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Assessment Of Poverty Alleviation Effect Of Industrial Poverty Alleviation：Based On Poverty Vulnerability Perspective

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Abstract: Industrial poverty alleviation is a fundamental solution to achieve stable poverty alleviation for poor households, and is a fundamental guarantee to reduce poverty vulnerability and eliminate poverty-causing factors. This study selects data from the China Labor Force Dynamics Survey (CLDS), estimates poverty vulnerability using the vulnerability theory of expected poverty, and quantitatively analyzes the degree of impact of industrial poverty alleviation on poverty vulnerability by combining the double difference method and propensity score matching method. The results show that (1) from a prospective perspective, the implementation of industrial poverty alleviation policies reduces the poverty vulnerability of poor households by about 14%, lowering their likelihood of falling into poverty in the future; (2) in terms of regional location, industrial poverty alleviation improves the poverty vulnerability of poor households to a slightly higher extent in eastern China than in central and western China. Based on this, this study proposes relevant policy recommendations to provide implications for the next adjustment of industrial poverty alleviation policies and the effective implementation of rural revitalization.

Keywords: Precise poverty eradication; Industrial poverty alleviation; Poverty vulnerability; Rural revitalization

1. Introduction

Since the reform and opening up of China in 1978, China has implemented a series of poverty alleviation policies and achieved great results in poverty reduction and eradication, contributing to the promotion of worldwide poverty eradication programs. By 2020, China has fully achieved the goal of eradicating absolute poverty under current standards, all poor counties have been removed from the list, and regional poverty from the perspective of absolute poverty has been solved, making a great contribution to

alleviating world poverty. After this, China's poverty alleviation work has entered a new stage. Although absolute poverty has disappeared, relative poverty will continue to exist. Therefore, it is necessary to establish a good institutional system, continue to consolidate and expand the achievements in poverty alleviation, promote rural revitalization in depth, and solidly promote common prosperity.

Industrial poverty alleviation is the formation of industrialization mechanism based on products, resources as well as services to develop poverty alleviation industries, enhance the endogenous motivation of poor households, promote sustainable income growth of farmers, and help poor households achieve poverty alleviation and prosperity. Industrial poverty alleviation emphasizes participatory and blood-building capacity building, which is an important cornerstone for poor regions and poor groups to jump out of the poverty trap, reduce their poverty vulnerability and eliminate the causes of poverty. In particular, industrial poverty alleviation and industrial prosperity take increasing rural residents' income as the basic goal and developing related industries as the leverage, gradually forming an industrial development model with stable promotion of industries and extensive participation of farmers, allowing poor households to maximize their participation in poverty alleviation projects and achieve higher income levels, cultivating their ability to resist various risks, and helping to fight poverty and increase income. Therefore, in order to achieve stable and timely poverty alleviation for the rural poor in China, it is necessary to play the key role of industrial poverty alleviation and industrial prosperity, to form a situation in which industries drive poverty alleviation and enrichment and industries consolidate the effect of poverty alleviation, and to fully establish a long-term mechanism for poverty return interdiction, so as to ensure the effective implementation of rural revitalization strategy. Therefore, this study measures the degree of impact of industrial poverty alleviation on poverty vulnerability, and then evaluates the implementation effect of industrial poverty alleviation to promote the establishment of a long-term mechanism for poverty eradication and provide corresponding policy recommendations for the effective implementation of rural revitalization.

2. Theoretical foundation and literature review

2.1 Industrial poverty alleviation

Industrial poverty alleviation is the key to transform from "blood transfusion" to "blood creation", and is also an important fulcrum to realize rural revitalization. Industrial poverty alleviation promotes the continuous improvement of local economic development capacity and raises the income level and affluence of poor households through deep and characteristic development of industries, so that they can get out of poverty stably. The industrial poverty alleviation mode is to promote the economic development of the poor area by driving the industrial development of the poor area, so that the poor households can get out of

poverty and not return to poverty, which can realize the "trickle-down effect" and to a certain extent can surpass the "trickle-down effect". Industrial poverty alleviation gradually breaks through the traditional practice of developmental poverty alleviation in the past, through leading enterprises and cooperatives (Ward, 2016), strengthening large-scale operation, forming benefit linkage mechanism, and jointly resisting risks.

Based on the effective implementation of industrial poverty alleviation and precise policy, the industrial poverty alleviation mode has gradually moved towards diversification, mainly in the modes of "finance+", "tourism+" and "Internet+". Lin Wanlong et al. (2018) summarized the modes of poverty alleviation and development for the poverty reduction mechanism of poor households as industrial development type, targeting type and relief type. Industrial poverty alleviation increases the income avenues of poor households, especially in special hardship areas such as contiguous special hardship areas and three regions and three states, by cultivating and developing regional special industries, such as vegetable and fruit cultivation, e-commerce industry, and tourism, and continuously exploring new models of industrial development to improve the self-development capacity of poor regions and prevent the phenomenon of poverty return. Tranquility et al. (2019) argue that by increasing new business subjects and developing local special industries, poor households can join the process of industrial development to strengthen the channels of income generation and promote rural revitalization. In the development process of industrial poverty alleviation, "passive poverty alleviation" is replaced by "active poverty alleviation", and the industrial poverty alleviation model is constantly updated and iterated, so that various new business subjects need to be selected and cultivated to actively participate in the development of industrial projects and broaden their income generation channels, so as to achieve stable poverty alleviation (Tang Hongtao and Xie Ting, 2022). Therefore, in the process of industrial poverty alleviation, it is crucial to clarify the synergistic development relationship among participants, and actively guide enterprises and cooperatives to drive the development of poor households and rural economy, improve the livelihood level of poor households, and truly play an active role in promoting income generation, helping to get rid of poverty, and seeking to get rich.

There are many methods of measuring poverty in existing studies, such as Engel coefficient method, factor analysis method, and international poverty standard method (Zhu Honggen and Song Chengxiao, 2021; Li, Yun et al. 2022). Based on a sample of 863 households, Hu Han et al. (2018) measured the net effect of industrial poverty alleviation and found that the participation of poor households in industrial poverty alleviation significantly increased their proportion of choosing livelihood strategies and income levels. By building a propensity score probability model to measure the effect of industrial poverty alleviation in three dimensions: economic status, standard of living, and spiritual dependence, Wang Lijian

(2018) et al. showed that poverty coefficient, worker ability, skill training, degree of industrial adaptation, financial support, and rural infrastructure were the six significant factors affecting whether poor people participated in industrial poverty alleviation. Chen Shoudong and Gu Tianyi (2019) analyzed the industrial poverty alleviation mechanism in six pilot poverty alleviation reform zones based on a quasi-natural experimental research method to assess the effect of industrial poverty alleviation on poverty alleviation. Shen Hongliang et al. (2020) measured the degree of contribution of industrial poverty alleviation to the livelihood level of farm households based on the generalized exact matching method based on farm household research data and found that industrial poverty alleviation reduced the income gap.

However, a series of problems still exist in the implementation of industrial poverty alleviation, such as unclear beneficiary mechanism, poor management of poverty alleviation funds, introduction without sales, and high natural and market risks (Wang Zhitao and Xu Bingxia, 2020; Yu Bintong et al., 2021), which in turn may lead to industrial poverty alleviation not reaching the expected effect. Therefore, the implementation effect of industrial poverty alleviation becomes an important element of this study. The established literature has already provided in-depth analysis of the current situation, problems, sustainability and its mechanism of action of industrial poverty alleviation in China from different perspectives respectively, which has good reference value, but there is still room for further expansion, especially in terms of quantitative measurement of the effect of industrial poverty alleviation. Therefore, this study assesses the effect of industrial poverty alleviation on poverty alleviation in the context of the current situation of industrial development in China.

2.2 Poverty Vulnerability

Poverty vulnerability refers to the identification of individuals or households that are likely to fall into poverty in the future, giving targeted poverty alleviation measures and related policies that can significantly improve their ability to resist various risks. Poverty vulnerability is forward-looking and cannot be measured and measured at past or present nodes, and can only be assessed prospectively using certain analytical tools (Wang Zhitao and Xu Bingxia, 2020; Zhang Dong,Liu Wenzhang, 2022). Among the existing studies on the measurement of poverty vulnerability, the vulnerability to expected poverty (VEP) proposed by Chaudhuri et al. (2002) is more widely used and can measure poverty vulnerability based on cross-sectional data or panel data of fewer years. Tranquility et al. (2018) used the VEP analysis tool to argue the impact of relocation on the welfare level of farm households from a vulnerability perspective, and the study showed that relocation reduced their vulnerability to poverty. Zuo Xiaofan (2020) chose VEP as a measure of poverty vulnerability to analyze the effect of neighborhoods on poverty vulnerability. Meanwhile, Zuo Xiaofan and Lu Jixia (2020) chose the VEP method to empirically analyze the poverty reduction effect of agricultural land transfer based on the PSM method. He

Xin et al. (2020) constructed a poverty vulnerability indicator using the VEP method to study the poverty status of the rural elderly population and examined the extent of the effect of residence patterns on their poverty vulnerability. Therefore, this study also attempts to adopt a prospective assessment approach to measure the poverty vulnerability problem of poor households, and then measure the impact of the implementation of industrial poverty alleviation policies on the poverty alleviation effect of poor households.

3. Research design

3.1 Data Sources

This study uses data from the China Labor Force Dynamics Survey ("CLDS") database, which is organized and implemented by the Social Science Research Center of Sun Yat-sen University. The CLDS adopts a multi-stage, multi-level probability sampling method proportional to the size of the labor force, and targets the working-age population aged 15-64 in households.

Since the 2018 CLDS data were not released for the time being, according to the research needs and data availability, this study selected two micro-survey data from the 2014 CLDS and 2016 CLDS respectively for empirical study. The study population was defined as poor farm households, so households with a rural household in this database were selected. However, the CLDS database does not directly give the situation of whether farm households are poor households, and to address this situation, this study follows the criteria for defining poor households, and considers farm households with annual net per capita income below the national poverty line standard in that year as poor households. Through data collation, 6124 valid samples were finally obtained.

3.2 Variable definition

3.2.1 Explained variables

To ensure the reliability and accuracy of the assessment of poverty alleviation effect, the explanatory variable selected in this study is poverty vulnerability (Vul), and the effect of industrial poverty alleviation on poverty vulnerability is measured from a forward-looking perspective by studying the effect of industrial poverty alleviation on poverty vulnerability and assessing the degree of impact of the implementation of industrial poverty alleviation policies on the poverty alleviation effect of poor households.

Since poverty vulnerability has a forward-looking characteristic and cannot be directly observed, it can only be assessed using specific methods. Therefore, this study uses VEP (i.e., the desired poverty vulnerability method) to measure the impact of industrial poverty alleviation on poverty vulnerability, and then calculates the degree of poverty vulnerability of the sample households. Poverty vulnerability was measured as follows.

$$Vul_{i,t} = P(Y_{i,t+1} \le z) \quad (1)$$

where equation (1) $Vul_{i,t}$ portrays the poverty vulnerability of a household or individual i in period t, $Y_{i,t+1}$ portrays the

future income of a household or individual i in period t+1, and z represents the poverty line.

The future income level can be expressed as a function of the observable variable X_i and the error term e_i, and then substitution into equation (1) enables to obtain.

$$Y_{i,t+1} = f(X_i, \alpha_i, e_i) \quad (2)$$

$$Vul_{i,t} = P(Y_{i,t+1} = \mathrm{f}(X_i, \alpha_i, e_i) \le z) \quad (3)$$

Assuming that future income obeys a log-normal distribution and based on the generalized least squares (FGLS) method, poverty vulnerability is calculated (Amemiya, 1977).

In the first step, the income equation is estimated, as shown in the following equation.

$$\ln Y_i = X_{\mathrm{i}}\beta + e_i \quad (4)$$

$$\hat{\mathrm{e}}_i^{\,2} = X_i\rho + \eta_i \quad (5)$$

Among them, the observable variables include household head characteristics variables, household characteristics variables, external environment variables, and industry adaptation variables.

In the second step, FGLS estimation is performed as follows Eq.

$$\hat{E}(\ln Y_i | X_i) = X_{\mathrm{i}}\hat{\beta}_{FGLS} \quad (6)$$

$$\hat{V}(\ln Y_i | X_i) = \hat{\sigma}_{e,\mathrm{i}}^{\,2} = X_{\mathrm{i}}\hat{\rho}_{FGLS} \quad (7)$$

In the third step, the poverty vulnerability of household i is estimated.

$$\hat{V}ul_{\mathrm{i}} = \phi\left(\frac{\ln \mathrm{z} - X_i\hat{\beta}_{FGLS}}{\sqrt{X_i\hat{\rho}_{FGLS}}}\right) \quad (8)$$

In this study, three poverty lines, the national poverty standard of 2300 yuan, the World Bank extreme poverty standard of $1.9 per person per day, and the low- and middle-income poverty standard of $3.1, were selected to calculate the poverty vulnerability of farm households①. Generally speaking, households with poverty vulnerability above the vulnerability line are considered vulnerable, and the vulnerability line is selected in two ways: first, the incidence of poverty is considered as the vulnerability line, also known as the low vulnerability line; second, 50% is selected as the vulnerability line, i.e., a household is considered vulnerable when its future probability of falling into poverty is higher than 50%, also known as the high vulnerability line.

3.2.2 Core explanatory variables and control variables

The core explanatory variable selected for this study is whether poor households participate in industrial poverty alleviation. Among them, participate in industrial poverty alleviation projects, otherwise. In this study, control variables are selected from four aspects: household head characteristics, household characteristics, external environment, and industrial adaptability. First, to avoid the influence of human capital

on the analysis results, variables reflecting the ability characteristics of the household head, such as the age of the household head, health level, and whether or not he or she participates in the workforce, are included in this chapter. Second, this chapter includes the characteristic variable of household. Among them, the household size reflects the household's demographic status, the larger the number of people the more likely the household is to participate in industrial poverty alleviation, the number of agricultural machinery indicates the household's asset status, and whether or not the household participates in the low-income subsidy reflects the household's economic status. Then, this study also included external environment variables; the availability of street lights in the community, the proportion of hardened roads, and the distance to the commercial center reflect the locational conditions of poor households. Better transportation conditions in the community not only provide convenience for poor households to obtain employment information, but also reduce transportation costs in community industrial development and increase the proportion of poor households participating in industrial development. Finally, this study added industrial adaptability variables, including education level, whether to participate in skill training, and the number of people working in non-farm jobs with stable income. Among them, the higher the education level and the higher the skill level of the agricultural labor force, indicating their relatively higher receptiveness to new things and employment skills, their relatively higher competitiveness in industrial development, and their stronger industrial adaptability (see Table 1 for descriptive statistics of the variables).

Table 1 Descriptive statistics of variables

Variable Category	Variable Name	Abbreviations	Variable Description (Unit)	Average	Standard deviation
Explained Variables	Poverty Vulnerability	Vul1	Poverty vulnerability under the $1.9 poverty line standard	0.3744	0.3572
		Vul2	Poverty vulnerability under the national poverty line standard of 2300	0.4024	0.3591
		Vul3	3.1 Poverty vulnerability under the dollar poverty line standard	0.5238	0.3471
Core explanatory	Whether to participate in industrial	T	Yes=1, No=0	0.7405	0.4384

variables	poverty alleviation				
	Household head characteristics variables				
	Age of household head	age	Age of the head of household	51.8806	10.1715
	Health status of head of household	health	Very unhealthy=1, relatively unhealthy=2, average=3, healthy=4, very healthy=5	3.6311	1.0227
	Whether to participate in work	job	Yes=1, No=0	0.8656	0.3411
	Household characteristics variables				
	Family size	famsize	Total number of families	4.6736	1.8175
	Number of agricultural machinery	machine	Total number of agricultural machines in the household	0.4289	1.1157
Control Variable	Whether to participate in the low-income subsidy	subsidy	Yes=1, No=0	0.5413	0.4983
	External environment variables				
	Distance to commercial center	distance	Distance to nearest commercial center (km)	19.0788	18.3314
	Percentage of road hardening	hroad	The proportion of traffic road hardened surface (%)	63.7989	24.7591
	Availability of street lights	lamp	Yes=1, No=0	0.3532	0.4780
	Industry Adaptive Variables				
	Education level	edu	Illiterate or semi-literate=0, elementary school=3, junior high school=6, high school or junior college=9, college=12,	4.6589	2.5805

		bachelor's degree =13, graduate and above=16		
Whether to participate in skills training	ability	Yes=1, No=0	0.6896	0.4627
Number of people working in non-farm jobs with stable income	twork	Households with non-farm jobs Total number of people with stable income	1.2552	1.0227

3.3 Model Construction

When evaluating the effects of public policy implementation, the net effect of this policy should be given high priority. However, the effects of fixed effects make this effect impossible to measure accurately. One is the individual effect, the difference between the individuals who participate or do not participate in the policy itself, which can bias the results if individuals who participate and do not participate in the policy are compared directly. The second is the time effect, which can bias the measurement results due to indirect interventions from other policies, and thus the impact of the policy being evaluated needs to be separated out. To address these issues, the researcher mainly simulated a "quasi-natural experiment" state, i.e., by setting up a treatment group and a control group to achieve consistent estimates. Therefore, this study uses a "quasi-natural experiment" to measure the difference in the effect of participation in industrial poverty alleviation between the two groups by setting up a treatment group and a control group, so as to accurately portray the effect of industrial poverty alleviation implementation.

3.3.1 Difference-in-difference（DID）

The difference-in-difference (DID), which is the difference between the mean change in the treatment group and the mean change in the control group, more accurately reflects the intervention effect of policy implementation on the study subjects by controlling for ex ante differences among the study subjects and filtering fixed effects such as time (Ravallion, 2007). By setting up a control group (not participating in industrial poverty alleviation, $T=0$) and a treatment group (participating in industrial poverty alleviation, $T=1$) this study assesses the difference in the effect of whether the sample households participate in industrial poverty alleviation based on DID, and measures the degree of impact of industrial poverty alleviation on poverty vulnerability, and then assesses the effect of industrial poverty alleviation.

This study mainly analyzes the average treatment effect of industrial poverty alleviation from the following two models, and analyzes the change of poverty removal

rate in the treatment and control groups before and after industrial poverty alleviation. In addition, based on the double difference method, we analyze the changes of poverty status and poverty vulnerability of the treatment and control groups before and after the project. To measure the implementation effect of industrial poverty alleviation, this chapter measures the average treatment effect of industrial poverty alleviation based on a double-difference, double-difference model with the inclusion of covariates.

The two-difference model is set as follows (9).

$$Y_{it} = \beta_0 + \alpha_0 P_{it} + \beta_1 T_{it} + \alpha_1 \cdot P_{it} T_{it} + \varepsilon_{it} \quad (9)$$

The two-difference model with the addition of covariates is shown in equation (10).

$$Y_{it} = \beta_0 + \alpha_0 P_{it} + \beta_1 T_{it} + \alpha_1 \cdot P_{it} T_{it} + \theta X_{it} + \varepsilon_{it} \quad (10)$$

Since 2015, China began to promote and implement industrial poverty alleviation policies on a large scale in each poor contiguous area, therefore, this study uses 2015 as the cut-off point for the implementation of industrial poverty alleviation policies to analyze the policy effects before and after the implementation of industrial poverty alleviation. Equation (1), Y_{it} is the explained variable to measure the effect of industrial poverty alleviation policy, and the following table i and t denote different poor households and different periods, respectively. T_{it} is the treatment variable of whether poor household i participates in industrial poverty alleviation in period t, and is 1 if it participates in industrial poverty alleviation, and is 0 otherwise. P_{it} is a time dummy variable. In this study, 2015 is used as the cut-off point. 2016 represents the year after the implementation of the industrial poverty alleviation policy and takes the value of 1; 2014 represents the year before the implementation of the industrial poverty alleviation policy and takes the value of 0. The cross term $P_{it}T_{it}$ reflects the net effect of the implementation of the industrial poverty alleviation policy. X_{it} represents the covariate of household i in period t, indicating the set of variables with a high degree of association with industrial poverty alleviation policy. ε_{it} is a random interference term.

3.3.2 Propensity Score Matching (PSM)

Propensity score matching (PSM) makes policy evaluation more reasonable by controlling for between-group differences and matching based on propensity values to exclude sample selection bias and endogeneity to a certain extent (Rosenbaum and Rubin, 1983). The essence of the propensity score matching method is "dimensionality reduction", using a probability model to condense the multidimensional covariates that are unbalanced between groups into one-dimensional propensity scores, achieving the effect of "dimensionality reduction". In this

study, we select individual, household, and community factors that affect the poverty status of poor households, and analyze the effect of industrial poverty alleviation on the explanatory variables based on the propensity score matching method to measure the policy effect of industrial poverty alleviation. As in equation (11), the propensity score value is $P(X_i)=\Pr(T=1|X_i)$, $T=1$ indicates that poor households participated in industrial poverty alleviation, and X_i indicates the covariate. The average treatment effect of industrial poverty alleviation ATT is the difference between the effect of the experimental group and the control group.

$$ATT = E_{P(X)|T=1}\{E[Y^T|T=1,P(X)]-E[Y^C|T=0,P(X)]\} \quad (11)$$

4. Empirical analysis

4.1 Poverty vulnerability analysis based on DID

Based on the difference-in-difference method to examine the effect of industrial poverty alleviation on poverty vulnerability, the results are shown in Table 2. Among them, models (1) and (2) represent the poverty vulnerability of poor households under the World Bank $1.9 extreme poverty line, models (3) and (4) represent the poverty vulnerability of poor households under the national poverty line with the national poverty standard of $2300, models (5) and (6) represent the poverty vulnerability of poor households under the World Bank $3.1 poverty line, models (1), (3) and (5) represent treatment effects before the inclusion of covariates, and models (2), (4), and (6) represent treatment effects after the inclusion of covariates. The results of the DID analysis in Table 9 show that the average treatment effects of household poverty vulnerability for poor households under the three different poverty lines before the inclusion of covariates are -0.0223, -0.0229 and -0.0348, respectively, with negative coefficients, and are significant at the 1% level; after the inclusion of covariates, the average treatment effects of household poverty vulnerability under the three different poverty lines are -0.1697, -0.1801 and -0.1917, all with negative coefficients and significant at the 10% level, indicating that the effective implementation of industrial poverty alleviation policies reduces poverty vulnerability, i.e., it has a significant mitigating effect on the future poverty that poor households may face.

Table 2 Results of DID regression based on poverty vulnerability indicators

Variable Name	$1.9 poverty line		2300 national poverty line		$3.1 poverty line	
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
P×T	-0.0223	-0.1697*	-0.0229	-0.1801*	-0.0348*	-0.1917*

	（0.0211）	（0.0045）	（0.0211）	（0.0107）	（0.0201）	（0.0105）
age		-0.0170***		-0.0172***		-0.0166***
		（0.0003）		（0.0003）		（0.0003）
health		-0.1667***		-0.1671***		-0.1568***
		（0.0024）		（0.0023）		（0.0023）
job		-0.2867***		-0.2822***		-0.2549***
		（0.0066）		（0.0067）		（0.0068）
famsize		0.0078***		0.0072***		0.0058***
		（0.0014）		（0.0014）		（0.0014）
machine		-0.0056**		-0.0032		0.0018
		（0.0025）		（0.0026）		（0.0021）
subsidy		0.0087		0.0089		0.0041
		（0.0058）		（0.0058）		（0.0056）
distance		0.0002		0.0002		-0.0001
		（0.0002）		（0.0002）		（0.0002）
hroad		-0.0034***		-0.0035***		-0.0034***
		（0.0001）		（0.0001）		（0.0001）
lamp		0.0041		0.0050		0.0129**
		（0.0054）		（0.0054）		（0.0052）
edu		-0.0269***		-0.0272***		-0.0261***
		（0.0009）		（0.0009）		（0.0009）
ability		-0.0882***		-0.0849***		-0.0893***
		（0.0051）		（0.0051）		（0.0049）
twork		-0.0169***		-0.0140***		-0.0163***
		（0.0027）		（0.0027）		（0.0025）
Constant terms	0.4613***	2.8373***	0.4877***	2.8773***	0.6105***	2.9079***
	（0.0132）	（0.0204）	（0.0131）	（0.0207）	（0.0120）	（0.0222）
Fixed time	yes	yes	yes	yes	Fixed time	yes
Individual fixed	yes	yes	yes	yes	Individual fixed	yes
R2	0.0155	0.7364	0.0151	0.7388	0.0138	0.7422
N	6124	6124	6124	6124	6124	6124

4.2 Poverty vulnerability analysis based on PSM

4.2.1 Balance test

This study combines the Probit probability model to calculate the propensity score value. In order to further verify the impact of industrial poverty alleviation on the effect of poverty alleviation on poor households, a balance test is needed to exclude the bias of sample selection, as shown in Table 3. On the one hand, the vast majority of variables were significantly different before matching, and after matching, no significant differences existed. On the other hand, the standardized bias rate of covariates after matching is less than 20%, indicating a good test result (Rosenbaum et al., 1985). Therefore, the sample matching passed the balance test.

Table 3 Balance test

Covariates	Sample Category	Average		Deviation rate（%）	Rate of deviation change（%）	T-test	
		Processing groups	Control groups			t-value	P>|t|
age	U	52.465	50.212	21.7	97.5	7.63	0.000
	M	52.466	52.41	0.5		0.25	0.806
health	U	3.5711	3.8024	-23.1	64.9	-7.80	0.000
	M	3.5706	3.4895	8.1		1.70	0.125
job	U	0.9010	0.7646	37.2	55.6	13.93	0.000
	M	0.9012	0.8406	16.5		8.63	0.000
famsize	U	4.6977	4.6048	5.1	71.3	2.70	0.007
	M	4.6988	4.7905	-1.4		-0.60	0.550
machine	U	0.5288	0.1441	38.6	70.5	11.96	0.000
	M	0.5241	0.6377	-6.1		-2.48	0.135
subsidy	U	0.7056	0.0724	70.8	92.4	13.88	0.000
	M	0.7057	0.6578	2.9		4.89	0.168
distance	U	19.803	17.011	15.5	82.8	5.24	0.000
	M	19.814	19.332	2.7		1.26	0.206
hroad	U	62.428	67.713	-21.8	60.3	-7.35	0.000
	M	62.44	58.758	5.2		2.88	0.143
lamp	U	0.3279	0.4254	-20.2	39.7	-7.03	0.000
	M	0.3275	0.2686	12.2		6.14	0.000
edu	U	4.5802	4.8836	-11.5	-95.9	-4.04	0.000
	M	4.5799	4.9856	22.5		10.88	0.000
ability	U	0.7052	0.6451	12.9	91.8	4.46	0.000

	M	0.7057	0.7106	1.1		-0.51	0.607
twork	U	1.2267	1.3367	-10.5	-2.3	-3.37	0.001
	M	1.2273	1.1213	9.6		0.75	0.564
Joint Inspection		Ps R2		LR chi2		p>chi2	
U		0.362		2541.16		0.000	
M		0.038		474.45		0.000	

Note: U means unmatched, M means matched.

4.2.2 Mean treatment effect analysis

After passing the equilibrium test, this study used poverty vulnerability as the explanatory variable and measured the degree of impact of industrial poverty alleviation on poverty vulnerability of poor households using k-nearest neighbor matching (1:1), k-nearest neighbor matching (1:4), radius matching, and kernel matching methods, as shown in Table 4. According to the results of PSM analysis, industrial poverty alleviation has a significant reduction effect on poverty vulnerability. Specifically, using the k-nearest neighbor matching (1:1), k-nearest neighbor matching (1:4), radius matching and kernel matching methods in the full sample case, the average treatment effects of industrial poverty alleviation on poverty vulnerability of poor households under the World Bank's $1.9 poverty line criterion are -0.1194, -0.1504, -0.1480 and -0.1472, respectively, all significant at the 1% level of significance significant at the 1% level, and the mean value of the average treatment effect under the four methods was -0.1413, indicating that the implementation of industrial poverty alleviation reduced the poverty vulnerability of poor households by 14.13% on average. Similarly, the average treatment effects of industrial poverty alleviation on poverty vulnerability of poor households when the national poverty line of 2300 yuan is used as the standard are -0.1105, -0.1449, -0.1396 and -0.1342, and all of them are significant at the 1% level of significance, and the average value of the average treatment effect under the four methods is -0.1323, indicating that the implementation of industrial poverty alleviation reduces the poverty vulnerability of poor households by Vulnerability of poor households was reduced by 13.23%. The mean treatment effects of industrial poverty alleviation on poverty vulnerability of poor households under the World Bank's $3.1 poverty line criterion were -0.1229, -0.1453, -0.1384 and -0.1299, all significant at the 1% level, and the mean value of the mean treatment effect under the four methods was -0.1341, indicating that the implementation of industrial poverty alleviation reduced the poverty vulnerability of poor households by The average treatment effect under the four methods was -0.1341, indicating that the implementation of industrial poverty alleviation reduced the poverty vulnerability of poor households by 13.41%. In summary, the direction and trend of the average treatment effect of the implementation of industrial poverty alleviation policies on the

poverty vulnerability of poor households under different measurement methods are consistent, all showing a significant negative effect (ATT<0, p<0.01), that is, the implementation of industrial poverty alleviation policies significantly reduces the poverty vulnerability of poor households.

Table 4 Average treatment effects of PSM

Indicators	Matching methods	Full sample	East of China	Midwestern China
$1.9 poverty line	K-Nearest Neighbor Matching（1:1）	-0.1194*** （0.0346）	-0.2116*** （0.0607）	-0.1446*** （0.0398）
	K-Nearest Neighbor Matching（1:4）	-0.1504*** （0.0305）	-0.1691*** （0.0538）	-0.1307*** （0.0373）
	Radius Matching（Radius=0.01）	-0.1480*** （0.0288）	-0.1893*** （0.0552）	-0.1294*** （0.0354）
	Nuclear matching（Window width=0.06 kernel function=normal）	-0.1472*** （0.0276）	-0.1789*** （0.0466）	-0.1388*** （0.0332）
	Average value	0.1413	0.1872	0.1359
2300 national poverty line	K-Nearest Neighbor Matching（1:1）	-0.1105*** （0.0345）	-0.2098*** （0.0622）	-0.1306*** （0.0392）
	K-Nearest Neighbor Matching（1:4）	-0.1449*** （0.0305）	-0.1694*** （0.0550）	-0.1286*** （0.0369）
	Radius Matching（Radius=0.01）	-0.1396*** （0.0288）	-0.1871*** （0.0563）	-0.1208*** （0.0349）
	Nuclear matching（Window width=0.06 kernel function=normal）	-0.1342*** （0.0276）	-0.1726*** （0.0475）	-0.1258*** （0.0328）
	Average value	0.1323	0.1847	0.1265
$3.1 poverty line	K-Nearest Neighbor Matching（1:1）	-0.1229*** （0.0326）	-0.1922*** （0.0613）	-0.1265*** （0.0347）
	K-Nearest Neighbor Matching（1:4）	-0.1453*** （0.0289）	-0.1787*** （0.0557）	-0.1164*** （0.0329）

Radius Matching（Radius=0.01）	-0.1384***（0.0274）	-0.1901***（0.0569）	-0.1138***（0.0309）
Nuclear matching（Window width=0.06 kernel function=normal）	-0.1299***（0.0262）	-0.1597***（0.0481）	-0.1138***（0.0289）
Average value	0.1341	0.1802	0.1176

To analyze the differences in the impact of industrial poverty alleviation on poverty vulnerability across regions, this study examined the average treatment effect of the impact of industrial poverty alleviation policies on poverty vulnerability by region (see Table 4). The estimation results show that the effective implementation of industrial poverty alleviation policies plays a significant role in poverty vulnerability mitigation in both eastern and central-western China. However, the impact of industrial poverty alleviation policies on poverty vulnerability varies slightly depending on the regions where poor households are located. Among them, the alleviation effect of industrial poverty alleviation policies on poverty vulnerability is slightly higher in the eastern region than in the central and western regions.

4.3 Robustness test

As can be seen from Table 4, the test results under the four different matching methods are similar and all show a significant positive effect (ATT>0, p<0.01), indicating that the average treatment effect of industrial poverty alleviation on poverty vulnerability is robust.

In addition, this study was further aided by the propensity score matching-double difference method (PSM-DID) test. According to the analysis results in Table 5, the direction and trend of the average treatment effect of effective implementation of industrial poverty alleviation policies on poverty vulnerability of poor households under different poverty line criteria are consistent with the analysis results in Table 4, i.e., they all show a significant negative effect (ATT<0, P<0.01), which again proves the robustness of the assessment results.

Table 5 Robustness tests based on poverty vulnerability indicators

Indicators	Before Diff（T-C）	After Diff（T-C）	DID
$1.9 poverty line	-0.191***（0.012）	-0.336***（0.013）	-0.145***（0.021）
2300 national poverty line	-0.169***（0.012）	-0.307***（0.017）	-0.138***（0.021）
$3.1 poverty line	-0.161***（0.011）	-0.286***（0.017）	-0.125***（0.020）

5. Conclusions and Recommendations

5.1. Research conclusions

Based on relevant literature studies, this study estimated poverty vulnerability based on China Labor Force Dynamics Survey (CLDS) data using the vulnerability theory of expected poverty, and quantitatively analyzed the degree of impact of industrial poverty alleviation on poverty vulnerability using double difference method and propensity score matching method. The results of the study indicate that.

(1) From a prospective perspective, the implementation of industrial poverty alleviation policies significantly reduced the poverty vulnerability of poor households. The effective implementation of industrial poverty alleviation policies has significantly improved the poverty vulnerability of rural households and reduced the probability of poor households falling into poverty in the future.

(2) In terms of regional location, industrial poverty alleviation improves the poverty vulnerability of poor households in eastern China to a slightly higher extent. In the eastern region of China, the effective implementation of industrial poverty alleviation policies reduces poverty vulnerability by about 18%; in the central and western regions of China, the effective implementation of industrial poverty alleviation policies reduces poverty vulnerability by about 12%, which is slightly lower than that in the eastern region of China.

5.2. Policy Recommendations

In order to effectively promote the poverty-benefiting mechanism of industrial development and help rural revitalization, this study puts forward the following policy recommendations.

First, scientifically plan industrial revitalization projects and promote industrial integration. Industrial development needs to make full use of local resource endowments, and develop special industries based on the implementation and development of resource advantages in poor areas, etc., so that they can adapt to the development of the area. On the one hand, actively guide poor areas to gradually transform from industrial coverage to long-term industrial development, deeply promote production and marketing docking, lengthen industrial product chains, strengthen the brand value of industries, promote the formation of sustainable livelihoods for poor households, and enable poor households to obtain more stable income and achieve stable poverty alleviation. On the other hand, promote the integrated development of one, two and three industries, and actively promote poverty alleviation and poverty-led models such as market-oriented allocation of land elements, special industries and industrial diversification, so that industrial development can play an important role in the effective linkage between poverty alleviation and rural revitalization.

Secondly, poverty alleviation should be combined with helping the will, wisdom and skills to promote material and spiritual "double poverty alleviation". Poverty alleviation should be effective and future-oriented, i.e. to enhance the endogenous development capacity of farmers and alleviate the poverty vulnerability of poor

households. In the process of industrial poverty alleviation, we should strengthen professional education and special skills training required for rural revitalization, improve the level of human capital, stimulate the endogenous power to increase income and get rich, and continuously strengthen the sustainable risk resistance. According to the development plan of poverty alleviation industries and the trend of industrial structure adjustment, we should provide targeted training and education for farmers who are on the verge of returning to poverty, enhance their endogenous development capacity, promote higher quality and fuller employment, strengthen their ability to increase and stabilize their income, and realize common prosperity.

Thirdly, innovate the industrial development mode and build the benefit linkage mechanism. In the process of industrial development, by strengthening the main force of farmers, enterprises and cooperatives, strengthening the joint drive of new business entities and farmers, innovating the development of industrial models, and constantly strengthening the mechanism of benefit to the poor, truly playing an active role in promoting income and seeking prosperity. Focus on the primary processing, fine processing and deep processing of agricultural products, and improve the logistics and transportation management mechanism in the process of industrial development. In addition, actively develop contract farming, promote enterprises to sign long-term production and sales contracts with farmers, and adopt rent, salary and share capital to guarantee farmers' reasonable income, so as to embed farmers in the chain of industrial development and ensure that farmers can share the value-added income of rural industrial development to the greatest extent.

Fourth, strengthen the infrastructure construction in deep poverty areas and promote coordinated regional development. Infrastructure such as roads, water conservancy and networks are the foundation for deep poverty areas to completely escape from poverty. We should continuously increase investment in infrastructure such as roads, communication networks and big data in deep-poverty areas, strengthen the implementation of labor mobility policies, and promote models such as "finance+" and "ecology+" to reduce the vulnerability to poverty in deep-poverty areas and promote industrial deeper development. In addition, targeted support measures should continue to be implemented in deep poverty areas to strengthen the risk resistance of farmers, promote sustainable local economic development, and achieve poverty eradication without returning to poverty.

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