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# Research on the Innovation-Driving Mechanism for the Synergistic Development of Two-Way FDI in China's Manufacturing Industry: Based on the Perspective of the New Development Pattern of "Dual Circulation"

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**Abstract:** The new pattern of "dual circulation" is a new development model for China to seek mutual promotion between international and domestic markets in the new era. In this context, this paper explores the synergistic relationship between two-way FDI and its impact mechanism on the improvement of China's manufacturing innovation capability. By taking 27 segments of the Chinese manufacturing industry as data samples from 2003 to 2018, we use the Granger cause, orthogonalized impulse response function, and physical capacity coupling system to verify the two-way FDI synergistic development relationship in the Chinese manufacturing industry and measure its degree of synergy. In addition, we empirically explore the mediating role of industrial structure upgrading in the impact of two-way FDI synergistic development on innovation capability in the Chinese manufacturing industry, and further analyze the industrial heterogeneity of this mediating role among labor-intensive, capital-intensive, and technology-intensive manufacturing segments. The study finds that firstly, there are different degrees of synergistic development in the Chinese manufacturing segments, and this synergistic development significantly contributes to the innovation capability and industrial structure upgrading of the Chinese manufacturing industry. Secondly, industrial structure upgrading of the Chinese manufacturing industry plays an essential mediating effect in the innovation-driving process of the two-way FDI synergistic development, and the mediating effect shows significant industrial heterogeneity. More specifically, the mediating effects in labor-intensive and technology-intensive industries are significantly positive, and the mediating effect in technology-intensive industries is more prominent. However, the mediating effect in capital-intensive industries is significantly negative. The paper provides empirical evidence to clarify the innovation-driving mechanism of the two-way FDI synergistic development in China's manufacturing industry from the perspective of the new development pattern of "dual circulation" and provides valuable references for research in related fields.

**Keywords:** dual-circulation development pattern; two-way FDI synergistic development; industrial structure upgrading; innovation capability; mediating effect; industry heterogeneity



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## 1. Introduction

As the focus of globalization shifts from "market" to "production", the "international production" mainly represented by transnational corporations and their subsidiaries dominates the development of the world economy, and also lays the core position of international investment in the global economy. Empirical evidence from international investment (UNCTAD) shows that international investment flows have increased 6.5 times over the past

30 years for all countries, growing much faster than world trade and output. The reason for this is not only the economic development of developed countries in the post-war period, but also the growing power of developing countries in the field of foreign investment. On the one hand, from the perspective of FDI performance, FDI has been the largest source of external funds for developing countries since 2000. FDI flows into developing countries accounted for about 25% of the total global scale, and contributed nearly 30% to their GDP on average. On the other hand, from the perspective of OFDI's performance, developing countries accounted for about 28% of the global total outward investment from 2009 to 2019, which was far higher than the average level of 10.48% in the decade before the financial crisis, and became an important way to participate in globalization. Hence, developing countries have gradually taken on the dual role of both host and investor of international direct investment, being both beneficiaries of IFDI and investors of OFDI. Therefore, for developing economies, exploring the scale and balance of two-way international investment is one of the key issues for global economic growth. As the largest developing economy in the world, the empirical data and experience from China are representative and instructive for other developing economies.

Since the reform and opening up, China has gradually developed into the world's second largest economy, and its position as a major outward investment country is becoming more and more solid. As the pillar industry of China's economy and the main field of two-way international investment, the achievements of China's manufacturing industry are obvious to all. According to the data of the World Bank, the value added of China's manufacturing industry accounted for about 30% of the global manufacturing industry in 2019, which has ranked first in the world for ten consecutive years. However, at the same time, the "two-way squeeze" dilemma of "high-end return" and "low-end diversion" has led to the problems of "unreasonable industrial structure", "low-end locking", and "insufficient innovation" in China's manufacturing industry, which has long restricted the high-quality development of China's manufacturing industry. In this regard, the 14th Five-Year Plan of China proposes that, on the one hand, after entering the new development pattern of "dual circulation", China should make full use of both domestic and international markets and resources, improve the level of international two-way investment, and adhere to the equal emphasis on "bringing in" and "going out". On the other hand, it should promote the optimization and upgrading of the manufacturing industry, enhance its competitive advantages, and achieve high-quality development of the manufacturing industry.

In addition, "insisting on innovation-driving" is at the core of China's modernization drive, so it is crucial to improve the technological innovation capability of the manufacturing industry. For this reason, in recent years, the Chinese government and enterprises have carried out many practical explorations on how to improve the level of coordinated development of international two-way investment, and thus promote the innovation capability of the manufacturing industry. However, compared with this, relevant studies in academia are insufficient, especially the lack of comprehensive empirical studies on the synergy of two-way FDI in the manufacturing industry, industrial structure upgrading, and innovation capability. Therefore, this paper explores the impact mechanism of the synergistic development of two-way FDI on the innovation capability of China's manufacturing industry from the perspective of "dual circulation", using data from 27 segments of China's manufacturing industry as a sample. This paper provides empirical evidence to clarify the innovation-driving mechanism of the two-way FDI synergistic development in China's manufacturing industry, and also provides valuable references for research in related fields.

## 2. Literature Review

According to the research themes, previous related studies can be roughly divided into the following three categories: firstly, the impact of IFDI and OFDI on industrial structure upgrading. Many studies confirm that IFDI or OFDI will promote industrial structure upgrading by influencing factors such as market structure [1], trade structure [2], employment level [3], technology spillover effect [4], competition effect [5], and association effect [6]. Siriopoulos et al.'s study argues that multiple factors, such as the adoption of International Financial Reporting Standards, governance quality and other governance indicators, are determinants of IFDI in GCC countries; thus, a higher level of the two-way FDI scale is a central prerequisite for the synergistic relationship study. [7]. In terms of international investment in different directions, Yan Zhou and Chuanyu Wang [8] find that IFDI helps to increase the proportion of secondary and tertiary industries in the national economy to promote industrial restructuring and upgrading in China. By using data from Southeast Asian countries, Ritchie [9] shows that OFDI has a positive impact on industrial structure upgrading. By using data from Finland, Deschryvere and Jyriki [10] confirm that new investments lead to industrial structural changes by promoting the redistribution of R&D capital and R&D labor in industries. The second category is the impact of two-way FDI on innovation capacity. The empirical study by Hongling Wang et al. [11] finds that IFDI significantly improves the independent innovation and R&D capabilities of host country enterprises. The empirical study of Youde Dong and Shing Meng [12] shows that OFDI significantly promotes the innovation capabilities of Chinese enterprises, and that manufacturing, operation, and R&D are the main channels of the reverse spillover effect of OFDI. Meanwhile, the empirical study by Lei Xu et al. [13] confirms that the two-way FDI synergistic development offers a significant contribution to innovation capability in China's manufacturing industry, and there is significant industry heterogeneity in this innovation-driving effect. In addition, Ascani and Gagliardi [14], Yu Zhang and Dianchun Jiang [15], and Juan Li [16] also identify the role of international investment in promoting innovation capability. The third category is the impact of industrial structure upgrading on innovation capability. Some studies conclude that the upgrading of industrial structures would affect innovation capability. For example, the study by Jinbo Wang and Jiying Tong [17] finds that a lower level of industrial structure development inhibits innovation capability and a higher degree of industrial structure optimization promotes innovation capability. Empirical studies such as those conducted by Weiqing Li and Xianzhong Nie [18], Fenghua Wu and Ruiming Liu [19], and Peng Wang and Jie Zhao [20] also confirm there is a positive effect of industrial structure upgrading on regional innovation capability enhancement. Another part of the studies argues that innovation capacity enhancement, in turn, affects industrial structure upgrading in the reverse direction. For example, Kazuyuki and Xiao [21] found that innovation activities, mainly those that attract re-innovation, significantly improve output levels and promote the upgrading of industrial structures in a study of Chinese manufacturing firms; Hong Fu et al. [22] found that innovation can effectively promote the advancement of industrial structures by promoting abandonment, increasing output and optimizing allocation.

Previous studies show that firstly, although there are studies that focus on the impact of one-way FDI on innovation, few have explored the synergistic development of two-way FDI, and addressed specific mechanisms. Secondly, most of the existing literature on the technology spillover effects of international investment is based on the micro level of enterprises, with few scholars focusing on the industry level, resulting in a relative lack of research findings and policy recommendations from the meso perspective. Finally, although studies have shown that international investment provides resources for the development of manufacturing innovation capabilities, and that industrial upgrading can also positively contribute to manufacturing innovation to a certain extent, the transmission mechanism of industrial upgrading and the integration of these three elements in the same logical framework have been neglected. In view of this, this paper tries to improve the existing research from the following three aspects. Firstly, the article applies the Granger cause and the orthogonalized impulse response function to verify the existence of the synergistic development relationship between two-way FDI and analyzes the driving mechanism of international two-way investment with regard to manufacturing innovation capability based on the perspective of the new development pattern of "dual circulation". Secondly, based on the panel data of 27 segments of the Chinese manufacturing industry from 2003 to 2018 (see Appendix A), the article attempts to expand the research perspective from the micro level of enterprises to the meso level of industries, and puts forward corresponding conclusions and suggestions to broaden the relatively scarce research perspective of industries in the literature at present. Thirdly, the article introduces industrial structure upgrading to build a complete research framework and tries to clarify the transmission mechanism of industrial structure upgrading in the relationship between two-way FDI synergistic development and manufacturing innovation capability by constructing a mediating effect model, aiming to provide valuable references for research in related fields in the growth paths for developing economies.

## 3. Theoretical Analysis

### *3.1. Synergistic Development Relationship between IFDI and OFDI in China's Manufacturing Industry*

From the perspective of the new development pattern of "dual circulation", one of the critical goals of China's modernization is to integrate the domestic and international markets and resources, enhance the level of two-way international investment, and thus promote domestic and international dual circulation. Therefore, analyzing the theoretical mechanism of the synergistic development relationship between two-way FDI is not only the key issue regarding the research questions of this paper, but also has the practical significance of bridging policy practice.

The exploration of the synergistic relationship between two-way FDI has evolved from the relevant studies on the coordinated development relationship between two-way FDI, and can be found in the early transmission mechanisms of exchange rate and interest rate. Furthermore, this coordinated development relationship has been confirmed by many scholars. For example, Shireen's [23] study shows a significant two-way panel causality between IFDI and OFDI in open economies; Gu and Lu's [24] study concludes that IFDI is an essential driver of OFDI, due to the knowledge and technology spillover effects, but when considering the pressure of market competition, the increase in IFDI may also inhibit OFDI behavior. In addition, a related study by Lingyun Huang et al. [25] also identifies the coordinated development relationship between two-way FDI.

For the synergistic development relationship, we try to explain the possible mutual influence mechanism. On the one hand, IFDI can influence the scale of OFDI through many pathways [26–28], among which positive and negative agglomeration effects are important mechanisms for IFDI to influence OFDI. Firstly, the positive agglomeration economic effect of IFDI mainly brings about the enhancement of ownership advantage through the scale economic effect and technology spillover effect of agglomeration, which in turn promotes the expansion of the OFDI scale of industries in the host country. Secondly, the negative agglomeration economic effect of IFDI mainly weakens the ownership advantage through the intensified competition effect of agglomeration and the low-end locking effect of agglomeration, thereby inhibiting the expansion of the OFDI scale in the host country. Thirdly, since there is heterogeneity in the influence of IFDI on OFDI through positive and negative agglomeration effects in different regions and industries, it is difficult to determine the net effect of IFDI on OFDI. However, it is certain that IFDI will affect OFDI through positive and negative agglomeration effects [29]. On the other hand, the rapid rise of the OFDI scale in the home country can promote the expansion of the IFDI scale through factors such as economic scale, capital factors and human capital [30]. Firstly, the expansion of OFDI can increase the economic scale of the home country by acquiring resources, technology and markets, and the larger economic scale of the home country can create a favorable macroeconomic environment to obtain more IFDI. Secondly, the expansion of the OFDI scale will affect the exchange rate fluctuation by influencing the demand for the home country's currency in the international market. The smaller the exchange rate fluctuation, the lower the costs and risks in the international investment process of MNCs, while wealth accumulation and demand for highly qualified labor will increase, all of which promote the expansion of the IFDI scale [31]. Finally, the OFDI's overseas market competition mechanism, R&D resource sharing mechanism, technology cluster absorption mechanism and two-way technology exchange mechanism all have positive effects on the productivity and innovation capacity of the investing countries and improve the level of human capital, while countries with richer human capital reserves are able to attract more IFDI. Thus, it can be inferred from the above studies that there is a synergistic relationship between two-way FDI, which will be strengthened through the above mechanisms.

Given that manufacturing is the pillar industry of China's economy, and the main industry where two-way FDI occurs, this paper puts forward corresponding hypotheses based on the above analysis. By sorting out relevant studies, we draw Figure 1 of the interactive development mechanism of two-way FDI in China's manufacturing industry.

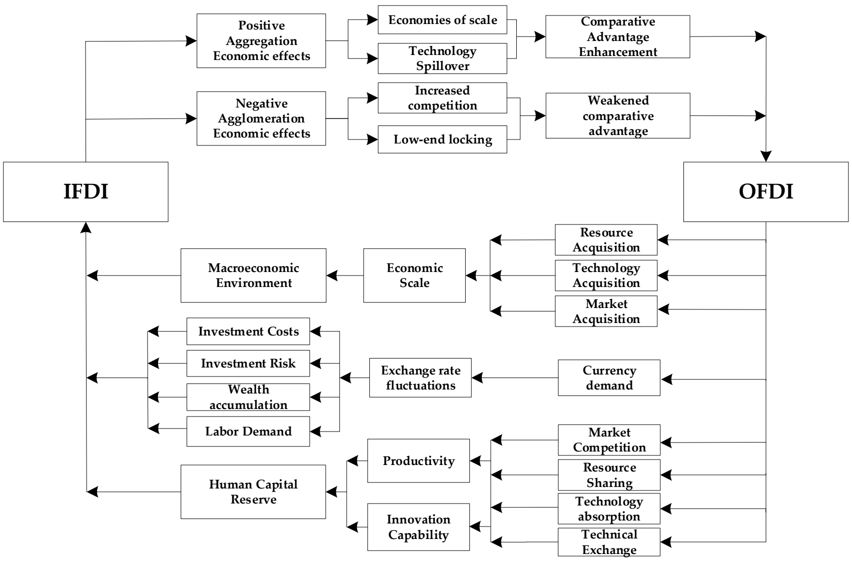


**Figure 1.** Synergistic development mechanism of two-way FDI in China's manufacturing industry.

**Hypothesis 1 (H1).** *A synergistic relationship exists between two-way FDI in China's manufacturing industry.*

### 3.2. The Impact of the Synergy of Two-Way FDI on Manufacturing Innovation Capacity

In terms of IFDI, Kemeny [32] studied the impact of IFDI on technology upgrading in different countries and found that IFDI can significantly promote the innovation capacity of all countries, especially the developing countries. In addition, the innovation-driving effect of IFDI can be also realized through effective transmission mechanisms, such as knowledge externalities [33], the promotion of scientific and technological, innovation in high-tech industries [34], trade openness and human capital accumulation etc. [35]. In terms of OFDI, Dongli Liu and Hong Liu [36] verified the reverse technology spillover effects of OFDI and found that the two stages of OFDI reverse technology spillover, namely foreign acquisition and domestic dissemination, jointly promoted the innovation capability of the home country. The OFDI innovation-driving effect can also be realized through effective mechanisms such as international knowledge transfer [37], increasing the number of patents [38], increasing R&D investment and external learning effects [39], and reverse green technology transfer [40]. The above studies have fully confirmed that both IFDI and OFDI can promote innovation capability through their positive spillover effect. In addition, according to [41], positive IFDI spillover is mainly realized through the demonstration effect, learning effect, competition effect and linkage effect, and positive OFDI spillover is mainly realized through international R&D input sharing, overseas R&D feedback, reverse technology transfer and non-core production link stripping.

In fact, the spillover effects of IFDI and OFDI are not always positive, and the driving effect on the improvement of innovation capability is not always positive either. IFDI and OFID may also inhibit the improvement of innovation capability due to the negative spillover effect. According to Chen Li [42], IFDI and OFDI can actually form negative spillover effects through the following mechanisms: technological innovation crowding out, technological dependence, low-end manufacturing, high-end industrial transfer, and industrial factor imbalance. In fact, any country or multi-national corporation in the process of international investment activities hopes to strengthen the positive spillover effect of IFDI and OFDI to bring about a positive driving effect on improving innovation capability, and to weaken the negative spillover effect of IFDI and OFDI. Mengqi Gong et al. [43] found that IFDI and OFDI in China's industrial sector have a negative impact on the efficiency of total factor emission reduction, and the interaction between IFDI and OFDI significantly promotes the efficiency of total factor emission reduction in the industrial sector. This study suggests that the coordinated development of two-way FDI can produce a positive complementary effect, thereby weakening the negative spillover effect of IFDI or OFDI. Pei Yu and Ge Peng [44] found that one-way FDI can promote China's manufacturing industry's position in the global value chain, and the benign interaction of two-way FDI can significantly strengthen this role, which also indicates that the synergistic development of two-way FDI can strengthen the positive spillover effect of IFDI or OFDI.

In view of the above analysis and the fact that the manufacturing sector is the main field of China's scientific and technological innovation, it is reasonable to believe that the two-way FDI synergistic development in manufacturing industries can drive the improvement of manufacturing innovation capacity by strengthening the positive spillover effect of IFDI or OFDI and weakening the negative spillover effect of IFDI or OFDI. So, the article puts forward the following hypothesis (the specific influence mechanism is shown in Figure 2).

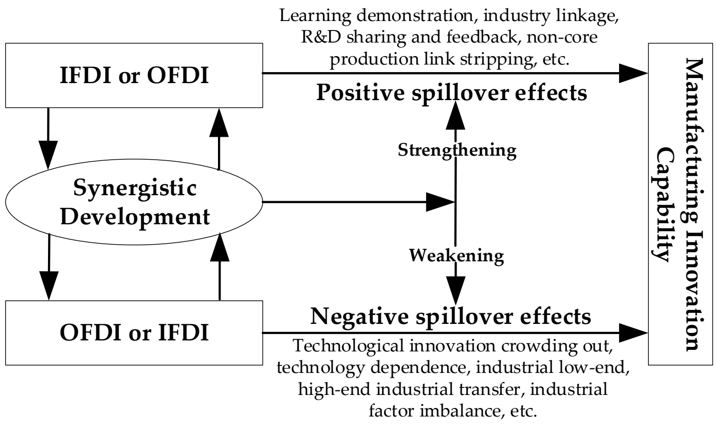


**Figure 2.** Mechanism of the innovation-driving effect of two-way FDI in China's manufacturing industry.

**Hypothesis 2 (H2).** *The two-way FDI synergistic development can significantly drive the innovation capability of the manufacturing industry.*

### *3.3. Mediating Effects of Industrial Structure Upgrading*

From the perspective of "one-way FDI", the industrial structure upgrading effect of OFDI has been recognized in classical theories such as Vernon's [45] "product life cycle theory" and Kojima's [46] "marginal industrial expansion theory". Vernon points out that the OFDI activities of developed countries, such as the United States, in developing countries are mostly focused on labor-intensive manufacturing, which in turn promotes capital-intensive and technology-intensive manufacturing in the home countries. In addition, Mathews [47] argues that the OFDI activities of multi-national corporations in developing countries can obtain new competitive advantages through the channels of "resource linkage", "leverage effect" and "learning by doing", and then promote the adjustment of home country industries to high value-added and capital-intensive ones. Eventually, it promotes the upgrading of the home country's industrial structure. Similarly, the industrial structure upgrading effect of IFDI is also found by Lin Zhang [48] and other studies, who suggest that IFDI can promote the upgrading of the technology level through the channels of capital allocation, industrial linkage, technology demonstration, and personnel flow, and finally promote the industrial structure upgrading in the host country.

From the perspective of “two-way synergy”, the synergistic development of two-way FDI can promote the upgrading of China’s manufacturing industry structure through its balanced scale and mutual promotion relationship [49]. In terms of the equilibrium scale of two-way FDI, on the one hand, as the scale of OFDI expands, if there is insufficient domestic IFDI on a balanced scale to meet the capital demand, it will affect or even inhibit the upgrading of China’s manufacturing industry structure, and increase the risk of “industrial hollowing out” of China’s manufacturing industry. In short, if IFDI is expanded blindly beyond the equilibrium scale, it will aggravate the risk of “industrial hollowing out” of the manufacturing industry. On the other hand, a part of China’s foreign exchange reserves originated from IFDI, and the balanced scale of OFDI can partially release the pressure of China’s foreign exchange reserves and create a better internal macro environment for the upgrading of the manufacturing industry structure. In terms of the mutual reinforcing relationship of two-way FDI, on the one hand, the large amount of IFDI since the reform and opening up has laid a good foundation for OFDI. The technology spillover effect of IFDI has dramatically enhanced the ability of Chinese enterprises to “go out”, which in turn has dramatically increased the opportunity of the reverse spillover of OFDI to promote the upgrading of China’s manufacturing industry structure; on the other hand, the OFDI of the Chinese manufacturing industry can significantly enhance the recognition of Chinese manufacturing enterprises in the international market, which is conducive to attracting more excellent overseas enterprises to invest in the Chinese market. The IFDI increases the opportunity to upgrade the industrial structure of the Chinese manufacturing industry through the positive spillover effect.

After the financial crisis, technological innovation and industrial structure upgrading became virtual channels for more and more countries to cope with the crisis and enhance their international competitiveness. China has also implemented industrial upgrading and innovation-based country strategies, and the relationship between industrial upgrading and regional innovation has received extensive attention from scholars. For example, Weiqing Li and Xianzhong Nie’s empirical research [18] on China’s provincial level shows that the upgrading of industrial structures has a significant positive spillover effect on China’s overall independent regional innovation, and that the more significant the spillover effect is, the stronger the regional innovation capacity will be. The empirical study by Peng Wang and Jie Zhao [20] shows that the increase in the share of the primary industry is not conducive to regional innovation output, and that in contrast, the increase in the share of secondary and tertiary industries can effectively promote the improvement of regional innovation capacity, especially the share of secondary industries. At the regional level, the above studies fully confirm the promotion effect of industrial structure upgrading on innovation capability. Since the manufacturing industry has always been an essential carrier of regional economic development, we can propose that upgrading the manufacturing industry’s industrial structure can also boost the innovation capability of the manufacturing industry.

The two-way FDI synergistic development of China’s manufacturing industry should be able to promote the upgrading of industrial structures, and thus drive the improvement of manufacturing innovation capability through the tendency of balanced scales and mutual promotion relationships. Based on this, this paper maps out the above mechanism (Figure 3) and puts forward the following hypothesis:

**Hypothesis 3 (H3).** *Industrial structure upgrading mediates the impact of two-way FDI synergistic development on China’s manufacturing innovation capability.*

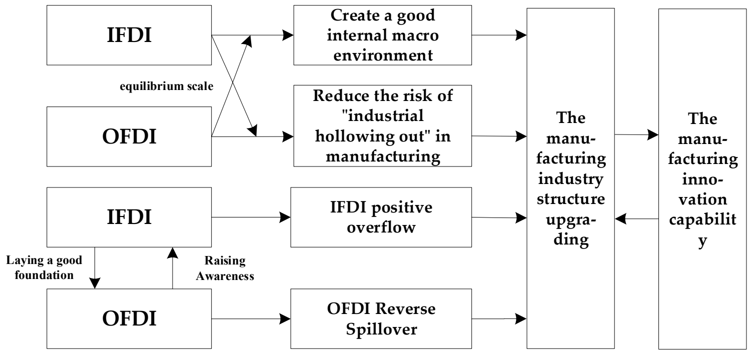


**Figure 3.** The mechanism of the mediating effect of industrial structure.

### *3.4. Industry-Based Heterogeneity*

The level of two-way FDI synergistic development can be influenced by multiple factors, such as the level of financial development [50], the degree of coupling [51], the quality of institutions, and the level of human capital [25]. Therefore, the level of the synergy of two-way FDI development in different regions or industries exhibits significant variability, due to the influence of multiple factors. Consequently, there is significant variability in the impact on manufacturing innovation capacity [52]. In addition, Nisha Ja and Yonghui Han [33] conducted a sub-sectoral study, investigating the industrial structure upgrading effect of two-way FDI. Their findings showed that two-way FDI in China has a significant non-linear impact on industrial restructuring. The elasticity of the industrial structure promotion of FDI is "inverted U-shaped", and that of OFDI is "J-shaped", and there is significant industry heterogeneity. Therefore, in this study, Chinese manufacturing industries are classified into technology-intensive, capital-intensive, and labor-intensive according to the differences among the segments. Industry heterogeneity is investigated in the impact of two-way FDI on innovation capability through industrial structure upgrading.

**Hypothesis 4 (H4).** *There is industry heterogeneity in the mediating role played by industrial structure upgrading in the innovation-driving effect of two-way FDI synergistic development.*

## 4. Research Design

### *4.1. Variable Description and Indicator Construction*

1. Response variable: *IC* (manufacturing innovation capacity). There are traditional indicators for measuring innovation capabilities, such as innovation efficiency, innovation input and innovation output, etc. According to the description of the regional innovation process by Yongzhong Li et al. [53], innovation output is more important for the measurement of innovation capability, so this paper chooses innovation output as the measure of innovation capability. Specifically, we adopt the method of Guanghe Ran et al. [54] and use the number of invention patent applications to measure the innovation capability of the manufacturing industry.
2. Explanatory variable: *TWDI* (the degree of two-way FDI synergistic development in manufacturing). As can be observed from the above-mentioned two-way FDI synergistic development mechanism, IFDI and OFDI, as the two complex systems that closely cooperate and interact with each other, are highly similar in the synergistic relationship in the coupling mechanism [25]. The coupling mechanism refers to the synergy of two or more systems together to generate incremental forces to accomplish tasks that no single system or incomplete system can accomplish, and the coupling degree can be used to analyze the degree of close cooperation and mutual influence between these systems [55,56]. Therefore, this paper uses the coupling degree to initially measure the degree of the synergy of two-way FDI, as shown by the following equation:

$$COR_{it} = (IFDI_{it} \times OFDI_{it}) \div (\varphi IFDI_{it} + \gamma OFDI_{it})^{\theta} \quad (1)$$

Because of the inaccessibility of the source of data on the segmental flow of IFDI and OFDI in China's manufacturing industry and the existence of the effects of import and export creation by IFDI and OFDI among China and major countries [57], this paper estimates the segmental IFDI and OFDI flows through the following formulas [58]: $IFDI_{it} = \frac{W_{it}}{W_t} \times IFDI_t$ and $OFDI_{it} = \frac{C_{it}}{C_t} \times OFDI_t$, where $IFDI_t$ and $OFDI_t$ represent the total IFDI and OFDI flows of 27 manufacturing segments in year t, respectively, $W_t$ and $C_t$ represent the sum of the foreign capital and export delivery value of 27 manufacturing industries in year t, $W_{it}$ and $C_{it}$ represent the foreign capital and export delivery values of segment i in year t, respectively and φ and γ are specific weights used to measure the proportion relationship between systems. In this paper, from the perspective of "dual-circulation", the two-way international investment is considered to be complementary and equally important, so φ and γ are each valued at 0.5. In addition, θ is the adjustment coefficient, and the usual range of values is [2,5], and the value of 2 is taken in this paper.

Given the differences between IFDI and OFDI, in order to avoid high coupling when both values are low, this paper introduces a coordinated development indicator [59,60] to characterize the extent to which higher levels of IFDI and OFDI are closely coordinated and interact with each other.

$$D_{it} = (COR \times T)^{1/2} \tag{2}$$

where $T$ is the comprehensive investment indicator, $T = (IFDI_{it} + OFDI_{it})/2$, and $D_{it}$ is the degree of coupling coordination of the $i$th segment in year t. Furthermore, this paper applies the method of Xu Lei et al. [13] by combining Equations (4) and (5) to derive the following formula to measure the degree of two-way FDI synergy development in China's manufacturing industry:

$$TWDI_{it} = [(IFDI_{it} \times OFDI_{it}) \div (IFDI_{it} + OFDI_{it}) \div 2]^{1/2} \tag{3}$$

3. Mediating variable: $STR$ (industrial structure upgrading). According to Ping He et al. [61], the measure of industrial structural upgrading needs to consider whether the industry is shifting from the low end to the high end and whether this shift positively influences output efficiency, added value, and market competitiveness of the industry. Following this idea, this paper adopts the structural advancement value to measure the industrial structural upgrading of the manufacturing industry. This indicator not only reflects the development degree and direction of some specific manufacturing segment relative to the overall manufacturing industry, but also meets the requirement that the sum of the indicator value of the advancing industry and the lagging industry is 0. The specific calculation formula is as follows:

$$V_{it} = \frac{b_{it} - a_i(1+r)^n}{B_t - A} \times 100\% \tag{4}$$

where $V_{it}$ denotes the structural advancement value of the $i$th segment in year $t$. $a_i$ and $b_{it}$ denote the added value of the $i$th segment in the original period and reporting period, respectively, $A$ and $B_t$ denote the added value of the overall manufacturing industry in the original period and reporting period, respectively. $r$ denotes the average annual growth rate of the added value of the overall manufacturing industry. $n$ denotes the years between the reporting period and the original period, where the original period is 2003 and the reporting period is the year $t$. If $V_i < 0$, it means that the development of the $i$th segment in year t relatively lags behind as a whole; if $V_i > 0$, it means that the development of the $i$th segment in year t relatively overtakes as a whole. To reduce the effect of heteroscedasticity, all variables in the model need to be logarithmic, and the variable $V_{it}$ has a negative value, so it is converted into a full-scale percentage score using the indext score method, and the calculation formula is as follows:

$$STR_{it} = \frac{V_{it} - V_{min}}{V_{max} - V_{min}} \times 100 \tag{5}$$

In this formula, $V_{max}$ and $V_{min}$ are the maximum and minimum structural advancement values among all the manufacturing segments.

4. Control variables: *GOF* indicates government support, which is measured by government capital input according to the method of Nanpei Li et al. [62]. *OPEN* indicates the degree of openness, which is measured by the ratio of the sum of foreign capital, Hong Kong, Macao and Taiwan capital to industry paid-in capital. *TCD* indicates foreign trade competitiveness, which is measured by the ratio of the export delivery value to the main business revenue. *LI* denotes the labor input of innovation, that is, scientific research personnel input, using R&D personnel converted to full-time equivalents to characterize the labor input of innovation. *MI* denotes the capital input of innovation, and is measured by using the ratio of internal expenditure of R&D funds to the main business revenue.

### *4.2. Model Design*

To test the above research hypotheses, this paper builds a mediating effect model [63] to systematically examine the relationship among two-way FDI synergistic development, industrial structure upgrading, and innovation capability in China's manufacturing industry, with a focus on verifying whether two-way FDI synergistic development in China's manufacturing industry promotes innovation capability through the mediating effect of industrial structure upgrading.

Firstly, the direct impact of two-way FDI synergistic development on the innovation capability of the Chinese manufacturing industry is examined from the input–output perspective of innovation activities, and the following benchmark panel model is constructed and regressed:

$$\ln IC_{it} = \gamma_0 + \gamma_1 \ln TWDI_{it} + \gamma_2 \ln GOF_{it} + \gamma_3 \ln OPEN_{it} + \gamma_4 \ln TCD_{it} + \alpha \ln MI_{it} + \beta \ln LI_{it} + \mu_i + \varepsilon_{it} \quad (6)$$

Secondly, the direct impact of two-way FDI synergistic development on the industrial structure upgrading of China's manufacturing industry is examined with industrial structure upgrading as the explanatory variable, demonstrated by the following equation:

$$\ln STR_{it} = \theta_0 + \theta_1 \ln TWDI_{it} + \theta_2 \ln GOF_{it} + \theta_3 \ln OPEN_{it} + \theta_4 \ln TCD_{it} + \theta_5 \ln MI_{it} + \theta_6 \ln LI_{it} + \mu_i + \varepsilon_{it} \quad (7)$$

Finally, the mediating variable of industrial structure upgrading is introduced in model (6), as follows:

$$\ln IC_{it} = \varphi_0 + \varphi_1 \ln TWDI_{it} + \varphi_2 \ln STR_{it} + \varphi_3 \ln GOF_{it} + \varphi_4 \ln OPEN_{it} + \varphi_5 \ln TCD_{it} + \varphi_6 \ln MI_{it} + \varphi_7 \ln LI_{it} + \mu_i + \varepsilon_{it} \quad (8)$$

Referring to the method of Xing Bao [64], the test of mediating effects is mainly used to judge the significance of $\gamma_1$, $\theta_1$, $\varphi_1$, and $\varphi_2$ in models (6)–(8). If $\gamma_1$, $\theta_1$, $\varphi_1$, and $\varphi_2$ are significant, the mediating effect is approved. If $\gamma_1$ is significant, but either $\theta_1$ or $\varphi_1$ is insignificant, then we need to verify the mediating effect through the Sobel test.

### *4.3. Sample Selection and Data Sources*

This paper uses panel data from China's manufacturing industry from 2003 to 2018 for empirical testing and estimation. Considering the consistency of statistical caliber and the data availability, this paper reasonably adjusts the sample and selects 27 manufacturing industry segments as the research object and all the data are standardized. The original data of all the variables in the empirical model of this paper are obtained from *China Statistical Yearbook on Science and Technology*, *Statistical Yearbook on Science and Technology of Industrial Enterprises*, *Statistical Bulletin of China's Outward Foreign Direct Investment*, and *China Industrial Statistical Yearbook*. Based on the original data, the article calculates the values of all the variables according to the measurement method mentioned earlier.

## **5. Empirical Analysis**

### *5.1. Testing the Relationship and Measuring the Degree of Synergistic Development of Two-Way FDI in China's Manufacturing Industry*

The test of the synergistic relationship between two-way FDI in China's manufacturing industry includes the following three steps: firstly, the Granger cause test is used to verify the synergistic relationship between the two-way FDI. Secondly, an orthogonalized impulse response function plot is drawn to observe the mutual influence between the two over a lag period. Finally, we verify the synergistic development relationship between two-way FDI. Since data smoothness is the premise of the Granger cause test, this paper first performs LLC, IPS, and Fisher tests on the sample data. The test results are shown in Table 1. ln*IFDI* and ln*OFDI* are proved to be smooth series by LLC and IPC tests, but their smoothness is not proved in the Fisher test. ln*IFDI* and ln*OFDI* rejected the original hypotheses of LLC, IPS, and Fisher tests after first-order difference, so further co-integration tests are needed for the first-order single integer variables. According to the test results of Table 2, it can be observed that all three tests reject the original hypothesis, indicating that there is a long-run equilibrium relationship between the variable series. Then, the Granger cause test is conducted on the two-way FDI data of the manufacturing industry in China, and the results are shown in Table 3. When the lag order is chosen as 2, OFDI is the Granger cause of IFDI and IFDI is the Granger cause of OFDI, so there is a significant co-evolutionary relationship between IFDI and OFDI of the manufacturing industry in China.

**Table 1.** Unit root test results.

| Inspection Method | LLC Test | IPS Test | Fisher Test |
|---|---|---|---|
| ln*IFDI* | −3.938 *** | −5.219 *** | −3.869 *** |
| Δln*IFDI* | −8.352 *** | −10.078 *** | −11.257 *** |
| ln*OFDI* | −4.548 *** | −6.082 *** | 7.329 |
| Δln*OFDI* | −4.510 *** | −10.024 *** | −7.507 *** |

Note: ① *** denotes significance at the 1% level. ② Δ denotes first-order difference. ③ The results of LLC, IPS, and Fisher tests correspond to the values of the statistics of adjusted t*, Z-t-tilde bar, and inverse normal z, respectively.

**Table 2.** Co-integration test results.

| Inspection Method | Statistical Quantities | Value | *p*-Value |
|---|---|---|---|
| Kao test | ADF t | 2.759 | 0.003 |
| Pedroni test | Modified PP t | −7.015 | 0.000 |
| Westerlund test | Variance ratio | −4.628 | 0.000 |

**Table 3.** Granger cause test results.

| Original Hypothesis | Hysteresis Order | $\chi^2$ | *p*-Value | Judgment |
|---|---|---|---|---|
| Δln*OFDI* is not Δln*IFDI*'s Granger cause | 2 | 61.231 | 0.000 | Reject the original hypothesis |
| Δln*IFDI* is not Δln*OFDI*'s Granger cause | 2 | 16.576 | 0.000 | Reject the original hypothesis |

To further verify the synergistic development relationship of two-way FDI, this paper obtains the orthogonalized impulse response function plots of IFDI and OFDI of the manufacturing industry in China through 1000 Monte Carlo simulations with Stata15.0 software. According to the characteristics of the sample data, the lag order is selected as 3, and the duration of the shock effect is set to 10 periods, according to the sample duration. Since there are two variables in total, four impulse response graphs are obtained, and the results are shown in Figure 4. The vertical axis of the impulse response function plot is the impulse response intensity, the horizontal axis is the lag order, the middle dashed line is the zero scale line; and the upper and lower lines represent the 5% and 95% impulse response confidence intervals.

As can be observed from the impulse response plot of IFDI to OFDI, the exogenous impact of one standard deviation of IFDI will stimulate the positive impact of OFDI in the first phase and negative impact in the second phase, and then the impulse response curve fluctuates around the zero scale line and gradually becomes stable. As can be observed from the impulse response plot of OFDI to IFDI, the exogenous impact of one standard deviation of OFDI will stimulate the negative impact of IFDI in the first phase and the positive impact in the second phase. Then, the impulse response curve fluctuates around the zero scale line and gradually becomes stable. In summary, the impulse response function analysis further verifies the significant synergistic relationship between IFDI and OFDI in 27 segments of China's manufacturing industry. H1 is, therefore, verified.

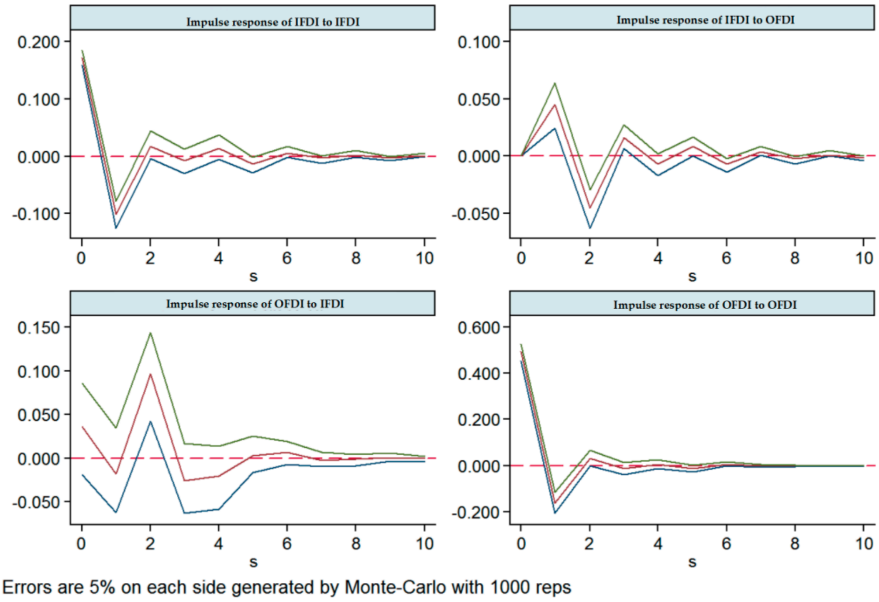


**Figure 4.** Impulse response function results. Note: the upper line in green color represents the 5% impulse response confidence interval, the lower line in blue color represents the 95% impulse response confidence interval lines, and the middle line in red color represents the true value of the regression.

The degree of synergistic development of two-way FDI in China's manufacturing industry is ranked from highest to lowest by the mean value of each industry and is summarized in Table 4. In addition, the two-way FDI synergy development trend of China's manufacturing industry segments is plotted in Figure 5.

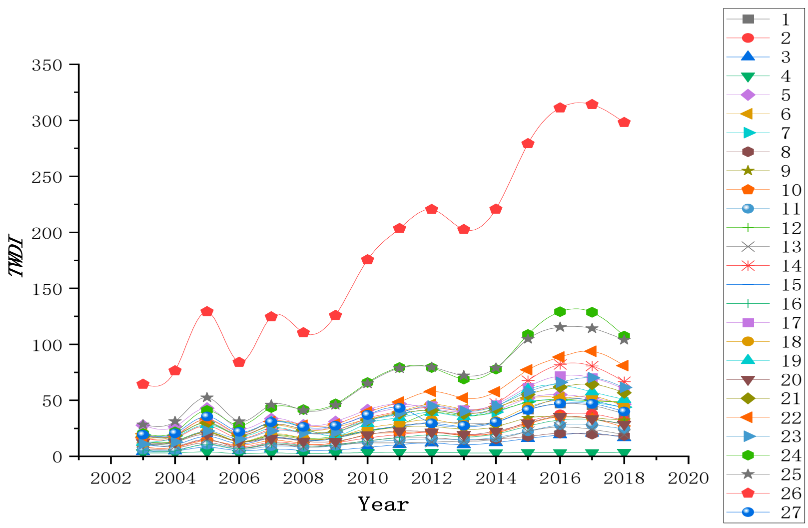


**Figure 5.** Synergistic development trend of two-way FDI in China's manufacturing industry segments.

**Table 4.** Degree of the synergy of two-way FDI development in China's manufacturing industry segments.

| Industry | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | Average Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 26 | 64.51 | 76.42 | 129.29 | 84.03 | 124.63 | 110.42 | 125.83 | 175.60 | 203.52 | 220.41 | 202.48 | 220.73 | 279.21 | 311.13 | 314.17 | 298.08 | 183.78 |
| 24 | 20.46 | 21.88 | 41.03 | 27.51 | 43.43 | 41.80 | 46.82 | 66.01 | 79.40 | 79.24 | 68.96 | 77.88 | 108.86 | 129.19 | 128.63 | 107.46 | 68.03 |
| 25 | 28.28 | 31.31 | 52.45 | 31.24 | 46.05 | 40.99 | 45.78 | 65.01 | 78.61 | 79.58 | 72.12 | 78.94 | 104.65 | 115.33 | 114.23 | 103.86 | 68.03 |
| 22 | 16.56 | 18.55 | 33.27 | 20.56 | 30.95 | 27.82 | 28.71 | 39.66 | 48.56 | 57.96 | 52.09 | 57.65 | 77.24 | 88.67 | 93.75 | 80.98 | 48.31 |
| 17 | 18.81 | 19.57 | 32.82 | 19.68 | 28.05 | 24.29 | 26.72 | 36.98 | 43.41 | 45.60 | 41.76 | 46.47 | 62.13 | 71.83 | 70.24 | 60.33 | 40.54 |
| 14 | 16.13 | 16.39 | 27.23 | 16.27 | 24.00 | 20.86 | 23.03 | 33.92 | 39.97 | 43.57 | 40.52 | 47.29 | 67.64 | 82.09 | 80.59 | 66.63 | 40.38 |
| 5 | 27.71 | 26.55 | 42.95 | 24.94 | 33.62 | 28.04 | 30.97 | 41.63 | 46.75 | 42.67 | 39.22 | 41.07 | 52.04 | 55.11 | 51.97 | 46.53 | 39.49 |
| 21 | 17.78 | 18.74 | 29.84 | 18.60 | 28.14 | 23.75 | 22.00 | 32.17 | 38.21 | 41.07 | 37.95 | 42.89 | 55.20 | 61.88 | 64.35 | 56.85 | 36.84 |
| 23 | 11.08 | 12.79 | 22.56 | 15.42 | 22.67 | 21.00 | 21.48 | 31.60 | 38.86 | 44.82 | 40.31 | 44.95 | 57.54 | 66.07 | 70.19 | 61.52 | 36.43 |
| 6 | 20.22 | 18.29 | 30.54 | 18.97 | 27.46 | 23.25 | 25.94 | 33.17 | 39.81 | 46.48 | 42.10 | 44.14 | 51.98 | 52.70 | 50.44 | 47.72 | 35.83 |
| 19 | 12.46 | 16.95 | 28.28 | 20.20 | 30.37 | 25.79 | 18.23 | 29.37 | 34.62 | 39.34 | 35.52 | 44.00 | 59.65 | 63.55 | 57.57 | 50.81 | 35.42 |
| 7 | 19.12 | 18.23 | 30.27 | 18.20 | 25.45 | 20.95 | 23.44 | 31.96 | 37.51 | 41.54 | 36.98 | 39.54 | 48.69 | 50.18 | 48.02 | 43.89 | 33.37 |
| 27 | 19.22 | 20.64 | 35.57 | 21.92 | 30.51 | 26.20 | 27.20 | 36.98 | 43.18 | 29.40 | 27.30 | 30.59 | 41.34 | 47.18 | 46.96 | 40.06 | 32.76 |
| 12 | 13.36 | 13.62 | 21.96 | 13.21 | 18.87 | 16.36 | 17.95 | 22.84 | 28.12 | 38.86 | 36.04 | 40.34 | 48.11 | 50.87 | 49.46 | 48.63 | 29.91 |
| 18 | 11.62 | 12.59 | 22.08 | 13.26 | 19.89 | 16.23 | 17.08 | 25.04 | 29.54 | 32.61 | 28.13 | 31.43 | 43.93 | 50.77 | 53.70 | 44.47 | 28.27 |
| 1 | 13.26 | 13.28 | 21.22 | 13.16 | 17.10 | 14.31 | 17.04 | 22.84 | 27.23 | 30.28 | 29.78 | 30.78 | 41.51 | 47.04 | 45.35 | 37.81 | 26.37 |
| 15 | 10.66 | 10.20 | 17.88 | 11.17 | 16.33 | 14.19 | 16.28 | 23.09 | 26.70 | 29.40 | 26.44 | 30.30 | 42.24 | 51.50 | 49.69 | 43.14 | 26.20 |
| 9 | 10.51 | 12.96 | 21.20 | 13.04 | 18.18 | 15.24 | 16.43 | 22.14 | 26.05 | 26.68 | 24.13 | 26.58 | 34.27 | 35.45 | 34.38 | 32.01 | 23.08 |
| 20 | 12.23 | 12.86 | 19.79 | 12.95 | 16.10 | 13.53 | 13.50 | 19.23 | 22.68 | 21.74 | 19.55 | 22.47 | 29.68 | 35.71 | 33.59 | 28.56 | 20.88 |
| 2 | 8.15 | 8.22 | 14.62 | 8.66 | 12.54 | 10.52 | 12.00 | 16.43 | 19.50 | 21.57 | 19.59 | 21.19 | 30.89 | 37.43 | 37.85 | 31.92 | 19.44 |
| 10 | 8.25 | 8.02 | 13.96 | 9.86 | 14.17 | 11.28 | 12.31 | 19.61 | 21.06 | 21.62 | 18.63 | 20.89 | 28.97 | 35.49 | 33.69 | 25.81 | 18.98 |
| 16 | 5.86 | 4.87 | 10.87 | 6.87 | 11.73 | 9.52 | 10.24 | 13.89 | 16.81 | 19.14 | 17.32 | 20.02 | 26.95 | 32.47 | 32.82 | 29.07 | 16.78 |
| 11 | 6.19 | 5.63 | 10.39 | 6.11 | 9.13 | 8.25 | 9.45 | 12.91 | 14.33 | 15.51 | 14.84 | 16.81 | 22.38 | 28.02 | 28.13 | 24.47 | 14.53 |
| 13 | 12.37 | 8.96 | 15.20 | 7.30 | 10.69 | 8.35 | 9.97 | 11.96 | 12.09 | 12.72 | 13.40 | 15.21 | 22.22 | 26.17 | 24.06 | 19.45 | 14.38 |
| 8 | 6.60 | 7.16 | 12.19 | 7.58 | 10.79 | 9.10 | 10.80 | 13.65 | 16.81 | 16.75 | 14.79 | 15.44 | 17.81 | 20.55 | 19.70 | 18.42 | 13.63 |
| 3 | 4.23 | 4.78 | 8.16 | 5.07 | 6.49 | 5.35 | 5.63 | 7.99 | 10.52 | 11.91 | 10.27 | 12.25 | 15.91 | 19.24 | 20.66 | 16.65 | 10.32 |
| 4 | 3.23 | 3.05 | 3.97 | 2.43 | 3.03 | 2.48 | 2.80 | 3.35 | 3.58 | 3.51 | 3.20 | 3.06 | 3.35 | 3.29 | 3.29 | 3.47 | 3.19 |

As shown in Table 4 and Figure 5, the degree of synergistic development of two-way FDI in the 27 manufacturing segments increases with each year, which indicates that the country has made significant achievements in enhancing the level of two-way international investment and synergistic development of two-way FDI. In addition, the measurement result of the annual average degree of two-way FDI synergistic development indicates the differentiated development of the 27 segments of China's manufacturing industry. More specifically, among the segments of the manufacturing industry, the degree of two-way FDI synergistic development in communication equipment, computer and other electronic equipment manufacturing, transportation equipment manufacturing and electrical machinery and equipment manufacturing is more advanced. The degree of two-way FDI synergistic development in wood processing and wood, bamboo, rattan, palm and grass products industries, beverage manufacturing and tobacco products industries is the lowest.

### *5.2. Empirical Results and Mechanism Analysis of the Impact of the Synergy of Two-Way FDI on Manufacturing Innovation Capability*

#### 5.2.1. Robustness Test for Overall Manufacturing Data

Before the parameter estimation of models (6)–(8), it is necessary to test the data of all the variables for smoothness first, and a unit root test is conducted using Stata 15.0 software. As shown in Table 5 of the test results, in the LLC test, all the variable data pass the smoothness, test except for variables ln*LI* and ln*MI*. In the IPS test, all the variable data are smooth. However, in the Fisher test, all the variable data failed the smoothness test, except ln*IC* and ln*STR*. Moreover, after first-order difference, all the variables reject the original hypothesis of the LL, IPS and Fisher tests, that is, all variables show first-order integrality, so a further co-integration test is needed. According to the test results in Table 6, it can be observed that all three tests reject the original hypothesis and prove that there is a co-integration relationship between the variable series, indicating that there is a long-term equilibrium relationship.

**Table 5.** Unit root test for all variables.

| Inspection Method | LLC Test | IPS Test | Fisher Test |
|---|---|---|---|
| ln*IC* | −10.750 *** | −6.531 *** | −3.869 *** |
| Δln*IC* | −8.955 *** | −10.349 *** | −11.257 *** |
| ln*TWDI* | −6.574 *** | −5.098 *** | 1.017 |
| Δln*TWDI* | −3.925 *** | −8.580 *** | −10.969 *** |
| ln*STR* | −6.421 *** | −8.471 *** | −14.050 *** |
| Δln*STR* | −14.375 *** | −11.521 *** | −11.129 *** |
| ln*GOF* | −7.203 *** | −7.214 *** | 0.525 |
| Δln*GOF* | −15.072 *** | −10.748 *** | −11.664 *** |
| ln*OPEN* | −2.453 *** | −4.339 *** | 1.021 |
| Δln*OPEN* | −7.164 *** | −10.157 *** | −9.260 *** |
| ln*TCD* | −3.836 *** | −5.333 *** | 2.067 |
| Δln*TCD* | −8.600 *** | −10.519 *** | −9.737 *** |
| ln*LI* | 1.075 | −5.109 *** | 4.007 |
| Δln*LI* | −5.368 *** | −11.226 *** | −9.406 *** |
| ln*MI* | 2.779 | −2.862 ** | 7.329 |
| Δln*MI* | −3.634 *** | −10.049 *** | −7.507 *** |

Note: ① *** and ** denote significance at the 1% and 5% levels, respectively. ② Δ denotes first-order difference. ③ The results of LLC, IPS, and Fisher test correspond to the values of the statistics of adjusted t*, Z-t-tilde bar, and inverse normal z statistics, respectively.

**Table 6.** Results of co-integration tests for all variables.

| Inspection Method | Statistical Quantities | Value | *p*-Value |
|---|---|---|---|
| Kao test | ADF t | −2.8908 | 0.0019 |
| Pedroni test | Modified PP t | 7.9742 | 0.0000 |
| Westerlund test | Variance ratio | 5.6456 | 0.0000 |

### 5.2.2. The Multi-Collinearity Test

In this paper, the data of 27 manufacturing industry segments in China from 2003 to 2018 are used as the overall sample to construct the panel data model. In order to ensure the accuracy of the multi-variable regression and the validity of the linear regression in the empirical study, a multi-collinearity test (VIF test) for the three models is involved in this paper. The test results of the VIF values of each estimated variable indicate that there is no serious problem of multi-collinearity in models (6)–(8), as shown in Table 7.

**Table 7.** The results of the multi-collinearity test of models (6)–(8).

| Variables | (6)_VIF Value | (7)_VIF Value | (8)_VIF Value |
|---|---|---|---|
| ln*TWDI* | 6.67 | 6.67 | 6.71 |
| ln*STR* | | | 1.28 |
| ln*GOF* | 9.07 | 9.07 | 9.07 |
| ln*OPEN* | 2.59 | 2.59 | 2.67 |
| ln*TCD* | 3.61 | 3.61 | 3.61 |
| ln*LI* | 9.72 | 9.72 | 9.73 |
| ln*MI* | 2.21 | 2.21 | 2.30 |
| Mean | 6.78 | 6.78 | 5.05 |

### 5.2.3. Main Effects and Endogeneity Test

In order to verify H2, the panel data of 27 manufacturing industry segments in China from 2003 to 2018 are selected to estimate model (6), and the estimation results are listed in Table 8. From the three tests of F, LR, and Hausman, it is clear that FE estimation should be selected. In order to test the robustness of model (6), the DWH test is conducted to test the endogeneity of model (6). According to the test results in Table 9, the endogenous problem exists in model (6). Therefore, the instrumental variable method is necessary to eliminate the endogeneity problem. In this paper, the first-order lag term of the variable *TWDI*, the first-order and second-order lag terms of the variable *OPEN*, and the first-order and second-order lag terms of the variable *TCD* are selected as instrumental variables. To verify the reasonableness of the selected instrumental variables, the LR test, Cragg–Donald F test, and Sargan test are used to test whether the instrumental variables are under-identified, weakly instrumental (weakly correlated), or over-identified. The results of these tests are also listed in Table 9. The test values show that the instrumental variables selected in this paper do not have problems of under-identification, weak instrumental variable, or over-identification, indicating that the instrumental variables selected in this paper are reasonable. In order to compare the estimation results of the model parameters, the FE estimation results with instrumental variables are presented in Table 8. By comparing the results of three estimation methods of ordinary standard error FE, cluster robust standard error FE and heteroscedastic robustness IV, it can be observed that the estimated coefficients of the core variable *TWDI* are all significantly positive at the 1% significance level, indicating that the two-way FDI synergistic development relationship can significantly contribute to the improvement of China's manufacturing innovation capacity. Therefore, H2 is verified.

**Table 8.** Estimation results of the impact of two-way FDI synergistic development on manufacturing innovation capacity.

| Variables | OLS | FE | RE | OLS_robust | FE_robust | RE_robust | FE_IV |
|---|---|---|---|---|---|---|---|
| ln*TWDI* | 0.626 ***<br>(0.086) | 0.475 ***<br>(0.084) | 0.523 ***<br>(0.080) | 0.626 ***<br>(0.143) | 0.475 ***<br>(0.179) | 0.523 ***<br>(0.160) | 1.065 ***<br>(0.179) |
| ln*GOF* | 0.051<br>(0.044) | −0.017<br>(0.055) | −0.027<br>(0.050) | 0.051<br>(0.123) | −0.017<br>(0.122) | −0.027<br>(0.125) | 0.105<br>(0.084) |
| ln*OPEN* | −0.327 ***<br>(0.038) | −0.259 **<br>(0.104) | −0.237 ***<br>(0.070) | −0.327 ***<br>(0.066) | −0.259<br>(0.330) | −0.237<br>(0.149) | |
| ln*TCD* | −0.028<br>(0.046) | −0.140<br>(0.084) | −0.105<br>(0.066) | −0.028<br>(0.084) | −0.140<br>(0.104) | −0.105<br>(0.084) | |
| ln*LI* | 0.747 ***<br>(0.082) | 1.071 ***<br>(0.086) | 1.037 ***<br>(0.081) | 0.747 ***<br>(0.183) | 1.071 ***<br>(0.171) | 1.037 ***<br>(0.194) | 0.765 ***<br>(0.141) |
| ln*MI* | 0.280 ***<br>(0.054) | 0.036<br>(0.084) | 0.072<br>(0.058) | 0.280 ***<br>(0.082) | 0.036<br>(0.074) | 0.072<br>(0.061) | 0.029<br>(0.041) |
| *_cons* | −2.055 ***<br>(0.572) | −4.530 ***<br>(0.852) | −4.431 ***<br>(0.650) | −2.055 *<br>(1.127) | −4.530 ***<br>(1.616) | −4.431 ***<br>(1.104) | |
| F value | 597.810 *** | 406.510 *** | | 92.470 *** | 109.380 *** | | 243.580 *** |
| R2 | 0.894 | 0.860 | 0.886 | 0.894 | 0.860 | 0.886 | 0.820 |
| F test | | 14.080 *** | | | | | |
| Wald chi2(6) | | | 2670.790 *** | | | 547.740 *** | |
| LM test | | | 457.330 *** | | | | |
| Hausman test | | 17.860 *** | | | | | |
| N | 432 | 432 | 432 | 432 | 432 | 432 | 378 |

Note: ① The OLS_robust, FE_robust, RE_robust and FE_IV brackets are clustering robust standard errors, and the OLS, FE and RE brackets are ordinary standard errors; ② ***, **, * denote significance at the 1%, 5% and 10% levels, respectively. ③ The background color of gray in the table indicates that FE estimation should be selected.

**Table 9.** Results of the endogeneity test for model (6).

| | DWH Test | Anderson Canno. Corr. LR Test | Cragg–Donald F Test | Sargan Test |
|---|---|---|---|---|
| Statistical values | 31.901 *** | 108.366 *** | 24.813 (10%) | 5.100 |

Note: *** denotes significance at the 1% level.

It is worth noting that the coefficients of the variable *GOF* are insignificant in all three FE estimates, which indicates that the policy incentives for innovation do not have significant incentive effects in practice. The possible reasons may include the rent-seeking behavior of a few officials [65], and the "innovation erosion" [66] caused by the "false innovation" behavior of some enterprises. In the FE estimation of clustered robust standard errors, the coefficient of the variable *OPEN* is negative, but insignificant. In the FE estimation of common standard errors and the FE estimation of clustered robust standard errors, the coefficient of the variable *TCD* is negative and insignificant. In the three FE estimations, the coefficient of the variable *MI* is positive, but insignificant. The possible reason for such results is that the effects of openness to the outside world, foreign trade competitiveness, and R&D investment intensity on innovation capability in China's manufacturing industry are not necessarily linear relationships. The effects of these three control variables on manufacturing innovation capability may also depend on external environmental factors, such as intellectual property protection [67]. In all three FE estimates, the coefficient of the variable *LI* is significantly positive at the 1% significance level, indicating that research talent investment does significantly enhance the innovation capability of the Chinese manufacturing industry.

#### 5.2.4. Mediating Effect and the Endogeneity Test

According to the step-by-step regression of mediating effects, model (7) and model (8) should be tested sequentially. In order to avoid the interference of the endogeneity problem on the robustness regression results of model (7) and model (8), the article respectively conducts endogeneity tests, and the results are shown in Table 10. Given the endogeneity problem of both model (7) and model (8), the instrumental variable method is used for adjustment. The instrumental variables selected for model (7) are the first-order lag term of *TWDI*, the first-order and second-order lag terms of *TCD*, and the first-order and second-order lag terms of *MI*. The instrumental variables selected for model (8) are the first-order lag term of *TWDI*, the first- and second-order lag terms of *OPEN*, and the first- and second-order lag terms of *TCD*, respectively. From the three tests of LR, Cragg–Donald F, and Sargan in Table 10, it can be observed that regarding the instrumental variables selected in model (7) and model (8), there are no problems of under-identification, weak instrumental variables, or over-identification, indicating that the selection of instrumental variables is appropriate.

**Table 10.** Endogeneity test results for model (7) and model (8).

| | DWH Test | Anderson Canno. Corr. LR Test | Cragg–Donald F Test | Sargan Test |
|---|---|---|---|---|
| Statistical values of model (7) | 3.598 * | 114.777 *** | 26.535 (10%) | 7.656 |
| Statistical values of model (8) | 30.783 *** | 106.699 *** | 24.299 (10%) | 5.215 |

Note: *** and * denote significance at the 1% and 10% levels, respectively.

From the three tests of F, LR and Hausman, it is clear that the most appropriate estimation method for model (7) should be RE, while for model (8), it is FE. In order to compare the estimation results of the model parameters, the results of model (6)–(8) and their IV_2SLS estimation results are simultaneously presented in Table 11. It can be observed from Table 11 that firstly, in the three types of FE and RE estimations in model (7), the estimated coefficients of the core explanatory variable *TWDI* are significantly positive at the 5% level of significance in the RE estimation, with common standard errors and clustered robust standard errors. In the RE estimation with instrumental variables, the estimated coefficients of the core explanatory variable *TWDI* are significantly positive at the 10% level of significance, which fully indicates that the two-way FDI synergistic development relationship can promote the upgrading of China's manufacturing industry structure.

**Table 11.** Results of the overall sample test for mediating effects.

| Variables | FE (6) | RE (7) | FE (8) | FE _robust (6) | RE _robust (7) | FE _robust (8) | FE _IV (6) | RE _IV (7) | FE _IV (8) |
|---|---|---|---|---|---|---|---|---|---|
| ln*TWDI* | 0.475 *** (0.084) | 0.187 ** (0.095) | 0.456 *** (0.085) | 0.475 *** (0.179) | 0.187 ** (0.065) | 0.456 ** (0.177) | 1.065 *** (0.179) | 0.265 * (0.153) | 1.041 *** (0.168) |
| ln*STR* | | | 0.100 ** (0.040) | | | 0.100 (0.070) | | | 0.062 (0.038) |
| ln*GOF* | −0.017 (0.055) | −0.018 (0.058) | −0.015 (0.055) | −0.017 (0.122) | −0.018 (0.058) | −0.015 (0.120) | 0.105 (0.084) | 0.047 (0.070) | 0.103 (0.058) |
| ln*OPEN* | −0.259 ** (0.104) | 0.148 ** (0.072) | −0.257 ** (0.104) | −0.259 (0.330) | 0.148 *** (0.055) | −0.257 (0.317) | | 0.067 (0.076) | |
| ln*TCD* | −0.140 (0.084) | −0.076 (0.070) | −0.122 (0.084) | −0.140 (0.104) | −0.076 (0.056) | −0.122 (0.106) | | | |
| ln*LI* | 1.071 *** (0.086) | 0.010 (0.096) | 1.077 *** (0.086) | 1.071 *** (0.171) | 0.010 (0.101) | 1.077 *** (0.170) | 0.765 *** (0.141) | −0.022 (0.133) | 0.771 *** (0.112) |
| ln*MI* | 0.036 (0.084) | 0.138 ** (0.068) | 0.027 (0.063) | 0.036 (0.074) | 0.138 ** (0.130) | 0.027 (0.074) | 0.029 (0.041) | | 0.025 (0.055) |
| *_cons* | 4.530 *** (0.852) | 2.775 *** (0.725) | 4.955 *** (0.863) | 4.530 *** (1.616) | 2.775 *** (0.621) | 4.955 *** (1.581) | | 2.534 *** (0.877) | 5.290 *** (0.633) |
| F value | 406.500 *** | | 354.000 *** | 109.400 *** | | 96.700 *** | | | 243.700 *** |
| $R^2$ | 0.860 | 0.212 | 0.861 | 0.860 | 0.212 | 0.861 | 0.820 | 0.212 | 0.824 |
| F test | 14.080 *** | | 14.270 *** | | | | | | |
| Wald chi2(6) | | 35.420 *** | | | 73.040 *** | | | | |
| Sobel test | | | | | 1.280 | | | 1.188 | |
| N | 432 | 432 | 432 | 432 | 432 | 432 | 378 | 378 | 378 |

Note: ① The standard errors represented in parentheses are consistent with Table 7; ② ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

Secondly, in the three types of FE estimations in model (8), the estimated coefficients of the core explanatory variable *TWDI* are all significantly positive at the 1% or 5% significance level. The estimated coefficients of the mediating variable *STR* are only significant in the ordinary standard error FE estimation. Following the process of testing for mediating effects by Zhonglin Wen [63] and Xing Bao [64], it is necessary to compare the estimated coefficients of the core explanatory variable *TWDI* and the estimated coefficients of the mediating variable *STR* for models (6)–(8). The regression results show that the coefficient $\gamma1$ (0.475) is significant at the 1% level of significance, and the coefficients $\theta1$ (0.187) and $\varphi2$ (0.100) are significant at the 5% level of significance. The coefficient $\varphi1$ (0.456) is also significant at the 1% significance level in estimating the expected standard error. According to the test process of the mediating effect, it can be judged that industrial structure upgrading played a significant mediating effect. In addition, the coefficient $\gamma1$ and coefficient $\theta1$ are significantly positive in the estimation of robust standard errors of the clustering and IV estimation of heteroscedasticity, with the inclusion of instrumental variables. However, the coefficient $\varphi2$ of the mediating variable in model (8) is not significant, so further Sobel tests are needed. The Z-statistic values of both Sobel tests in Table 11 are more significant than the critical value of 0.97 [54] at the 5% significance level, indicating that there is a significant mediating effect. In conclusion, H3 is verified in that the two-way FDI synergistic development is indeed mediated by the upgrading of the manufacturing industry structure, which in turn promotes the improvement of innovation capability.

It is worth noting that firstly, in different RE estimations in model (7), the estimated coefficients of variables *GOF* and *LI* are not significant, which indicates that the investment of Chinese government funds and scientific research talents has not produced a good practical effect on the upgrading of the industrial structure of the manufacturing industry. The reason for this may lie in the "rent-seeking behavior of a few officials" mentioned above, and it may also be due to the inefficiency of China's R&D talent investment in industrial structure impact [68]. Secondly, the coefficients of the variable *OPEN* estimated in the heteroscedasticity robust IV estimation are insignificant; and the coefficients of the variable *TCD* estimated in the first two RE estimations are not insignificant, indicating that the degree of China's openness to the outside world and competitiveness of foreign trade is not the core influencing factor of China's industrial structure upgrading.

### 5.3. Exploring the Industry Heterogeneity of the Intermediary Effect

In order to explore the industrial heterogeneity of the mediating effect of industrial structure upgrading, the manufacturing segments are classified into labor-intensive, capital-intensive and technology-intensive, according to the method of Lei Xu et al. [13]. The mediating effect of industrial structure upgrading on the innovation-driving mechanism of the synergy of two-way FDI development is verified. After classification, each group of samples is classified as long panel data, so the feasibility generalized least squares (FGLS) method is adopted to estimate the mediating effect model, and the estimation results are shown in Table 12.

**Table 12.** Industry heterogeneity test and estimation results of the mediating effect of industrial structure upgrading.

| Variables | Labor-Intensive | | | Capital-Intensive | | | Technology-Intensive | | |
|---|---|---|---|---|---|---|---|---|---|
| | (6) | (7) | (8) | (6) | (7) | (8) | (6) | (7) | (8) |
| ln*TWDI* | 0.060 *** | 0.030 | −0.053 | 0.140 ** | −0.116 * | 0.179 *** | 0.532 *** | 0.170 *** | 0.501 *** |
| | (0.029) | (0.020) | (0.044) | (0.063) | (0.060) | (0.062) | (0.136) | (0.030) | (0.143) |
| ln*STR* | | | 1.496 *** | | | 0.014 * | | | 0.187 |
| | | | (0.062) | | | (0.031) | | | (0.116) |
| ln*GOF* | 0.093 *** | 0.007 *** | 0.099 *** | −0.002 | 0.168 *** | −0.015 | −0.387 *** | −0.043 * | −0.376 *** |
| | (0.017) | (0.002) | (0.019) | (0.031) | (0.023) | (0.031) | (0.095) | (0.026) | (0.094) |
| ln*OPEN* | 0.167 *** | −0.214 *** | 0.196 *** | −0.204 *** | 0.056 *** | −0.208 *** | −0.408 ** | −0.091 ** | −0.404 ** |
| | (0.046) | (0.109) | (0.039) | (0.039) | (0.025) | (0.038) | (0.176) | (0.039) | (0.172) |
| ln*TCD* | −0.251 *** | −0.002 | −0.044 * | −0.104 *** | −0.110 *** | −0.123 *** | 0.230 ** | 0.079 *** | 0.240 ** |
| | (0.022) | (0.016) | (0.026) | (0.046) | (0.023) | (0.044) | (0.103) | (0.026) | (0.102) |
| ln*LI* | 0.820 *** | 0.980 *** | 0.887 *** | 1.051 *** | 0.218 *** | 1.045 *** | 1.449 *** | 0.085 ** | 1.437 *** |
| | (0.029) | (0.002) | (0.029) | (0.068) | (0.039) | (0.067) | (0.168) | (0.034) | (0.167) |
| ln*MI* | 0.219 *** | 0.133 *** | 0.156 *** | 0.117 *** | 0.107 *** | 0.131 *** | 0.281 ** | −0.031 | 0.270 ** |
| | (0.015) | (0.002) | (0.022) | (0.042) | (0.033) | (0.039) | (0.135) | (0.032) | (0.133) |
| *_cons* | −2.241 *** | −2.779 *** | −8.732 *** | −3.884 *** | 0.971 *** | −3.869 *** | −6.826 *** | 2.642 *** | −7.407 *** |
| | (0.235) | (0.004) | (0.329) | (0.550) | (0.327) | (0.542) | (1.211) | (0.289) | (1.247) |
| Wald chi2(6) | 9743.470 *** | 23.090 *** | 5320.890 *** | 815.280 *** | 408.610 *** | 870.770 *** | 1020.210 *** | 125.300 *** | 1146.700 *** |
| Wald test | 766.370 *** | 9857.240 *** | 401.940 *** | 659.410 *** | 5.805 *** | 5.805 *** | 85.230 *** | 1760.140 *** | 68.390 *** |
| Wooldridge test | 31.863 *** | 44.532 *** | 27.942 *** | 60.288 *** | 175.748 *** | 27.942 *** | 8.231 ** | 448.993 *** | 9.320 ** |
| Breusch–Pagan LM test | 194.640 *** | | 208.537 *** | 141.633 *** | 188.743 *** | 208.537 *** | 7.690 *** | 66.553 *** | 29.180 ** |
| Pesaran test | | 1.643 | | | | | | | |
| Sobel test | | | 1.497 | | | | | | 1.810 |
| N | 192 | 192 | 192 | 144 | 144 | 144 | 96 | 96 | 96 |

Note: ① ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively. ② The standard errors in parentheses are robust standard errors; ③ the Wald test, Wooldridge test, Breusch–Pagan LM test and Pesaran test represent the values of the statistics of the respective tests.

To obtain more accurate estimation results, the improved Wald test, Wooldridge test, and Breusch–Pagan LM test (partially replaced by the Pesaran test) are used in this paper to test the between-group heteroscedasticity, within-group autocorrelation, and between-group contemporaneous correlation of the disturbance terms, respectively. It is noteworthy that inter-group contemporaneous correlation exists in model (6) and model (8), and all three problems mentioned above exist simultaneously in the remaining models. Meanwhile, since the mediating effect of industrial structure upgrading in the labor-intensive and technology-intensive industries is not significant according to the stepwise regression test, further Sobel tests are required. The Z-statistic values of both Sobel tests in Table 12 are more significant than the critical value of 0.97 at the 5% significance level [69], indicating that a significant mediating effect exists. So far, by comparing the mediating effect of industrial structure upgrading in the three manufacturing industries, we can observe that there is significant industry heterogeneity in this mediating effect. By analyzing the empirical results, we can observe that firstly, the mediating effect of industrial structure upgrading is significantly positive in labor-intensive and technology-intensive manufacturing industries, and the mediating effect is more significant in technology-intensive manufacturing industries. This is because the mediating effect of industrial structure upgrading in the synergy of two-way FDI on manufacturing innovation capability is not necessarily a simple linear relationship. The institutional environment of different manufacturing industries, the scale of the industry, market players, and other factors may affect the magnitude of the mediating effect. Secondly, the mediating effect of industrial structure upgrading is negative in capital-intensive manufacturing industries. In recent years, with the development of high-grade industries and the improvement of technology reverse spillover-taking capacity in China, many multi-national enterprises have begun to strip non-core businesses at the high-end of the industrial chain and non-core links in the core business to limit the technology spillover in China's capital-intensive industries [70].

It is worth noting that the estimated coefficients of variables *LI* and *MI* in the aggregate effects model are significantly positive in all three manufacturing industries, which confirms that the investment in research talent and funding directly affects the improvement of China's manufacturing innovation capability. In a sense, adequate investment in talent and funding enables manufacturing enterprises to successfully carry out research activities and integrate innovative knowledge and technology. By comparing the estimated coefficients of the variables *LI* and *MI*, we can observe that among the three types of industries, the investment in research talent and funding has the most significant innovation-driving effect in the technology-intensive manufacturing industry. This is probably because the labor and capital factors that affect the innovation capacity are limited by the difference in the "incentive effect" and "cost effect" of innovation activities in each industry [71]. In addition, the variable *GOF* has different effects on the innovation capacity of the three manufacturing industries, with positive effects on the innovation capacity of labor-intensive industries, inhibitory effects on the innovation capacity of technology-intensive industries, and insignificant effects on the innovation capacity of capital-intensive industries. The reason for this may be the "false innovation", "innovation erosion", and "rent-seeking behavior of a few officials" mentioned above. Finally, by comparing the estimated coefficients and symbols of the variables *OPEN* and *TCD* for each industry, we can observe that the degree of openness significantly promotes the innovation capacity of labor-intensive manufacturing industries, but inhibits the innovation ability of capital-intensive and technology-intensive industries. The degree of foreign trade competition significantly inhibits the innovation capacity of labor-intensive and capital-intensive industries.

## 6. Conclusions and Suggestions

### *6.1. Conclusions*

This article uses panel data of 27 segments in China's manufacturing industry from 2003 to 2018 to empirically investigate the influence mechanism of two-way FDI synergistic development on innovation capability in the manufacturing industry by constructing a mediating effect test model, with industrial structure upgrading as a mediating variable. The main conclusions of the article include the following:

(1) A significant synergistic relationship exists between two-way FDI in the Chinese manufacturing industry. It significantly contributes to the improvement of Chinese manufacturing innovation capability. At the same time, investment in research talent is also the main driver for improving China's manufacturing innovation capability. However, due to phenomena such as "rent-seeking behavior", "false innovation", and "innovation erosion", government funding has been ineffective in providing policy incentives for manufacturing innovation.

(2) The synergistic development of two-way FDI in China's manufacturing industry has a significant driving effect on the upgrading of the manufacturing industry structure. However, due to the possible inefficiency of the investment of scientific research talents, the expected effect of upgrading the manufacturing industry structure has not been achieved.

(3) The industrial structure upgrading of the Chinese manufacturing industry is an essential link between two-way FDI synergistic development and innovation capacity enhancement. Industrial structure upgrading does play a mediating effect in the

driving effect of two-way FDI synergistic development on manufacturing innovation capacity. There is significant industry heterogeneity in this mediating effect, among which the mediating effect is significantly positive in labor-intensive and technology-intensive industries, with the more prominent mediating effect in technology-intensive industries. In contrast, however, the mediating effect in capital-intensive industries is significantly negative.

### *6.2. Suggestions*

Based on the above findings, the following policy insights can be drawn from this paper:

(1) When the economy enters the stage of "high-quality development", China must make full use of global resources and markets, including the critical factor of two-way international investment, to shift from "made in China" to "created in China". To take the road of "high-quality development", China's manufacturing industry should pay full attention to the innovation-driving effect of the two-way FDI in the manufacturing industry, by focusing on "bringing in" and "going out". The government should also take advantage of the "Free Trade Area" and "the Belt and Road Initiative" to optimize the domestic business environment and actively participate in international cooperation, promote the peaceful and synergistic development of two-way FDI and advance the implementation of the strategy of manufacturing power.

(2) In the face of both the complicated COVID-19 epidemic prevention and control measures, and the new situation of economic and social development in the world, we have to rely on the benign and synergistic development of two-way FDI in the manufacturing industry to promote innovation capability, among which the mediating effect of upgrading the industrial structure of the manufacturing industry should not be ignored. In the new round of global competition, Chinese manufacturers should try to break the bottleneck between the two-way FDI synergistic development and industrial structure upgrading to improve innovation capability. Specifically, we should take the effective linkage of high-quality "going out" and high-level "bringing in" as the grasping hand and pay attention to the fact that the development of manufacturing innovation capability is a systematic project. According to the characteristics and the factor endowment of different manufacturing industries, the government should consolidate and strengthen traditional advantageous industries, plan and layout strategic emerging industries, accelerate the transformation and upgrading of the green, intelligent, information and service-oriented manufacturing industry, and finally promote the improvement of the innovation ability of the manufacturing industry.

### *6.3. Limitations and Prospects*

This paper attempts to explore the innovation-driving mechanism of two-way FDI in China's manufacturing industry, and the limitations of this study must be further addressed in future research in the following directions. Firstly, the mechanism exploration of this paper is based on the mediating effect model of the stepwise regression. Future research can try to expand the mechanism model and may consider introducing the SEM model and PSM-DID model to cope with the possible endogeneity problem. Secondly, more exogenous policy factors, such as intellectual property protection, governance indicators and international accounting standards [7], can be further included in future research when exploring the synergistic mechanism of two-way FDI.

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## Appendix A

The 27 Chinese manufacturing industry segments are as follows: 1 agricultural and sideline products processing industry, 2 food manufacturing, 3 beverage manufacturing, 4 tobacco products, 5 textiles, 6 textile and apparel industry, 7 leather, fur, feathers (down) and their products, 8 wood processing and wood, bamboo, rattan, palm and grass products, 9 furniture manufacturing, 10 paper and paper products, 11 printing and reproduction of recording media, 12 education and sporting goods manufacturing, 13 petroleum processing and coking and nuclear fuel processing industry, 14 chemical materials and chemical products manufacturing, 15 pharmaceutical manufacturing, 16 chemical fiber manufacturing, 17 rubber and plastic products industry, 18 non-metallic mineral products industry, 19 ferrous metal smelting and rolling processing industry, 20 non-ferrous metal smelting and rolling processing industry, 21 metal products industry, 22 general equipment manufacturing, 23 special equipment manufacturing, 24 transportation equipment manufacturing, 25 electrical machinery and equipment manufacturing, 26 communications equipment, computers and other electronic equipment manufacturing, 27 instrumentation and cultural and office machinery manufacturing.

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