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Evaluation of the Efficiency of Matching between Village Characteristics and Industrial Allocation from the Perspective of Rural Revitalization—A Study based on 209 Villages in Fuping County, Hebei Province, China

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Abstract: To identify the developmental efficiencies and weaknesses of village industries in helping the villages become wealthy and to formulate individualized development strategies for village industries, we constructed a village characteristics–industrial allocation matching degree model with efficient matching between village characteristics and industrial allocation as the study subject. The efficiency of industrial allocation was empirically analyzed, and the rationality of the current industrial allocation in villages,Hebei Province, was determined to provide a reference for the formulation of differentiated development strategies for industries in these villages. The results show the following. ① The efficiency of matching between village characteristics and industrial allocation in 77.9% of the villages was in the unacceptable range or the transition range. Among them, the matching degree in the southern region was significantly higher than those in other regions. ② Grade C—the grade with an overly advanced industrial allocation in the "just above the match threshold" group—predominated; 58.6% of the villages in the transition range belonged to this type. Of these 58.6%, 22% had an impediment rate above 5%. ③ The main weakness of the villages was the lack of arable land and irrigation among the factors causing mismatches.

Keywords: village characteristics; industrial allocation; matching coordination degree; matching efficiency

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1. Introduction

After China realizes its target of complete poverty reduction in 2020, rural revitalization will be the main strategy for agricultural and rural development in China over the next three to five decades. Village development will be a key task for rural revitalization. Industrial prosperity is the precondition for village development. Village industry development is especially important in the context of consolidating the fruits of poverty elimination and achieving the transition from poverty reduction to wealth accumulation. Local governments need to take into full account the rationality of the village economic structure, the leading role of characteristic industries, and the sustainability of industries in leading local development.

The village characteristics are the substantial features of a village [1] and embody the multiple targets of rural development and the multiple requirements on the rural areas in the sustainable development of nature, society, and economy [2,3]. The interactions between village characteristics and external systems generate society's overall capacity to support local development [4]. Currently, Chinese villages are facing such problems as insufficient endogenic vitality [5], weak radiation and driving capacity of industries [6], and structural disconnection [7].

Village industrial allocation determines production factor allocation [8] and is ultimately reflected in the various aspects and processes of local industries. The match between village characteristics and industrial allocation can facilitate the local industrial system's gradual upgrade and development [9], hence achieving the improvement and upgrade of industrial allocation, as well as the optimal allocation and utilization of resources [10]. For instance, Guo et al. [11] believe that effective allocation of production factors can improve the profitability of rural industries and is key for rejuvenation of rural industries. Paying attention to differences between village characteristics and identifying the multiple functions of villages and their weaknesses can lay the foundation for determining primary village functions and development paths [12]. Such decisions can enable villages to fully realize their multiple functions, formulate their individual development strategies, determine their development directions [13], and drive their development [14].

There are different ideas on how to match village characteristics with their industrial development strategies. Some scholars believe that the answers originate in the villages' essential characteristics [15,16], whereas some researchers think that the solutions should focus on enhancing the endogenic vitality of the local economy, the main measure of poverty elimination [17,18]. Most researchers tend to concentrate on studying one-way relationships independently and within an industry itself. Few existing studies couple research on the key factors closely related to sound industrial development with research on the interactions between village characteristics and industrial allocation to identify weaknesses.

This paper studies the match efficiency between the village characteristics and industrial allocation in Fuping County, Hebei Province, China. We perform an empirical analysis on the two systems' economic effects and influences on the industries and local society, make scientific judgments on the two systems' match levels, identify the weaknesses in different villages, evaluate the rationality of their existing industrial allocations, and provide some tailored recommendations.

2. Description of the Study Area

Fuping County in Hebei Province is located 106 km to the west of Baoding city and 120 km from the provincial capital. It covers a total area of 2496 km^2 and has a population of 230,400 people. The county has a total arable land area of 219,000 hm^2, and per capita arable land ownership is 0.06 hm^2. It belongs to the moderate, semi-humid, and semi-dry continental monsoon climate zone, with an annual average temperature of 12.6℃ and a multi-year average annual precipitation of 582 mm. The freshwater resources per capita are as high as 2534 m^3, and the annual average relative humidity is 54%. The annual average frost-free time is between 140 and 190 days. Fuping County is 500 to 2000 meters above sea level, and the local forest coverage rate is 43%. It is a typical mountainous county and an old revolutionary base. It is among the clustered poverty prefectures and counties in the Yanshan Mountain–Taihangshan Mountain Region at the national and provincial levels and a Poverty-elimination Demonstration County of Hebei Province in the periphery of Beijing. Fuping County has 209 administrative villages, among which 164 have been evaluated as impoverished villages, accounting for

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78.5% of the total. At the end of 2017, 12,200 people in Fuping County were still living below the poverty line, and the percentage of impoverished people had dropped by 47 percentage points. The farmers' per capita disposable income had grown by 57%. The key measures for local poverty elimination have included comprehensive rural development, traditional crop and animal production, and household handcrafts.

3. Model Creation and Variable Selection

3.1. Model Creation

Multiple methods have been used to measure the correlations between a regional characteristics and industrial allocation, such as the capacity coupling system method, principal component analysis, the comprehensive index model, and the elasticity coefficient model. Among them, the capacity coupling system model has been widely applied in many fields due to its calculation simplicity, significant hierarchy, and expandability to multiple systems [19-22].

On the basis of the capacity coupling system model, this paper created the "village characteristics–industrial allocation" match model. The village characteristics–industrial allocation interaction is defined as the mutual interaction and influence between industrial allocation and village characteristics. This interrelation can be positive or negative and forms a collective system consisting of multiple combinations. Village characteristics and industrial allocation are two independent and open systems. They can mutually constrain or support each other in their development. Such nonlinear coupling creates conditions for the industrial system's gradual structural upgrade [23]. Second, the paper establishes the calculation functions and evaluation criteria for the village characteristics–industrial allocation model.

3.1.1. Creating the Efficacy Function

Variable U_i(i=1,2) is respectively the comprehensive order parameter of the two systems; U_{ij}(j=1,2,⋯,n) is the indicator j of order parameter i, and its value is X_{ij}; α_{ij} and β_{ij} are, respectively, the upper and lower limits of the order parameter at the critical points of the system stability. The efficacy function coefficient U_{ij} of the industry allocation–village characteristics system can be defined as follows:

$$U_{ij}=\begin{cases}(X_{ij}-\beta_{ij})/(\alpha_{ij}-\beta_{ij}) & u_{ij} \text{ has a positive effect,}\\ (\alpha_{ij}-X_{ij})/(\alpha_{ij}-\beta_{ij}) & u_{ij} \text{ has a negative effect.}\end{cases} \quad (1)$$

U_{ij}=In Eq. (1), the normalized efficacy function coefficient U_{ij} indicates the size of X_{ij}'s efficacy function contribution to the system. It reflects the degree of satisfaction with the indicator's difference from the ideal value; its value is between 0 and 1; a higher value means a higher degree of satisfaction. This paper uses the highest and lowest actual values to determine the order parameters' upper and lower limits [24]. In other words, in the efficacy function calculation, the highest and lowest values of the indicator in the same region and the same year are used as the upper and lower limits of the order parameters, respectively.

3.1.2. Calculation of Matching Efficiency

Based on the capacity coupling system model, the efficiency of matching between village characteristics and industrial allocation is C:

$$C=\{(U1\times U_2)/[(U1+U_2)/2]^2\}^2 \quad (2)$$

where U_i(i=1,2) is, respectively, the comprehensive order parameter of industrial allocation and village characteristics, and λ_{ij} is the weight of the corresponding order parameter. These can be expressed as

$$U_i=\sum_{j=1}^{n}\lambda_{ij}\,u_{ij}, \quad \sum_{j=1}^{n}\lambda_{ij}=1 \quad (3)$$

The equation for calculating the matching coordination degree is

$$\text{Match}=(C\times D)^{1/2}$$
$$T=aU1+bU_2 \quad (4)$$

where Match represents the matching efficiency between the industrial allocation and the village characteristics; C is the degree of system coupling; T is the comprehensive coordination index; and a and b are undetermined coefficients. The development of a village characteristic system will inevitably comprehensively influence the industrial allocation. The initial industrial allocation and the subsequent industrial development are subject to the influences of multiple factors [25-27]. The village characteristic system shall be given a higher weight; therefore, a=0.4, and b=0.6.

3.1.3. The Evaluation Criteria for Coordination and Matching Efficiency

The relative development model E needs to be introduced to visually reflect the status of the systems' interaction process. Some scholars, for example Si et al. [23], use the ratio of the two systems' order parameters, i.e., E= U_1/U_2,and comparethe value of E and 1 to evaluate the two systems' relative development. Some researchers believe that E is rarely 1, so E's value should be a range, for example taking 0.8 and 1.2 as the lower and upper limits of the range. Other experts opt to conduct the evaluation based on the value of U_i. Based on comprehensive considerations, this paper chooses the last method to evaluate the two systems' relative coordination. $U_1<U_2$ means that the industrial allocation lags behind; $U_1>U_2$ means that the industrial allocation is overly advanced; and $U_1=U_2$ indicates that the industrial allocation is compatiblewith the village characteristics.

To better reveal the coordination status between the industrial allocation system and the village characteristic system and align them with the actual situation in the study area, we drew on the study results of Liao [28], Huo [29], Yang and Jiang [30], and Wuboli et al. [31] and established a system for coordination evaluation (see Table 1).

Table 1. Evaluation criteria and categories on the matching efficiency between village characteristics and industrial allocation.

Matching efficiency	Less than 0.2	0.2-0.29	0.3-0.39	0.4-0.49	0.5-0.59	0.6-0.69	0.7 or higher
Matching level	Strong mismatch	Moderate mismatch	Slight mismatch	On the brink of mismatch	Just above the match threshold	Slight match	Well matched
Sub-level	A, B, and C	A, B, and C	A, B, and C	A, B, and C	A, B, and C	A, B, and C	A, B, and C
Range	Unacceptable				Transition		Acceptable
Coordination	$U_1>U_2$	The industrial allocation is overly advanced					
	$U_1=U_2$	The industrial allocation is compatible with the village characteristics					
	$U_1<U_2$	The industrial allocation lags behind					

3.2. Variable Selection and Data Source

3.2.1. Variable Selection

After establishing the matching efficiency model of village characteristics–industrial allocation, the next step is to select the key indicators that could reflect the two systems' essential features and nature, so as to analyze their interactions. We selected 20 independent variables and six dependent variables (see Table 2).

Table 2. Indicator system for assessing the match levels between village characteristics and industrial allocation.

Dimension	Indicator	No.	Relationship	Unit	Indicator weight
Village characteristics	Dispersion of the natural villages	X_1	-	%	0.064205
	Area of slopes ≥15°	X_2	-	mu	0.051544
	Frequency of geological hazards	X_3	-	%	0.057959
	Penetration rate of transport infrastructure	X_4	+	%	0.046905
	Investment intensity of arable land improvement	X_5	-	%	0.060984
	Per capita arable land	X_6	+	mu	0.050721
	Proportion of irrigated area	X_7	+	%	0.068438

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	Area of farm crops	X_8	+	mu	0.063067
	Areas of woodland and orchards	X_9	+	mu	0.064073
	Number of farm animals (cattle, pigs, goats, and sheep)	X_{10}	+		0.061573
	Small processing enterprises	X_{11}	+		0.121344
	Cooperatives	X_{12}	+		0.127298
	Proportion of local population in labor force	X_{13}	+	%	0.075162
	Proportion of labor force with a middle-school education or above	X_{14}	+	%	0.074355
	Labor skill pressure index	X_{15}	-	%	0.066671
	Labor force loss pressure index	X_{16}	-	%	0.070613
	Illiteracy rate	X_{17}	+	%	0.067739
	Farmers mainly engaged in the primary sector	X_{18}	+	Persons	0.06934
	Farmers mainly engaged in the secondary sector	X_{19}	+	Persons	0.038097
	Famers mainly engaged in the tertiary sector	X_{20}	+	Persons	0.054916
Industry structure	Number of industry types	Y_1	+	Number	0.130297
	Per capita income from industries	Y_2	+	RMB	0.126012
	Investment intensity on industry transition	Y_3	-	%	0.124261
	Proportion of local GDP in primary sector	Y_4	+	%	0.072598
	Proportion of local GDP in secondary sector	Y_5	+	%	0.123553
	Proportion of local GDP in tertiary sector	Y_6	+	%	0.11886

Regarding village characteristics, some researchersbelieve that it is hard for impoverished areas to eliminate poverty due to their poor natural resources, weak economic foundation, and outdated social services; that impoverished areas lack the endogenic vitality for development; and that it is necessary to seek high matching efficiency between the industry allocation and the village characteristics. Therefore, this paper identifies village characteristics from natural, economic, and social dimensions.

Taking into account the actual situation in the study area, we chose three indicators in the natural dimension, including the dispersion degree of natural villages, area of slopes ≥15°, and the impacts of geological hazards. These indicators were chosen because Fuping County has a high dispersion degree of natural villages, with a value range between 0.04and 1, and this indicator has a high impact on the industries that require central management and central planning. Among the administrative villages in Fuping County, the areas of land on slopes ≥15° vary between 0 and 307,000 m². The land on slopes ≥15° generally has poor soil conditions, which become a major constraining factor for industries with high requirements of soil quality. In addition, all of Fuping County is mountainous, and the frequencies of geological hazards are 0to 45%; both the frequency and the damages of geological hazards are higher than in flat areas.

In the selection of economic and social indicators, this paper focuses land and population as core variables to reflect the differences among the administrative villages. The economic indicators include the penetration rate of transport infrastructure,intensity of investment in arable land improvement, per capita arable land,area proportion of available irrigated farmland, area of farm crops , areas of woodland and orchards, number of farm animals (cattle, pigs, goats, and sheep), number of small processing enterprises, and

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number of cooperatives. The social indicators are the proportion of the local population in the labor force, the proportion of the labor force with a middle-school education or above [38], the labor skill pressure index, the labor force loss pressure index, the illiteracy rate [39], the number of farmers mainly engaged in the primary sector, the number of farmers mainly engaged in the secondary sector, and the number of famers mainly engaged in the tertiary sector .

The indicators of industrial allocation consist of the number of industry types [41], the per capita income from industries [17], the proportion of local GDP that comes from the primary sector, the proportion from the secondary sector, the proportion from the tertiary sector,and the investment intensity in industry transition.

3.2.2. Data Source and Processing

All the data in this paper come from the Fuping County Statistical Yearbooks and the Hebei Provincial Statistical Yearbooks of various years, as well as materials provided by the Statistical Bureau, Agricultural Bureau, and Poverty Elimination Office of Fuping County. Moreover, a "Village Basic Information Survey" was sent to each administrative village. All 209 forms sent out were filled out and collected, for a response rate of 100%. Moreover, 4180 questionnaires for sampling-based survey were sent out, and 4130 effective responses were received, for a response rate of 98.8%.

Among the 20 indicators of village characteristics, the values of X_1, X_6, X_8, X_9, X_{10}, X_{11}, X_{12}, X_{13}, X_{14}, X_{18}, X_{19}, and X_{20} were obtained by processing the survey results. The values of X_2, X_3, X_7, X_5, X_{15}, X_{16}, and X_{17} were calculated based on the data provided by the Statistical Bureau of Fuping County and the Statistical Bureau of Hebei Province, as well as information collected during the 2016-2017 basic situation survey on administrative villages. Specifically, the damage from geological hazards is the frequency of occurrence of each type of geological hazard; the investment intensity in arable land improvement is the ratio between a village's total investment in arable land improvement and the village's total registered arable land, or in other words the average amount of improvement investment on each mu (1 mu = 0.0666666666666667 hm^2) of arable land. Transport infrastructure penetration rate is the density of transport infrastructure, which is used to measure the quality of transport infrastructure. The labor skill pressure index is the proportion of residents in the village longing for or having some income-earning skills. The labor loss pressure index is the proportion of the labor force above 18 years old who have left the village and are migrant workers.

The industrial allocation consists of six indicators. Among them, the values of Y_1, Y_2, Y_4, Y_5, and Y_6 were obtained through the survey; Y_2 was calculated from the data provided by the Statistical Bureau of Fuping County. The industrial transition investment intensity is the total investment in each mu of arable land divided by the arable land area. The total investment in each mu of land includes the expenses on seeds, pesticide, fertilizer, water, electricity, and labor. The expenses on seeds, pesticide, fertilizer, water, and electricity are calculated based on field investment; and the labor cost is estimated from the research results of Wang et al. [32]. We assumed that the cost of male labor is 1, the female cost is 0.8, the elderly cost is 0.5, and the underage cost is 0.2.

3.2.3. Data Normalization and Indicator Weight Determination

This paper uses positive and negative indicators to convert the original data into the range [0,1] to eliminate the impacts of different indicator units and dimensional differences on indicator selection.

A higher positive indicator value indicates higher industrial development capacity. Assume that P_{ij} is the normalized value of indicator i of industry j, V_{ij} is the value of indicator i of industry j, and n is the number of industries. The positive indicator normalization function is as follows:

$$P_{ij} = \frac{V_{ij} - \min\limits_{1\le j\le n}(V_{ij})}{\max\limits_{1\le j\le n}(V_{ij}) - \min\limits_{1\le j\le n}(V_{ij})} \qquad (5)$$

The equation indicates the distance of the indicator value V_{ij} from the minimum value in relation to the distance between the maximum and the minimum values. This means that the shorter the distance between the indicator's value and the maximum value, the greater the normalized value is.

For negative indicators, a lower values mean higher capacity for industrial development. Their normalization equation is as follows:

$$P_{ij} = \frac{\max\limits_{1\le j\le n}(V_{ij}) - V_{ij}}{\max\limits_{1\le j\le n}(V_{ij}) - \min\limits_{1\le j\le n}(V_{ij})} \quad (6)$$

The equation divides the distance between the maximum value and the indicator value V_{ij} by the distance between the maximum value and the minimum value. This means the longer the distance between the indicator value and the maximum value is, the higher the normalized value is.

This paper applies the criteria importance through intercriteria correlation (CRITIC) method to determine the weight of each indicator. As CRITIC considers different indicators' value ranges and the correlations between indicators, it is more objective. The weights are calculated as follows:

$$w_{dj} = \frac{I_{dj}}{\sum\limits_{j=1}^{n} I_{dj}} = \frac{\sqrt{\frac{\sum\limits_{i=1}^{m}(X_{idj}-\bar{X}_{dj})^2}{m-1}} \times \sum\limits_{k=1}^{n}(1-|r_{djk}|)}{\sum\limits_{j=1}^{n}\left[\sqrt{\frac{\sum\limits_{i=1}^{m}(X_{idj}-\bar{X}_{dj})^2}{m-1}} \times \sum\limits_{k=1}^{n}(1-|r_{djk}|)\right]} \quad (7)$$

where X_{idj} is the nondimensionalized value of indicator j of dimension d and belonging to administrative village i, $i \in \{1,2,\cdots m\}$, $d \in \{1,2,3,4,5\}$, $j \in \{1,2,\cdots,n\}$; $\bar{X}_{dj}$ is the average of indicator j at dimension d; r_{djk} is the correlation between indicator j of dimension d and indicator k of the same dimension; as correlations can be negative, the absolute value of r_{djk} is used in the equation; and I_{dj} is the amount of information contained in indicator j of dimension d. The results of w_{dj} and the non-dimensionalized indicator value X_{idj} are used to calculated their weighted sum (z_{id}), $z_{id} = \sum_{j=1}^{n} w_{dj} X_{idj}$, which is administrative village i's index value of dimension d. The CRITIC method is further used to calculate w_d, the weight of each dimension in relation to the entire system; the weights of all indicators under dimension d are then recalculated as $W_{dj} = w_{dj} \times W_d$. The final calculation results are available in Table 2.

4. Result Analysis

4.1. Match Levels between Village Characteristics and Industrial Allocation

To visually present the match levels between the 209 villages' profiles and their industrial allocation and do an in-depth analysis on the match status, Fuping County is divided into five parts: Central, Eastern, Western, Southern, and Northern. Specifically, Central Fuping County consists of two townships, Fu*zhen and Tian**zhen, which cover 42 administrative villages. Eastern Fuping County covers Ping*zhen and Wang*kou Townships and has 42 administrative villages. Southern Fuping County covers two townships, Cheng*zhuang and Bei*yuan, and has 48 administrative villages. Western Fuping County includes three townships, Long*guan, Wu*kou, and Xia*xiang, with 30 administrative villages. Northern Fuping County consists of four townships, Shi*zhai, Sha*xiang, Da*xiang, and Tai*xiang and has 46 administrative villages (see Figure 1).

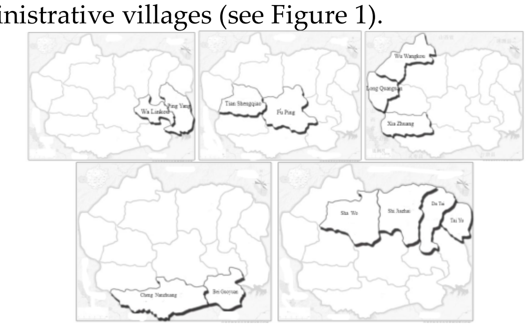

Figure 1. Township and village coverage of Eastern, Central, Western, Southern, and Northern Fuping county.

The two-system match levels of the administrative villages in Central Fuping County range between 0.31 and 0.55, with most concentrating in the 0.41-0.48 range. The top ten administrative villages in terms of match levels are Long*cun, Qing*cun, Yan*cun, Ge*cun, Zhao*cun, Dong**cun, Huang**cun, *Jiao*cun, Se**cun, and Mu**cun, in the sequence from high to low. The administrative villages with the lowest match levels are Ta*cun, at 0.31, and Luo**cun, at 0.32. In terms of overall match levels, the top three administrative

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villages are Long*cun, Luo**cun, and Zhu**cun, while lowest two are Cheng*cun and Di**cun. In terms of coupling levels, the top three administrative villages are Yan*cun, Shi*cun, and Ge**cun, and the lowest two are Ta*cun and Bei**pucun. In terms of match level grade, five administrative villages have match levels between 0.3 and 0.39, in the range of slight mismatch; 12 administrative villages belong to the group of “just above the match threshold”, accounting for 28% of all the villages in Central Fuping County. As for the relationships between industrial allocation and village characteristics, most of the villages in Western Fuping County have an industrial allocation lagging behind their village characteristics. Among them, 48.8% have a lagging rate above 50%, and 62.7% have a lagging rate above 40%. In other words, industrial allocation lag is too severe to be ignored(see Figure 2).

In Eastern Fuping County, the match levels have an overall even distribution, with an average of 0.479. Specifically, the match level of Dong*yucun is the highest, belonging to the group “just above the match threshold”, while the low match level can be found in Xi*linkou, which puts it in the category of slight mismatch. Only a small proportion of the villages had a slight mismatch, and 65% of the villages are of the group “on the brink of mismatch”(see Figure 3).

The match levels of Southern Fuping County, with an average of 0.465, are higher than those of the other four parts of the county. As for specific administrative villages, Tai*cun has the highest match level, in the range “just above the match threshold”, while *An*cun has the lowest match level and belongs to the range of slight mismatch(see Figure 4).

The average match level of Western Fuping County is 0.446. Among the administrative villages, **Wancun has the highest match level, in the range “just above the match threshold”, while Hei**cun has the lowest match level and belongs to the group of “slight mismatch”(see Figure 5).The villages in Northern Fuping County have an average match level of 0.441; among them, Wu**cun has the highest match level and is of the group “just above the match threshold”, while Xia*cun has the lowest match level, in the range “moderate mismatch”(see Figure 6).

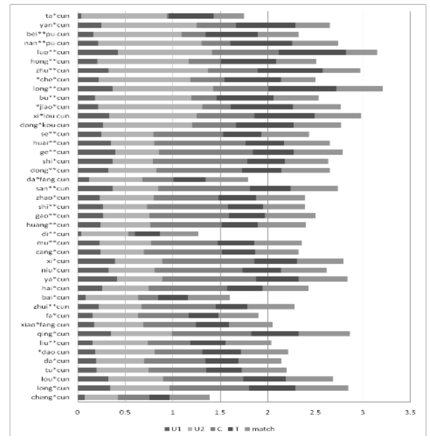

Figure 2. The village characteristics–industrial allocation match levels of the villages in Central Fuping county.

Figure 3. The village characteristics–industrial allocation match levels of the villages in Eastern Fuping county.

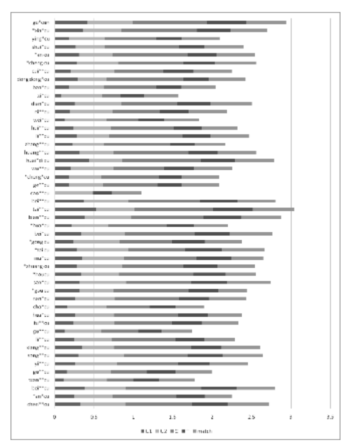

Figure 4. The village characteristics–industrial allocation match levels of the villages in Southern Fuping county.

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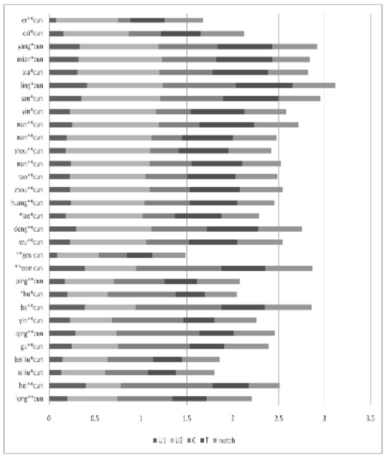

Figure 5. The village characteristics–industrial allocation match levels of the villages in Western Fuping county.

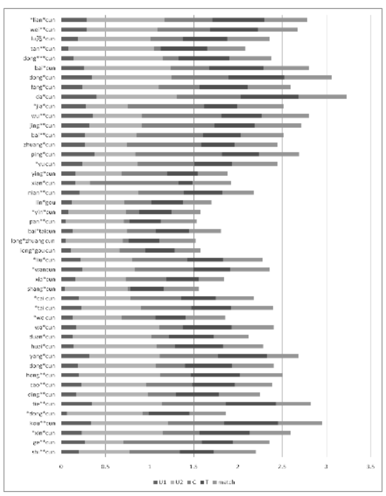

Figure 6. The village characteristics–industrial allocation match levels of the villages in Northern Fuping county.

The modeling results indicate low match levels between the profiles and industrial allocation of the 209 villages (Figure 7) in Fuping County. Most of the villages' match levels are between 0.3 and 0.59, putting them in the unacceptable and transition ranges. The match levels of a few villages are in the moderate mismatch range of 0.2 to 0.29. None of the degrees of matching fall in the "acceptable" range of 0.6 to 0.99 nor the "strong mismatch" range (0-0.19)(Table 3).

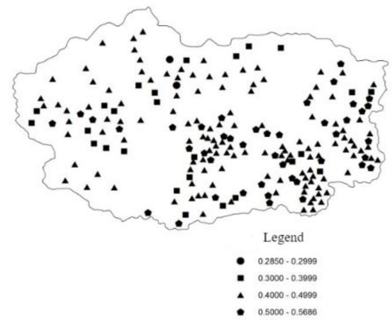

Figure 7. Distribution of the village characteristics–industrial allocation match levels of administrative villages in Fuping County.

This indicates that the current industrial development strategies of Fuping County can partially meet the villages' needs. However, there exists mismatch and incoordination between the village characteristics and local industry development in approximately half of the administrative villages. The mismatch could be due to differences in industry identification perspectives or measurement methods during the industrial policymaking.

Table 3. The match levels and grades of villages in Fuping County.

Acceptable range	MATCH	Match (sub ranges)	Grades	Number of Townships	Number of Villages	Match Level
Unacceptable Range	0.2-0.29	0.27-0.299	A	1	2	Moderate mismatch
		0.24-0.26	B	0	0	
		0.2-0.23	C	0	0	
	0.3-0.39	0.37-0.399	A	5	11	Slight mismatch
		0.34-0.36	B	6	9	
		0.3-0.33	C	4	6	
	0.4-0.49	0.47-0.499	A	13	61	On the brink of mismatch
		0.44-0.46	B	13	44	
		0.4-0.43	C	13	30	

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Transition range	0.5-0.59	0.57-0.599	A	0	0	Just above the Threshold for Match
		0.54-0.56	B	4	6	
		0.5-0.53	C	9	40	

4.1.1. Classification of the Relationship between the Two Systems

Further assessment and comparison of the village characteristics and the industrial allocation to evaluate the matching efficiency between the two systems could identify the controlling factors that lead to the mismatch and incoordination and could help find the best strategy for achieving the coordinated development of industry and village characteristics at higher levels（see Table 4）.

By comparing the comprehensive order parameters of the two systems, the two systems' relationships are classified into three types: impediment, lagging behind, and overall stagnation. First, among the impediment type, grades B and C of “just above the match threshold” consist of three situations: overly advanced industrial allocation, appropriate industrial allocation, and impeded industrial development. Grade C—the level with overly advanced industrial allocation in the “just above the match threshold” group—is the predominant type; 58.6% of the villages of the transition range belonged to this type. Among these villages, the villages with an impediment rate above 10% account for 25% of the villages of grade C—human resources lagging behind; and 22% of the villages have an impediment rate above 5%. Therefore, most villages in the transition range have an industrial allocation that is in pace with the village characteristics.

The lagging-behind range covers the highest number of townships and most villages. It also has three subcategories, grades A, B, and C, and covers three types, industrial allocation of low level but advanced; industry allocation of low level but of the same pace; and lagging-behind industrial allocation. In each subcategory, the majority villages have $U_1>U_2$, indicating that although these villages are on the brink of mismatch, their industrial layout and resources are evolving toward coordinated development. During poverty reduction, the attention should focus on villages at this stage, as they are on the brink of matching. With strong and effective support, the villages at this stage, especially those of grade A, are likely to move to the transition range with a matching efficiency of 0.5-0.59.

In the overall stagnation group, 68% of the villages have an overall stagnation rate above 50%. Both from the perspective of their two-system matching efficiency and in terms of their ratio of comprehensive order parameters, the villages of this stage face a severe insufficiency of resources and urgently need to identify their resource weaknesses. They need to identify the industry types that match their resource characteristics. The government should enhance the poverty reduction support and policy support to these villages.

Table 4. Match levels and grade judgment of the administrative villages in Fuping County.

Range	Match	Match level	U_1 versus U_2	Match category determination	No. of townships	No. of villages
Unacceptable range	0.2-0.29	Moderate mismatch (grade A)	$U_1>U_2$	Very low industrial allocation, but industry is advanced	1	2
	0.3-0.39	Slight mismatch (grade A)	$U_1>U_2$	Super-low industrial allocation, but industry is advanced	5	10
			$U_1<U_2$	Industrial allocation in stagnation	1	1
		Slight mismatch (grade B)	$U_1>U_2$	Super-low industrial allocation, but the industry is advanced	6	9

		Slight mismatch (grade C)	$U_1>U_2$	Industrial allocation is super-low, but the industry is advanced	4	6
	0.4-0.49	On the brink of mismatch (grade A)	$U_1>U_2$	Low industrial allocation, but level is advanced	13	37
			$U_1=U_2$	Industrial allocation and resources are of a low but at the same pace	4	6
			$U_1<U_2$	Industrial allocation lags behind	8	18
		On the brink of mismatch (grade B)	$U_1>U_2$	Industrial allocation is of a low level and overly advanced	10	26
			$U_1=U_2$	Industrial allocation and resources are of a low level but at the same pace	5	5
			$U_1<U_2$	Industrial allocation lagging behind	7	13
		On the brink of mismatch (grade C)	$U_1>U_2$	Industrial allocation of a low level and ahead of village characteristics	10	20
			$U_1<U_2$	Industrial allocation lags behind	6	10
Transition Range	0.5-0.59	Just above the match threshold (grade B)	$U_1>U_2$	Overly advanced industrial allocation	2	2
			$U_1=U_2$	Industrial allocation suits local circumstances	2	3
			$U_1<U_2$	Industry development is impeded	1	1
		Just above the match threshold (grade C)	$U_1>U_2$	Overly advanced industrial allocation	8	27
			$U_1=U_2$	Industrial allocation matches the village characteristics	5	9
			$U_1<U_2$	Industry development is impeded	4	4

4.1.2. Analysis of the Matching Efficiency Types of the Administrative Villages

4.1.2.1. Analysis of the Villages on the Brink of Mismatch

The match efficiency of villages of this category is in the range of 0.4-0.49; they are scattered across all parts of Fuping County and account for 64.6% of the total. This means almost two-thirds of the administrative villages are on the brink of mismatch in their two-system matching status; however, 45.2% of these villages have a match efficiency between 0.47 and 0.499, a relatively good grade (A, which is a match efficiency range of 0.4-0.49). Such villages are on the brink of mismatch, so the poverty reduction is easier to carry out in them than in other villages. Hence, they should be prioritized for government support(Figure 8).

Based on the comparison of their comprehensive order parameters, the villages with a matching efficiency of 0.4-0.49 consist of three groups: industrial allocation is of a low level and is overly advanced; the industrial allocation keeps pace with resources but is of a low level; and the industrial allocation lags behind. The proportions of villages with $U_1>U_2$ amongall villages in each match efficiency range are, respectively, 60.6%, 59.1% and 66.7%. This means that among Fuping County's 135 villages that are on the brink of mismatch, 61.4% have industrial allocations that are more advanced than their resources; such a situation provides resource potential for the expansion and development of follow-up industries. At the same time, as the industrial allocation is advanced, the villages face some challenges in accepting the industrial allocation. Hence, the local governments need to strengthen their promotion of these villages' industries, raise their awareness of the need to do so, and provide more financial and policy support.

The villages with $U_1=U_2$ account for 9.8% and 11.3% of all villages in their respective match-efficiency subranges, with none in the match efficiency grade C subrange. The villages of this category have an ideal status of coordination. Yet their relatively matching efficiency indicates low-level coordination. Especially for the impoverished villages in mountainous areas that lack resources, low-level coordination is not conductive to their poverty reduction and often leads to the "low-level trap".

The villages with $U_1<U_2$ make up, respectively, 29.54%, 29.5%, and 33.3% of the villages of the three different match efficiency ranges, indicating that in Fuping County, 30.3% of the villages have industry that lags behind the local development or is unsuitable for the local resources. However, among the villages with industrial allocation lagging behind, 75.6% are in a relatively ideal situation for rural villages, and it is relatively easy for them to undergo industrial upgrade. Therefore, the government should upgrade these villages' industrial allocation, support the development of industries for which there is a local advantage, and speed up and upgrade the industrial allocation adjustment so as to achieve rapid economic growth there.

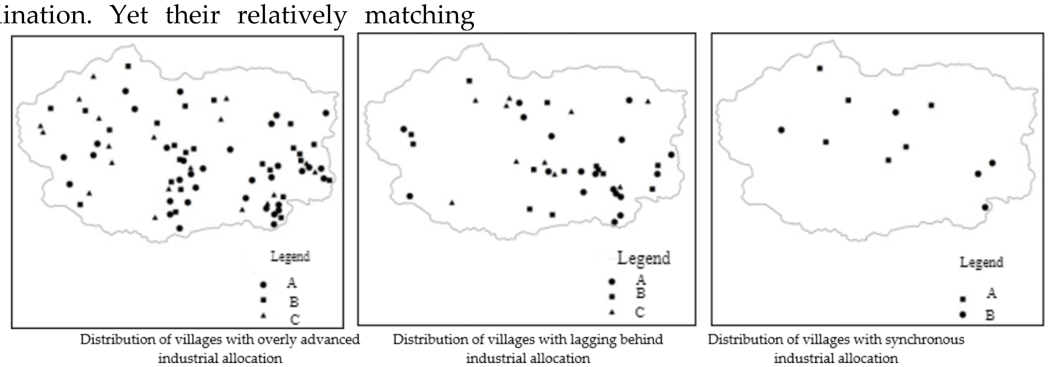

Figure 8. Distribution of villages on the brink of mismatch.

4.1.2.2. Analysis of the Villages that Are Just above the Match Threshold

Forty-six villages are in the match efficiency range of 0.5-0.59, making up 22% of the 209 villages. In terms of village numbers, this is the second-biggest group. However, one should not be optimistic and think these villages' coordination is higher than other villages'. Among them, 86.95%, or 40 villages, are just above the match threshold. In other words, these villages are at high risk of sliding back into the group of "on the brink of mismatch". Therefore, for poverty reduction and promotion of development, local government should pay special attention to these villages, on the basis of maintaining their existing industrial allocation and development, timely upgrading and adjustment of industries, and promoting the further coordinated development between industries and village characteristics(See Figure 9).

The proportions of villages with $U_1>U_2$ in the subefficiency match ranges are, respectively, 66.6% and 67.5%, and they do not exist in the grade-A subgroup of the 0.57-0.599 range. Sixty-three percent of the villages have an industrial allocation exceeding their village characteristics. This indicates that among the transition villages in Fuping County, over two-thirds have an advanced industrial allocation during the industry-based poverty reduction.

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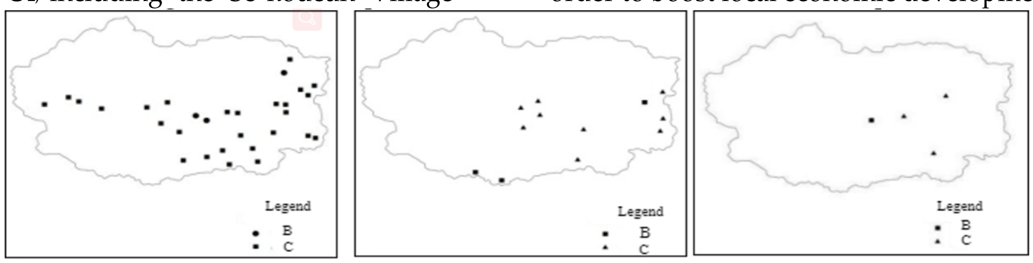
The villages with U_1=U_2 account for 50% and 22.5% of the subcategories grade B and grade C, respectively. This means that among the villages of "just above the match threshold" in Fuping County, 26% have an ideal industrial allocation that is in line with the local reality and is of high vitality. For villages in this group, their industries should be further upgraded so that they can develop in the direction of higher coordination and more prosperity and provide references and examples for the development of neighboring villages.

Among the transition-range villages, only five villages have U_1<U_2, including the Se*koucun Village and Long*cun Village from Fu*zhen Township, Nan*cun Village from Wang*kouxiang Township, Guang*cun Village from Bei*yuanxiang Township, and Bo*cun Village from Da*xiang Township. The industrial allocation of these five villages are of the impediment category, due to a lack of labor or land resources, so their basic conditions are not strong enough to support industrial development. It is necessary to further analyze the local situation, find the insufficiencies in local conditions and address them, and enable them to meet the requirements of the allocated industries in order to boost local economic development.



Distribution of villages with advanced industrial allocation
Distribution of villages with impeded industrial allocation
Distribution of villages with suitable industrial allocation

Figure 9. The distribution of villages of the "just above the match threshold" group.

4.1.2.3. Analysis of the Villages of Slight and Moderate Mismatch

The numbers of villages of slight mismatch and moderate mismatch account for 1.44% and 1% of the total, respectively. Only a proportion of the villages belong to these two groups, yet they are challenges in the process of poverty elimination and rural development. China's poverty elimination follows the concept of "leaving no one behind". In the process, it is necessary to find out whether the industry size and development level are appropriate and in line with the local reality. The government needs to identify the weaknesses in the village characteristics and overcome the weaknesses to facilitate local industrial development. The proportions of U_1>U_2 are high among all the four match level subgroups: respectively, 100%, 90.9%, 100% and 100%. Such high proportions indicate that in most of the administrative villages, the industry types supported during poverty elimination based on industrial development have a low penetration rate and are ahead of the villages' resource profile. Therefore, in future industry-based poverty elimination, the weaknesses in village resources should be identified, and the industry category should be selected according to the villages' resource availability. Moreover, various kinds of policy support should be enhanced to help the villages get out of poverty as soon as possible and achieve balanced development(See Figure 10).

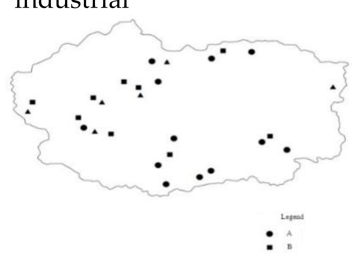


Figure 10. Distribution of villages of slight and moderate mismatch, super-low industrial allocation, and advanced industrial level.

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4.1.2.4. Case Studies on the Match Levels of Specific Impoverished Villages

The contents above are mainly an analysis of the two-system matching efficiency from the macro perspective. In the following section, case studies are conducted on specific villages to identify the weaknesses in typical villages and determine the rationality of their industrial allocation, in order to make more specific and tailored assessments of village characteristics and industrial allocation efficiency. Based on the matching efficiency average, five impoverished villages were randomly selected from the 0.2-0.59 range, as typical cases, and the matching efficiency of their industry layout and resource allocation was comprehensively analyzed(See Table 5).

Table 5. Comprehensive analysis of the match levels of five administrative villages in Fuping County.

Township	Village	Match level	U_1	U_2	Match	Match type	Industrial allocation weakness	Village weakness
Cheng**zhen	Song*goucun	0.512	0.288	0.244	0.512	Just above match threshold, coordinated (grade C)	Low industrial income, great difficulty in industrial transition	Low proportion of irrigated area, high proportion of areas with slope ≥15°, small reclaimable land area, and high reclamation difficulty.
Xia*xiang	Cai*cun	0.491	0.205	0.210	0.470	On the brink of mismatch, uncoordinated (grade A)	Low proportions of the 2nd sector and the tertiary sector in local GDP	Small arable land area, a few small processing enterprises, and a few cooperatives.
Wang**xiang	Qian*cun	0.441	0.276	0.221	0.441	On the brink of mismatch, uncoordinated (grade B)	Lack of industry diversity	Frequent geological hazards, lack of skilled workers, low proportion of irrigated area, and lack corresponding technologies
Sha*xiang	Shang*cun	0.4	0.136	0.23	0.461	On the brink of mismatch, uncoordinated (grade C)	Low per capita income from nonfarming sources, unable to support local industry development	Transport infrastructure is insufficient, lack small processing enterprises, low crop planting area, and lack of skilled workers
Long*zhen	*Hu*cun	0.346	0.23	0.102	0.346	Slight match, uncoordinated (grade B)	Low income from industries, industrial transition facing severe difficulties	Low per capita arable land ownership, small proportion of farmers engaged in secondary and tertiary sectors, low cropland area.

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5. Conclusions and Discussion

The modeling calculation of matching efficiency in the previous section indicates that the matching efficiency between the village characteristics and industrial allocation among the administrative villages in Fuping County does not look promising. The matching efficiency of most villages lies in the unacceptable range and the transition range of 0.3-0.59; only a few villages are in the moderate mismatch range of 0.2-0.29. Further analysis indicates that among the townships of grade C in the "just above match threshold" category, 58.6% have an advanced industrial allocation. In particular, the villages with a hindrance rate above 10% make up 25% of the villages of grade C and with lagging-behind human resources; the villages with a hindrance rate above 5% account for 22% of the total. In the search for specific controlling factors that lead to mismatch and incoordination, we discovered that the townships with matching efficiency between 0.4 and 0.49 can be found in all parts of Fuping County, and the villages of this range account for 64.6% of the total. This means almost two-thirds of the villages have an "on the brink of mismatch" matching efficiency between village characteristics and industrial allocation. However, among these villages, 45.2% are of grade A, the relatively good subrange of 0.47-0.499, which means their allocated industrial types are ahead of their local reality, which provides resource potential for the expansion and development of follow-up industries. The advanced industrial allocation also poses challenges to local villages' acceptance to the industries.

High matching efficiency means a comparative advantage for industry development, and industrial advantage can boost local economic development and further influence the whole township's comprehensive development. Areas of high matching efficiency can follow their existing industrial development pathway, further expand, and consolidate their existing industries. Areas with low matching efficiency need to adjust their existing industry development directions in a timely way. If a village's characteristics significantly lag behind the development of its allocated industries, such a mismatch will inevitably hinder the relevant industries' development.

How can we accurately understand the village characteristics and precisely identify the practical issues, and how can we comprehensively control the driving factors to industry development? These questions test the policymakers' ability to see into the essence of phenomena at the stage of industrial allocation, identify systematic differences between villages, and predict future industrial development. First, it is necessary to consider the interconnections between the same industries in different areas, the relations between the different industries in the same area, and the linkages between upstream, downstream, and relevant industries. It is also necessary to explore the competitive and cooperative relations between the poverty-reducing industries, along with their industrial structures, features, and correlations. Second, it is important to establish the concept of zoning and subregions, to highlight the regional advantages and avoid the early occurrence of bottlenecks of industries. The policymakers should attach importance to regional special features, such as policies and regulations, local culture, and folk customs, identify the common features from among the numerous differences, and further narrow down the scope of changes, so that the industry-based poverty reduction is more in line with the local reality. Third, it is necessary to consider the carrier acceptability, i.e., the carrying capacity of villages. Industrial allocation is an intervention process; the carrying capacity of villages is a precondition determining local industrial development. For example, in the same region, animal-farming pollution conflicts with green tourism development, and solar photovoltaic deployment competes with crop production in land use. This requires the consideration of interactions between different industries and different aspects of the same industry in the industry selection stage.

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