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Trinity for Innovation: Industry-University-Research Amends Factor Misallocation Based on the Dual Perspective of Capital and Labor Force

Liwen Cheng [a], Zhouyi Gu [b], Changsong Wang [c, *], Jie Hong [c]

[a] *School of Sino-German Robotics, Shenzhen Institute of Information Technology, Shenzhen, 518029, China*

[b] *School of Information Technology, Zhejiang Financial College, Hangzhou, 310018, China*

[c] *Institute of Agricultural Economics and Information, Jiangxi Academy of Agricultural Sciences, Nanchang, 330200, China*

ABSTRACT

Based on provincial panel data in China, this study is the first to investigate whether industry-university-research collaborative innovation (IURCI) can help to improve factor misallocation. It is found that IURCI can significantly improve capital misallocation and labor misallocation, and the effect has regional differences, which shows that the improvement effect is obvious in areas with factor under-allocation, such as the central and western regions, but not obvious in areas with factor over-allocation, which conforms to the rule of diminishing marginal returns. A regulatory effect model is built to explore the impact of regional heterogeneity, through which we find that after considering three external environmental conditions, including economic development level, academic research level, and marketization degree, the improvement effect of IURCI on factor misallocation undergoes significant changes. The research results show that to deepen the marketization reform of factor allocation, we can start with IURCI. The government should form a sustainable and normalized industry-university-research collaborative innovation ecological mode through pilot cases and adopt measures according to local conditions to ensure the efficient use and reasonable distribution of capital and human resources of enterprises, universities, and scientific research institutions.

KEYWORDS

Industry-university-research cooperation innovation (IURCI); Capital misallocation; Labor misallocation; Factor misallocation

* Corresponding author: Changsong Wang
E-mail address: jxswcs@163.com

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1. Introduction

In 2020, the Chinese government issued “the Opinions on Building a More Complete Institutional Mechanism for Market-Based Allocation of Factors”, which clearly pointed out that accelerating the market-based allocation of factors is crucial for achieving the Two Centenary Goals and promoting high-quality economic and social development. Currently, there is a general misallocation of resources in China, which significantly dampens industry productivity, corporate R&D investment, exports, foreign direct investment, energy efficiency, technology spillovers, and economic performance (Yang et al., 2020; Kong et al., 2021; Zhu et al., 2019; Wu et al., 2018). Qin et al. (2022) emphasize that labor and capital misallocation significantly affect the high-quality development of enterprises and reduce the efficiency of the factor resource allocation of enterprises. Given this, with high-quality development as the goal, it is imperative to explore an innovative path to solve the factor misallocation problem. In January 2022, the Chinese government issued "The Overall Plan for Comprehensive Reform of Market-Based Allocation of Factors," emphasizing the need to explore collaborative allocation of innovation resources in terms of technology factors. This involves promoting the integration of technology and capital elements of development and forming a technological innovation system that is enterprise-oriented and deeply integrates the advantages of industry, universities, and research institutes. It is evident that China plans to start from the collaborative innovation of Industry-University-Research (IUR), to promote technology, talent, capital, and other types of factors for enterprise agglomeration, optimize factor allocation efficiency, and further achieve high-quality economic and social development. Therefore, examining the improvement effect of factor misallocation from the perspective of IURCI not only enriches the theory of factor allocation but also provides practical references for building a collaborative innovation community. This is of great strategic and practical significance for deepening the reform of factor market allocation and realizing high-quality economic development.

From the literature, it is evident that factor misallocation and its influencing factors have been widely studied by scholars. On one hand, many scholars have focused on the factors that deepen factor misallocation. For example, Mense et al. (2023) and Ugarov (2019) argue that market segmentation can exacerbate factor misallocation by limiting the free flow of factors; Hsieh and Moretti (2019), along with Liu et al. (2020) suggest that different forms of government regulation or intervention can deepen distortions in factor markets, such as administrative monopolies, government housing restriction policies, and locally established economic growth targets. Additionally, market-based competition, ownership discrimination, market endogeneity and monopoly power have all contributed to the factor misallocation problem in China to some extent (Boeri et al., 2021). On the other hand, some scholars have also considered how to improve factor misallocation. For example, Cheng, et al. (2020) study the improvement effect of OFDI on factor misallocation and find that OFDI has a significant improvement effect on capital misallocation and labor misallocation, but this effect is affected by external factors such as the level of excess capacity, resource allocation status, and regional differences. Zhang (2022) point out that the servitization of manufacturing can clearly improve capital misallocation, but it will intensify labor misallocation with regional heterogeneity. Moreover, scholars have also explored the ameliorating effects of other factors on factor mismatch, such as trade liberalization, service industry opening, transportation infrastructure improvement, exchange rate changes, financial development, industrial agglomeration level, and the process of marketization (Li et al., 2019; Shenoy, 2017). The study found that not all elements improve factor misallocation as expected, and there are also situations that exacerbate factor misallocation. In the process of policy formulation, the organic combination of factor misallocation improvement factors will obtain twice the result with half the effort.

At the same time, existing research shows that the effect of industry-university-research collaborative innovation (IURCI) is mostly positive. For example, collaborative innovation between industry, university and research institute has a visible positive impact on innovation capabilities, enterprise innovation output, regional innovation efficiency, enterprise innovation, regional independent innovation capability, and economic growth (Li

and Xing, 2020; Wang et al., 2018; Bikard et al., 2019; Wang et al., 2022). The IURCI takes enterprises, universities and research institutions as the main bodies, with the participation of government and intermediary services, which is a more in-depth and multi-innovation activity to achieve resource sharing and complementary advantages. It is worth thinking about whether this kind of activity can truly integrate the resources of various entities to realize complementary advantages and resource sharing, thus enhancing the efficiency of resource utilization. In other words, can IURCI indeed improve factor misallocation? What is the mechanism of action of IURCI on factor misallocation? Will the relationship between the two be strengthened or weakened by regional heterogeneity? Few research has been conducted to systematically explore the intrinsic relationship between IURCI and factor misallocation, and there is a lack of strategic research based on the perspective of regional heterogeneity. Accordingly, this paper incorporates IURCI and factor misallocation into the same analytical framework through the data of 29 provinces in China from 2011-2018 to explore the mechanism of the role of IURCI in factor misallocation and provide a new direction and new idea for the reform of market-oriented factor allocation in China.

Compared with the existing studies, the possible marginal contributions of this paper are as follows: Firstly, there is a lack of theoretical analysis and empirical testing on the new issue of how IURCI affects factor misallocation. This paper fills this gap and extends research on the pathways for improving factor misallocation and its influencing factors. Secondly, it explores the effects of IURCI on labor and capital misallocation while examining regional variability. This provides guidance and policy suggestions for local governments on how to improve factor misallocation by developing IURCI based on local characteristics. Thirdly, we investigate the moderating effect of regional heterogeneity on the relationship between the two, thus enhancing research on the influence pathway of the mechanism of action.

The subsequent structure of this paper is as follows: in the first part, we elaborate the theoretical model and form the research hypothesis to lay the foundation for the subsequent empirical study; the second part constructs the econometric model and explains the data sources and parameter estimation; the third part empirically analyzes and verifies the mechanism of the IURCI on factor misallocation, which is based on the aforementioned econometric model and data; and the fourth part concludes and puts forward suggestions for policy formulation.

2. Theoretical Analysis and Research Hypothesis

Based on the social division of labor theory, economic growth theory and value chain theory, this section attempts to analyze the action paths of industry-university-research collaborative innovation (IURCI) on factor misallocation through the synergistic effect, resource allocation effect and knowledge spillover effect and then to decompose the improvement mechanism hypothesis into several conditional hypotheses based on the external environment, such as economic foundation, cooperative subjects and market.

2.1. The Improvement Effect of industry-university-research collaborative innovation (IURCI) on Factor Misallocation

First, according to the theory of the social division of labor, IURCI refers to collaborative innovation activities, which gather advantages among universities, enterprises and research institutions through the division of labor and collaboration, with the goal of creating a 1+1+1>3 effect (Sutphin, 2010). Compared with independent innovation, through mutual collaboration with universities and research institutions, enterprises can obtain cutting-edge technologies or knowledge from universities and research institutions by complementary advantages and resource sharing, which significantly reduces production and operation costs, promotes the transformation of enterprises from labor-intensive or capital-intensive to technology-intensive, and stimulates the vitality of innovation, creation and entrepreneurship in enterprises (Lyu et al., 2019). With the deepening of the synergy effect,

the "externalization" of innovation investment has prompted enterprises to focus on highly skilled personnel, intelligent hardware and software equipment, enterprise management and other projects that can enhance the "internalization" benefits, thus promoting the effective allocation of resources and further improving the productivity of enterprises (Battese, 1995). As a result, based on the social division of labor theory, the synergistic effect of IURCI on factor misallocation is summarized as the following logical chain: industry-university-research collaborative innovation→reducing production and operation costs of enterprises→deepening the synergistic effect→shifting the input to projects that can enhance internal efficiency→improving resource allocation efficiency.

Second, industry-university-research cooperation can be divided into scientific cooperation and technical cooperation (Bozeman et al., 2013). Among them, scientific cooperation helps enterprises obtain knowledge innovation resources, and technical cooperation helps enterprises obtain technological innovation resources. According to economic growth theory, innovation is the core element of sustainable economic growth. Hence, the high-quality knowledge innovation resources and technological innovation resources generated by the IURCI can be regarded as technological or R&D factors, investing in the production and operation of enterprises. Then, with the deepening of industry-university-research cooperation, technological or R&D investment gradually increases, which continuously drives the improvement of technological innovation efficiency and total factor productivity to promote resource allocation approaching the Pareto optimal state infinitely, further improving the factor misallocation problem (Lee, 1996). As a result, based on economic growth theory, the resource allocation effect of IURCI to improve factor misallocation is summarized as the following logical chain: “industry-university-research collaborative innovation→increasing the input of technological” or “R&D factors→enhancing regional productivity→reducing resource consumption→rationalizing resource allocation”.

Finally, according to value chain theory, the global value chain follows the distribution of the smile curve, while China's participation is not sufficient, mainly at the low end of the smile curve. Some scholars have proven that IURCI can significantly improve the independent innovation capability of enterprises (Wang et al., 2022). In view of this, it can also drive enterprises to strengthen product development, technological innovation and other technical aspects to encourage enterprises to climb up to the middle and high end of the smile curve. Meanwhile, universities and research institutions can generate obvious knowledge spillover effects in the R&D process (Lyu et al., 2019). In the era of digital economy, to realize value multiplication, enterprises will use the value chain to associate the knowledge spillover from technology links with production and operation links, transform technology into productivity, enhance production and operation capabilities, effectively expand the middle of the value chain represented by manufacturing links, promote the flattening of the smile curve, and realize the optimal allocation of resources. As a result, based on value chain theory, the knowledge spillover effect of the IURCI to improve factor misallocation is summarized as the following logical chain: industry-university-research collaborative innovation→enterprise climbing up to the technology links→industry-university-research cooperation generating the knowledge spillover effect→promoting the value multiplication of production and operation links→improving the efficiency of resource use. In summary, Hypothesis 1 is proposed:

Hypothesis 1: IURCI is conducive to improving factor misallocation.

2.2. Condition Analysis for Improving Factor Misallocation Through industry-university-research collaborative innovation (IURCI)

Excellent improvement effects cannot be achieved without a good economic foundation, sufficient academic-research[1] resources, and a mature market environment.

[1] In this paper, the two main bodies, universities and research institutions, who provide technological innovation services for enterprises, are collectively referred to as "academic-research".

2.2.1. Economic Development Level

The economic development level of each city varies, which is one of the characteristics of regional differentiation. The higher the level of regional economic development is, the stronger the economic agglomeration effect, and the more talent, equipment and technologies are concentrated, the stronger the technological innovation capability, and the greater the synergy and complementary effect of IURCI, which in turn strengthens the improvement effect of IURCI on factor misallocation. Meanwhile, in the atmosphere of IURCI, it is easier for enterprises with low efficiency but high investment to complete transformation and upgrading through the knowledge spillover effect, thereby further improving the factor misallocation phenomenon.

Hypothesis 2: The higher the level of regional economic development is, the better the effect of IURCI on improving factor misallocation.

2.2.2. Academic-Research Resources

IURCI is actually a kind of knowledge production activity with the participation of multiple subjects. To achieve the overall synergy effect of "1+1+1>3", it must be built on the basis of sufficient and high-quality resources of universities and research institutions. The higher the level of academic-research resources, the more adequate the cooperative base in IURCI, thereby the higher the value of scientific research or technological innovation results, and thus the more conducive to improving enterprise productivity and correcting factor misallocation problems.

Hypothesis 3: The level of academic-research resources can effectively enhance the improvement effect of IURCI on factor misallocation.

2.2.3. Degree of Marketization

It has been found that a moderate degree market-based competition is conducive to reducing the degree of factor misallocation in enterprises. In a moderate market competition environment, to avoid the elimination of the best and the worst, enterprises will constantly improve the level of technological innovation based on the reduction of R&D costs using IURCI, which will in turn improve the efficiency of production factor allocation and then promote the transformation and upgrading of enterprises from the rough development mode to the high-quality development mode.

Hypothesis 4: The degree of marketization motivates enterprises to improve factor misallocation through IURCI.

3. Model, Variables and Data Description

3.1. Econometric modeling

To verify the correctness of the theoretical analysis and related hypotheses in the second part of this paper, we first establish the following econometric model to verify whether industry-university-research collaborative innovation (IURCI) can improve factor misallocation:

$$misallocation_{it} = \alpha_i + \beta_1 innovation_{it} + \gamma X_{it} + \varepsilon_{it} \quad (1)$$

Among them, the subscript i denotes the province in China, and the subscript t denotes the year. $misallocation_{it}$ is the degree of factor misallocation; $innovation_{it}$ is the core explanatory variable, i.e., the degree of IURCI; X_{it} is a series of control variables affecting factor misallocation; and ε_{it} is the random error term.

Then, to further explore the corrective effect of the external environment on the relationship between the two, based on model (1), the proxy scalars of economic development level (GDP), academic-research resources (resource), and market degree (market) and their interaction terms are introduced. The moderation effect model is

set as follows:

$$misallocation_{it} = \propto_i + \beta_1 innovation_{it} + \beta_2 D(GDP/resource/market)_{it} + \beta_3 innovation_{it} \times D\left(\frac{GDP}{\frac{resource}{market}}\right)_{it} + \gamma X_{it} + \varepsilon_{it} \quad (2)$$

3.2. Variable Selection and Measurement

3.2.1 The explained variables

Drawing on Hsieh and Klenow (2009), this paper represents factor price distortions in the form of "price taxes", thereby creating the factor mismatch index:

$$\tau_{K_i} = \frac{1}{\hat{\gamma}_{K_i}} - 1 \qquad \tau_{L_i} = \frac{1}{\hat{\gamma}_{L_i}} - 1 \quad (3)$$

Considering that τ_{K_i} and τ_{L_i} may have negative values, referring to the method of Li et al. (2019), the absolute value is taken to indicate the degree of factor misallocation, and the larger the absolute value is, the more serious the factor misallocation is reflected. In addition, $\hat{\gamma}_{K_i}$ and $\hat{\gamma}_{L_i}$ are the relative distortion coefficients as follows:

$$\hat{\gamma}_{K_i} = \left(\frac{K_i}{K}\right) \Big/ \left(\frac{s_i \eta_{K_i}}{\eta_K}\right) \quad \hat{\gamma}_{L_i} = \left(\frac{L_i}{L}\right) \Big/ \left(\frac{s_i \eta_{L_i}}{\eta_L}\right) \quad (4)$$

where $s_i = \frac{P_i Y_i}{Y}$ indicates the market share of output volume of region i(Y_i) in the overall output volume (Y); $\eta_K = \sum_i^N s_i \eta_{K_i}$ is the weighted average of capital contribution, which is derived with the market share; the numerator $\frac{K_i}{K}$ reflects the actual share of capital used by region i; and the denominator $\frac{s_i \eta_{K_i}}{\eta_K}$ reflects the share of capital used by region i in the ideal state of efficient factor allocation. Similarly, the relative distortion coefficient of labor can be explained. When the relative distortion coefficient is greater than 1, region i has a factor misuse problem; conversely, it has a factor underutilization problem.

Accordingly, first, we measure the factor output elasticity using the variable coefficient panel model and then obtain the degree of labor mismatch ($misallocation_L$) and the degree of capital factor mismatch ($misallocation_K$) for each region by using equations (3) and (4).

3.2.2 Core explanatory variable

Drawing on Wang (2022), the entropy method is used to build an evaluation system of collaborative innovation indicators for the three main bodies, enterprises, universities and research institutions, and the coupling coordination degree model is established based on this evaluation system. The main steps are as follows:

First, the index evaluation system of the collaborative innovation system is built, and the index weights are determined using the entropy method, as shown in Table 1.

Table 1. Indicator evaluation system and weights.

Innovation Subject	Indicators	Weights
Enterprises	1- Internal expenditure on R&D expenses	0.088
	2-Government funds in R&D expenditure	0.059

	3-Number of R&D projects	0.093
	4-R&D project personnel	0.092
	5-R&D project funding input	0.092
	6-R&D personnel full time equivalent	0.091
	7-Number of enterprise R&D institutions	0.155
	8-New product development expenditure	0.097
	9-New product business revenue	0.096
	10-Number of valid invention patents	0.138
	1-R&D funding internal expenditure	0.141
	2-Government funds in R&D expenditure	0.146
	3-R&D project number	0.082
	4-R&D project personnel	0.075
Universities	5-R&D project funding input	0.135
	6-R&D personnel full time equivalent	0.075
	7-Number of research institutions	0.093
	8-The number of scientific papers published	0.080
	9-The number of valid invention patents	0.174
	1-R&D funding internal expenditure	0.137
	2-Government funds in R&D expenditure	0.144
	3-R&D project number	0.105
	4-R&D project personnel	0.096
Research Institutions	5-R&D project funding input	0.153
	6-R&D personnel full time equivalent	0.092
	7-Number of research institutions	0.030
	8-The number of scientific papers published	0.105
	9-The number of valid invention patents	0.138

Note: The data are obtained from the China Science and Technology Statistical Yearbook, Science and Technology Statistics of Higher Education Institutions. In addition, the years and provinces with missing values are excluded, and the data of 29 provinces from 2011-2018 are finally retained.

Second, since industry-university-research cooperation is based on the innovation collaboration system, which is composed of the three main bodies, enterprises, universities and research institutions, we can use the coupling model in physics to define the coupling degree of the system as follows:

$$C = 3\frac{\sqrt[3]{f(x) \times g(y) \times h(z)}}{f(x) + g(y) + h(z)} \tag{5}$$

In equation (5), f(x), g(y) and h(z) denote the innovation development level of the three major sub-innovation systems of enterprises, universities and research institutions, respectively, which have been calculated by the entropy value method. The coupling degree C takes the value range of [0,1]; when C=0, there is no coupling, while C=1 indicates the existence of quality coupling.

Finally, as a means to reflect the regional differences of the system (Tao et al., 2023), this paper introduces the coupling coordination degree model based on the coupling degree model as follows:

$$D = \sqrt{C \cdot T} \tag{6}$$

$$T = \alpha f(x) + \beta g(y) + \gamma h(z) \tag{7}$$

In equation (6), D is the degree of the system coupling coordination degree, which is the index used to measure the degree of Industry-university-research Collaborative Innovation (IURCI) in this paper. In equation (7), T is the comprehensive coordination index of the three major sub-innovation systems. In the process of IURCI, because universities and research institutions are mainly responsible for innovation research and knowledge integration, while enterprises not only need to invest in R&D funds but also need to bring the innovation results into value and

improve production and operation efficiency, this paper sets $\alpha = 0.4$ and $\beta = \gamma = 0.3$.

3.2.3 The moderating variables

First, regional economic development level (GDP): this paper measures the economic development level of each region by GDP per capita and deflates and logarithms the index. Second, the level of academic research (resource): since universities and research institutions are important factors affecting regional innovation, the number of research institutions and universities can reflect the level of academic research in each region to a certain extent. Therefore, this paper introduces the number of research institutions and universities (referred to as "the number of academic research resources") as the academic research level of each region and takes the logarithm. Third, the degree of marketization (market): Referring to the practice of Zhang et al. (2024), it is proposed to use "the relative index of marketization process in each region of China" to measure the degree of marketization.

In addition to the above variables, considering that factor misallocation is largely influenced by others, based on the existing research results, two control variables, the degree of government control (GOV) and the level of industrial structure development (theil), are introduced. Among them, GOV is measured by the ratio of general budget fiscal expenditure to GDP in the region; the level of industrial structure development is measured by the Theil index borrowing from Gan (2011), which represents the development of regional industrial structure, and when theil=0, the industrial structure is in a balanced and reasonable state.

3.3. Data Description

Considering the completeness of the core variables, the panel data of 29 provinces in China from 2011-2018 are selected in this paper (Tibet and Chongqing are excluded because some data are missing), and the main variables and definitions are shown in Table 2. The input and output of the degree of factor misallocation are taken from the statistical yearbooks of each province and the China Statistical Yearbook of previous years, in which the capital input draws on the capital stock, the labor input is the number of employed persons in each province, and the output is the real GDP (with 2011 as the base period, the GDP of other years is converted to be expressed in the constant 2011 prices according to the GDP deflator). The data on the degree of industry-university-research

Table 2. Variable Definition.

Variable Name	Variables	Symbols	Definitions
Explained variables	Capital Misallocation	$misallocation_K$	Capital misallocation of each province
Explained variables	Labor Misallocation	$misallocation_L$	Labor misallocation of each province
Explanatory variables	IURCI	$innovation$	The coupling coordination degree of industry-university-research innovation systems in each province
Moderating variables	Level of Regional Economic Development	GDP	GDP per capita of each province (deflated by 2011 as the base period)
Moderating variables	Level of Academic-research	$resource$	Total number of research institutions and universities in each province
Moderating variables	Degree of Marketization	$market$	Drawing on Fan Gang et al. (2011) and Wang Xiaolu (2017),use the relative index of marketization process in each region of China
Control variables	Degree of Government Control	GOV	General budget fiscal expenditure as a share of GDP by provinces
Control variables	Level of Industrial Structure Development	$theil$	Draw on GanChunhui(2011),use the Theil index

collaborative innovation (IURCI) and the level of academic research are received from the China Science and Technology Statistical Yearbook and the Compilation of Science and Technology Statistics of Higher Education Institutions. Other raw data are collected from the statistical yearbooks of each province.

4. Empirical Analysis

4.1. Descriptive Statistical Analysis

Table 3 reflects the descriptive statistics of the main variables in this paper. From the factor misallocation, it can be found that both of the 29 provinces have obvious capital misallocation and labor misallocation problems, as well as regional differences. Regarding the Industry-university-research Collaboration and Innovation (IURCI), the minimum value is 0.030, and the maximum value is 0.710, which indicates that there is a significant difference in the level of IURCI among different provinces, and it is necessary to promote the IURCI of the low-level provinces with the high-level provinces. Meanwhile, other variables also have the problem of unbalanced regional development.

Table 3. Descriptive Statistics.

Variables	Sample Size	Average Value	Standard Deviation	Minimum Value	Maximum Value
Capital Misallocation	232	0.280	0.197	0.001	1.097
Labor Misallocation	232	0.375	0.351	0.000	1.918
IURCI	232	0.299	0.151	0.030	0.708
Level of Regional Economic Development	232	5.951	0.430	4.961	6.978
Level of Academic-research	232	5.204	0.598	3.526	6.267
Degree of Marketization	232	6.588	1.953	2.330	10.830
Degree of Government Control	232	0.247	0.104	0.110	0.627
Level of Industrial Structure Development	232	0.994	0.348	0.256	1.932

Table 4 further introduces the regional variability and time-varying nature of the factor misallocation, which shows that (1) labor misallocation is decreasing year by year, while capital misallocation is difficult to improve. This is consistent with China's demographic dividend and the low productivity of enterprises. (2) Labor misallocation is the highest in the eastern region. This is mainly because most of the eastern regions are first-tier coastal provinces, which have higher economic development levels, resulting in higher human resource costs and higher demand, thus leading to unbalanced labor allocation. (3) The central region has the highest capital misallocation. This is attributed to the fact that the central region is close to the first-tier developed city clusters, which leads to the capital import and export prices being too high relative to the economic level of the region, and then the capital allocation is gradually out of the Pareto optimal state. Overall, the factor misallocation in China has improved and shows significant regional heterogeneity, which is consistent with the findings of Bai and Liu (2018).

Table 4. Factor Misallocation by Subgroup.

Variables Region	Variables	2011	2012	2013	2014	2015	2016	2017	2018
Eastern Region	Capital Misallocation	0.226	0.230	0.224	0.261	0.234	0.243	0.251	0.250
	Labor Misallocation	0.572	0.554	0.552	0.507	0.505	0.500	0.492	0.483
Western Region	Capital Misallocation	0.326	0.333	0.310	0.377	0.351	0.323	0.304	0.298

Central Region	Labor Misallocation	0.392	0.370	0.341	0.329	0.327	0.320	0.312	0.326
	Capital Misallocation	0.454	0.457	0.207	0.193	0.203	0.210	0.228	0.252
	Labor Misallocation	0.243	0.241	0.231	0.220	0.217	0.210	0.203	0.193

Note: (1) Eastern region-Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, Hainan, Liaoning; (2) Western region-Inner Mongolia, Guangxi, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang; (3) Central region-Shanxi, Anhui, Jiangxi, Henan, Hubei, Hunan, Heilongjiang, Jilin.

4.2. Research on the Mechanism of the Action of Industry-university-research Collaborative Innovation (IURCI) on Factor Misallocation

This part empirically investigates whether IURCI can improve factor misallocation by using Eq. 1. The results are shown in Table 5. Considering the path dependence of factor misallocation (Bai and Liu,2018), both the fixed effects model and the dynamic panel model are established for comparative analysis. In the dynamic panel model, we use the differential GMM estimation method (DIFF-GMM).

It can be seen that, whether in the static panel model or the dynamic panel model, industry-university-research collaborative innovation (innovation) has a significant improvement effect on capital misallocation ($misallocation_K$) and labor misallocation ($misallocation_L$), which shows that the diversified innovation synergy built through in-depth cooperation among industry, universities and research institutions can not only help to build a 1+1+1>3 labor dividend but also accelerate the technological innovation of enterprises and promote capital investment in the direction of high efficiency and high benefits. At the same time, it also verifies the correctness of hypothesis 1 in the theoretical part of this paper.

Furthermore, in the empirical results of the dynamic panel model, both capital misallocation and labor misallocation have obvious lagged effects, i.e., factor misallocation in the previous period (L1.) greatly affects factor misallocation in the current period, which reflects that once factor misallocation occurs, it is difficult to reverse but continues to intensify. Hence, it is of practical value to study how to improve factor misallocation. Meanwhile, the path dependence of labor misallocation is stronger than that of capital misallocation, which indicates that the cumulative effect of labor misallocation is stronger and more difficult to improve than that of capital misallocation.

Finally, observing the regression results of the control variables, we find that (1) the degree of government control (GOV) can clearly improve factor misallocation, which suggests that the current government intervention is moderate and effective and indirectly confirms that the IURCI encouraged by the government is helpful for enterprises to invest capital and human resources into projects that can improve quality and efficiency, thus optimizing resource allocation and improving factor misallocation; (2) the level of industrial structure development (theil) has a significant positive impact on factor misallocation, which means that the more unreasonable the industrial structure development is, the larger the income gap is. The resource allocation will be far from the Pareto optimal, and the factor misallocation will be intensified.

4.3. Robustness Test

To verify the robustness of the findings, this section reconstructs the static panel and dynamic panel models and then replaces the explanatory variables to test whether the relationship between the degree of industry-university-research collaborative innovation (IURCI) and factor misallocation still exists. Referring to Kan et al. (2017), the degree of IURCI is measured as follows and defined as innovation1 in this paper:

IURCI=the full-time equivalent of R&D personnel in industrial enterprises above the scale × the proportion of R&D expenditure in universities to GDP + the equivalent full-time equivalent of R&D personnel in industrial enterprises above the scale × the proportion of R&D expenditure in science and technology institutions to GDP

The regression results obtained are shown in Table 6.

Table 5. Research on the Mechanism of the Action of IURCI on Factor Misallocation.

Estimation Method	Static Panel (FE Fixed Effect)		Dynamic Panel (DIFF-GMM)	
Dependent Variable	$misallocation_K$		$misallocation_L$	
-	Model 1-1	Model 1-2	Model 1-3	Model 1-4
L1.	-	-	0.298***	0.590***
			(0.007)	(0.008)
innovation	-0.709**	-0.456***	-0.186***	-0.192***
	(0.284)	(0.136)	(0.036)	(0.028)
GOV	0.085	-0.768***	-0.746***	-0.220***
	(0.547)	(0.262)	(0.068)	(0.052)
theil	0.011	0.003	0.038**	0.060***
	(0.089)	(0.043)	(0.016)	(0.008)
_cons	0.459**	0.698***	0.375***	0.189***
	(0.201)	(0.096)	(0.034)	(0.015)
R2	0.040	0.157		
AR(1)			0.081	0.286
AR(2)			0.534	0.729
Sargan Test			0.288	0.318
Observations	232	232	203	203

*Notes: (1) *, **, and *** represent significance levels at 1%, 5%, and 10%, respectively. The parentheses in the table are standard errors; (2) L1. represents the lagged first-order term of the explanatory variables; (3) AR(1), AR(2), and Sargan tests provide the corresponding p-values.*

Table 6. Robustness Test.

Estimation Method	Static Panel (FE Fixed Effect)		Dynamic Panel (DIFF-GMM)	
Dependent Variable	$misallocation_K$		$misallocation_L$	
-	Model 1-5	Model 1-6	Model 1-7	Model 1-8
L1.	-	-	0.299***	0.607***
			(0.008)	(0.006)
innovation	-0.073*	-0.016	-0.039***	-0.019***
	(0.037)	(0.018)	(0.004)	(0.003)
GOV	-0.137	-0.955***	-0.819***	-0.225***
	(0.537)	(0.262)	(0.061)	(0.045)
theil	0.034	0.040	0.030*	0.074***
	(0.088)	(0.043)	(0.018)	(0.004)
_cons	0.620**	0.645***	0.538***	0.205***
	(0.263)	(0.128)	(0.038)	(0.022)
R2	0.029	0.113		
AR(1)			0.081	0.299
AR(2)			0.622	0.696
Sargan Test			0.193	0.318
Observations	232	232	203	203

*Notes: (1) *, **, and *** represent significance levels at 1%, 5%, and 10%, respectively. The parentheses in the table are standard errors; (2) L1. represents the lagged first-order term of the explanatory variables.*

As seen, after replacing the original explanatory variables, the estimation results are basically consistent with the above, and the IURCI has a significant improvement effect on both capital misallocation and labor misallocation, which verifies that the conclusions of this paper are robust and reliable.

4.4. Further Exploring the IURCI Effect on Capital Misallocation Moderated by Regional Heterogeneity Characteristics

In this section, we use Eq. (2) to explore whether the improvement effect of industry-university-research

collaborative innovation (IURCI) on capital misallocation is affected from the perspective of regional heterogeneity characteristics. The regression results are shown in Table 7. To investigate the moderating effect of the external factors, Models 2-1 and 2-2 reflect the improvement effect of incorporating the moderating variable regional economic development level (GDP); Models 2-3 and 2-4 capture the improvement effect of incorporating the academic research level ($resource$); and Models 2-5 and 2-6 represent the marketization degree (market).

After considering regional heterogeneity and incorporating the interaction term, we find that the interaction term of the academic-research level ($resource$) and the marketization degree (market) significantly weakens the effect of the IURCI on capital misallocation. However, the level of regional economic development (GDP) does not show an obvious moderating effect. The possible reasons are as follows: (1) China's industry-university-research cooperation has a common problem, i.e., the real core needs of industry are ignored, which results in a serious disconnect between the knowledge chain, innovation chain and industry chain; therefore, capital is not invested in the sectors that can promote the high-efficiency development of enterprises, aggravating capital misallocation; and (2) China's rough and ready enterprises account for the majority. Confronted with fierce market competition, they tend to pursue short-term benefits, invest a great deal of money to enhance marketing capabilities, and ignore technological innovation capabilities. As a result, against the background of IURCI, fierce market competition makes enterprises view the industry-university-research project only as window dressing-costing with no substantial benefits, which further aggravates the problem of unreasonable capital allocation. (3) The stronger the economic development level of a region is, the stronger the capital of the region. However, this does not mean that the financial support obtained by industry-university-research cooperation will be greater. Due to the regional policy differences or administrative monopoly of each region, more funds will be committed to infrastructure construction or social security. As a result, the moderating effect of the economic development level in the course of improving capital misallocation by IURCI is not remarkable.

Table 7. The Moderating Effect of Regional Heterogeneity Characteristics.

$misallocation_K$	GDP		resource		market	
	Model 2-1	Model 2-2	Model 2-3	Model 2-4	Model 2-5	Model 2-6
innovation	-0.266**	-0.276	-0.197	-0.521***	-0.151	-0.430**
	(0.135)	(0.172)	(0.161)	(0.189)	(0.149)	(0.167)
GDP	0.013	-0.012				
	(0.045)	(0.045)				
Innovation ×GDP		0.025				
		(0.270)				
resource			-0.022	0.059		
			(0.035)	(0.043)		
Innovation ×resource				0.494***		
				(0.158)		
market					-0.024	-0.034**
					(0.017)	(0.017)
Innovation ×market						0.188***
						(0.056)
GOV	0.654***	0.639***	0.600***	0.294	0.501**	-0.121
	(0.169)	(0.232)	(0.183)	(0.205)	(0.195)	(0.266)
Theil	-0.093*	-0.092*	-0.091*	-0.069	-0.155**	-0.135**
	(0.054)	(0.055)	(0.050)	(0.050)	(0.061)	(0.060)
_cons	0.212	0.220	0.295**	0.092	0.513***	0.747***
	(0.302)	(0.315)	(0.184)	(0.205)	(0.178)	(0.187)
R2	0.171	0.171	0.172	0.207	0.178	0.219
Observations	232	232	232	232	232	232

*Note: *, **, and *** represent significance levels at 1%, 5%, and 10%, respectively. The parentheses in the table are standard errors.*

4.5. Further Exploring the IURCI Effect on Labor Misallocation Moderated by Regional Heterogeneity Characteristics

As in the previous section, we use Eq. (2) to explore whether the improvement effect of industry-university-research collaborative innovation (IURCI) on labor misallocation is influenced from the perspective of regional heterogeneity characteristics. The regression results are listed in Table 8. The explanatory variables and estimation methods of Models 2-7 to 2-12 are consistent with those in Table 7.

The interaction terms of the three regional heterogeneity characteristics in Table 8 show that, except for the academic research level (resource), the level of regional economic development (GDP) and the marketization degree (market) can obviously strengthen the effect of IURCI on labor misallocation. The possible reasons are as follows: (1) the higher the level of regional economic development is, the stronger the economic agglomeration effect, and the more concentrated the labor resources are. As a result, under the atmosphere of IURCI, a large number of labor resources from enterprises, universities and research institutions create the agglomeration effect in the region, which drives the labor flow in a direction that is more conducive to improving collaborative efficiency and thus improving labor misallocation. (2) The stronger the marketization of the region is, the greater the role of the market mechanism, which motivates labor to flow freely, and industry-university-research cooperation is conducive to breaking cross-sectoral human resource barriers, thus promoting the rationalization of labor allocation. (3) The stronger the academic research level is, the greater the opportunity for industry-university-research cooperation, while industry-university-research cooperation requires government policy support and is limited by the quantity of human resources in the three main bodies; therefore, in the context of IURCI, the academic research level does not significantly improve labor misallocation.

Table 8. The Moderating Effect of Regional Heterogeneity Characteristics.

$misallocation_L$	GDP		resource		market	
	Model 2-7	Model 2-8	Model 2-9	Model 2-10	Model 2-11	Model 2-12
innovation	-0.416**	0.153	-0.466***	-0.534***	-0.240	-0.340
	(0.187)	(0.247)	(0.137)	(0.173)	(0.168)	(0.230)
GDP	-0.017	-0.103*				
	(0.057)	(0.061)				
Innovation ×GDP		-0.606***				
		(0.177)				
resource			0.045	0.046		
			(0.049)	(0.049)		
Innovation ×resource				0.166		
				(0.262)		
market					-0.024**	-0.033***
					(0.011)	(0.011)
Innovation ×market						-0.152***
						(0.043)
GOV	-0.777***	-0.742***	-0.743***	-0.751***	-0.619**	-0.614**
	(0.264)	(0.257)	(0.263)	(0.264)	(0.268)	(0.261)
Theil	-0.004	-0.036	0.004	-0.006	-0.023	0.039
	(0.048)	(0.049)	(0.043)	(0.045)	(0.044)	(0.046)
_cons	0.799**	1.119***	0.458	0.473*	0.784***	0.642***
	(0.344)	(0.348)	(0.278)	(0.279)	(0.103)	(0.108)
R2	0.158	0.171	0.161	0.163	0.177	0.227
Observations	232	232	232	232	232	232

*Note: *, **, and *** represent significance levels at 1%, 5%, and 10%, respectively. The parentheses in the table are standard errors.*

4.6. Estimation Results for Subfactor Allocation Status

This part mainly investigates whether, under different factor allocation states, the improvement effect, i.e., industry-university-research collaborative innovation (IURCI), acts on factor misallocation changes. In the above empirical studies, all factor misallocation is treated as an absolute value, without distinguishing between positive and negative. In contrast, this part treats $misallocation>0$ as factor over-allocation and $misallocation<0$ as factor under-allocation. The estimated results are displayed in Table 9.

The regression results of the fixed-effects model show that the IURCI has a considerable improvement effect on regions with an under-allocation of capital and labor, but the improvement effect on regions with factor over-allocation is not obvious, which is basically consistent with the previous conclusions and verifies that the regression results of this paper are robust. In regions with factor over-allocation, the economic agglomeration and innovation agglomeration formed by industry-university-research cooperation will lead to the crowding effect. According to the Law of Diminishing Marginal Returns, with the increasing capital and labor factors, problems such as environmental pollution, industry monopoly and market failure will gradually appear, resulting in the slow-down and insignificant improvement of factor allocation efficiency; in regions with factor under-allocation, Industry-university-research cooperation is in the early stage of growth, and the marginal returns are in the increasing stage, so to maximize their benefits, the three main bodies will push capital and labor factors to gather in the direction that can improve the efficiency of resource allocation, thus improving the problem of factor under-allocation.

Table 9. Regression Results for Subfactor Allocation Status.

FE Model	Factor Under-allocation		Factor Over-allocation	
	$misallocation_K$	$misallocation_L$	$misallocation_K$	$misallocation_L$
innovation	-1.363**	-0.605***	-0.311	-0.270
	(0.728)	(0.120)	(0.523)	(0.211)
The Control Variables	Yes	Yes	Yes	Yes
R2	0.098	0.214	0.049	0.294
Individual Fixed Effect	Yes	Yes	Yes	Yes
Time Fixed Effect	Yes	Yes	Yes	Yes
Observations	144	128	88	104

*Note: *, **, and *** represent significance levels at 1%, 5%, and 10%, respectively. The parentheses in the table are standard errors.*

4.7. Estimation Results by Sub-group

The development of the eastern, central and western regions of China has always been uneven, and the growth of the eastern coastal cities tends to be better than that of the central and western regions. Therefore, is the improvement effect of IURCI and factor misallocation affected by regional differences? In this section, 29 provinces are divided into three major regions as above, i.e., eastern, central and western. The regression results obtained by the fixed-effects panel model are shown in Table 10.

Table 10. Regression Results by Sub-group.

FE Model	Eastern Region		Western Region		Central Region	
	$misallocation_K$	$misallocation_L$	$misallocation_K$	$misallocation_L$	$misallocation_K$	$misallocation_L$
innovation	-0.497**	-0.252	-0.303	-0.590***	-3.577***	-0.427**
	(0.226)	(0.277)	(0.655)	(0.207)	(0.964)	(0.198)
The Control Variables	Yes	Yes	Yes	Yes	Yes	Yes

R2	0.326	0.159	0.012	0.265	0.269	0.226
Individual FE	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	88	88	80	80	64	64

*Note: *, **, and *** represent significance levels at 1%, 5%, and 10%, respectively. The parentheses in the table are standard errors.*

We notice that the improvement effect of IURCI on capital misallocation is the most obvious in the central region, and the improvement effect of IURCI on labor misallocation is the most significant in the western region, which coincides with the conclusion obtained above: the factor allocation status is generally insufficient in the central and western regions, while the factor allocation status in the eastern region is excessive. In addition, according to the conclusion obtained by the factor allocation status in section 4.6, the regions with factor under-allocation are stronger than the regions with factor over-allocation in terms of the improvement effect of the IUICI on factor misallocation. Accordingly, the improvement effect in the eastern region is less obvious than that in the central and western regions.

5. Summary and Suggestions on Policy Formulation

There has been a serious factor misallocation problem in China, which is related to the special historical background and national conditions of China. Exploring how to improve factor misallocation is the inevitable requirement for practicing factor market allocation reform and promoting high-quality economic development. Based on the panel data of 29 provinces in China from 2011-2018, this paper empirically investigates the effect of industry-university-research collaborative innovation (IURCI) on factor misallocation in four dimensions: sub-factor, sub-regional heterogeneity characteristics, subfactor allocation status, and sub-region. The results show that (1) from the sub-factor, capital misallocation and labor misallocation generally exist in all provinces in the sample interval, and IURCI can significantly improve labor and capital misallocation; (2) from the sub-regional heterogeneity characteristics, the academic research level and the marketization degree can significantly reduce the improvement effect of IURCI on capital misallocation, while the level of regional economic development and marketization degree will greatly strengthen the improvement effect of IURCI on labor misallocation. (3) In terms of factor allocation status, IURCI has an obvious improvement effect on regions with capital and labor under-allocation, although the improvement effect is not clear in regions with factor over-allocation; (4) In terms of regions, IURCI has the strongest improvement effect on capital misallocation in the central region and the strongest improvement effect on labor misallocation in the western region.

Based on the above research, suggestions for policy formulation are proposed as follows:

5.1. Rganic combination of the policy of industry-university-research collaborative innovation (IURCI) and factor market allocation reform

Empirical research shows that IURCI will have a significant impact on factor misallocation; therefore, combining the policy of IURCI with policies related to factor allocation reform can achieve the effect of 1+1>2. When formulating the policy of factor allocation reform, it should emphasize the clear relationship between the interests of each subject, especially the relationship of the labor between the rights, responsibilities and benefits, break the barriers to the free flow of labor, and ensure the smooth circulation of labor factors; at the same time, in the formulation of the IURCI policy, the cooperation between industry, university and research institution should be carried out based on the real core needs of enterprises, closely connect the technology chain, innovation chain and industry chain, to effectively promote the transformation and upgrading of enterprises. In addition, the Government should improve the mechanism of complementary innovation functions based on the principles of complementary

advantages and win-win cooperation.

5.2. Try-university-research cooperation needs to create a good political and economic atmosphere

To effectively play a role in the improvement effect of IURCI on factor misallocation, regions in China need to fully consider their own economic development level, academic research level and marketization degree. On the one hand, in regions with a strong economic development level, enterprises are prone to overcapacity, low efficiency, widening gaps, environmental pollution and other problems, so they should be guided to carry out industry-university-research cooperation according to their real core needs. Meanwhile, universities and research institutions should be encouraged to introduce industry-education integrated composite talent, effectively promoting development; on the other hand, most of the existing industry-university-research cooperation is initiated and dominated by the government with passive participation of enterprises, universities and research institutions. Therefore, there are high cross-border barriers, which make the cooperation unsustainable. Local governments should make precise policies based on the local marketization degree, build an innovation ecosystem with synergistic development of higher education, technology and the market, develop excellent pilot cases of resource sharing, result transformation and technology transfer, and improve the enthusiasm and sustainability of collaboration among enterprises, universities and research institutions.

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Data Availability Statement

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy restrictions.

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Conflicts of Interest

The authors declare no conflicts of interest.

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