

# An Empirical Analysis on the Coordinative Development of China's Arteriovenous Industry Coupling

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**Keywords:** Artery industry; Vein industry; The coupling; Empirical analysis

**Abstract.** Objective: To analyze the correlation and coordination degree between the arterial industry and the venous industry in China and propose the corresponding development path. Methods: The data of coupling coordination development from 2008 to 2016 were analyzed and evaluated, and an empirical study was conducted to quantify the interaction, interaction and coordination between the arterial and venous industries through coupling coordination degree and coupling correlation degree. Results: The coupling of arteriovenous industry developed rapidly, from the low-level coordination in 2008 to the development stage of intermediate coupling coordination in 2016. Conclusion: To strengthen the coordinated development of the arterial and venous industries, it is necessary to strengthen the interaction between the two sides of the arterial and venous industries and establish a benign mode of coordinated development to ensure the coordinated development of the arterial and venous industries.

## Introduction

With the rapid development of economy and economic aggregate, the contradiction between resources and environment becomes increasingly prominent. Too much industrial waste, too much pollution and the lack of effective disposal of enterprises is also the main cause of this problem. The report of the 19th national congress of the communist party of China (CPC) put forward that "green water and green mountains are mountains of gold and silver", indicating that this contradiction has increasingly attracted the attention of the central government and the government. Therefore, the research on the vein industry is imperative.

The concept of vein industry was introduced into China as early as 2005, which is the opposite of artery industry in circular economy [1]. However, in terms of the current situation in China, the development of the vein industry has encountered a real bottleneck due to the coordination problems between the arteries and veins. Tang Y, L. J took Shanghai (China) arterial and venous industry as the research object, indicating that the lack of policy strength, technology and social participation limits the coordinated development of Shanghai arterial and venous industry [2]. Chen Shengtao established a relevant model of interaction and coupling between the two industries by sorting out relevant studies on the arterial industry and the venous industry. Taking the manufacturing industry as the empirical object, he found that the two industries rarely promote each other, and there are problems such as the chaotic market of circular economy and the lack of laws and regulations [3].

In order to solve this problem, many scholars consider the coordination of arteriovenous industry from a quantitative perspective from the coupling of arteriovenous industry. Chi Ermin made a systematic analysis of the coupling between circular economy industries, and summarized several coupling relationship chains between industries [4]. Zhang Shuang et al. analyzed the coupling relationship and collaborative contingency between the arteriovenous industry and the evolution process of the collaborative development mode of the arteriovenous industry, and pointed out the pseudo-coordination and system construction obstacles in the development of the arteriovenous industry [5]. Liu Jiana used the coupling correlation to analyze the interactive relationship between the arteriovenous industry and empirically analyzed the coupling development degree of the Arteriovenous industry in Liaoning province [6]. However, how to quantify the interaction,

interaction and coordination of the arteriovenous industry through coupling coordination degree and coupling correlation degree, and conduct quantitative research with other research objects using the econometric model, so far, no attention has been paid by scholars. This paper takes the secondary industry in China as the artery industry and the comprehensive utilization of waste resources as the corresponding vein industry as the research object to explore, in order to broaden the research scope for the coordinated development of the arterial and venous industries.

## Experiment Design

Coupling is a concept in physics, referring to an interactive development pattern formed by mutual influence and restriction between two or more independent systems [7]. Later, this concept, coupled degree model and coupled degree of coordination model were introduced into the field of economics. Many scholars studied and analyzed the mutual influence and coordinated development degree between different industries from this perspective [8-10]. Although arterial industry and venous industry are concepts in circular economics, the circulation of material flow between them naturally leads to the mutual coupling and coordination between the two industrial systems. Therefore, the coupling degree model and the coupling degree model can be used to more directly study the current situation and development of the coordination between the arterial and venous industries.

**Construct the Coupling coefficient Degree Model of Arterial and Venous Industry.** In order to construct the coupling model of arterial and venous industry, it is necessary to determine the development level of the two systems and their subsystems. Here, respectively,  $U_d$  and  $U_j$  is the total development level of the arterial industry and the vein industry, and  $u_{di}$  is the contribution of the index represented by the  $i$ -th sub-system index of the arterial industry to the total development level of the arterial system.  $u_{jj}$  is the contribution of the  $j$ -th sub-system index of the venous industry to the overall development level of the venous system. Formula (1) is used to calculate the development level of the arteriovenous industry.

$$U_d = \sum \lambda_{di} u_{di} \quad U_j = \sum \lambda_{jj} u_{jj} \quad (1)$$

$\lambda$  is the weight of each subsystem to the total development level, this paper adopts the linear weighting method. In addition, the dimensionless treatment is needed due to the different dimensionality of different indexes in the model. In this paper,  $x_{di}$  and  $x_{jj}$  are set as the value of the index of the  $i$ -th and  $j$ -th subsystems in the arterial industry and the venous industry. The contributions  $u$  of each arterial subsystem were calculated by the following formula.

When the indicator is positive:

$$u_{di} = \frac{x_{di} - \min(x_{di})}{\max(x_{di}) - \min(x_{di})} \quad (2)$$

When the indicator is negative:

$$u_{di} = \frac{\min(x_{di}) - x_{di}}{\min(x_{di}) - \max(x_{di})} \quad (3)$$

Vein industry is the same. According to the capacity coupling coefficient model in physics [11], the coupling degree model of arteriovenous industry can be obtained as follows:

$$C = 2\sqrt{(U_d \times U_j) / \prod(U_d + U_j)} \quad (4)$$

Where  $C$  is between 0 and 1.

**Construct the coupling coordination degree model of arterial and venous industry.** Although the coupling degree model can measure the degree of coupling between arterial industry and vein industry and reflect the degree of interaction and mutual influence between arterial industry and vein industry, it cannot reflect the development level of arterial industry and vein industry itself. Especially when the development level of both is similar, even if the development level of both is very low, the degree of coupling can be high. It is necessary to use the degree of

coupling coordination to reflect the degree of coordination between the arterial industry and the venous industry and explain the trend and characteristics of their coordinated development. The model is as follows:

$$D = \sqrt{T \times C}, \quad T = \alpha U_a + \beta U_j \quad (5)$$

Where D is the coupling coordination degree and T is the comprehensive coordination index, indicating the contribution of the development level of the arteriovenous industry to the coupling coordination degree.  $\alpha, \beta$  is the undetermined coefficient reflecting the weight of the influence of the arteriovenous industry on the coordination degree, ( $\alpha + \beta = 1$ ). In this paper,  $\alpha, \beta$  are set as 0.8 and 0.2 respectively according to the development scale of arterial industry and venous industry. D is also between 0 and 1.

**Evaluation standard.** When the coupling coordination degree and coupling correlation degree take different values, it reflects the different coordination degree and coupling development of the arterial and venous industry. Referring to the studies of huoying, qiaopengliang, wuyuming et al. [9, 11, 12], the development status corresponding to the specific values of coupling correlation degree and coupling coordination degree was divided, as shown in table 1 and table 2.

Table 1 Coupling correlation degree stage discrimination

Stage of development	Degree of Coupling correlation	coupling state
Bud period	$C=0$	no coupling
Growth period	$0 < C \leq 0.3$	Low coupling
Primary maturity	$0.3 < C \leq 0.7$	Intermediate coupling
Advanced maturit	$0.7 < C \leq 1$	High coupling

Table 2 Stage discrimination of coupling coordination degree

Stage of development	Degree of coupling coordination	Coordinated development type
Germination (ambivalent type)	$0 \leq D < 0.1$	Out of whack
	$0.1 \leq D < 0.2$	Gross incongruity
	$0.2 \leq D < 0.3$	Mild dissonance
Primary (disorder type)	$0.3 \leq D < 0.4$	Barely coordination
	$0.4 \leq D < 0.5$	Harmonic coordination
	$0.5 \leq D < 0.6$	Primary coupling coordination
Medium (moderate type)	$0.6 \leq D < 0.7$	Intermediate coupling coordination
	$0.7 \leq D < 0.8$	Good coupling coordination
	$0.8 \leq D < 0.9$	High quality coupling coordination
Advanced (coupled type)	$0.9 \leq D \leq 1$	Extreme coupling coordination

## Empirical Analysis

**Indicators and data.** There are many articles about coupling and coordination between industries using coupling degree, but there is no uniform standard. The relevant researches on the arterial and venous industry are mainly theoretical and qualitative. In this paper, six indicators from the three dimensions of economic benefit, output and social contribution are selected to evaluate the arterial and venous industries with the secondary industry in China as the artery industry and the comprehensive utilization of abandoned resources as the corresponding vein industry. The specific indicators are shown in table 3.

Table 3 Evaluation indexes of the coupling development of arterial industry and vein industry

Venous industry		Arterial industry	
Total assets [hundred million yuan]	Industrial economic scale	Total assets [hundred million yuan]	output
Number of enterprises above scale [number]		Number of enterprises above scale [numbe]	
Industrial waste gas treatment [billion cubic metres]	output	Crude steel [ten thousand tons]	Social contribution
Industrial waste disposal [ten thousand ton]		Fertilizer [ten thousand tons]	
Industrial waste liquid treatment [tons]		Cement [ten thousand tons]	
Ratio of employed population to total employed population [%]	Social contribution	Ratio of employed population to total employed population [%]	

In this paper, the secondary industry in China is selected as the arterial industry and the waste resources comprehensive utilization industry as the corresponding vein industry. The relevant data from 2008 to 2016 were selected from China industrial statistical yearbook, China environmental statistical yearbook, and EPS data platform.

**Empirical results and analysis.** According to the above Eq (1) - (5), the coupling correlation degree and coupling coordination degree of China's arterial and venous industries from 2008 to 2016 can be calculated, as shown in table 4.

The table 4 shows that arterial industry and vein industry and coupling correlation C and coupling coordination degree D between 2008 and 2016 are on the rise, arterial industry and vein industry reflects the venous industry in China, the arterial industry 9 years in various all have different degrees of ascension, all to the good direction, coupling correlation C and coupling coordination degree D reflects the mutual promotion of artery industry and venous industry in China, and to evolve in the direction of the coupling development, deepening mutual influence degree.

From 2008 to 2016, the coupling degree C of China's arterial industry and vein industry always fluctuated between 0.4 and 0.6, indicating that China's arterial industry and vein industry had passed the transitional development stage from the growth stage to the early stage of mature development, which was in a Intermediate coupling state. According to the results, the interaction and correlation between the arterial industry and the venous industry in China need to be strengthened. Although the vein industry has developed a lot, its growth time is still short. From the development trend, there is still a lot of room for growth. With the further development of China's vein industry, the mutual cooperation and influence between the arterial industry and the vein industry are deepening, and the coupling development of the arterial and vein industry will enter a new stage.

Table 4 Evaluation results of the coupling development of arterial industry and vein industry (2008-2016)

	$U_j$	$U_d$	Coupling correlation C	Coupling stage	Degree of coupling coordination D	Coordinated development type
2008	0.37960	0.2993	0.409103	Early maturation	0.359207	Barely coordination
2009	0.42268	0.3824	0.448095	Early maturation	0.418318	Harmonic coordination
2010	0.50261	0.4896	0.498009	Early maturation	0.495102	Harmonic coordination
2011	0.53704	0.2586	0.417806	Early maturation	0.362381	Barely coordination
2012	0.57680	0.3626	0.471877	Early maturation	0.437431	Harmonic coordination
2013	0.64119	0.4896	0.526912	Early maturation	0.523427	Primary coupling coordination
2014	0.77849	0.5841	0.577683	Early maturation	0.599907	Primary coupling coordination
2015	0.86072	0.6658	0.612708	Early maturation	0.657138	Intermediate coupling coordination
2016	0.89923	0.7258	0.63373	Early maturation	0.694201	Intermediate coupling coordination

In general, the coupling and coordination degree between the arterial industry and the venous industry in China has been continuously improved from 2008 to 2016. After 8 years of continuous running-in, the coupling coordination degree D of the development of the artery industry increased

from 0.359207 to 0.694201, and its coupling development went through four stages of continuous improvement, from barely coordination to harmonic coordination to primary coupling coordination to intermediate coupling coordination. In 2008 and 2011, the coupling development of the arterial industry and the venous industry was in a barely coordinated stage, which was a state of primary coupling development of disordered type. In 2009, 2010, and 2012, the coupling development of the arterial industry and the venous industry was in a harmonic coordinated stage, still in the primary coupling development state. After 2013, the coupling development of arterial industry and vein industry was in the primary coupling type. After 2015, the coupling development of the arterial industry and the venous industry basically achieved intermediate coupling coordination. However, due to the influence of economic, the degree of coupling coordination between the two industries declined from harmony to barely coordination in 2011. In the next few years, appropriate policies should be adopted to strengthen the coupling degree between the arterial industry and the venous industry, so as to promote the arterial industry and the venous industry to continue to maintain a moderately coupled development state, and actively move towards a highly coupled development state.

## Summary

In this paper, coupling development of the middle arteriovenous industry is studied by coupling correlation and coupling coordination. The development of arteriovenous industry in China is illustrated by empirical data. Finally, some policy Suggestions about the development path are given.

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