a great driving force for the growth of the global economy. According to the Boao Forum for Asia Annual Conference 2018, the employment

market is stable and economic growth is rising steadily in emerging economies. Second, the existing studies do not pay enough attention to the fact that the industrial upgrading of emerging countries has been impeded. In this study, industrial upgrading refers to the process of industrial evolution from low value-added and low technical level to high value-added and high technical level. Industrial upgrading must rely on technical progress. Fernandez showed that the manufacturing industries of emerging economies are at the low end of the global value chain, which make them fall into the situation in which their income per capita and technology improve slowly [1]. Third, Baldwin showed that the industrialization path in developed countries is extremely complex, and developing countries cannot successfully copy their development model [2]. Moreover, as more later-developing countries enter into the global economy, some countries with low wages and rich resources will fall into long-term decline after a period of prosperity. Therefore, industrial upgrading helps to avoid the "lock-in" and "crowding-out" effects, which is conducive to promoting the upgrading of the value chain in emerging economies.

In this paper, we choose China as one typical representative of emerging countries to analyze the relationship between innovation activity and manufacturing upgrading. First, along with the new development stage of China's economy entering the new normal, the industrial structure of China's manufacturing industry has been further optimized and the technical innovation capacity of enterprises has been further strengthened. In 2017, China, as the largest emerging economy, contributed to about one-third of the global economic growth. Second, at present, most of China's manufacturing enterprises are at the middle and low end of the industrial chain. China's manufacturing enterprises should increase the spending on R&D and human input to enhance the technical innovation capacity of enterprises. It is still a major practical problem that needs to be solved in China's economy. In addition, there is a significant difference in the development of manufacturing in different regions of China, which provide a perfect sample to conduct empirical testing.

At present, the improvement of China's manufacturing innovation capability is mainly due to the cross-border flow of technology and the ability to learn-by-doing, but excessive dependence on foreign technology forces China's manufacturing industry to lock in the downstream of the value chain [3]. In order to cope with this dilemma, the Chinese government introduced the "Made in China 2025" charter, whose aim is to build internationally competitive manufacturing. "Made in China 2025" puts forward five principles, namely innovation-driven, quality first, green development, structural optimization, and talent-oriented. Under this background, the technological innovation activities of manufacturing enterprises will undergo a disruptive change. In summary, to achieve further upgrading of the manufacturing industry, China vigorously promotes the "innovation-driven" strategy.

The recent studies could be divided into the following two branches. The first branch of literature is mostly related to the manufacturing industry in some regions or countries. Koopman et al. studied metal products and found that from the perspective of increments, the industrial competitiveness of emerging economies, such as China and India, decreased significantly, while the competitiveness of developed economies in Europe and America was significantly underestimated [4]. Taking Latin America as an example, Giuliani et al. showed that global purchasers would restrict local enterprises' industrial upgrading in order to maintain their leading position in the global value chain [5]. With the development of the manufacturing industry, the scale of producer services expands gradually. In turn, producer services can further reduce the relevant costs in the value chain of the manufacturing industry on the basis of improving the knowledge content and added value of manufacturing products, which is strong support for the manufacturing industry to realize the value chain upgrading [6].

The second branch of literature mainly focuses on the relationship between innovation activity and manufacturing upgrading. Most of the studies supports the idea that innovation promotes the upgrading of the manufacturing industry. The relevant studies focus on technology innovation of enterprises, knowledge spillover and technology transfer, and government institutional quality [3,7–10]. From the perspective of technical innovation, Stuart points out that technology is the core competitiveness of enterprise development, and innovation is the key driving force of enterprise

competitive strategy [11] The enterprise R&D center can reduce the coordination cost of R&D activities within the company, expand the scope and depth of technical knowledge, and further promote manufacturing upgrading [12,13]. For enterprises, Bernile et al. show that the improvement of innovation efficiency and the promotion of technical innovation level help to enhance international competitiveness and functionality upgrades [14]. From the perspective of the value chain, Aghion also defines upgrading as a change in manufacturers' economic role, which is manifested in the improvement of manufacturers' value [15].

Some scholars have also studied the role of innovation in promoting manufacturing upgrading from the perspectives of product innovation and institutional innovation. On one hand, Dangelico et al. show that product innovation improves the efficiency of resource utilization and promotes sustainable development of enterprises [16]. Amiti studies the relationship between the tariff and quality upgrading for products from the perspective of product quality, and production innovation is conducive to quality upgrading for products [17]. On the other hand, some other scholars have emphasized the important role of institutional innovation in the promotion of manufacturing upgrading. Chang et al. built a panel data model and found that government policy had a positive effect on the innovation performance of enterprises [18]. Czarnitzki et al. point out that the R&D support from the government can make up for the low performance of an enterprise's innovation [19,20].

However, most research studies in the manufacturing industry are concentrated on developed countries, such as Europe and the United States, but research on emerging economies is insufficient. Moreover, most scholars only study the impact of innovation on the upgrading of the manufacturing industry from the perspective of technical innovation. Few scholars consider the impact of different forms of innovation in the roles of enterprises and government. Pietrobelli et al. show that the overall institutional environment and innovation system play a crucial role in the development of overall innovation capability [21].

The rest of the paper is organized as follows. Section 2 analyzes the evolution and innovation level of China's manufacturing industry; Section 3 puts forward the hypothesis and expounds the relationship between innovation activity and manufacturing upgrading; Section 4 establishes the function model and chooses the data indices; Section 5 is the regression analysis; Section 6 is the robustness checks; Section 7 is the research conclusion and policy suggestion.

This paper contributes to the literature in the following three ways. First, this paper focuses on emerging countries to comprehensively explore the relationship between innovation activity and manufacturing upgrading. Second, this paper selects four indicators to measure the manufacturing upgrading and three forms of innovation to measure the innovation activity, which helps to achieve more robust and convincing results. Moreover, this paper also explores the relative importance of three forms of innovation in promoting the manufacturing upgrading. Third, this paper selects the European Union as the representative for developed economies to compare the innovation driving force of manufacturing upgrading between emerging countries and developed countries, which helps draw more meaningful policy implications for emerging countries.

## 2. The Typical Facts of China

### *2.1. The Development Trend of China's Manufacturing Upgrading*

From Figure 1a we can draw conclusions that with China's manufacturing upgrading, the level of the manufacturing structure is improving. Whether from an overall perspective or from a regional perspective, the proportion of output value of labor-intensive industries and technology-intensive industries declined during 2001–2015, and the proportion of output value of capital-intensive industries increased during 2001–2015. For instance, at the overall level, from 2001 to 2015, the proportion of output value of labor-intensive industries declined from 20.06% to 19.71%, the proportion of output value of capital-intensive industries increased from 32.65% to 35.24%, and the proportion of output

value of technology-intensive industries decreased from 47.29% to 45.05%. From a regional perspective, the proportion of output value of labor-intensive industries in the Eastern region is lower than that in the Central region and in the Western region in 2015, while the proportion of output value of technology-intensive industries is higher than that in the Central region and in the Western region in 2015. Therefore, we find that manufacturing upgrading is better in the Eastern region and weaker in the Central region and in the Western region.

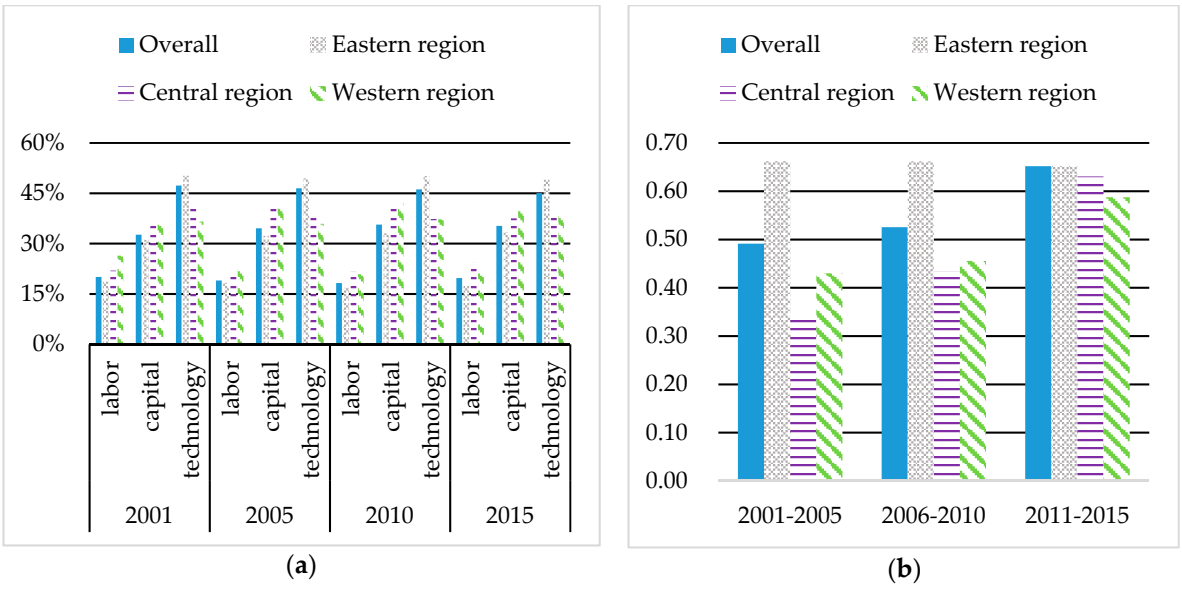


**Figure 1.** (**a**) Proportion of output value of different factor-intensive industries among China's manufacturing industry during the period of 2001–2015. (**b**) Average value of manufacturing innovative efficiency among different regions of China during the period of 2001–2015. Note: Calculated according to *China Industrial Statistical Yearbook*.

### *2.2. The Innovation Level of China's Manufacturing Industry*

This paper chooses to use the Data Envelopment Analysis (DEA) method to evaluate the efficiency of China's manufacturing upgrading. Data Envelopment Analysis (DEA) is the most commonly used non-parametric envelopment efficiency analysis method, used to evaluate the efficiency of multi-input and multi-output. Compared with efficiency evaluation methods such as parametric analysis, the method of DEA has the following advantages. First, DEA is more suitable for handling the problem of multi-input and multi-output. Differing from other efficiency evaluation methods dealing with single output, DEA can deal with multi-input-multi-output problems and does not need to construct a production function to estimate parameters. Second, no weight assumption is required. The weights in the DEA are not affected by human subjectivity, but are generated by mathematical programming and do not need to be assigned with weights in advance. The evaluation results are relatively fair. Third, it is not affected by rigid input and output indices. DEA method will not affect the final efficiency evaluation result due to the difference of measurement units. The larger the efficiency value is, the higher the innovation efficiency is. More directly, a higher level of innovation means a more reasonable allocation of innovation resource and input-output structure.

This paper uses the Data Envelopment Model (DEA) to calculate the innovative efficiency of the provinces from 2001 to 2015. The two input indices are measured by R&D internal expenditure and R&D full-time personnel equivalent. The two output indices are measured by numbers of patent applications and new product sales revenue. The results are reported in Figure 1b.

In Figure 1b, the innovation efficiency overall, and for the three regions, was no more than 0.7; this shows that the innovation level of China's manufacturing industry is not high. As can be seen from Figure 1b, the innovation efficiency of the Eastern region is higher than that of the Central and Western regions. Through the three stages of comparison, the overall innovation efficiency continues rising, while the innovation efficiency in the Eastern region remains basically stable. The innovation efficiency of the Central and Western regions has also been increasing.

It can be seen from Table 1 that the innovation efficiency of manufacturing industries in various provinces during the period of 2001–2013 have generally increased, while the innovation efficiency during 2013–2015 decreased. For convenience, the abbreviations of provinces are shown in Table 1. This also shows that China's manufacturing industry has experienced a period of rapid development, and then it has entered a bottleneck period. We found that the innovation efficiency is related to the level of economic development. The innovation efficiency of developed provinces, such as Chongqing and Guangdong, are close to 1, while the innovation efficiency of underdeveloped provinces, such as Gansu and Qinghai, are less efficient. The high-quality economic foundation would lead to the enhancement of innovation activities and the improvement of innovation efficiency, which, in turn, promotes industrial upgrading.

**Table 1.** The innovation efficiency of manufacturing industries in China during 2001–2015.

| | **2001** | **2003** | **2005** | **2007** | **2009** | **2011** | **2013** | **2015** |
|---|---|---|---|---|---|---|---|---|
| Beijing (BJ) | 0.568 | 0.241 | 0.447 | 0.215 | 0.580 | 0.726 | 0.884 | 0.598 |
| Tianjin | 0.948 | 1.000 | 1.000 | 0.654 | 0.796 | 0.751 | 0.746 | 0.717 |
| Hebei | 0.309 | 0.207 | 0.306 | 0.302 | 0.394 | 0.475 | 0.738 | 0.578 |
| Liaoning | 0.297 | 0.264 | 0.323 | 0.285 | 0.519 | 0.461 | 0.638 | 0.723 |
| Shanghai | 1.000 | 0.975 | 1.000 | 0.799 | 0.742 | 0.837 | 1.000 | 0.771 |
| Jiangsu | 0.639 | 0.485 | 0.470 | 0.566 | 0.521 | 0.925 | 0.907 | 0.671 |
| Zhejiang | 0.416 | 0.795 | 0.242 | 0.851 | 1.000 | 1.000 | 0.595 | 0.579 |
| Fujian | 0.661 | 0.734 | 0.705 | 0.441 | 0.601 | 0.409 | 0.461 | 0.367 |
| Shandong | 1.000 | 0.552 | 0.613 | 0.677 | 0.739 | 0.528 | 0.739 | 0.669 |
| Guangdong | 0.892 | 0.732 | 0.989 | 1.000 | 1.000 | 0.979 | 1.000 | 0.739 |
| Hainan | 1.000 | 1.000 | 1.000 | 1.000 | 0.893 | 0.466 | 0.691 | 0.499 |
| Shanxi | 0.150 | 0.196 | 0.394 | 0.217 | 0.279 | 0.332 | 0.425 | 0.349 |
| Heilongjiang | 0.256 | 0.174 | 0.269 | 0.187 | 0.218 | 0.219 | 0.432 | 0.276 |
| Jilin | 0.929 | 0.186 | 0.765 | 0.390 | 1.000 | 1.000 | 1.000 | 1.000 |
| Anhui | 0.472 | 0.227 | 0.421 | 0.618 | 0.596 | 1.000 | 0.882 | 0.747 |
| Jiangxi | 0.269 | 0.182 | 0.302 | 0.303 | 0.272 | 0.381 | 0.444 | 0.382 |
| Henan | 0.312 | 0.245 | 0.421 | 0.400 | 0.474 | 0.519 | 0.701 | 0.597 |
| Hubei | 0.323 | 0.234 | 0.440 | 0.292 | 0.462 | 0.366 | 0.462 | 0.416 |
| Hunan | 0.389 | 0.234 | 0.440 | 0.292 | 0.462 | 0.366 | 0.462 | 0.416 |
| Neimenggu | 1.000 | 0.497 | 0.514 | 0.252 | 0.370 | 0.364 | 0.350 | 0.246 |
| Guangxi | 0.718 | 0.382 | 0.723 | 0.410 | 0.514 | 0.417 | 0.551 | 0.575 |
| Chongqing | 1.000 | 1.000 | 1.000 | 0.897 | 1.000 | 1.000 | 1.000 | 1.000 |
| Sichuan | 0.451 | 0.320 | 0.371 | 0.291 | 0.560 | 0.609 | 0.698 | 0.704 |
| Guizhou | 0.193 | 0.228 | 0.272 | 0.469 | 0.677 | 0.693 | 0.788 | 0.673 |
| Yunnan | 0.416 | 0.306 | 0.242 | 0.355 | 0.444 | 0.514 | 0.595 | 0.579 |
| Shaanxi | 0.141 | 0.109 | 0.328 | 0.218 | 0.384 | 0.444 | 0.573 | 0.361 |
| Gansu | 0.262 | 0.123 | 0.259 | 0.222 | 0.261 | 0.550 | 0.678 | 0.507 |
| Qinghai | 0.403 | 0.165 | 0.269 | 0.403 | 0.269 | 0.304 | 0.327 | 0.287 |
| Ningxia | 0.672 | 0.671 | 0.240 | 0.167 | 0.358 | 0.386 | 0.417 | 0.427 |
| Xinjiang | 0.331 | 0.394 | 0.382 | 0.319 | 0.457 | 0.462 | 0.910 | 0.498 |

Note: Calculated according to *China Science and Technology Statistical Yearbook*.

## 3. Theoretical Analyses

### *3.1. Theoretical Hypotheses*

As mentioned above, this paper analyzes the relationship between innovation activity and manufacturing upgrading of emerging countries from the following three aspects.

In this study, technological innovation mainly indicates the increase of output per unit input of enterprises and is manifested in the improvement of internal production technology and equipment. It is also manifested in the increase of raw material utilization efficiency and the simplification of processing technology [20]. Jiang et al. show that technical innovation has a positive role in promoting the upgrading of manufacturing [22]. On one hand, the increasingly diverse demand of the market encourages enterprises to implement technical innovation. Innovation activities would lead to technical progress and the optimization of resources allocation, and in turn, drive the manufacturing upgrade. Romer emphasizes that the technical change drives economic growth [23]. Technical innovation also increases labor productivity to promote industrial upgrading. Jer shows that innovation promotes industrial upgrading by enhancing innovators' positions in the international division [24]. Jefferson et al. confirm that technical innovation plays a significant role for enterprises in developing new products and improving production efficiency [25]. Berchicci and Chen et al. suggest that technical innovation can significantly improve the innovation performance of enterprises [26,27]. On the other hand, if an enterprise implements technical innovation, it will be more conducive to the improvement of innovation abilities. The enterprises with technical innovation would be more specialized; this is embodied in the transfer of technology matching elements, such as knowledge and information, from internal to other related enterprises. In addition, Tsai and Wang point out that the R&D investment in high-tech sectors has a spillover effect on productivity growth [28]. The development of high-tech industries is accompanied by the development of innovation activity and industrial upgrading. For emerging countries, low-tech enterprises can imitate the technology from domestic high-tech enterprises or from the enterprises in developed economies. Based on the analyses above, we can propose hypothesis 1 as follows.

**Hypothesis 1 (H1):** *Technical innovation does promote upgrading of the manufacturing industry.*

Product upgrading is a key indicator of the concentrated expression of enterprise innovation and industrial upgrading. This paper analyzes the impact of product innovation on manufacturing upgrading from the following two perspectives. On one hand, from the perspective of product innovation motivation, consumers' demand for new products encourages manufacturing companies to develop new products and promote high-tech product evolution. As for enterprises, the emergence of new products has enhanced their competitiveness and accelerated technical progress, and as a result, manufacturing would upgrade along with this progress [20]. On the other hand, from the perspective of product evolution, Hausmann et al. proposed "product space" at the global level, and pointed out that the comparative advantage of products is a key factor in industrial upgrading [29]. Emerging countries should gradually upgrade their product mix from goods with traditional cost advantages to goods with modern technical advantages. Product innovation with destructive creation is the key reason for the formation of the industry's competitiveness. Dangelico et al. studied green product innovation under a dynamic capability perspective. They show that from the perspective of sustainable development, the improvement of green innovation capability can promote market performance [16]. Innovation and imitation strategies are conducive to new product performance [30]. After undergoing product innovation with destructive creation, the industry would launch a series of innovations and form an industrial cluster, which leads to the sustainable development of the industry and the upgrading of manufacturing. For emerging countries, the enterprises could use their own abundant resources to conduct product innovation to enhance their competitiveness in the market. At the same time, the enterprises of emerging countries need a lot of financial, technical, and human resource support,

which promotes the upgrading of manufacturing. Based on the analyses above, we can propose hypothesis 2 as follows.

**Hypothesis 2 (H2):** *Product innovation does promote manufacturing upgrading.*

In this paper, institutional innovation mainly refers to the improvement of government system efficiency. For governments, the ways to achieve institutional innovation include the improvement of industrial policies and the establishment of public systems. Potts et al. showed that institutional innovation promotes economic growth and industrial upgrading [9]. The mechanism of institutional innovation affecting industrial upgrading can be summarized as two points. First, institutional innovation would make up for market defects [20]. A good institutional environment is conducive to the effectiveness of resources allocation and the enhancement of innovation activity. This helps to promote technical progress and the upgrading of manufacturing. More directly, the capacity of technical innovation depends on the quality of the country's institutions [20,31]. Kole and Mulherin find that government innovation policies have a positive effect on enterprises' innovation performance [32]. Second, institutional innovation would enhance market competitiveness. Michael points out that the innovation environment and the innovation ability of enterprises are the important factors affecting productivity, and the improvement of labor productivity is the key to the formation of competitive advantage in an industry [33]. Institutional innovation improves the environment of innovation activity and promotes manufacturing upgrading. For emerging countries, the perfect patent system and the sophisticated government system are conducive to developing innovation activities of enterprises. Based on the analyses above, we can propose hypothesis 3 as follows.

**Hypothesis 3 (H3):** *Institutional innovation does promote manufacturing upgrading.*

### *3.2. A Simple Model*

It is assumed that technical innovation, product innovation, and institutional innovation drive manufacturing upgrading. The Cobb-Douglas function models are:

$$Y_{t1} = A_t * K_t^{\alpha} * L_t^{\beta} * TE_t^{\sigma} * O_{t1} \quad (1)$$

$$Y_{t2} = A_t * K_t^{\alpha} * L_t^{\beta} * PR_t^{\gamma} * O_{t2} \quad (2)$$

$$Y_{t3} = A_t * K_t^{\alpha} * L_t^{\beta} * IN_t^{\theta} * O_{t3} \quad (3)$$

where $Y_{it}$ ($i$ = 1, 2, 3) is the manufacturing upgrading index in year $t$; $A_t$ is the manufacturing technical level in year $t$; $K_t$ is the manufacturing capital input in year $t$; $L_t$ is the manufacturing labor input in year $t$; $TE_t$ is the manufacturing technical innovation index in year $t$; $PR_t$ is the manufacturing product innovation index in year $t$; $IN_t$ is the manufacturing institutional innovation index in year $t$; $O_{it}$ ($i$ = 1, 2, 3) is the other variable; $\alpha$, $\beta$, $\sigma$, $\gamma$, and $\theta$ are the elastic coefficients of labor input, capital input, technical innovation index, product innovation index, and institutional innovation index to manufacturing upgrading index, respectively.

Taking the natural logarithm of both sides of three equations and adding stochastic error ($\mu_{it}$, $i$ = 1, 2, 3), the following linear regression model is obtained.

$$lnY_{t1} = lnA_t + \alpha lnK_t + \beta lnL_t + \sigma lnTE_t + lnO_{t1} + \mu_{t1} \quad (4)$$

$$lnY_{t2} = lnA_t + \alpha lnK_t + \beta lnL_t + \gamma lnPR_t + lnO_{t2} + \mu_{t2} \quad (5)$$

$$lnY_{t3} = lnA_t + \alpha lnK_t + \beta lnL_t + \theta lnIN_t + lnO_{t3} + \mu_{t3} \quad (6)$$

The parameter estimation method for linear regression model is used to estimate the elastic coefficients $\sigma$, $\gamma$, $\theta$ of the manufacturing technical innovation index, product innovation index, and institutional innovation index to the manufacturing upgrading index. If the elasticity coefficient is greater than 0, it indicates that the innovation index has a positive impact on manufacturing upgrading; if the elasticity coefficient is equal to 0, the innovation index has no effect on the manufacturing upgrading; if the elasticity coefficient is less than 0, it indicates that the innovation index has a negative impact on the manufacturing upgrading. The magnitude of the absolute value of the elasticity coefficient reflects the extent of the impact of this innovation index to manufacturing upgrading.

## 4. Econometric Specification and Data Selection

### *4.1. Econometric Specification*

This paper mainly discusses the relationship between innovation activity and manufacturing. Therefore, the manufacturing upgrading index is the dependent variable, and the corresponding index of technical innovation, product innovation, and institutional innovation are selected as the key explaining variables. Based on existing research, the other variables include economic development level, investment growth rate, and human capital level [20]. On the basis of these analyses, the following econometric model is established.

$$Y_{it} = \beta_0 + \beta_1 * Innov_{it} + \lambda * OV_{it} + \varepsilon_{it} \quad (7)$$

where $i$ is the province ($i$ = 1, 2, ... , 30, Tibet is eliminated because of the lack of data); $t$ is the year; $Y$ is the manufacturing upgrading index; the key explaining variable *Innov* is the innovation index, consisting of technical innovation TE, product innovation PR, and institutional innovation IN, which are represented by R&D internal expenditure, new product sales revenue, and institutional comprehensive index; *OV* is a collection of other variables, which consists of economic development level (EDL), investment growth rate (INV), and human capital level (HC); $\beta_0$ is a constant term, $\beta_1$ is key explaining variable coefficient, $\lambda$ is the coefficient of other variables , and $\varepsilon$ is stochastic error.

### *4.2. Variable and Data*

#### 4.2.1. The Dependent Variable

$Y$ is the manufacturing upgrading index. Industrial upgrading is mainly manifested in two aspects. One is the improvement of the industrial structure, and the other is the increase of industrial quality and efficiency. There are four dependent variables selected in this paper. The main business income of the high-tech manufacturing industry and total profit and tax of the manufacturing industry can reflect industrial efficiency from the perspective of profitability. Labor-productivity and Total Factor Productivity (TFP), as important indicators of industrial upgrading, reflect changes in industrial structure and production efficiency. Manufacturing upgrading is manifested in the optimization of manufacturing structure, the enhancement of labor-productivity, and the improvement of technical level and product quality. The high-tech industry has developed rapidly in the past 20 years, and the upgrading of the high-tech manufacturing industry can reflect the upgrading of China's manufacturing industry to some extent. The development of core industries can represent the development of manufacturing upgrading in a region. The development of high-tech industries reflects the degree of regional manufacturing structure, so the manufacturing revenue of high-tech industries can be used to measure manufacturing upgrading. The data comes from *China Industrial Statistics Yearbook*.

#### 4.2.2. The Key Explaining Variable

This paper selects indices from two perspectives, technical innovation and product innovation at the micro level, and institutional innovation at the macro level.

(a) Technical innovation (TE) and product innovation (PR)

This paper uses R&D internal expenditure to measure technical innovation, and uses the new product sales revenue of large-sized and medium-sized industrial enterprises to measure product innovation. The data comes from *China Science and Technology Statistics Yearbook* and *Provincial Statistics Yearbook*.

(b) Institutional innovation (IN)

*IN* is an institutional innovation index. This paper is based on the principal component analysis of Sun Ninghua and Zeng Lei to calculate the index of institutional innovation [34].

#### 4.2.3. Other Variables

In baseline regression, the other variables include economic development level, investment growth rate, and human capital level.

First, EDL is the level of economic development in terms of GDP per capita. As the economy grows, consumer demand grows and diversifies, which stimulates the increase of innovation activities and new products and provides a better environment for innovation activity. It is conducive to industrial upgrading. The data comes from *China Industrial Statistics Yearbook*.

Second, INV indicates the growth rate of investment. It is measured by the proportion of the fixed asset investment in the current year and that in the previous year. The increase of investment is conducive to the development of innovation activity and the upgrading of the manufacturing industry. But once the investment scale exceeds a certain extent, it will cause inflation, overcapacity, etc. [20]. The data comes from *China Statistics Yearbook*.

Third, HC is the level of human capital level, expressed as the ratio of the number of students in regional higher education institutions to the total number of people in the region. Recently, human capital as the source of innovation has played an increasingly prominent role in industrial upgrading. Higher education level is the concentrated embodiment of regional human capital level. The increase of human capital level is to the benefit of manufacturing upgrading. The data comes from *China Statistics Yearbook*.

Besides, in order to eliminate the impact of the related index above, this paper separately conducts price adjustment and logarithm of treatment on the relevant data.

## 5. Regression Analyses

According to the conclusion in Section 2, we divide the overall area into the Eastern region and the Central and Western regions. Based on the panel data of 30 provinces in China from 2001 to 2015, this paper uses the method of Ordinary Least Square (OLS), fixed effects, and random effects models. The results are reported in Tables 2–8.

In order to accurately compare the impact of various innovation indices on manufacturing upgrading, it is necessary to calculate the standardized coefficients of the three innovation indices, calculated as follows:

$$\hat{\rho} = \rho_i * \frac{sd_i}{sd_Y} \tag{8}$$

where $\hat{\rho}$ and $\rho_i$ are the standardized estimated coefficient and the original estimated coefficient, respectively, $Y$ is the manufacturing upgrading, $i$ is technical innovation, product innovation, and institutional innovation, and $sd$ is the standard deviation of the variable. For the corresponding calculation results, see the last row in Tables 2–8.

**Table 2.** Baseline regression results during 2001–2015.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| TE | 0.25 *** | | | 0.16 *** | | | 0.41 *** | | |
| | (4.81) | | | (3.52) | | | (4.85) | | |
| PR | | 0.20 *** | | | 0.18 *** | | | 0.22 *** | |
| | | (4.89) | | | (4.32) | | | (3.83) | |
| IN | | | 0.34 *** | | | 0.20 *** | | | 0.44 *** |
| | | | (7.33) | | | (4.82) | | | (5.55) |
| EDL | 1.03 *** | 0.85 *** | 0.98 *** | 1.20 *** | 1.17 *** | 1.45 *** | 0.30 | 0.28 | 0.42 |
| | (5.42) | (4.28) | (5.47) | (4.40) | (4.38) | (5.71) | (1.07) | (0.95) | (1.52) |
| INV | −0.16 *** | −0.89 *** | −0.56 *** | −0.22 | −0.19 | −0.12 | −1.00 *** | −1.22 *** | −0.71 *** |
| | (−5.48) | (−6.32) | (−4.03) | (−1.42) | (−1.25) | (−0.79) | (−5.23) | (−6.01) | (−3.67) |
| HC | 22.49 *** | 33.99 *** | 9.23 | 11.01 * | 16.40 *** | 4.50 | 41.34 *** | 57.35 *** | 19.03 |
| | (3.13) | (5.47) | (1.30) | (1.71) | (2.94) | (0.71) | (3.44) | (5.16) | (1.38) |
| Constant | −7.22 *** | −4.73 *** | −3.69 ** | −7.04 *** | −6.81 *** | −7.44 *** | −3.20 | −0.55 | 0.82 |
| | (−4.41) | (−2.89) | (−2.33) | (−2.85) | (−2.81) | (−3.14) | (−1.36) | (−0.23) | (0.35) |
| Obs. | 450 | 450 | 450 | 165 | 165 | 165 | 285 | 285 | 285 |
| $R^2$ | 0.61 | 0.61 | 0.63 | 0.60 | 0.62 | 0.63 | 0.65 | 0.64 | 0.66 |
| $\hat{\rho}$ | 0.195 *** | 0.197 *** | 0.214 *** | 0.169 *** | 0.198 *** | 0.123 *** | 0.295 *** | 0.238 *** | 0.311 *** |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

### *5.1. Baseline Regression Results*

(A) From the perspective of the overall level.

According to the estimation results for Columns (1) to (3) in Table 2, we find that three forms of innovation have a positive coefficient at the 1% significance level, indicating that technical innovation, product innovation, and institutional innovation can all promote the upgrading of China's manufacturing industry, which validates hypothesis 1, hypothesis 2, and hypothesis 3, respectively. From the perspective of technical innovation, technical innovation promotes manufacturing upgrading by technical progress and the increase of productivity. From the perspective of product innovation, product innovation promotes manufacturing upgrading by developing new products to enhance enterprises' competitiveness in the market. From the perspective of institutional innovation, institutional innovation promotes manufacturing upgrading by providing a good development environment for enterprises to carry out innovation activity through the improvement of policy and the establishment of a system.

After measuring the standardized coefficient in Table 2, it can be concluded that institutional innovation has the greatest impact on manufacturing upgrading at the overall level. For emerging countries, such as China, the important reason for the rapid development of the manufacturing industry is the country's institutional support and policy guidance.

In addition, we draw other conclusions from Table 2. Economic development and human capital have a positive driving effect on China's manufacturing upgrading [35]. For emerging countries, human capital is an important source of innovation to improve productivity and industrial structure. Due to the sluggish growth of innovation levels caused by excessive investment, investment growth has a negative effect on manufacturing upgrading [36].

(B) From the perspective of the regional level.

According to the results of the Hausman test, from the estimation results, as shown in Columns (4) to (9) in Table 2, we can draw some conclusions, as follows.

First, we examine the impact of innovation on manufacturing upgrading. Technical innovation, product innovation, and institutional innovation can drive manufacturing upgrading in the Eastern region and in the Central and Western regions.

On one hand, the elastic coefficients of three forms of innovation in all regions are significantly positive, demonstrating that technical innovation, product innovation, and institutional innovation have a positive driving effect on manufacturing upgrading in the Eastern region and in the Central and Western regions. On the other hand, compared with the Eastern region, the Central and Western regions have a less active atmosphere for innovation. Under the guidance and support of government, three forms of innovation promote the upgrading of the manufacturing industry.

Second, after measuring the standardized coefficient in Table 2, it can be concluded that product innovation has the greatest impact on manufacturing upgrading in the Eastern region. In the Central and Western regions, institutional innovation has the greatest impact on manufacturing upgrading. The possible reasons are as follows. The economic development level of the Central and Western regions lags behind the Eastern region and started later than the Eastern region. The Western region has an advantage in resources and the Central region has an advantage in labor. The state has promoted the accumulation and inflow of elements of the Central and Western regions, such as funds, high-quality talents, and advanced technologies, by implementing policies such as the "Rise of Central China" and the "Development of Western Regions". The successful development experience of the manufacturing industry in the Eastern region will be used to promote the development and upgrading of the manufacturing industry in the Central and Western regions. In order to encourage the transformation and upgrading of the manufacturing industry in the Central and Western regions, the state continuously sends more mature technical experience to the Central and Western regions.

Besides, we can also draw some new conclusions from Table 2. First, improving the level of regional economic development has a significant impact on manufacturing upgrading in the Eastern region and has no significant impact in the Central and Western regions. The possible reason is that the economic foundation of the Western region is weak, and the driving effect of economic growth on the manufacturing industry has not yet been reflected. Second, improving the level of human capital is conducive to promoting the upgrading of manufacturing in the Eastern and Central and Western regions. Third, accelerating the growth rate of investment has no significant impact on the upgrading of manufacturing in the Eastern regions and has a negative impact in the Central and Western regions. The possible reason is that excessive investment growth can lead to repeated investment, excessive competition, and overcapacity. It is not conducive to industrial upgrading in the Central and Western regions. For emerging countries, this is a point of caution in the process of industrial upgrading.

### *5.2. Regression Results for Different Periods*

**Table 3.** Regression results during 2001–2007.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| TE | 0.21 *** | | | 0.34 *** | | | 0.18 ** | | |
| | (4.08) | | | (4.96) | | | (2.39) | | |
| PR | | 0.10 *** | | | 0.19 *** | | | 0.12 *** | |
| | | (3.05) | | | (3.09) | | | (2.95) | |
| IN | | | 0.27 *** | | | 0.28 *** | | | 0.23 *** |
| | | | (5.89) | | | (3.50) | | | (3.49) |
| EDL | 0.56 ** | 0.41 | 0.72 *** | 1.13 ** | 1.58 *** | 1.14 ** | 1.26 *** | 0.82 ** | 0.92 ** |
| | (2.00) | (1.29) | (2.91) | (2.41) | (3.36) | (2.17) | (3.54) | (2.00) | (2.62) |
| INV | −0.24 * | −0.30 ** | −0.21 | −0.32 | −0.28 | −0.72 *** | −0.12 | −0.17 | −0.08 |
| | (−1.73) | (−2.07) | (−1.55) | (−1.22) | (−0.90) | (−2.64) | (−0.71) | (−1.05) | (−0.46) |
| HC | 20.32 *** | 22.31 *** | 0.25 | 14.92 * | 4.58 | −25.38 * | −4.21 | −1.26 | −12.90 |
| | (3.14) | (3.36) | (0.04) | (1.66) | (0.39) | (−1.69) | (−0.43) | (−0.14) | (−1.28) |
| Constant | −2.63 | −0.37 | −1.35 | −8.48 ** | −11.54 *** | −4.11 | −8.73 *** | −4.73 | −3.88 |
| | (−1.11) | (−0.14) | (−0.61) | (−1.99) | (−2.65) | (−0.84) | (−3.11) | (−1.48) | (−1.23) |
| Obs. | 210 | 210 | 210 | 77 | 77 | 77 | 133 | 133 | 133 |
| $R^2$ | 0.51 | 0.49 | 0.55 | 0.55 | 0.47 | 0.71 | 0.49 | 0.51 | 0.52 |
| $\hat{\rho}$ | 0.156 *** | 0.091 ** | 0.176 *** | 0.359 *** | 0.181 *** | 0.200 *** | 0.129 ** | 0.124 *** | 0.203 *** |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

In order to better measure the impact of innovation on the process of China's manufacturing upgrading, this paper divides the entire period into two stages for empirical testing. The financial crisis occurred in 2008, and the two stages are in different market and institutional environments. The regression results of 2001–2007 are shown in Table 3, and the regression results of 2008–2015 are shown in Table 4.

According to the regression results in Tables 3 and 4, the coefficients of all three types of innovation are significantly positive. It indicates that the regression results of 2001–2008 and 2009–2015 are basically consistent with the basic regression results. It proves that innovation is conducive to China's manufacturing upgrading.

According to the comparison between the regression results of 2001–2007 and 2008–2015, the coefficients and significance of the three types of innovation have increased at the overall level and in the Central and Western regions, indicating that innovation activities have a stronger driving effect on China's manufacturing upgrading during 2009–2015 at the overall level and in the Central and Western regions. The coefficients of EDL and HC are also consistent with the basic regression results. The INV coefficients are almost non-significant. The possible reason is that in the process of manufacturing upgrading, the problem of excessive investment is improved by constantly guiding the investment allocation. The resource allocation is more reasonable with the increase of capital liquidity. It indicates that innovation does play an important role in driving the upgrading of Chia's manufacturing. From the perspective of standardized coefficient, institutional innovation has a greater impact in the Central and Western regions during 2001–2007, while technical innovation has a greater impact in the Eastern region. During 2008–2015, product innovation had a greater impact on the upgrading of China's manufacturing at the overall level, while it was technical innovation in the Eastern region and in the Central and Western regions.

**Table 4.** Regression results during 2008–2015.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| TE | 0.18 ** | | | 0.15 *** | | | 0.73 *** | | |
| | (2.47) | | | (3.44) | | | (6.65) | | |
| PR | | 0.40 *** | | | 0.07 * | | | 0.53 *** | |
| | | (7.59) | | | (1.96) | | | (6.85) | |
| IN | | | 0.24 *** | | | 0.11 *** | | | 0.27 *** |
| | | | (4.45) | | | (3.25) | | | (3.13) |
| EDL | 0.08 | 0.49 * | 0.54 * | 0.46 | 0.76 *** | 0.86 *** | −1.05 *** | −1.12 *** | −0.29 |
| | (0.24) | (1.81) | (1.87) | (1.62) | (2.70) | (3.15) | (−2.68) | (−2.87) | (−0.70) |
| INV | −0.31 * | −0.07 | −0.13 | 0.09 | 0.05 | 0.10 | −0.61 ** | −0.32 | −0.31 |
| | (−1.76) | (−0.37) | (−0.75) | (1.63) | (0.34) | (0.68) | (−2.55) | (−1.31) | (−1.22) |
| HC | 121.88 *** | 71.35 *** | 100.03 *** | 35.79 *** | 40.27 *** | 38.37 *** | 125.24 *** | 102.55 *** | 134.22 *** |
| | (8.76) | (4.94) | (7.11) | (3.03) | (3.25) | (3.27) | (6.98) | (5.23) | (6.62) |
| Constant | 0.49 | −6.74 *** | −1.31 | −0.37 | −2.57 | −2.39 | 3.73 | 4.86 | 5.28 |
| | (0.17) | (−2.89) | (−0.51) | (−0.15) | (−0.97) | (−0.95) | (1.08) | (1.42) | (1.48) |
| Obs. | 210 | 210 | 210 | 77 | 77 | 77 | 133 | 133 | 133 |
| $R^2$ | 0.63 | 0.54 | 0.22 | 0.91 | 0.88 | 0.30 | 0.52 | 0.14 | 0.49 |
| $\hat{\rho}$ | 0.138 ** | 0.337 *** | 0.153 *** | 0.070 *** | 0.063 * | 0.117 *** | 0.480 *** | 0.425 *** | 0.180 *** |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

### *5.3. Comparisons with the Studies on the European Union*

As a group of developed countries, the European Union's experience of innovation and industrial upgrading deserves the attention of emerging countries. We selected some representative relevant studies and compared them with our study. The findings are as follows.

In the face of fierce global competition, different from the rapid development of China's manufacturing, under the double squeeze of the international financial crisis and the rapid rise of emerging economies, the industrial competitiveness of European Union countries gradually fades and their market share continues to shrink. According to data from the World Bank Database, the 15

European Union countries accounted for 23.87% of the world's manufacturing value-added in 2000, which accounts for almost a quarter of global manufacturing value-added. By 2015, its share had fallen to 17.39%. At the same time, China's share of the world's manufacturing value-added rose sharply, from 6.5% to 26.74%, up 20 percentage points.

First, from the perspective of technical innovation, the European Union's share of added value in high-tech sectors has declined since the 1980s. Sun Yanhong showed that the lack of innovation and the low proportion of R&D in the GDP have been a hindrance to the European Union's industrial development [37]. Austria, Belgium, Germany, Finland, France, the United Kingdom, and the Netherlands are the seven member-states with the highest R&D intensity in the European Union, but their average R&D intensity is only 62% of that of the United States. As the European Union seems to have been "attaching importance to small and medium-sized enterprises but ignoring large enterprises, and attaching importance to the service industry but ignoring the manufacturing industry", it lost the opportunity for the new round of scientific revolution and industrial transformation. This illustrates the importance of technical innovation to the development of the manufacturing industry, and our research has also come to such a conclusion.

Second, from the perspective of product innovation, facing the stimulation of the "re-industrialization" of the United States and the rise of emerging countries in the manufacturing industry, the European Union lost its competitive advantage in many products, such as China overtaking in high-speed railways and aircrafts. In addition, many small and medium-sized innovative enterprises in the European Union have been acquired by foreign enterprises. The implementation of product innovation is an important way for the European Union to revitalize the real economy, which is consistent with the conclusion of this paper that "product innovation promotes manufacturing upgrading".

Third, from the perspective of institutional innovation, Bart et al. studied the industrial development process of the European Union, and they propose that the reason for the slowdown of European Union's growth is the European Union's institutional environment. It inhibits industrial structure adjustment and hinders the effective allocation of resources [38]. Julia et al. believe that government policies can help the French and Germans in electro-mobility develop new products and markets [39]. This shows that a good institutional environment is conducive to the transformation and upgrading of the manufacturing industry. We have also come to the conclusion that "institutional innovation promotes manufacturing upgrading".

Recognizing the importance of the real economy to the competitiveness of the European Union, the European Union put forward the "re-industrialization" policy, trying to enhance its economic competitiveness by revitalizing the manufacturing industry. It shows that the innovation-driven effect of manufacturing upgrading is of universal applicability. This has important implications for emerging countries.

## 6. Robustness checks

### *6.1. Regression Results with Time-Lagged Effect*

In order to reduce the endogenous problems caused by time lag effect, this paper replaces the current term of the innovation variable with the corresponding lag one phase term. Table 5 shows the results, in which L.TE, L.PR, and L.IN are the first-order lags of technical innovation, product innovation, and institutional innovation. The *L.TE* and *L.IN* coefficients are positive. The coefficient magnitude and significance level of *L.PR* are reduced, but the coefficient is still positive, revealing that there is a certain time lag effect on the impact of innovation on manufacturing upgrading [40]. However, the three forms of innovation still have a positive driving effect on manufacturing upgrading. The estimation results of the control variables are also consistent with the basic regression results, which indicates that the regression results in this paper have better robustness. After measuring the standardized coefficient, it can be concluded that in the Eastern region and in the Central and

Western regions, technical innovation will still have the greatest impact on manufacturing upgrading. At the overall level, institutional innovation has the greatest impact.

**Table 5.** Regression results with time-lagged effect.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| L.TE | 0.19 *** | | | 0.08 * | | | 0.42 *** | | |
| | (3.74) | | | (1.86) | | | (5.19) | | |
| L.PR | | 0.12 *** | | | 0.03 | | | 0.26 *** | |
| | | (3.88) | | | (1.11) | | | (5.19) | |
| L.IN | | | 0.27 *** | | | 0.12 *** | | | 0.41 *** |
| | | | (5.89) | | | (3.23) | | | (5.22) |
| EDL | 1.27 *** | 1.09 *** | 1.28 *** | 1.40 *** | 1.47 *** | 1.55 *** | 0.20 | −0.22 | 0.42 |
| | (6.50) | (5.22) | (7.00) | (5.43) | (5.72) | (6.29) | (0.70) | (−0.69) | (1.51) |
| INV | −0.52 *** | −0.54 *** | −0.40 *** | −0.01 | −0.03 | 0.04 | −0.68 *** | −0.78 *** | −0.52 *** |
| | (−3.61) | (−3.80) | (−2.76) | (−0.08) | (−0.18) | (0.29) | (−3.56) | (−4.09) | (−2.62) |
| HC | 21.73 *** | 20.92 *** | 7.48 | 7.66 | 9.19 | 0.28 | 47.47 *** | 46.16 *** | 27.25 * |
| | (2.97) | (2.85) | (0.99) | (1.23) | (1.35) | (0.04) | (4.04) | (3.89) | (1.96) |
| Constant | −8.65 *** | −6.62 *** | −6.33 *** | −7.80 *** | −7.97 ** | −8.19 ** | −2.50 | 2.24 | 0.77 |
| | (−5.18) | (−3.92) | (−3.91) | (−3.30) | (−3.33) | (−3.56) | (−1.07) | (0.92) | (0.32) |
| Obs. | 450 | 450 | 450 | 165 | 165 | 165 | 285 | 285 | 285 |
| $R^2$ | 0.60 | 0.60 | 0.62 | 0.54 | 0.53 | 0.56 | 0.67 | 0.67 | 0.67 |
| $\hat{\rho}$ | 0.149 *** | 0.119 *** | 0.171 *** | 0.086 * | 0.033 | 0.077 *** | 0.299 *** | 0.279 *** | 0.287 *** |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

### *6.2. Regression Results for Alternative Measurements of Manufacturing Upgrading*

In order to investigate the robustness of the test results under different manufacturing upgrading indices, this paper selects dependent variables from labor-productivity, profitability, and TFP to re-estimate. The data comes from China Industrial Statistics Yearbook and China Statistics Yearbook. The results of re-estimation with labor-productivity, profitability, and TFP as dependent variables are shown in Tables 6–8, respectively.

#### 6.2.1. Labor-Productivity as the Measurement of Manufacturing Upgrading

Labor-productivity refers to the output of each employee per unit of time. The increase of labor productivity is conducive to the improvement of production efficiency and industrial upgrading. This paper uses the main business income of the high-tech manufacturing industry to represent the profitability of China's manufacturing industry. It can be seen from Table 6 that at the overall level and in the Eastern region, the elasticity coefficients of innovation variables in all the equations are positive at the critical level of 1%, which indicates that the innovation indices are positively correlated with labor-productivity. It suggests that innovation has a positive driving effect on the upgrading of China's manufacturing. However, the elasticity coefficients of innovation variables in the Central and Western regions are not significant, which means that innovation has no significant effect on labor-productivity. It is inconsistent with most results and may be caused by endogenous problems.

The EDL coefficients at the overall level and in the Central and Western regions are significantly positive at the critical level of 1%, with significant negativity in the Eastern region. The possible reasons are that in the Central and Western regions, due to late starting and weak economic foundation, regional economic growth plays an important role in promoting local labor productivity. The Eastern region's residents' living standards have lagged behind the region's economic growth, and the psychological gap brought by excessive economic growth has had a negative impact on workers' efficiency. It limits the improvement of labor productivity and the rationalization of manufacturing. The INV coefficients are significantly negative, because over-investment is bad for upgrading manufacturing. The HC coefficients are positive, which is similar to the basic regression results.

From the perspective of the standardized coefficient, product innovation has the greatest impact on the upgrading of China's manufacturing at the overall level and in the Central and Western regions. In the Eastern region, technical innovation has the greatest impact on manufacturing upgrading.

**Table 6.** Regression results for labor-productivity as the measurement of manufacturing upgrading.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| TE | 3.09 *** | | | 5.53 *** | | | 0.66 | | |
| | (3.48) | | | (4.54) | | | (0.55) | | |
| PR | | 2.93 *** | | | 3.66 *** | | | 1.04 | |
| | | (5.44) | | | (4.69) | | | (1.42) | |
| IN | | | 2.31 *** | | | 5.60 *** | | | −0.17 |
| | | | (2.84) | | | (5.66) | | | (−0.14) |
| EDL | 19.10 *** | 13.64 *** | 19.95 *** | −27.21 *** | −23.02 *** | −27.18 *** | 32.41 *** | 29.69 *** | 33.10 *** |
| | (5.63) | (3.83) | (5.91) | (−3.63) | (−3.12) | (−7.28) | (7.63) | (6.31) | (8.04) |
| INV | −12.07 *** | −12.03 *** | −11.60 *** | −13.21 *** | −12.09 *** | −14.25 *** | −13.29 *** | −13.46 *** | −13.55 *** |
| | (−4.83) | (−4.94) | (−4.53) | (−3.07) | (−2.79) | (−3.45) | (−4.71) | (−4.80) | (−4.67) |
| HC | 593.58 *** | 460.33 *** | 587.38 *** | 982.09 *** | 848.93 *** | 1032.30 *** | 454.04 *** | 381.04 ** | 516.99 ** |
| | (4.67) | (3.67) | (4.27) | (5.42) | (4.34) | (8.27) | (2.62) | (2.19) | (2.51) |
| Constant | −193.33 *** | −150.39 *** | −164.58 *** | 196.62 *** | 168.37 ** | 259.84 *** | −272.78 *** | −255.83 *** | −272.24 *** |
| | (−6.66) | (−5.21) | (−5.56) | (2.87) | (2.45) | (7.54) | (−7.94) | (−7.31) | (−7.83) |
| Obs. | 450 | 450 | 450 | 165 | 165 | 165 | 285 | 285 | 285 |
| $R^2$ | 0.63 | 0.65 | 0.63 | 0.54 | 0.54 | 0.56 | 0.73 | 0.74 | 0.73 |
| $\hat{\rho}$ | 10.029 *** | 12.011 *** | 6.056 *** | 22.448 *** | 15.463 *** | 13.281 *** | 1.480 | 3.506 | −0.375 |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

### 6.2.2. Profitability as the Measurement of Manufacturing Upgrading

The total profit and tax of the manufacturing industry can better measure the contribution value of the manufacturing industry, which is an important manifestation of the upgrading of the manufacturing industry. In Table 7, it shows that the elastic coefficients of the innovation variables in all equations are positive at the critical level of 1%, which is basically the same as the previous regression results, indicating that innovation has a positive driving effect on manufacturing upgrading.

The coefficients of economic development level and human capital level are both positive, similar to the results of the basic regression. The effect of human capital in the Eastern region is more significant. The possible reason is that enhancing human capital levels is conducive to improving total-factor energy efficiency. The quantity of key universities in the Eastern region is relatively larger and the quality is obviously better than that in the Central and Western regions. Most of the higher-level talent also flows to Eastern regions. The INV elasticity coefficients are positive in all three equations in the country, but they are not significant. The reason is that the key to the development of the manufacturing industry is technical advancement and productivity improvement, rather than the continuous expansion of investment scale. Excessive investment growth can lead to repeated investment, excessive competition, and overcapacity. Therefore, the regression results of this paper are robust.

It can be concluded from Table 7 that technical innovation has a greater impact on manufacturing upgrading at the overall level and in all regions, followed by product innovation. Science and technology are the primary productive forces and have been playing a key role in the national economy development. Technical innovation is the key to emerging countries' manufacturing upgrading. Technical progress is an important reason for the continuous development of the manufacturing industry of emerging countries.

**Table 7.** Regression results for profitability as the measurement of manufacturing upgrading.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| TE | 0.24 *** | | | 0.18 *** | | | 0.29 *** | | |
| | (4.58) | | | (3.12) | | | (3.56) | | |
| PR | | 0.17 *** | | | 0.14 ** | | | 0.19 *** | |
| | | (4.25) | | | (2.48) | | | (3.51) | |
| IN | | | 0.18 *** | | | 0.19 *** | | | 0.20 ** |
| | | | (3.80) | | | (3.68) | | | (2.54) |
| EDL | 1.19 *** | 1.05 *** | 1.14 *** | 0.65 * | 0.710 ** | 0.86 *** | 1.48 *** | 1.41 *** | 1.46 *** |
| | (6.41) | (5.38) | (6.39) | (1.89) | (2.02) | (2.60) | (5.39) | (5.06) | (5.47) |
| INV | 0.12 | 0.01 | 0.22 | −0.12 | −0.11 | −0.04 | 0.18 | −0.01 | 0.32 * |
| | (0.86) | (0.06) | (1.53) | (−0.61) | (−0.59) | (−0.19) | (0.99) | (−0.07) | (1.66) |
| HC | 34.28 *** | 45.62 *** | 36.78 *** | 51.13 *** | 59.55 *** | 47.82 *** | 17.81 | 27.09 ** | 20.36 |
| | (4.85) | (7.45) | (5.14) | (6.33) | (8.26) | (5.87) | (1.53) | (2.56) | (1.51) |
| Constant | −8.6 *** | −6.37 *** | −5.42 *** | −3.11 | −2.95 | −2.96 | −11.50 *** | −9.50 *** | −8.05 *** |
| | (−5.34) | (−3.95) | (−3.44) | (−1.00) | (−0.94) | (−0.97) | (−5.04) | (−4.20) | (−3.55) |
| Obs. | 450 | 450 | 450 | 165 | 165 | 165 | 285 | 285 | 285 |
| $R^2$ | 0.68 | 0.68 | 0.67 | 0.71 | 0.70 | 0.63 | 0.67 | 0.67 | 0.67 |
| $\hat{\rho}$ | 0.273 *** | 0.244 *** | 0.165 *** | 0.247 *** | 0.200 ** | 0.152 *** | 0.276 *** | 0.272 *** | 0.187 ** |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

#### 6.2.3. TFP as the Measurement of Manufacturing Upgrading

Total factor productivity (TFP) refers to the increase of output caused by reasons other than factor input. The increase of TFP represents technical progress, which reflects the improvement of productivity and industrial upgrading. As can be seen from Table 8, the elasticity coefficients of technical innovation and product innovation are significantly positive at the overall level and in the Central and Western regions, while they are significantly negative in the Eastern region. The possible reasons are that the Eastern region has limited resources, and the increase in the input of technical innovation and product innovation leads to a decrease in the input of production factors, which leads to the decline in TFP. While the Central and Western regions have rich factor endowments, enterprises promote manufacturing upgrading through technical improvement, product development, and other activities. The elasticity coefficients of institutional innovation are negative but not significant at the overall level, positive in the Eastern region, and negative in the Central and Western regions. Such results may be endogenous.

There are two significant positive EDL coefficients at the overall level and in the Eastern region, while there is one significant positive EDL coefficient in the Central and Western regions. It indicates that the economic growth is conducive to the upgrading of China's manufacturing. The INV elasticity coefficients are significantly positive in three equations in the Central and Western regions, there are two significant INV elasticity coefficients in the Eastern regions, and only one significant INV elasticity coefficient at the overall level. It shows that the increase of investment within a certain limit can improve TFP and promote China's manufacturing upgrading. There are two significant negative HC elasticity coefficients at the overall level and in all regions. The possible reason is that higher education means higher wages and higher investment. Manufacturing in many emerging countries, including China, is now at the middle and low end of the value chain, and most manufacturing workers are engaged in low-skilled jobs. Large-scale employment of workers with higher education means a large increase in costs, which is not conducive to the transformation and upgrading of manufacturing enterprises.

As we can be seen from Table 8, first, the regression results of TFP are slightly different from the regression results of the other three measurements. Second, the value of $R^2$ in Table 8 is smaller than that of the other three measurements. The possible reason is that for industrial upgrading dominated by government policies in China, the comprehensive method of TFP is a suboptimal indicator to measure the manufacturing upgrading.

From the perspective of standardization coefficient, product innovation has the greatest impact on China's manufacturing upgrading, institutional innovation has a greater impact on China's manufacturing upgrading in the Eastern region, and technical innovation has the greatest impact in the Central and Western regions.

**Table 8.** Regression results for TFP as the measurement of manufacturing upgrading.

| Variable | Overall Level of China | | | Eastern Region of China | | | Central and Western Regions of China | | |
|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| TE | 0.01 * | | | −0.01 *** | | | 0.05 *** | | |
| | (1.66) | | | (−2.66) | | | (5.29) | | |
| PR | | 0.07 * | | | −0.01 * | | | 0.02 *** | |
| | | (1.87) | | | (−1.66) | | | (2.77) | |
| IN | | | −0.02 | | | 0.03 * | | | −0.03 ** |
| | | | (−1.32) | | | (1.96) | | | (−2.07) |
| EDL | 0.03 * | 0.15 | 0.09 *** | 0.15 *** | 0.14 *** | −0.03 | 0.06 ** | 0.03 | 0.02 |
| | (1.66) | (1.40) | (4.23) | (4.17) | (3.82) | (−0.72) | (2.05) | (1.08) | (0.46) |
| INV | 0.22 | 0.19 | 0.33 ** | 0.57 * | 0.56 * | 0.25 | 0.25 *** | 0.24 ** | 0.23 ** |
| | (1.56) | (1.31) | (2.59) | (1.90) | (1.86) | (0.92) | (2.61) | (2.48) | (1.98) |
| HC | −0.68 | −8.13 ** | −3.05 *** | −5.55 *** | −4.84 *** | −0.19 | −9.88 *** | −7.95 *** | 0.05 |
| | (−0.84) | (−2.13) | (−2.96) | (−5.03) | (−4.86) | (−0.12) | (−4.13) | (−2.80) | (0.03) |
| Constant | 0.59 *** | −1.33 | 0.17 | −0.22 | −0.12 | 1.28 *** | 0.00 | 0.42 | 0.80 ** |
| | (3.86) | (−1.69) | (0.84) | (−0.57) | (−0.30) | (2.9) | (0.01) | (1.48) | (2.35) |
| Obs. | 450 | 450 | 450 | 165 | 165 | 165 | 285 | 285 | 285 |
| $R^2$ | 0.22 | 0.23 | 0.02 | 0.03 | 0.03 | 0.34 | 0.02 | 0.01 | 0.01 |
| $\hat{\rho}$ | 0.045 * | 0.399 * | −0.073 | −0.045 *** | −0.047 * | 0.080 * | 0.176 *** | 0.106 *** | −0.104 ** |

Note: t statistics in parentheses; * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

#### 6.2.4. Comparison with Three Measurements of Manufacturing Upgrading

From the comparison of results of baseline regression analyses and robustness checks, the three measurements of manufacturing upgrading all support the conclusion that "innovation is the driving force for manufacturing upgrading", which is consistent with the baseline results of this paper. Although there are some little differences in the empirical results of the three measurements, all of them do prove the important driving effect of innovation on manufacturing upgrading.

## 7. Conclusion

Emerging economies are one of the most important parts of the global economy. This paper chooses China as one typical representative of emerging countries to analyze the relationship between innovation activity and manufacturing upgrading. By using the data from Chinese provinces in the period of 2001–2015, this paper empirically investigates the relationship between innovation activity and manufacturing upgrading of emerging countries. We can draw several robust conclusions, as follows. First, technical innovation does promote the upgrading of manufacturing. Second, product innovation does promote manufacturing upgrading. Third, institutional innovation does promote manufacturing upgrading. This suggests that innovation activity has a driving effect on the manufacturing upgrading of emerging countries.

Based on the conclusions above, for the manufacturing upgrading of emerging countries, we can draw some policy implications, as follows.

First, for emerging countries, innovation is one of the most important driving forces for manufacturing upgrading. Emerging countries can enhance their innovation capability through technical innovation, product innovation, and institutional innovation. It is necessary for emerging countries to upgrade the manufacturing industry by conducting innovation activity. Second, the fundamental way to drive the upgrading of the manufacturing industry is technological innovation. Enterprises of emerging countries should increase R&D investment and actively carry out innovative activity to enhance the capacity for independent innovation. The government should attach importance to the construction of the innovation environment and provide broad space for enterprises to carry out innovation activity. Third, the experiences from developed countries suggest that emerging countries should realize the importance of the real economy, especially manufacturing industries.

Moreover, the innovation-driven effect on manufacturing upgrading is of universal applicability. Emerging countries can enhance their competitive advantages in the international market through manufacturing upgrading. Fourth, so-called "China experience", the successful experience in the process of China's manufacturing upgrading, can provide a good reference for emerging countries. As the largest emerging economy, "China experience" provides a development model for other emerging countries.

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## References

1. Fernández, V.R. Global Value Chains in Global Political Networks. *Rev. Radic. Political Econ.* **2015**, *47*, 209–230. [CrossRef]
2. Baldwin, R. Trade and Industrialization After Globalization's 2nd Unbundling: How Building and Joining a Supply Chain Different and Why It Matters. In *Globalization in an Age of Crisis: Multilateral Economic Cooperation in the Twenty-First Century*; NBER Working Paper No. 17716; University of Chicago Press: Chicago, IL, USA, 2013.
3. Herrigel, G.; Wittke, V.; Voskamp, U. The Process of C hinese Manufacturing Upgrading: Transitioning from Unilateral to Recursive Mutual Learning Relations. *Glob. Strategy J.* **2013**, *3*, 109–125. [CrossRef]
4. Robert, K.; William, P.; Wang, Z.; Wei, S.-J. Give Credit Where Credit Is Due:Tracing Value Added in Global Production Chains. NBER Working Paper No. 16426. 2010. Available online: https://www.nber.org/papers/w16426 (accessed on 1 March 2019).
5. Giuliani, E.; Bell, M. The Micro-Determinants of Meso-Level Learning and Innovation: Evidence from a Chilean Wine Cluster. *Res. Policy* **2005**, *34*, 47–68. [CrossRef]
6. Preissl, B. The German Service Gap or Re-organizing the Manufacturing—-Services Puzzle. *Metroeconomica* **2007**, *58*, 457–478. [CrossRef]
7. Mrabet, Z.; Lanouar, C. Trade liberalization, technology import and skill upgrading in Tunisian manufacturing industries: A dynamic estimation. *Afr. J. Econ. Manag. Stud.* **2013**, *4*, 338–357. [CrossRef]
8. Brandt, L.; Thun, E. Constructing a ladder for growth: policy, markets, and industrial upgrading in China. *World Dev.* **2016**, *80*, 78–95. [CrossRef]
9. Potts, J.; Kastelle, T. Economics of innovation in Australian agricultural economics and policy. *Econ. Anal. Policy* **2017**, *54*, 96–104. [CrossRef]
10. Wu, F.; Yan, X. Institutional Quality and Sustainable Development of Industries' Exports: Evidence from China. *Sustainability* **2018**, *10*, 4173. [CrossRef]
11. Stuart, T.E. Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strateg. Manag. J.* **2000**, *21*, 791–811. [CrossRef]
12. Lopez-Rodriguez, J.; Martinez-Lopez, D. Looking beyond the R&D effects on innovation: The contribution of non-R&D activities to total factor productivity growth in the EU. *Struct. Chang. Econ. Dyn.* **2017**, *40*, 37–45.
13. Argyres, N.S.; Silverman, B.S. R&D, organization structure, and the development of corporate technological knowledge. *Strateg. Manag. J.* **2004**, *25*, 929–958.
14. Bernile, G.; Bhagwat, V.; Rau, P.R. What Doesn't Kill You Will Only Make Risk-Loving Earl-Life Disasters and CEO Behavior. *J. Financ.* **2017**, *72*, 167–206. [CrossRef]
15. Aghion, P.; Bloom, N.; Blundell, R.; Griffith, R.; Howitt, P. Competition and innovation: An inverted-U relationship. *Q. J. Econ.* **2005**, *120*, 701–728.
16. Dangelico, R.M.; Pujari, D.; Pontrandolfo, P. Green product innovation in manufacturing firms: A sustainability-oriented dynamic capability perspective. *Bus. Strategy Environ.* **2017**, *26*, 490–506. [CrossRef]

17. Amiti, M.; Khandelwal, A.K. Import competition and quality upgrading. *Rev. Econ. Stat.* **2013**, *95*, 476–490. [CrossRef]
18. Chang, S.J.; Chung, C.N.; Mahmood, I.P. When and how does business group affiliation promote firm innovation? A tale of two emerging economies. *Organ. Sci.* **2006**, *17*, 637–656. [CrossRef]
19. Czarnitzki, D.; Licht, G. Additionality of public R&D grants in a transition economy: the case of Eastern Germany. *Econ. Transit.* **2006**, *14*, 101–131.
20. Xie, Z.; Wu, F.; Yang, Q. The Innovation-driven Effect of China's Manufacturing Upgrading—An Empirical Analysis based on Chinese Province-level Panel Data. *J. Beijing Inst. Technol. (Soc. Sci. Ed.)* **2018**, *4*, 97–108.
21. Pietrobelli, C.; Rabellotti, R. Global value chains meet innovation systems: are there learning opportunities for developing countries? *World Dev.* **2011**, *39*, 1261–1269. [CrossRef]
22. Jiang, D.; Yuan, Y. The Empirical Analysis of the Impact of Technical Innovation on Manufacturing Upgrading-Based on Subdivision Industry of China. In *Proceedings of the International Conference on Management Science and Engineering Management*; Springer: Cham, Switzerland, 2017; pp. 274–285.
23. Romer, P.M. Endogenous technological change. *J. Political Econ.* **1990**, *98*, S71–S102. [CrossRef]
24. Jer, R. What makes export manufacturers pursue functional upgrading in an emerging market? A study of Chinese technology new ventures. *Int. Bus. Rev.* **2014**, *23*, 741–749.
25. Jefferson, G.H.; Bai, H.; Guan, X.; Yu, X. R&D performance in Chinese industry. *Econ. Innov. New Technol.* **2006**, *15*, 345–366.
26. Berchicci, L. Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. *Res. Policy* **2013**, *42*, 117–127.
27. Chen, Y.; Vanhaverbeke, W.; Du, J. The interaction between internal R & D and different types of external knowledge sourcing: an empirical study of C hinese innovative firms. *R&D Manag.* **2016**, *46*, 1006–1023.
28. Tsai, K.H.; Wang, J.C. R&D Productivity and the Spillover Effects of High-tech Industry on the Traditional Manufacturing Sector: The Case of Taiwan. *World Econ.* **2004**, *27*, 1555–1570.
29. Hausmann, R.; Klinger, B. The Structure of the Product Space and the Evolution of Comparative Advantage. Center for International Development at Harvard University, 2007. Available online: https://ideas.repec.org/p/cid/wpfacu/146.html (accessed on 1 March 2019).
30. Kevin, Z.Z. Innovation, imitation, and new product performance: The case of China. *Ind. Mark. Manag.* **2006**, *35*, 394–402.
31. Tebaldi, E.; Elmslie, B. Does institutional quality impact innovation? Evidence from cross-country patent grant data. *Appl. Econ.* **2013**, *45*, 887–900. [CrossRef]
32. Kole, S.R.; Mulherin, J.H. The Government as Shareholder: A Case from the US. *J. Law Econ.* **1997**, *40*, 1–22. [CrossRef]
33. Michael, P. The Competitive Advantage of Nations. 1991. Available online: https://wenku.baidu.com/view/c225563231126edb6f1a1028.html (accessed on 1 March 2019).
34. Sun, N.; Zeng, L. Intermittent institutional innovation and China's economic fluctuations: Calibration model and dynamic analysis. *Manag. World* **2013**, *12*, 22–31.
35. Mao, Q.; Sheng, B. Foreign economic opening, regional market integration and total factor productivity. *Econ. Q.* **2011**, *11*, 181–210.
36. Wu, F.; Liu, R. Industrial upgrading and independent innovation capability construction—Based on the research of Chinese provincial panel data. *China Ind. Econ.* **2013**, *5*, 57–69.
37. Sun, Y. A tentative analysis of the economic transformation in Europe dince the 1970s—From the perspective of industrial structure. *Eur. Stud.* **2014**, *1*, 14–25.
38. Bart, A.; Robert, I.; Robert, M. ICT and productivity in Europe and the United States where do the differences come from? *CESifo Econ. Stud.* **2003**, *49*, 295–318.
39. Julia, H.; Axel, V. Shaping an emerging market for electric cars: How politics in France and Germany transform the European automotive industry. *Eur. Rev. Ind. Econ. Policy* **2011**, *3*.
40. Oiu, B.; Wu, F.; Tang, B.; Liu, X. Changing Comparative Advantage, Real Exchange Rate Impact and Sino-Japanese Trade Fluctuations. *China World Econ.* **2016**, *6*, 64–86.