The Impact of Participation in PPP Projects on Total Factor Productivity of Listed Companies in China

Xiangdong Liu 1 and Guangxi Cao 1,2,3,*

1 School of Management Science and Engineering, Nanjing University of Information Science & Technology, Ningliu Road 219, Nanjing 210044, China; 20181224006@nuist.edu.cn
2 Binjiang College, Nanjing University of Information Science & Technology, Xishan Road 333, Wuxi 214105, China
3 Collaborative Innovation Center on Forecast and Evaluation of Meteorological Disasters, Nanjing University of Information Science & Technology, Ningliu Road 219, Nanjing 210044, China
* Correspondence: caoguangxi@nuist.edu.cn

Abstract: The key to transforming China’s economy from high-speed growth to high-quality development is to improve total factor productivity (TFP). Based on the panel data of China’s listed companies participating in PPP (Public–Private Partnerships) projects from 2010 to 2019, this paper constructs the time-varying DID method to test the impact of participation in PPP projects on the company’s TFP empirically, explore the mechanism of the effect of participation in PPP projects on the company’s TFP, and then conduct heterogeneous analysis from four perspectives: region, industry, ownership form, and operation mode. The empirical results show that participation in PPP projects can significantly promote the growth of the company’s TFP, which mainly comes from the promotion of the innovation level of listed companies and the alleviation of financing constraints by participating in PPP projects. In addition, participation in PPP projects has a significant impact on TFP of listed companies in the eastern region, listed companies in the secondary and tertiary industries, state-owned listed companies, and listed companies participating in PPP projects under the BOT mode.

Keywords: PPP; total factor productivity (TFP); differences-in-differences (DID)

1. Introduction

With the rapid growth of the working population and the vigorous promotion of reform and opening-up policies, China’s economy has achieved high growth. However, in recent years, with the deepening of the aging population, the traditional development model of relying solely on labor as a factor of production to drive economic growth is no longer sustainable. The report of the 19th National Congress of the Communist Party of China pointed out that total factor productivity (TFP) should be continuously improved to provide the lasting impetus for high-quality economic development and industrial structure transformation and upgrading [1]. Therefore, high-quality development with TFP improvement as the main way is urgently needed in the current economic environment. Improving the company’s TFP is not only related to companies themselves, but also inseparable from the government’s policy support.

Since 2014, to encourage and guide social capital to participate in the construction and operation of infrastructure and public utilities, improve the quality and efficiency of public services, and meet the public demand for public products and services, China has issued a series of policies to promote government and social capital cooperation (Public–Private Partnerships, PPP). As of December 2020, according to the data published by China’s Ministry of Finance, there are 9792 PPP projects in China, with an investment amount of CNY 14.8 trillion, of which 6546 projects have been signed and landed, with an investment amount of CNY 10.3 trillion. The PPP model in China is developing rapidly. The PPP
model can effectively alleviate the financial pressure and debt pressure of local governments through the participation of social capital [2], reduce the government’s debt ratio [3], and can significantly promote the development of the real economy in the long run [4]. The PPP model can not only save costs, but also effectively reduce project risks [5], improve the efficiency of public services, and establish a good corporate image for companies [6]. At present, the PPP model has been applied in China increasingly, and many listed companies participate in PPP projects actively. As a new financing model and institutional innovation model, can the PPP model benefit listed companies? Can listed companies enhance their TFP by participating in PPP projects? What is the specific degree of impact? What are the ways to influence it? These questions have not yet been addressed and, thus, have become the focus of this paper. Therefore, this paper combines PPP projects with the company’s TFP and studies the impact of participation in PPP projects on the company’s TFP deeply.

The incremental contribution of this paper is as follows: firstly, this paper analyzes the mechanism of the impact of participation in PPP projects on the company’s TFP, enriches the literature on the incentive mechanism of social capital participation in PPP projects, and improves the intersection theory of the PPP model and TFP; secondly, this paper adopts the DID (differences-in-differences) method to test the impact of participation in PPP projects on the company’s TFP and its heterogeneity, which expands the research on the impact factors of the company’s TFP and provides some reference for the government to formulate policies and companies to form strategic plans.

The rest of this paper is arranged as follows. The second part presents a literature review. The third part is the internal mechanism analysis and research hypotheses. The fourth part offers the research design. The fifth part is empirical results and analysis. The sixth part is conclusions and policy recommendations.

2. Literature Review

2.1. Research on TFP

In many studies, scholars often use TFP to represent the level of technological progress, but existing studies show that TFP can also describe the contribution of other factors to the increase in total output in addition to technological progress. At present, the research on TFP mainly includes macro and micro research. In macro research, scholars mainly explore the level of economic development and the sources of TFP growth [7–9]. In micro research, scholars analyze the main factors affecting the company’s TFP through estimating and decomposing the company’s TFP. Existing studies have found that the factors that affect the company’s TFP include firm operation decisions, government industrial policies, human capital, technological progress, foreign direct investment, financial market efficiency, social institutional environment, and capital market development [10–15]. However, few scholars have studied the impact of participation in PPP projects on the company’s TFP.

Combined with the relevant research of international scholars, according to whether it is necessary to set a specific function form, the measurement methods of TFP can be divided into three categories, namely the parametric method, non-parametric method, and semi-parametric method [16–18]. Since the semi-parametric method can solve the endogeneity problem to a certain extent, most international scholars use this method to measure TFP at present. The semi-parametric method mainly includes the OP method and the LP method. The OP method is a semi-parametric method proposed by Olley and Pakes [19], which can solve the endogeneity problem between factor input indicators and disturbance terms effectively, using corporate investment as a proxy variable. The LP method is a modification of the OP method by Levinsohn and Petrin [20]. The intermediate input is selected as the proxy variable, which solves the productivity shock problem and the problem caused by zero investment under the OP method, and improves the accuracy of the estimation results [21,22].
2.2. Research on the Impact of Participation in PPP Projects on Companies

Scholars have been concerned about the impact of participation in PPP projects on companies. Participation in PPP projects can enhance the share price of companies and create value for companies [23,24]. Participation in PPP projects can improve corporate performance [25], increase investment intensity, and promote corporate operations [26]. The companies can also increase market share, reduce costs through technological innovation, improve market competitiveness, and obtain expected investment returns by participating in PPP projects [27]. In addition, participation in PPP projects also has an impact on the capital efficiency and tax burden of companies [28,29].

Summing up the above views, we can see that in the process of participating in PPP projects with various impacts on companies, on the one hand, it is accompanied by the improvement of investment and financing efficiency and the alleviation of financing constraints, and on the other hand, it is accompanied by the promotion of technological innovation and the improvement of the innovation level of companies. We will start from these two points and explore the internal mechanism of the impact of participation in PPP projects on the company’s TFP.

3. Internal Mechanism Analysis and Research Hypotheses

This paper studies the internal mechanism of participation in PPP projects on the company’s TFP from the perspectives of improving the level of innovation and alleviating financing constraints.

3.1. Improve the Level of Innovation

Participation in PPP projects increases the R&D funding of listed companies and reduces the risk of innovation activities effectively. On the one hand, participation in PPP projects enables companies to obtain policy support in many aspects such as tax incentives and financial subsidies. In addition, companies can make full use of these advantages to promote technological innovation and knowledge innovation, promote the improvement and upgrading of old processes, and the creation of new technologies [30]. This can help achieve innovation in various aspects such as production processes and management levels, improve the technological knowledge stock of companies effectively [31], and absorb cutting-edge innovative ideas, thus, promoting the growth of the company’s productivity and the improvement of TFP. On the other hand, since there is a great uncertainty when companies conduct innovation activities, the innovation inputs may not be transformed into innovation outputs fully. The spillover effect of the company’s innovation results makes it easy for other companies and competitors in the market to copy and steal the innovation results without paying any R&D costs, which in turn affects the company’s motivation and initiative to carry out innovation activities. This makes it risky for companies to conduct innovation activities [32]. Participation in PPP projects reduces this risk significantly and corrects the externalities of innovation activities. The financial support and policy support provided make companies more active in carrying out innovation activities, increasing investment incentives, and reducing the cost and risk of innovation. This compensates for the spillover losses brought by externalities to companies and protects their innovation interests. The innovation activities also promote the rational flow of resources within the company from the inefficient departments to the efficient departments [33], so that the input ratio of labor, capital, and other elements within the company will be optimal, thus, improving the efficiency of resource allocation and TFP.

Participation in PPP projects enhances the investment efficiency of listed companies and forms an innovation in the business model. Companies have limited resources, and when they have a lot of idle resources or underutilized resources, it will affect the development of the company and the level of TFP. In the current rapidly developing and superior society, companies need to find new investment opportunities, develop new business areas, and invest in projects that can bring them higher returns. As a new type of financing model, the PPP model has many advantages. Companies can find new investment areas by
participating in PPP projects as a way to become a new growth point for the improvement of corporate efficiency and form a scale effect [25]. Since PPP projects are mostly used for infrastructure construction, which are public services closely related to the life of the masses, such as environmental protection and major municipal projects. These projects are generally higher in quality and requirements than traditional projects. Companies invest in these projects. It is conducive to the improvement of investment efficiency, the opening of new business models, and the formation of innovation in the investment field. In the PPP model, the government and companies are equal partners, and both sides share the benefits and risks. The government and companies exchange their management experience and technology with each other to form synergy effects, which can be used by companies to apply to PPP projects and expand their investment scale, improve their resource allocation efficiency, and enhance their investment efficiency.

Based on the above analysis, the first hypothesis of this paper is proposed:

Hypothesis 1. Participation in PPP projects improves the company’s TFP by improving its level of innovation.

3.2. Alleviate Financing Constraints

Financing constraint refers to the phenomenon that the cost of external financing is higher than the cost of internal financing due to the existence of information asymmetry in the capital market, which reflects the difficulty of obtaining funds from external sources.

First of all, participation in PPP projects directly provides financial support for listed companies. In order to guarantee and implement the vigorous development of PPP projects, China has introduced a series of policies to give social capital support in various aspects in terms of tax concessions and financial subsidies. This is conducive to solving the problem of corporate financing difficulties and alleviating corporate financing constraints. Companies can make full use of these funds to expand the scale of production and investment, seize development opportunities, improve the enthusiasm of R&D and innovation, and improve the efficiency of resource allocation within the company, thus, promoting the development of economies of scale. In addition, the financial support also brings the price compensation to the company [34], the company can make full use of the price advantage to improve the market share, expand the market scale, and promote TFP.

Second, participation in PPP projects enriches the financing sources of listed companies. The No. 42 document issued by the State Office points out that it is necessary to consider factors such as the management level, economic strength, professional ability of project partners, and selection of project partners with high-quality comprehensive capabilities. Therefore, participation in PPP projects also releases signals of good corporate development to a certain extent and indicates that companies are relatively high-quality, adding confidence to private investment and providing a kind of guarantee for companies [35]. This makes financial institutions more willing to provide financial support such as loans to listed companies participating in PPP projects, thus, enriching the financing sources of listed companies, reducing the time cost of financing for listed companies, and promoting the improvement of TFP. At the same time, the diversity of financing sources also reduces the liquidity risk of companies, which enables them to continue production and operation and invest in projects with higher returns, promoting the improvement of investment efficiency and TFP.

Third, participation in PPP projects strengthens the political connection between listed companies and the government. On the one hand, establishing a political connection with the government facilitates companies to obtain some key resources more easily, such as bank loans and tax concessions, which undoubtedly alleviate the financing constraints of companies and reduce their financing costs to a certain extent, thus, promoting the value creation and the company’s TFP. On the other hand, the process of participating in PPP projects also deepens the degree of cooperation and mutual understanding between companies and the government, which is conducive to the cooperation between companies and the government in other fields and other projects, broadening the scope of investment
for companies. Generally, companies participating in PPP projects can obtain some sub-
projects around the project in addition to the projects in the main contract [36]. In addition,
political connections enable companies to obtain relevant information about changes in
government policies, so that they can adjust the scale of investment and production
accordingly and avoid risks promptly. Moreover, when companies are in trouble, it is easier
for companies with political connections to obtain government assistance and support
to a certain extent. In general, strengthening political connections can help alleviate the
financing constraints of companies, broaden the investment scope of companies, and make
adjustments to avoid risks timely, thus, promoting the better operation of companies and
improving TFP.

Based on the above analysis, the second hypothesis of this paper is proposed:

Hypothesis 2. Participation in PPP projects improves the company’s TFP by alleviating its
financing constraints.

4. Research Design

4.1. Model Construction

In quantitative research, the traditional method of evaluating policy effects is mainly
by setting a dummy variable of whether the policy occurs or not, and then performing
regression analysis. This method is often inaccurate, and there are also endogenous
problems. In recent years, differences-in-differences (DID) has received wide attention
from scholars at home and abroad as a policy effect evaluation method [37–39]. Compared
with traditional methods, it is more accurate and scientific, and also can largely avoid
endogenous problems. The basic idea of the DID method is to construct a DID statistic
reflecting the effect of a policy by comparing the difference between the control group
and the treatment group before and after the implementation of the policy. The method
treats the implementation of public policy as a natural experiment, that is, all experimental
subjects are selected exogenously. All samples are divided into two groups, one for the
treatment group that is affected by the policy and the other for the control group that is not
affected by the policy. First, the difference of the corresponding indicator in the treatment
group before and after the policy implementation is calculated. Second, the difference of
the indicator in the control group before and after the policy implementation is calculated. Second, the difference of
the indicator in the control group before and after the policy implementation is calculated. Finally, the two differences are subtracted to obtain the multiplicative difference, which
is the net effect of the treatment group being affected by the policy. Therefore, this paper
refers to Yuan and Zhu [40] and adopts the DID method to study the impact of participation
in PPP projects on the company’s TFP based on the above theoretical hypothesis. Since the
time of participating in PPP projects of listed companies in China are all different, it was
necessary to adopt the time-varying DID method.

Based on the panel data of China’s listed companies in Shanghai and Shenzhen A-
shares from 2010 to 2019, this paper divided the experimental grouping variables (intel)
into “treatment group” and “control group”. The 154 listed companies participating in PPP
projects after screening were set as the “treatment group” and assigned a value of 1, while
the rest of the listed companies were set as the “control group” and assigned a value of 0.
At the same time, the experimental staging variables (time) were set to pre-experimental
and post-experimental according to the specific time of listed companies’ participation
in PPP projects. We assigned the value of 1 to the year when the listed companies were
confirmed to participate in PPP projects and later, and 0 to the year before the confirmation.
The interactive term “intel × time” of the two dummy variables of experimental grouping
and the experimental stage is the net effect brought by the listed companies’ participation
in PPP projects. The dummy variable “did” of listed companies’ participation in PPP
projects was, thus, generated, and the following model was constructed to test the effect of
participation in PPP projects on the company’s TFP.

\[
\ln TFP_{it} = \alpha + \beta intel_{it} \times time_{it} + \gamma X_{it} + \phi ind + \phi year + \theta area + \epsilon_{it}
\]
In (1), \( \ln TFP_{it} \) denotes TFP of firm \( i \) in year \( t \), and \( t \times time \) is the core explanatory variable representing the policy treatment effect in the DID model. \( X_{it} \) denotes the other control variables in the model that affects the company’s TFP, \( \varphi_{ind} \), \( \varphi_{year} \) and \( \vartheta_{area} \) denote the industry fixed effect, time fixed effect, and region fixed effect, respectively. \( \epsilon_{it} \) is the random error term. \( \beta \) is the coefficient of most interest in this paper and if \( \beta \) is statistically significantly positive, it indicates that participation in PPP projects enhances the company’s TFP.

### 4.2. Variable Description

Dependent variable: The company’s TFP. Lu and Lian [21] argue that the OP method cannot estimate samples with zero or missing investment, while the LP method can effectively avoid the problem of missing data caused by investment as a proxy variable, and can make the estimation results more accurate. Therefore, based on the studies of Li and Hu [41], Yang [22], and Qian et al. [42], we chose to use the LP method to measure the company’s TFP in this paper and used TFP measured by the OP method for the robustness test.

First, we set the form of the production function. The commonly used production function is the Cobb–Douglas production function (C-D function). The form of the C-D production function is as follows:

\[
Y_t = A_t L_t^\beta_l K_t^\beta_k
\]  

(2)

Secondly, the intermediate input factor \( M_t \) is introduced based on the C-D function and the logarithm is taken on both sides of the equation. In the process of measuring TFP using the OP method, using the investment amount as a proxy variable led to the problem of missing data, and sample firms with zero investment amount were not estimated. Under the LP method, we introduced the intermediate input \( M_t \) as a proxy variable. Indicators of intermediate input are more easily available, the sample size lost is much smaller than the OP method, and the estimation results are more accurate. Intermediate input refers to the value of all non-fixed asset goods and services consumed and converted during the production or provision of goods and services in a certain period. The TFP model is set as:

\[
y_t = \beta_0 + \beta_1 l_t + \beta_2 k_t + \beta_3 m_t + w_t + \epsilon_t
\]  

(3)

In (3), the variables are in logarithmic form, \( y_t \) denotes output, measured by the main business income of listed companies (CNY million); \( l_t \) denotes labor input, measured by the number of employees (number); \( k_t \) denotes capital input, measured by net fixed assets (CNY million); \( m_t \) denotes intermediate input, measured by cash paid for goods and services (CNY million); \( w_t \) denotes TFP, which was observed in each period and affects the company’s factor choice in the current period; \( \epsilon_t \) is a random error term that includes unobservable technology shocks and measurement errors. In addition, it has no effect on the company’s factor input choice; subscript \( t \) denotes the year. If the above indicators of the company are zero, it would not be possible to proceed in taking logarithms. So, we added 1 to all the above variables before taking logarithms in this paper.

The LP method has three assumptions. First, the intermediate input will only be influenced by capital and technology, and has nothing to do with any other factors, so the demand function of the intermediate input can be expressed as \( m_t = m_t(k_t, w_t) \). Second, the intermediate input increases with the productivity, that is to say, in the case of a certain capital, the higher the productivity of the company, the more intermediate inputs are used. Therefore, the demand of intermediate inputs function is a monotonic function, and we can take the inverse of this function with respect to productivity and obtain the productivity function \( w_t = w_t(k_t, m_t) \) with respect to intermediate inputs and capital. Third, \( w_t \) follows the first-order Markov process, which means that \( w_t = E(w_t|w_{t-1}) + \zeta_t \).
Based on the above assumptions, the Equation (3) can be rewritten in the following form:

\[ y_t = \beta_1 l_t + \varphi_t (k_t, m_t) + \epsilon_t \]  

In (4), \( \varphi_t (k_t, m_t) = \beta_0 + \beta_1 k_t + \varpi_t (k_t, m_t) \).

Using the LP method to measure the company’s TFP can be divided into two stages.

In the first stage, \( \beta_1 \) is estimated. The main idea is to construct a third-order polynomial, including \( k_t \) and \( m_t \), and replace \( \varphi_t (k_t, m_t) \) in Equation (4) with a non-parametric method; then Equation (4) can be rewritten as follows:

\[ y_t = \beta_0 + \beta_1 l_t + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \delta_{ij} k_t^i m_t^j + \epsilon_t \]  

Using the OLS estimation for Equation (5), the consistent estimate of the coefficient \( \beta_1 \) can be obtained, which is \( \hat{\beta}_1 \).

In the second stage, \( \hat{\gamma}_k \) and \( \hat{\gamma}_m \) are estimated, and then \( \hat{\omega}_t \) can be calculated. First, we use the \( \hat{\beta}_1 \) obtained from the first stage estimation, and then calculate \( \hat{\varphi}_t = y_t - \hat{\beta}_1 l_t \) according to Equation (4). Here, any of the possible alternative values of \( \hat{\gamma}_k \) and \( \hat{\gamma}_m \) are noted as \( \beta_k^* \) and \( \beta_m^* \), then the value of each period of \( \hat{\omega}_t \) can be predicted as \( \hat{\omega}_t = \hat{\varphi}_t - \beta_k^* k_t - \beta_m^* m_t \). Next we use these predicted values to predict the following equation:

\[ \hat{\omega}_t = \gamma_0 + \gamma_1 \hat{w}_{t-1} + \gamma_2 \hat{w}_{t-1}^2 + \gamma_3 \hat{w}_{t-1}^3 + \mu_t \]  

We can obtain a nonparametric consistent estimate \( \hat{E}(w_t | w_{t-1}) \) of the expectation \( E(w_t | w_{t-1}) \) by predicting Equation (6). In addition, the residual in Equation (3) can be calculated as \( \hat{\epsilon}_t = y_t - \hat{\beta}_1 l_t - \beta_k^* k_t - \beta_m^* m_t - \hat{E}(w_t | w_{t-1}) \). If the conditional moments of \( \hat{\epsilon}_t \) about \( k_t, m_{t-1}, l_{t-1}, k_{t-1}, m_{t-2} \) are 0, then the consistent effective estimates of \( \beta_k \) and \( \beta_m \) can be obtained by calculating \( \min_{(\beta_k, \beta_m)} \sum_i \sum_l (\hat{\epsilon}_i + \hat{\xi}_i) Z_i \). \( Z_i \) is the vector given by \( Z_i = \{ k_1, m_{t-1}, l_{t-1}, k_{t-1}, m_{t-2} \} \), where \( h \) is an element in \( Z_i \).

After completing the above steps, the two-stage estimation of the LP method is completed, and the consistent and effective estimates of \( \beta_1, \beta_k \) and \( \beta_m \) can be obtained. After calculation, the consistent and effective estimate of TFP \( \hat{w}_t \) can be obtained.

Independent variable: the interactive term “intel \times time” of the two dummy variables of experimental grouping and experimental staging is the net effect brought by the implementation of the policy, and the dummy variable “did” generated from this is the independent variable of this paper.

Control variables: (1) Debt to asset ratio (lev): The debt to asset ratio is a measure of the company’s ability to use funds provided by creditors to conduct business activities. Companies with high levels of debt often choose to scale down production and reduce costs, which will have an impact on the company’s TFP. The ratio of total liabilities to total assets is used to calculate the corporate debt to asset ratio. (2) Total asset turnover ratio (ctr): The total asset turnover ratio is a measure of a company’s asset operating capacity from an overall perspective. Good asset operating capacity facilitates companies to make high-quality investments and expand the scale of investment, thus, promoting the improvement of TFP. The ratio of the operating income to total assets is used to calculate the total assets turnover ratio. (3) Operating cash flow ratio (ocf): Through the analysis of the cash flow ratio of operating activities, it is possible to understand most of the sources of cash required to maintain the company’s operations, which allows us to determine whether the company is in good financial condition. We can also understand the level of the company’s performance and TFP. The ratio of cash flow from operating activities to total assets is used to measure the operating cash flow ratio. (4) Enterprise scale (size): A reasonable enterprise size is the key to improving the company’s TFP [43]. Therefore, we add the enterprise scale variable to the control variable, which is measured by the logarithm of total enterprise assets. (5) Enterprise age(age): There are systematic differences in management
and production between newly established enterprises and long-established enterprises. The disadvantages such as rigidity of enterprise structure caused by the age of enterprises tend to influence enterprises to make structural adjustments, thus, affecting the company’s TFP. The age of the enterprise is calculated based on the date of establishment of the enterprise. (6) Ownership concentration (top1): In the new market economy countries, there is a significant correlation between the level of ownership concentration and firm performance [44,45]. The largest shareholder of a listed company is called the “controller”. Even if he owns less than a majority of shares, the shareholder can use his power to appoint board members to influence the operation of the company and have an impact on TFP. The shareholding ratio of the largest shareholder of a listed company is used to measure ownership concentration. (7) Fixed assets to tang ratio (tang): The fixed assets to tang ratio is used to observe whether the fixed assets of a company are idle or not and, thus, to measure the operating capacity of the company. Lots of idle funds indicate that the company lacks investment projects. Its operating capabilities are general and its performance and TFP level are low. The ratio of fixed assets to total assets is used to measure the fixed assets to tang ratio.

4.3. Data Sources

The research period of this paper is from 2010 to 2019, and the research objects are listed companies participating in PPP projects in Shanghai and Shenzhen A-shares. The research samples were obtained from the “PPP Special Database” in the wind database, and detailed information such as the names, winning times, and investment amounts of PPP projects were obtained from it. The samples were selected according to the following criteria: First, we excluded companies with serious data deficiencies. Second, we excluded companies that issue both A shares and B shares or H shares. Third, we excluded *ST and ST companies because of the possibility of manipulating financial data. Last, we excluded financial companies because of their special financial structure. After excluding the above companies, 154 listed companies were finally obtained. The financial data of listed companies were mainly obtained from the CSMAR database.

Table 1 shows the descriptive statistics of all variables. It can be seen that the stationarity of the sample data was successfully increased and the standard deviations of all variables were relatively smaller after taking the natural logarithm of some variables with larger values and performing tailing processing.

| Variable | N  | Mean  | Std  | Min  | Max  |
|----------|----|-------|------|------|------|
| lntfp_lp | 13906 | 15.38 | 0.849 | 13.39 | 18.19 |
| tfp_op   | 13906 | 5.051 | 0.621 | 3.585 | 7.241 |
| fc       | 13906 | −2.842 | 0.528 | −4.537 | −0.368 |
| rd       | 13906 | 17.74 | 1.549 | 5.094 | 21.78 |
| did      | 13906 | 0.0291 | 0.168 | 0 | 1 |
| ctr      | 13906 | 0.614 | 0.360 | 0.0629 | 2.618 |
| ocf      | 13906 | 0.0436 | 0.0624 | −0.174 | 0.247 |
| age      | 13906 | 2.750 | 0.388 | 1.386 | 3.434 |
| top1     | 13906 | 33.73 | 13.91 | 8.790 | 74.98 |
| tang     | 13906 | 0.220 | 0.146 | 0.00208 | 0.725 |
| lev      | 13906 | 0.414 | 0.195 | 0.0503 | 0.900 |
| size     | 13906 | 7.854 | 1.141 | 3.332 | 12.44 |

5. Empirical Results and Analysis

5.1. Benchmark Regression

Table 2 lists the regression results of the time-varying DID model. Column (1) is the regression result only containing the independent variable and the dependent variable. The result shows that the coefficient of the “did” variable is 0.743 and passes the 1% significance test, indicating that participation in PPP projects is positively correlated with
the company’s TFP. Column (2) controls the fixed effects of a region, industry and time based on column (1). The result shows that the coefficient of the “did” variable is 0.374 and passes the 1% significance test, also indicating that participation in PPP projects is positively correlated with the company’s TFP. Column (3) adds control variables to column (1), and the result shows that the coefficient of the “did” variable is 0.381 and passes the 1% significance test, proving that participation in PPP projects is positively correlated with the company’s TFP. Column (4) controls the fixed effects of a region, industry and time based on column (3). The result shows that the coefficient of the “did” variable is 0.209 and passes the 1% significance test, which further proves that participation in PPP projects has a significant positive correlation with the company’s TFP. Thus, we can conclude that participation in PPP projects can significantly enhance the company’s TFP.

Table 2. Benchmark regression.

| Variable | (1)       | (2)       | (3)       | (4)       |
|----------|-----------|-----------|-----------|-----------|
| did      | 0.743 *** | 0.374 *** | 0.381 *** | 0.209 *** |
|          | (19.32)   | (9.68)    | (13.54)   | (7.45)    |
| ctr      | 0.871 *** | 0.920 *** | 0.634 *** | 0.061 *** |
|          | (57.72)   | (63.24)   | (8.23)    |           |
| ocf      | 0.759 *** | 0.634 *** |           |           |
|          | (9.19)    | (8.23)    |           |           |
| age      | 0.294 *** | 0.061 *** | 0.004 *** | 0.416 *** |
|          | (23.25)   | (4.67)    | (11.68)   |           |
| top1     | 0.005 *** | 0.004 *** | 0.004 *** | 0.004 *** |
|          | (12.67)   | (11.68)   |           |           |
| tang     | −1.102 ***| −1.149 ***|           |           |
|          | (−28.47)  | (−29.51)  |           |           |
| lev      | 1.285 *** | 1.137 *** |           |           |
|          | (39.13)   | (36.52)   |           |           |
| size     | 0.225 *** | 0.215 **  | 0.215 **  | 0.251 **  |
|          | (34.98)   | (34.43)   |           |           |

Region fixed effects | NO | YES | NO | YES |
Industry fixed effects | NO | YES | NO | YES |
Time fixed effects | NO | YES | NO | YES |
_cons      | 15.344 *** | 15.424 *** | 11.775 *** | 12.365 *** |
|           | (2127.38) | (344.55) | (241.72) | (207.18) |
N         | 14170 | 14170 | 13906 | 13906 |
Adj-r²    | 0.021 | 0.255 | 0.572 | 0.666 |

Note: (1) The variance inflation factor (VIF) test on the regression model shows that the VIF of the independent variables and all control variables in this paper was less than the multiple covariances critical criterion; (2) the t-test values are in parentheses; (3) ***, ** indicate that the variable coefficients passed the significance test of 1%, 5% respectively; (4) N indicates the number of sample observations. (5) YES and NO denote controlling for fixed effects and not controlling for fixed effects, respectively. Same below.

5.2. Parallel Trend Test

The parallel trend means that the treatment group and the control group must have had the same trend before participating in the PPP project. If this condition is not met, then the effects derived from the two differentials are not exactly those resulting from participation in the PPP project, and some of them are due to the differences between the treatment and control groups themselves. Following the method of Beck et al. [46], the dynamic heterogeneity analysis was used to verify the parallel trends more rigorously. In addition, we can judge the dynamic persistence characteristics of the effect of participation in PPP projects on the company’s TFP on this basis. Figure 1 reveals the visualization results of the dynamic heterogeneity analysis. The abscissa ranges from −7 to 6, which represents the number of years away from the listed companies’ participation in PPP projects. The hollow circles on the vertical axis represent the magnitude of the estimated coefficients.
corresponding to each time point. In addition, the vertical dashed lines connecting the upper and lower endpoints indicate the confidence intervals at the 95% confidence level corresponding to each one. If the confidence interval of the dummy variable includes 0 points, it means that the coefficient of the dummy variable is not significant, and vice versa. The results of Figure 1 show that the coefficients of all “did” variables were not significant in the 7 years before the listed company participating in PPP projects. This indicates that there is no significant difference between the company’s TFP in the treatment group and the control group before the listed companies participating in PPP projects, and the parallel trend hypothesis is established.

Figure 1. Parallel trend test.

The company’s TFP was almost always positively influenced after participating in PPP projects, and the estimated coefficient of the “did” variable is significantly greater than 0 starting from the 5th year after participating in PPP projects, which can indicate that participation in PPP projects can significantly improve the company’s TFP. From the perspective of dynamic heterogeneity, the company’s TFP increases slowly in the 1st–2nd years after participating in PPP projects and decreases slightly in the 3rd–4th years. However, in the 5th–6th years after participating in PPP projects, TFP shows a rapid incremental trend. The whole process presents a fluctuating trend, which indicates that participation in PPP projects has a dynamic and volatile effect on the improvement of the company’s TFP.

5.3. Robustness Test

The robustness test is shown in Table 3. In column (1), we used the method of substituting the dependent variable and used the value of TFP measured under the OP method as the dependent variable. The results show that the coefficient of the effect of the “did” variable on the company’s TFP is 0.113 and passes the 1% significance test. This indicates that the regression results support the main inference of this paper after adjusting the dependent variable. That is to say, participating in PPP projects can promote the company’s TFP.
Table 3. Robustness test.

| Variable                | (1) Tfp_op      | (2) PSM-DID     |
|-------------------------|-----------------|-----------------|
| did                     | 0.113*** (5.10) | 0.223*** (7.74) |
| Control variables       | YES             | YES             |
| Region fixed effects    | YES             | YES             |
| Industry fixed effects  | YES             | YES             |
| Time fixed effects      | YES             | YES             |
| _cons                   | 4.423*** (89.00)| 12.54*** (61.89)|
| N                       | 13906           | 13437           |
| Adj-r^2                 | 0.527           | 0.667           |

Note: *** represents statistically significant at the 1% level; brackets are t values.

In column (2), although the DID model can mitigate the endogeneity problem, it cannot address the problem of sample selection bias. To address this issue, we used the PSM method proposed by Rosenbaum and Rubin [47] to identify the true effect of participation in PPP projects on the company’s TFP. We adopted the method of caliper matching and selected companies that did not participate in PPP projects as the control group and used seven control variables, namely, the debt to asset ratio, total asset turnover ratio, operating cash flow ratio, enterprise scale, enterprise age, ownership concentration, and fixed assets to tang ratio as matching criteria. After that, we performed DID estimation based on the matched samples of the treatment group and the control group. Since the matched companies from the treatment group and the control group have similar ex-ante possibilities, we could attribute the difference in TFP between the treatment group and the control group to whether they participate in PPP projects or not. The results show that the coefficient of the effect of the “did” variable on the company’s TFP is 0.223 and passes the 1% significance test. This result proves that the PSM-DID estimation results still support the main inference of this paper that participation in PPP projects significantly enhances the company’s TFP.

The counterfactual test, which is a common trend hypothesis test between the control and treatment groups, was conducted to examine the effect of the dummy variable “did” on the company’s TFP when they are not involved in PPP projects. If the effect of the dummy variable “did” on the company’s TFP is not significant, it means that there is no other systematic error between the control group and the treatment group. If the effect of the dummy variable “did” on the company’s TFP is significant, it means that there were policies that affected the company’s TFP before participating in the PPP projects. Then, the effect of participation in PPP projects tested in the model may benefit from the implementation of other policies, which makes the conclusion drawn from the model unreliable. This paper assumes that the listed companies participated in PPP projects at earlier and later points in time, and replaces the actual point-in-time “intel × time” with the assumed earlier and later point-in-time cross-product as the main explanatory variable. The regression results of the counterfactual analysis are shown in Table 4. The main explanatory variable in column (1) is “Bef2intel × time”. In addition, its estimated coefficient represents the impact of this event on the company’s TFP when they were assumed to participate in PPP projects two years earlier. The main explanatory variable in column (2) is “Aft2intel × time”. In addition, its estimated coefficients represent the impact of this event on the company’s TFP when the time of participation in PPP projects was assumed to be delayed by two years. The regression results in Table 4 show that the regression coefficients of the processing variables are not significant when the time of participation in PPP projects is two years ahead. This indicates that the dummy variable “did” did not indeed bring any impact on the company’s TFP before the participation in PPP projects, and there is no systematic error. When participation in the PPP project is
delayed by two years, the regression coefficient of the processing variable is 0.03, which is significant at the 10% level. This proves that participation in PPP projects does have a positive impact on the company’s TFP. Therefore, it is credible that participation in PPP projects has a significant contribution to the company’s TFP as derived from the benchmark regression.

Table 4. Counterfactual test.

| Variable                      | (1)       | (2)     |
|-------------------------------|-----------|---------|
|                               | Two Years Ahead | Two Years Delayed |
| did                           | 0.0311    | 0.0300 *|
|                               | (1.56)    | (1.67)  |
| Control variables             | YES       | YES     |
| Region fixed effects          | YES       | YES     |
| Industry fixed effects        | YES       | YES     |
| Time fixed effects            | YES       | YES     |
| _cons                         | 14.06 *** | 14.06 ***|
|                               | (168.97)  | (168.96)|
| N                             | 18179     | 18179   |
| Adj-r^2                       | 0.491     | 0.491   |

Note: ***, * represent statistically significant at the 1%, 10% levels, respectively; brackets are t values.

5.4. Mechanism Test

According to the intrinsic mechanism analysis in the previous paper, the reason why participation in PPP projects can promote the growth of the company’s TFP is that participation in PPP projects enhances the innovation level and alleviates the financing constraints of companies. In this paper, the mechanism test was conducted using the intermediary effect test proposed by Wen and Ye [48].

Mediating variables: (1) Innovation level. The innovation level of the company is the direct driver to improve its TFP. In this paper, we chose the innovation input to measure the innovation level of companies, where the innovation input is measured by the R&D investment. We recorded the level of innovation as RD. (2) Financing constraint. The financing constraint is generally measured by the financing constraint indexes. Domestic and foreign scholars are more likely to use multivariate indicators to construct the financing constraint indexes, such as the KZ index, the WW index, and the SA index, etc. While Ju [49] argues that the KZ index and the WW index have endogenous problems, to avoid the interference of endogeneity, this paper used the SA index to measure financing constraints, which is denoted as FC. The SA index is calculated as:

\[ FC = -0.737 \times size + 0.043 \times size^2 - 0.04 \times age \]  

In (7), size represents the size of the company, which is measured by the logarithm of the total assets of the company. Age represents the age of the company, which is calculated based on the date of incorporation of the company. Since the SA index is negative, the smaller the value, the more serious the financing constraints faced by the company.

We selected R&D investment (RD) and the SA index (FC) as proxy variables. In addition, the three regression equations are as follows.

\[ \ln TFP_{it} = \alpha + \beta_{\text{intel}_{it}} \times \text{time}_{it} + \gamma X_{it} + \phi_{\text{ind}} + \phi_{\text{year}} + \theta_{\text{area}} + \epsilon_{it} \]  

\[ \text{mediation}_{it} = \alpha_1 + \beta_1 \text{intel}_{it} \times \text{time}_{it} + \gamma X_{it} + \phi_{\text{ind}} + \phi_{\text{year}} + \theta_{\text{area}} + \omega_{it} \]  

\[ \ln TFP_{it} = \phi + \text{pintel}_{it} \times \text{time}_{it} + \psi \text{mediation}_{it} + \gamma X_{it} + \phi_{\text{ind}} + \phi_{\text{year}} + \theta_{\text{area}} + \xi_{it} \]  

In (8)–(10), Mediation is a mediating variable (including R&D investment and the SA index). The specific test steps are as follows: The first step is to test the coefficient \( \beta \) of Equation (8). If it is significant, it indicates the existence of the mediating effect and the
test continues. In the second step, the coefficient $\beta_1$ of Equation (9) and the coefficient $\psi$ of Equation (10) are tested in turn. In addition, if both are significant, the indirect effect is significant and the fourth step test is conducted, otherwise, the third step test is conducted. In the third step, the Bootstrap method is used for hypothesis testing, $\beta_1 \times \psi = 0$. If it is significant, the mediating effect is significant and the fourth step test is conducted. Otherwise, the analysis is stopped. The fourth step is to test the coefficient $\rho$ of Equation (10). If it is not significant, it indicates that there is only a mediating effect. If it is significant, the fifth step is conducted. The fifth step is to compare the signs of $\beta_1 \times \psi$ and $\rho$. If the signs are the same, the ratio of the mediating effect to the total effect $\beta_1 \times \psi / \rho$ is reported. If the signs are different, the absolute value of the ratio of the indirect effect to the direct effect $|\beta_1 \times \psi / \rho|$ is reported. The results of the tests are reported in Tables 5 and 6.

### Table 5. Mechanism test of innovation level.

| Variable       | (1)             | (2)             | (3)             |
|----------------|-----------------|-----------------|-----------------|
|                | OLS             | OLS             | OLS             |
| did            | $0.209^{***}$   | $0.138^{*}$     | $0.222^{***}$   |
|                | $(7.45)$        | $(1.86)$        | $(7.81)$        |
| rd             |                 | $0.133^{***}$   |                 |
|                |                 | $(25.34)$       |                 |
| Control variables | YES         | YES             | YES             |
| Region fixed effects | YES         | YES             | YES             |
| Industry fixed effects | YES         | YES             | YES             |
| Time fixed effects | YES         | YES             | YES             |
| _cons          | $12.365^{***}$  | $10.543^{***}$  | $11.146^{***}$  |
|                | $(207.18)$      | $(26.82)$       | $(37.63)$       |
| N              | 13906           | 13557           | 13495           |
| Adj-r^2        | 0.666           | 0.467           | 0.699           |

Note: *** *, * represent statistically significant at the 1%, 10% levels, respectively; brackets are t values.

### Table 6. Mechanism test of financing constraint.

| Variable       | (1)             | (2)             | (3)             |
|----------------|-----------------|-----------------|-----------------|
|                | OLS             | OLS             | OLS             |
| did            | $0.209^{***}$   | $0.111^{***}$   | $0.119^{***}$   |
|                | $(7.45)$        | $(2.84)$        | $(5.48)$        |
| fc             | $0.560^{***}$   |                 |                 |
|                | $(107.34)$      |                 |                 |
| Control variables | YES         | YES             | YES             |
| Region fixed effects | YES         | YES             | YES             |
| Industry fixed effects | YES         | YES             | YES             |
| Time fixed effects | YES         | YES             | YES             |
| _cons          | $12.365^{***}$  | $-4.466^{***}$  | $15.138^{***}$  |
|                | $(207.18)$      | $(-14.45)$      | $(149.66)$      |
| N              | 13906           | 17625           | 17442           |
| Adj-r^2        | 0.666           | 0.823           | 0.816           |

Note: *** represents statistically significant at the 1% level; brackets are t values.

Table 5 shows the results of the mechanism test of the innovation level. The first step test result in column (1) shows that the coefficient of the “did” variable is 0.209, which passes the 1% significance test. It implies that there is a mediating effect of the effect of participation in PPP projects on the company’s TFP. In the second step test in columns (2) and (3), the paper finds that the “did” variable of participation in PPP projects has a significant effect on the mediating variable, which is consistent with the hypothesis that participation in PPP projects can increase the R&D investment of listed companies and promote the improvement of TFP as mentioned above. In the second step of the sequential
test, both coefficients are significant, which indicates that the indirect effect is significant. In addition, the fourth step is conducted. In the fourth step of the test, the coefficient $\rho$ is significant, and the fifth step of the test is conducted. The fifth step of the test shows that the sign of the coefficient of $\beta_1 \cdot \psi$ is the same as the sign of $\rho$, which means that there is a partial mediating effect of the mediating variable. In addition, hypothesis one of this paper is verified. According to the fifth step, the test results of this paper also indicate that the mediating effect of the innovation level enhanced by participation in PPP projects accounts for 8.27% of the total effect.

Table 6 shows the results of the mechanism test of financing constraints. The first step test result in column (1) shows that the coefficient of the “did” variable is 0.209, which passes the 1% significance test. It implies that there is a mediating effect of the effect of participation in PPP projects on the company’s TFP. In the test in column (2), this paper finds that the coefficient of the “did” variable is 0.111, which has a significant effect on the mediating variable. Since the SA index is negative, a larger SA index indicates a better financing constraint situation and less financing pressure, which indicates that participation in PPP projects significantly alleviates the financing constraint of companies. In the second step of the sequential test, both coefficients are significant, which indicates that the indirect effect is significant. In addition, the fourth step is conducted. In the fourth step test for column (3), the coefficient $\rho$ is significant and the fifth step test is conducted. The fifth step of the test shows that the sign of the coefficient of $\beta_1 \cdot \psi$ is the same as the sign of $\rho$, which means that there is a partial mediating effect of the mediating variable, and, thus, the research hypothesis two proposed in the mechanistic analysis of this paper is confirmed. According to the fifth step, the test results of this paper also indicate that the mediating effect of the alleviation of financing constraints brought about by participation in PPP projects accounts for 52.23% of the total effect.

5.5. Heterogeneity Analysis

In order to further explore the impact of participation in PPP projects on the company’s TFP under different corporate characteristics, this paper conducted a heterogeneous analysis from four perspectives: region, industry, ownership form, and operation mode.

5.5.1. Regional Heterogeneity

Compared with the central and western regions, the eastern region of China has a high level of openness, a high level of industrial diversification, a strong innovation capacity, and faces fewer financing constraints [50,51]. There may be heterogeneity in the impact of participation in PPP projects on TFP in different regions. The total sample was divided into the eastern region sample and the central and western region sample by region for analysis. The regression results are shown in Table 7. The results in column (1) show that the coefficient of the “did” variable is 0.142 and passes the 1% significance test, which indicates that participation in PPP projects has a significant contribution to the company’s TFP in the eastern region. The results in column (2) show that the coefficient of the “did” variable is 0.05 but it is not significant, indicating that participation in PPP projects does not have a significant contribution to the company’s TFP in the central and western regions. This is probably because the eastern region has a higher level of economic development, concentrated talents, convenient transportation, sufficient resources, and superior institutional conditions, which are more conducive to the development of innovative activities and the improvement of TFP. In contrast, the central and western regions lack the advantages of the eastern regions due to the constraints of the economic development level, while the scale of local fiscal expenditures is limited. The increase in fiscal expenditures for PPP projects will bring more financial pressure to local governments, not to mention providing a solid foundation for the growth of the company’s TFP.
Table 7. Regional heterogeneity.

| Variable                  | (1)          | (2)          |
|---------------------------|--------------|--------------|
|                           | Eastern Region | Central and Western Region |
| did                       | 0.142 ***     | 0.050        |
|                           | (3.96)        | (0.86)       |
| Control variables         | YES          | YES          |
| Region fixed effects      | YES          | YES          |
| Industry fixed effects    | YES          | YES          |
| Time fixed effects        | YES          | YES          |
| _cons                     | 12.055 ***    | 13.746 ***   |
|                           | (131.46)     | (38.06)      |
| N                         | 9950         | 3956         |
| Adj-r²                    | 0.662        | 0.614        |

Note: *** represents statistically significant at the 1% level; brackets are t values.

5.5.2. Industrial Heterogeneity

The R&D efficiency of companies in China’s primary industries (agriculture, forestry, animal husbandry, and fishery) is low, and the innovation output brought by large R&D capital investment is limited. In contrast, companies in the secondary and tertiary industries, mainly manufacturing, industry, and service industries, have a better R&D foundation and stronger innovation vitality. In addition, the marginal innovation output brought by R&D capital investment is relatively high [52]. There may be heterogeneity in the impact of participation in PPP projects on TFP in different industries. The overall sample was divided into primary, secondary, and tertiary industries according to industries for analysis. The regression results are shown in Table 8. Column (1) indicates the regression result of the primary industry. The result shows that the coefficient of the “did” variable is -0.065, which does not pass the significance test. Column (2) indicates the regression results of the secondary industry. The results show that the coefficient of the “did” variable is 0.262 and passes the 1% significance test, indicating that participation in PPP projects can significantly promote the growth of the company’s TFP in the secondary industry. Column (3) indicates the regression results for the tertiary industry. The results show that the coefficient of the “did” variable is 0.176 and passes the 5% significance test, indicating that participation in PPP projects significantly contributes to the company’s TFP in the tertiary industry. This is probably because, in the process of economic development, China’s industrial structure is constantly being optimized and adjusted, developing from mainly primary industry to mainly tertiary industry. The added value of products is becoming higher and higher. In addition, the country pays more and more attention to the development of secondary industry and tertiary industry. The primary industry has low technical content so the technological innovation brought about by participating in PPP projects cannot promote the improvement of TFP. The secondary and tertiary industries have high technological content, and the development of these two industries is of great significance to the upgrading of China’s economic structure and high-quality economic operation. The technological innovation brought by participation in PPP projects can promote the growth of TFP.

Table 8. Industrial heterogeneity.

| Variable                  | (1)          | (2)          | (3)          |
|---------------------------|--------------|--------------|--------------|
|                           | Primary Industry | Secondary Industry | Tertiary Industry |
| did                       | −0.065       | 0.262 ***    | 0.176 **     |
|                           | (−0.53)      | (8.41)       | (2.32)       |
| Control variables         | YES          | YES          | YES          |
| Region fixed effects      | YES          | YES          | YES          |
| Industry fixed effects    | YES          | YES          | YES          |
| Time fixed effects        | YES          | YES          | YES          |
5.5.3. Heterogeneity of Corporate Ownership

As of March 2021, the state-owned enterprises in China accounted for 79% of the turnover of PPP projects, while private enterprises accounted for 18% of the turnover and foreign enterprises accounted for 3% of the turnover. In terms of turnover, state-owned enterprises are significantly higher than non-state-owned enterprises. Thus, it can be seen that the participation of state-owned enterprises in PPP projects in China is significantly higher than that of non-state-owned enterprises. State-owned enterprises are mainly located in important industries and key fields that are related to national security and people’s livelihood, and they occupy an important dominant position in public service and infrastructure PPP projects that are related to national security and the lifeline of the national economy. While China’s state-owned enterprises enjoy a unique advantage in the credit market, non-state-owned enterprises face “ownership discrimination” in the financing process and do not receive effective financial support, which seriously hinders the improvement of TFP [53]. There may be heterogeneity in the impact of participation in PPP projects on the company’s TFP with different forms of ownership. The overall sample was divided into state-owned enterprises and non-state-owned enterprises according to the ownership form. The regression results are shown in Table 9. Column (1) indicates the regression results of state-owned enterprises. The results show that the coefficient of the “did” variable is 0.160 and passes the 1% significance test, indicating that participation in PPP projects has a significant contribution to the state-owned company’s TFP. Column (2) indicates the regression results for non-state-owned enterprises. The results show that the coefficient of the “did” variable is 0.071 and does not pass the significance test, indicating that participation in PPP projects does not significantly contribute to the growth of the non-state-owned company’s TFP. For state-owned enterprises, on the one hand, they need to undertake certain social responsibilities and administrative tasks. On the other hand, state-owned enterprises have close ties with the government and are more likely to obtain some key resources, such as bank loans, tax incentives, etc. These resources can effectively help enterprises to carry out their business and investment activities and innovation activities. Political affiliation can alleviate firms’ financing constraints, reduce financing costs, and increase TFP through information and resource effects [54]. Studies show that state-owned enterprises have more innovation inputs and a greater innovation output capacity than non-state-owned enterprises [55]. In addition, state-owned enterprises can reach cooperation with the government in numerous fields and projects, which can broaden the scope of investment. State-owned enterprises can also obtain timely information about changes in government policies so that they can adjust their investment and production scale promptly to avoid risks. Moreover, when state-owned enterprises are in trouble, it is easier for them to obtain government assistance and support. Participation in PPP projects can also further strengthen the political ties between state-owned enterprises and the government to a certain extent, giving full play to the advantages of state-owned enterprises in talent training and team planning to promote business operation and improve TFP.

Table 8. Cont.

| Variable | (1) Primary Industry | (2) Secondary Industry | (3) Tertiary Industry |
|----------|----------------------|------------------------|----------------------|
| _cons    | 15.038 ***           | 12.163 ***             | 13.322 ***           |
|          | (38.76)              | (130.06)               | (46.02)              |
| N        | 428                  | 10567                  | 2451                 |
| Adj r²   | 0.780                | 0.679                  | 0.668                |

Note: ***, ** represent statistically significant at the 1%, 5% levels, respectively; brackets are t values.
Table 9. Ownership heterogeneity.

| Variable                          | (1)  | (2)  |
|-----------------------------------|------|------|
|                                  | State-Owned Enterprises | Non-State-Owned Enterprises |
| did                              | 0.160 *** | 0.071 |
|                                  | (3.89) | (1.54) |
| Control variables                 | YES | YES |
| Region fixed effects              | YES | YES |
| Industry fixed effects            | YES | YES |
| Time fixed effects                | YES | YES |
| _cons                            | 12.359 *** | 13.317 *** |
|                                  | (96.62) | (46.23) |
| N                                | 5016 | 8890 |
| Adj-r²                           | 0.659 | 0.655 |

Note: *** represents statistically significant at the 1% level; brackets are t values.

5.5.4. Heterogeneity of PPP Operation Modes

At present, PPP projects with BOT mode account for 80.46% of all PPP projects in China, and the number of projects and the investment amount is in the absolute leading position. Companies in BOT mode can make full use of the off-balance-sheet financing to broaden the source of funds and ease financing constraints [56]. There may be heterogeneity in the impact of participation in PPP projects on the company’s TFP with different PPP operation modes. The overall sample was divided into BOT mode and non-BOT mode for analysis. In addition, the regression results are shown in Table 10. Column (1) shows the regression results under the BOT model. The result shows that the coefficient of the “did” variable is 0.222 and passes the 1% significance test, indicating that participation in PPP projects under BOT mode has a significantly positive impact on the company’s TFP. Column (2) shows the regression results under the non-BOT mode. The result shows that the coefficient of the did variable is -0.022 and does not pass the significance test. This may be because under the BOT model, the government intervenes less in the project and companies have a greater voice and stronger control over the project [57], which facilitates the creativity of companies and promotes better development of the project, thus, improving the company’s TFP. In addition, the project returns under the BOT model are clear and implemented strictly according to the winning bid, which reduces disputes between companies and the government, and is conducive to promoting solidarity and a win–win cooperation between the two parties.

Table 10. Heterogeneity of PPP operation modes.

| Variable                          | (1)  | (2)  |
|-----------------------------------|------|------|
|                                  | BOT Mode | Non-BOT Mode |
| did                              | 0.222 *** | −0.022 |
|                                  | (7.18) | (−0.38) |
| Control variables                 | YES | YES |
| Region fixed effects              | YES | YES |
| Industry fixed effects            | YES | YES |
| Time fixed effects                | YES | YES |
| _cons                            | 12.338 *** | 13.277 *** |
|                                  | (205.66) | (48.48) |
| N                                | 13742 | 13249 |
| Adj-r²                           | 0.665 | 0.625 |

Note: *** represents statistically significant at the 1% level; brackets are t values.

6. Conclusions and Policy Recommendations

This paper focuses on the impact of participation in PPP projects on listed companies’ TFP. The results can be listed as follows: (1) Participation in PPP projects can significantly
promote the growth of the company’s TFP. (2) The mechanism test shows that this promotion effect mainly comes from the promotion effect of participation in PPP projects on the innovation level of listed companies and the alleviation effect on financing constraints. (3) The heterogeneity test shows that participation in PPP projects has a significant contribution to the company’s TFP in the eastern region. Participation in PPP projects has a significant contribution to the company’s TFP in the secondary and tertiary industries. Participation in PPP projects has a significant contribution to the state-owned company’s TFP. Participation in BOT mode PPP projects has a significantly positive impact on the company’s TFP.

This paper focuses on the impact of participation in PPP projects on listed companies’ TFP in China, which enriches and deepens the literature on the incentive mechanism of social capital participation in PPP projects, expands the research on the influencing factors of the company’s TFP, and improves the intersection theory of the PPP model and TFP. Participation in PPP projects can significantly improve the company’s TFP and bring a good market response. This provides a confidence and motivation source for social capital to actively participate in PPP projects, and is of great significance to promote the healthy and stable development of the PPP model in China. The research of this paper also strengthens the understanding of all parties on the behavior of companies participating in PPP projects, which has certain practical significance for the government to formulate policies and companies to form strategic plans.

Companies should consider their regions, industries, and forms of ownership fully and decide whether to participate in PPP projects prudently, and the PPP operation modes should also be carefully considered. In the context of the national vigorous promotion of PPP projects, companies should seize the development opportunities, give full play to their advantages, and focus on their research direction and areas of expertise. They should participate in PPP projects in related industries and improve the overall technical level through the exchange of advanced technology, management experience, and other complementary advantages so that they can provide better quality products and services, increase market share, gain greater economic benefits, and realize the improvement of TFP. For the government, on the one hand, it should create a good investment environment, so as to attract more social capital to cooperate with the local government and create PPP projects of higher quality. On the other hand, it should encourage companies to participate in PPP projects actively, give them a certain right to speak, safeguard their legitimate rights and interests to the greatest extent, and increase their enthusiasm to participate in PPP projects.

Although this paper adopts the time-varying DID model to make a more rigorous empirical study on the impact of participation in PPP projects on the company’s TFP, there are some shortcomings due to some objective conditions and the limitations of researchers’ ability. This paper adopts the LP method to measure the company’s TFP. This is a more recognized method used by scholars, but it may have problems of unidentifiability and endogeneity. Further research and discussion are needed on other better methods to measure TFP.

**Author Contributions:** The research was designed and performed by G.C. and X.L.; the data were collected and analyzed by G.C. and X.L.; X.L. drafted the manuscript and all authors read and revised the final manuscript. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was funded by the Major Project of the National Social Science Foundation (grant no. 19ZDA105), the Social Science Foundation of Jiangsu, China (grant no. 17GLB003), and the Major Project of Philosophical and Social Science Research in Universities in Jiangsu, China (grant no. 2017ZDAXM005).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.
**Data Availability Statement:** Data generated or analyzed during the study are available from the corresponding author by request.

**Conflicts of Interest:** The authors declare no conflict of interest.

**References**

1. Xi, J.P. Secure a Decisive Victory in Building a Moderately Prosperous Society in all Respects and Strive for the Great Success of Socialism with Chinese Characteristics for a New Era. In Proceedings of the 19th National Congress of the Communist Party of China, Beijing, China, 18–24 October 2017; p. 2017-11.

2. Meng, W.; Wu, Y. Does the PPP Model Relieve Local Government Financial Pressure-An Empirical Study Based on the Data of Chinese Prefecture Level City. *J. Guizhou Univ. Financ. Econ.* 2019, 37, 63–72.

3. Yao, D.M.; Zhu, Y.Y.; Zhuang, Y. Does the Adoption of Public Private Partnership Policy Increase the Local Governments’ Debt?—An Empirical Study Based on Micro-Econometric Methods. *Stud. Int. Financ.* 2019, 6, 26–36.

4. Jiang, S.; Zhou, X.Y. Does the PPP model promote the growth of the real economy in China? *J. Financ. Econ.* 2019, 12, 36–46. (In Chinese)

5. Shrestha, A.; Chan, T.-K.; Aibinu, A.A.; Chen, C. Efficient risk transfer in PPP wastewater treatment projects. *Util. Policy* 2017, 48, 132–140. [CrossRef]

6. Shen, Q. Study on the Efficiency of Government and Social Capital Cooperation (PPP) Model. Ph.D. Thesis, Henan University, Kaifeng, China, 2017.

7. Beveren, I.V. Total factor productivity estimation: A practical review. *J. Econ. Surv.* 2012, 26, 98–128. [CrossRef]

8. Gang, Y.; Gang, F.; Yan, L. A Theoretical Analysis on Economic Growth in China and Total Factor Productivity. *Econ. Res. J.* 2003, 8, 13–20.

9. Miller, S.M.; Upadhyay, M.P. The effects of openness, trade orientation, and human capital on total factor productivity. *J. Dev. Econ.* 2000, 63, 399–423. [CrossRef]

10. Grossman, G.M.; Helpman, E. *Innovation and Growth in the Global Economy*; MIT Press: Cambridge, MA, USA, 1991.

11. Nelson, R.R.; Phelps, E.S. Investment in humans, technological diffusion, and economic growth. *Am. Econ. Rev.* 1966, 56, 69–75.

12. Acemoglu, D.; Zilibotti, F. Productivity differences. *Q. J. Econ.* 2001, 116, 563–606. [CrossRef]

13. Arrow, K.J. The economic implications of learning by doing. In *Readings in the Theory of Growth*; Springer: Berlin/Heidelberg, Germany, 1971; pp. 131–149.

14. Majumdar, R.; Bala Subrahmanya, M. Firm specific management decisions on Total Factor Productivity Growth in Indian electronics industry during liberalisation. *Int. J. Econ. Policy Emerg. Econ.* 2010, 3, 272–294. [CrossRef]

15. Duguet, E. Innovation height, spillovers and TFP growth at the firm level: Evidence from French manufacturing. *Econ. Innov. New Technol.* 2006, 15, 415–442. [CrossRef]

16. Moghaddasi, R.; Pour, A.A. Energy consumption and total factor productivity growth in Iranian agriculture. *Energy Rep.* 2016, 2, 218–220. [CrossRef]

17. Yang, T.G.; Wu, K.Y. Total Factor Productivity Change and its Driving Factors in Service Industry—Based on the Subdivision Industry. *Stat. Res.* 2017, 34, 69–78.

18. Wang, S.L.; Wang, X.L.; Hu, Z.B.; Men, X.L. Research on the Green Productivity Effect of Service Export Trade: Empirical Analysis Based on the Data of Sub-industry in 9 Developing Economies. *Word Econ. Stud.* 2019, 29–42+134. (In Chinese) [CrossRef]

19. Olley, G.S.; Pakes, A. The dynamics of productivity in the telecommunications equipment industry. *Econometrica* 1996, 64, 1263–1297. [CrossRef]

20. Levinsohn, J.; Petrin, A. Estimating production functions using inputs to control for unobservables. *Rev. Econ. Stud.* 2003, 70, 317–341. [CrossRef]

21. Lu, X.D.; Lian, Y.J. Estimation of total factor productivity of industrial enterprises in China: 1999—2007. *China Econ. Q.* 2012, 11, 541–558.

22. Yang, R.D. Study on the total factor productivity of Chinese manufacturing enterprises. *Econ. Res. J.* 2015, 2, 61–74.

23. Xu, L.P.; Hong, C.; Liu, N.; Zhang, S.X. Do PPP projects create value?-Empirical evidence from listed companies participating in PPP projects from 2012 to 2016. *Collect. Essays Financ. Econ.* 2019, 247, 42–52. (In Chinese)

24. Zhan, L.; Wang, B. The stock price response of listed companies participating in PPP and its heterogeneity: Empirical evidence from China’s Shanghai and Shenzhen stock markets. *Public Policy Res. Rev.* 2020, 8, 101–117. (In Chinese)

25. Li, C.W. PPP Investment, Resource Allocation Efficiency and Firm Performance. Ph.D. Thesis, Wuhan University, Wuhan, China, 2019.

26. Liu, X.X. The Impact of Government and Social Capital Cooperation on Business Operations. Ph.D. Thesis, University of International Business and Economics, Beijing, China, 2020.

27. Jing, S.L.; Wang, J.H. Research on the development strategy of PPP model in China based on the dynamic mechanism. *Res. Econ. Manag.* 2018, 39, 136–144. (In Chinese)

28. Jia, C.X. The Impact of PPP Project Investment on the Efficiency of Corporate Capital Use. Master’s Thesis, Xi’an University of Architecture and Technology, Xi’an, China, 2020.

29. Wang, B.S.; Deng, X.Y.; Liu, B.X. Can Participating in PPP Reduce Firm’s Tax Liability in China-A Quasi-natural Experiment Analysis. *J. Guizhou Univ. Financ. Econ.* 2019, 4, 31–39.

30. Xie, W.M.; Tang, Q.Q.; Lu, S.S. Government R&D funding, corporate R&D expenditure and independent innovation: Empirical evidence from Chinese listed companies. *Financ. Res.* 2009, 6, 86–99.
31. Griliches, Z. Introduction to “R&D and Productivity: The Econometric Evidence”. In R&D and Productivity: The Econometric Evidence; University of Chicago Press: Chicago, IL, USA, 1996; pp. 1–14.
32. Bai, J.H. Are Government R&D Subsidies Efficient in China? Evidence from Large and Medium Enterprises. China Econ. Q. 2011, 10, 1375–1400.
33. Chang, Q.L.; Xu, L. High-tech Industries, Capital Types and Corporate Innovation Efficiency—An Empirical Study Based on the Three-stage DEA Model. J. Henan Norm. Univ. 2018, 45, 49–53. (In Chinese)
34. Wang, W.; Ai, H. Government Subsidies, R&D Investment and Total Factor Productivity of Firms—An Empirical Analysis Based on GEM Listed Companies. J. Zhongnan Univ. Econ. Law 2018, 5, 88–96. (In Chinese)
35. Wu, A. The signal effect of government R&D subsidies in China: Does ownership matter? Technol. Forecast. Soc. Chang. 2017, 117, 339–345.
36. Cao, X.M.; Liu, Z. Analysis of the business situation of listed companies in PPP mode and policy recommendations. Secur. Mark. Her. 2018, 52–56+60. (In Chinese)
37. Card, D.; Katz, L.F.; Krueger, A.B. Comment on David Neumark and William Wascher,“Employment effects of minimum and subminimum wages: Panel data on state minimum wage laws”. ILR Rev. 1994, 47, 487–497.
38. Eissa, N.; Lieberman, J.B. Labor supply response to the earned income tax credit. Q. J. Econ. 1996, 111, 605–637. [CrossRef]
39. Baker, M.; Gruber, J.; Milligan, K. Universal child care, maternal labor supply, and family well-being. J. Political Econ. 2008, 116, 709–745. [CrossRef]
40. Yuan, H.; Zhu, C.L. Has the National High-tech Zone promoted the transformation and upgrading of China’s industrial structure? China Ind. Econ. 2018, 8, 60–77.
41. Li, W.J.; Hu, Y.M. Who is Encouraged by Pay Dispersion in State-owned Enterprises? Econ. Res. J. 2012, 12, 125–136.
42. Qian, X.S.; Kang, J.; Tang, Y.L.; Cao, X.P. Industrial Policy, Efficiency of Capital Allocation and Firm’s Total Factor Productivity—Evidence from a Natural Experiment in China. China Ind. Econ. 2018, 8, 42–59. (In Chinese)
43. Sun, X.H.; Wang, Y. The Influence of Firm Size on Productivity and its Difference—Based on the Empirical Test of Industrial Firms in China. China Ind. Econ. 2014, 5, 57–69. (In Chinese)
44. Makhija, A.K.; Spiro, M. Ownership structure as a determinant of firm value: Evidence from newly privatized Czech firms. Financ. Rev. 2000, 35, 1–32. [CrossRef]
45. Lemmon, M.L.; Lins, K.V. Ownership structure, corporate governance, and firm value: Evidence from the East Asian financial crisis. J. Financ. 2003, 58, 1445–1468. [CrossRef]
46. Beck, T.; Levine, R.; Levkov, A. Big bad banks? The winners and losers from bank deregulation in the United States. J. Financ. 2010, 65, 1637–1667. [CrossRef]
47. Rosenbaum, P.R.; Rubin, D.B. Assessing sensitivity to an unobserved binary covariate in an observational study with binary outcome. J. R. Stat. Soc. Ser. B 1983, 45, 212–218. [CrossRef]
48. Wen, Z.L.; Ye, B.J. Analyses of mediating effects: The development of methods and models. Adv. Psychol. Sci. 2014, 22, 731–745. [CrossRef]
49. Ju, X.S. The source of financing for innovative investment of Chinese listed companies. World Econ. 2013, 4, 138–159.
50. Dai, R.J. Heterogeneity and Convergence Analysis of Private Enterprises’ Financing Constraints: Empirical Data from Shanghai and Shenzhen A-Shares. Educ. Forum 2019, 26, 64–65. (In Chinese)
51. Wang, C.H. Regional Heterogeneity, Industrial Agglomeration and Innovation—An Empirical Study Based on Regional Panel Data. Zhejiang Sci. Soc. 2017, 11, 34–41+156. (In Chinese) [CrossRef]
52. Hong, T.; Li, B. Measurement and Classification of R&D Efficiency of Agricultural Listed Companies in China—An Empirical Analysis Based on SMB-Malmquist Model and Corporate Life Cycle. Sci. Res. Manag. 2020, 9, 65–77. (In Chinese)
53. Li, X.C.; Luo, D.M.; Jin, X.R. Resource mismatch and size distribution characteristics of Chinese firms. Soc. Sci. China 2017, 2, 25–43+205–206. (In Chinese)
54. Yu, W.; Wang, M.; Jin, X. Political connection and financing constraints: Information effect and resource effect. Econ. Res. J. 2012, 9, 125–139.
55. Luo, S.L. The Effect of Ownership Type on Firms’ Innovation Performance. Master’s Thesis, Beijing University of Posts and Telecommunications, Beijing, China, 2013.
56. Yang, Y.; Wang, Y.; Wang, S.; Wang, Q. Promoting Healthy and Sustainable Development of PPP in China. In Annual Report on The Development of PPP in China; Springer: Berlin/Heidelberg, Germany, 2020; pp. 1–23.
57. Tang, W.; Wu, H.L. Research on PPP project financing efficiency from government perspective—Taking BOT and BOO modes as examples. Sci. Res. Manag. 2014, 35, 156–161.