Exploring the Influences of Innovation Climate and Resource Endowments through Two Types of University–Industry Collaborative Activities on Regional Sustainable Development

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Abstract: “Innovation driven” is the proper term for promoting regional sustainable development under the general goal of national high-quality development. University–industry collaboration (UIC) has become an important innovation resource for regional sustainable development. The study aims to analyze the influencing factors and mediating mechanisms of university–industry collaboration scientific and technological (S&T) and business activities oriented for regional sustainable development in 30 provinces in China (excluding Tibet). Specifically, we used the partial least squares (PLS) structural equation modeling method to test the effects of innovation climate and resource endowments on regional sustainable development through two mode pathways of university–industry collaboration activities. The results show that the innovation climate and resource endowments significantly affect UIC in scientific and technological innovation activities, and then affect the regional economic development and human capital. UIC S&T innovation activities play positive mediating roles in promoting regional sustainable development. In addition, the innovation climate does not significantly impact the business activities of UIC. Therefore, region can get a greater sustainable development through UIC S&T innovation activities than business activities. Much more UIC S&T activities can improve the economic development, human capital, and environmental conditions in the region.

Keywords: university–industry collaboration activities; innovation climate; resource endowments; regional sustainable development

1. Introduction

In the national innovation system, most of the innovative behaviors generated in the process of technological progress occur at the regional level, such as the Silicon Valley model in the United States, which greatly promotes regional economic growth [1]. The roles of university in the regional development have attracted scholars’ attention. With the development of the knowledge-based economy, the functions of universities have evolved from a single teaching function to close links between teaching, scientific research, and social service functions. The function derivation makes the university, government, and industry boundaries merge [2]. The university has become an important source for innovation, and its relationship with regional economic development has become increasingly closer. As an engine of local economic growth and a participant in the regional innovation system, universities have become a tool generator for enterprise innovation optimization schemes [3]. Researchers prefer to cooperate with enterprises to strengthen the knowledge flow and scientific and technological (S&T) innovation between universities and enterprises, improving the knowledge conversion rate and commercialization behaviors [4]. Endogenous growth theory shows that technological innovation is the fundamental driving force to promote economic growth and sustainable development, and the fundamental driving force to

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promote regional sustainable development lies in technological innovation [5]. From the perspective of the supply side, in an open regional innovation system, universities are places where knowledge intensively meets and are also hubs for knowledge conversion [6]. Knowledge spillover has a positive impact on high-level innovation activities in the region, which will stimulate enterprises to carry out new technology research, promote innovation achievements into new products, and make science and technology more closely linked with regional economic development [7]. From a demand side perspective, the university’s own needs will drive regional economic development. For example, the increase in higher education investment and scientific research funding and the increase in consumer demand for students, teachers, and other personnel (such as university enrollment expansion) will have a certain positive impact on the regional economy [8].

With the accelerated technological changes faced by the industry, excessive consumption of resources, and fierce competition, people are paying more attention to a sustainable economy and society [9], and the demand for the effective use of resources and sustainable production in the region has further increased. Sustainable development is essentially the effective use of regional endowment resources to develop the economy in a greener and more sustainable way [10]. The Chinese government is increasingly paying attention to building a green innovation ecosystem. As a key factor in realizing resource conservation and environmental protection, innovation is crucial to the region’s long-term development [11]. Enterprises in the region need to improve the efficiency of green innovation and promote the green transformation of industries. This demand is supported by university–industry collaboration, which provides broad development opportunities [12].

The regional innovation system is a complex network composed of various main subject elements (universities, enterprises, and scientific research institutions), non-subject elements (material resources), and policy elements related to innovation that coordinate the relationship between various elements within the scope of the region. Thus, the system includes innovative subjects, resources, and economic factors. Regional innovation relies on the benign interaction between universities and enterprises in the effective use of resources [13]. University–industry collaboration is achieved through the transmission of technical information, with enterprises as technology demanders and universities technology suppliers. In essence, university–industry collaboration is an effective combination of the various production factors needed to promote innovation by connecting the supply and demand sides of technology [14]. Regional enterprises attach importance to cooperation with universities to improve the innovation level of the region, ease the pressure on competition and resources, and develop a low-carbon circular economy. Innovation depends on a particular environment or context. In terms of the innovation climate, the innovation climate affects the attitudes of school–enterprise researchers, encourages creative work methods [15], stimulates challenging work behavior, provides new technology, and influences the performance of UIC [16]. In terms of resource endowments, research universities have strong capabilities to produce new knowledge, promote knowledge flow transfer, and improve enterprise absorption and application. Researchers describe the innovative efforts to achieve sustainable development as “ecological innovation” and “innovation-oriented toward sustainable development.” These words actually refer to business activities related to new technologies and products, especially in green innovation. Enterprises are more likely to use the power of universities to achieve the purpose of making full use of university knowledge and optimizing resource utilization [3]. Generally speaking, universities generate new knowledge and cultivate new talents through basic and applied research and promote the economic growth of their surrounding environment through the research and development of new technologies and products. Universities also attract talent to enterprises and gradually strengthen knowledge production, flow, and transfer [17]. By grasping the market demand, enterprises absorb the intellectual achievements of universities, purchase technological achievements from colleges and universities, develop new products, and put them into the market, which promotes technology transfer and commercialization [18].
In fact, universities are “catalysts” of technological innovation, fostering knowledge production, flow, and transfer through their social services foundation. However, although many scholars focus on how enterprises with talent and technology need to obtain knowledge and human resources from universities to promote technological innovation and improve corporate performance, they lack to take into account social responsibility [3]. Some scholars have studied the influencing factors of UIC and its impact on regional innovation output [19]; however, the basis of such research has been in the use of resources between universities and enterprises for knowledge transfer and technological innovation, and empirical research rarely examines the different impacts of UIC S&T innovation activities and business activities on regional development at the same time [20]. In addition, many scholars have used comprehensive fuzzy evaluation methods and DEA methods to measure the transformation of university–industry collaboration results and regional innovation capabilities [21]. The panel threshold regression model is used to study the heterogeneous impact of regional R&D personnel and funding on scientific and technological performance. However, this method is not suitable for small sample data and cannot handle multi-faceted complex structure models.

University–industry collaboration is based on the cooperation between universities and enterprises in accordance with certain mechanisms and models. Technological innovation and the promotion of regional innovation and development are realized through complementary advantages, resource sharing, and systemic activities such as personnel training and transportation [22]. University–industry collaboration activities are based on goal-driven activities. From the perspective of cooperative motivation, under the condition of limited resources, schools focus on academic research results, while companies pay more attention to action-oriented business results, such as product output and sales [23]. Whether it is educational research or a commercialization goal, the final result will serve regional innovation. Therefore, do different types of university–industry collaboration activities have differential impacts on the region’s sustainable development? Drawing on Su et al. [20], they divided knowledge flow into knowledge innovation flow and knowledge application flow. We combined the regional innovation climate and resource endowments factors and divided UIC activities into scientific and technological innovation activities and business activities, which, respectively, represent the innovation output and achievement application activities of UIC. Patent invention, commissioned development, joint invention, and new product development belong to university–industry collaboration scientific and technological innovation activities. University–industry collaboration business activities include collaboration between universities and commercial departments; teachers are allowed to engage in research expansion and consulting services, conduct knowledge transfer, contract research and achievement transformation (technology transactions, technology licensing, and product sales), and other activities [24]. Hence, this study was dedicated to solving the following questions:

Q1: Do the innovation climate and resource endowments factors affect the regional sustainable development?

Q2: Which types of university–industry collaboration activities contribute to regional sustainable development?

Q3: Do university–industry collaboration activities affect the role of innovation climate and resource endowments on regional sustainable development?

To better answer the above three questions, this study took the cooperative activities of universities and enterprises as the research object, the university–industry collaboration S&T innovation activities and business activities as intermediary variables, using the PLS method to study the impact of the innovation climate and resource endowments on regional sustainable development by establishing a two-activity model of UIC, and analyzed the different role of two types of UIC activities.

The three main contributions of this study are as follows. First, this study divided UIC activities into S&T innovation activities and business activities to test the different mediating roles in the innovation climate and resource endowments for regional sustainable
development. Prior research focused on the university–industry collaborative impacts, lacking analysis on the different roles caused by the heterogeneity of UIC activities. Second, we use the PLS method because it can overcome multicollinearity and errors due to the small samples so that the model results are more authentic and accurate. When we analyze the interpretation and prediction of regional development by multiple factors, the PLS method can be used in more high-complexity situations. Finally, in terms of research content, most of research on UIC was mainly used as an independent variable. This study used university–industry collaboration activities as an intermediary variable to study the characteristics of university–enterprise resources and the impact of different types of UIC activities on regional sustainable development. The research results will help to deepen the relationship between UIC activities and regional sustainable development. The findings can lead universities to play a role as a source of knowledge, guide enterprises to improve technological innovation capabilities through university–industry collaboration activities under limited resources, address the relationship between the economy and environment, and promote the sustainable development of the regional economy and society.

The rest of this research is structured as follows. The Section 2 is a literature review and presentation of hypotheses, briefly discussing the regional innovation climate, resource endowments, university–industry collaboration activities, and sustainable development-related literature and putting forward related hypotheses based on the literature. The Section 3 is research design, which mainly introduces the sample collection and empirical research methods. The results are discussed in the Section 4. Sections 5 and 6 provide conclusions and suggestions, primarily analyzing the similarities and differences between the research in this study and previous studies and making suggestions and prospects for future research.

2. Literature Review and Hypotheses

2.1. University–Industry Collaboration and Regional Sustainable Development

2.1.1. Scientific and Technological Innovation Activities of UIC and Regional Sustainable Development

In the regional innovation system, technology is the primary productive force, talent is the primary resource, and innovation is the primary driving force. University–industry collaboration effectively connects the above three elements through knowledge creation, diffusion, and application. Under the goal of regional sustainable development, with the development of knowledge and technology, more and more companies realize the importance of technology creation and application and are actively cooperating with universities, establishing U–I alliances. They carry out scientific and technological innovation activities to improve the efficiency of resource utilization [25]. In the “U–I” scientific cooperation model, enterprises invest R&D funds and R&D orientation in universities. The provision of R&D funds from enterprises starts from the technical needs of enterprises, increasing researchers’ enthusiasm and promoting universities to provide enterprises with project ideas or breakthrough technology to improve the regional innovation level [26]. Moreover, the enterprise conducts secondary development based on the cutting-edge technology of universities and promotes the continuous improvement of enterprise technological process and new products. The technological innovation brought about by UIC innovation activities can help to optimize the enterprise technological process, promote the upgrading of enterprises, improve the regional innovation output and economic development level, and provide endogenous power for the region’s sustainable development. In addition, although technological progress cannot directly affect the environment, it can reduce the input of traditional factors by improving extensive production methods [27]. On the other hand, the environmental protection technology brought about by technological progress can reduce the emission of pollutants. For example, clean coal technology can reduce sulfur dioxide emissions, thereby reducing air pollution. Therefore, UIC S&T innovation activities can provide clean technology guarantees for regional sustainable development. To further
analyze the impact of UIC S&T innovation activities on regional sustainable development, this study proposed the following hypothesis based on the literature as mentioned above:

**Hypothesis 1 (H1).** Effective UIC scientific and technological (S&T) innovation activities have a positive impact on regional sustainable development.

### 2.1.2. Business Activities of UIC and Regional Sustainable Development

The standard output of universities is academic knowledge and educated highly skilled labor. High-quality human capital development is the endogenous driving force of regional economic development [28]. When there is a strong academic spirit to support school–enterprise interaction, the knowledge and ability of researchers will affect regional innovation capabilities and promote regional economic development through the expansion of derivatives [29]. In addition, the regional financial influence process of universities is regulated by a variety of factors. Studies have found that the population agglomeration effect brought by universities can make up for the lack of an urban agglomeration economy. The economic impact on small- and medium-sized cities is more obvious than that of large cities [30]. Small and micro-enterprises and start-ups are considered to be innovation intermediary institutions for university knowledge production to promote the regional economy. The stronger the regional absorptive capacity, the more conducive the university’s role in promoting the regional economy [31]. Based on the documents mentioned above, this study proposed the following hypothesis:

**Hypothesis 2 (H2).** Effective UIC business activities have a positive impact on regional sustainable development.

### 2.2. Innovation Climate, UIC Activities, and Regional Sustainable Development

#### 2.2.1. Innovation Climate, UIC Scientific and Technological Innovation Activities, and Regional Sustainable Development

In regional innovation system, in order to create and disseminate knowledge, universities and enterprises cooperate with each other, share resources, and are committed to establishing an open innovation ecosystem that integrates the education chain, industrial chain, talent chain, and innovation chain. Knowledge is the source of power for university–industry collaboration; the S&T innovation activities of university–industry collaboration involve creative mental work. Since the goal orientation of university–industry collaboration is clear, the development of UIC scientific and technological innovation activities needs to be accompanied by a corresponding innovation environment and climate. Innovation climate is a meaningful interpretation of the innovation environment. It refers to the support of schools and enterprises for innovation activities, which affects the internal motivation of researchers to carry out innovation activities. It is divided into three dimensions: vision, participatory safety, and task orientation [32]. The climate of innovation can help stimulate researchers’ willingness to research, bravely break through the constraints of existing resources, and positively promote technological innovation in significant scientific research projects. According to the theory of internal dynamics, researchers are more motivated to carry out innovative activities when they believe that the school encourages creative activities. The innovation efficiency will be higher, which will affect the technological innovation results of the scientific research team. This is because the innovation climate affects the internal motivation of the R&D personnel so that the R&D personnel are more creative, and the innovation of UIC scientific and technological activities is improved [33].

**Hypothesis 3a (H3a).** Innovation climate positively affects regional sustainable development through UIC S&T innovation activities.

### 2.2.2. Innovation Climate, UIC Business Activities, and Regional Sustainable Development

The climate of innovation reflects the people’s creative ideas; motivates employees to think independently; improves their cognition, purpose, and intellectual resources in a cre-
ative way; and contributes to innovation performance [15]. The organizational innovation climate not only provides employees with emotional support but also provides resources in the form of funds or work equipment, such as research funding and specialized laboratories [34]. They use resources and emotional support to enhance employees’ enthusiasm for invention, which affect personnel innovation behavior. Related research has found a significant relationship between the innovation climate, the number of patents granted, and the number of valuable results. The teams engaged in research projects usually have more creative effects, and the teams engaged in development projects are more able to implement useful results. It can be seen that innovation support and task orientation are the most important factors to promote the innovation climate of cooperative innovation achievements [32]. Under the task orientation, the innovation climate can stimulate a willingness to work on R&D, breaking through the constraints of existing resources [35]. In addition, it can promote the commercialization of UIC, resulting in the transformation of scientific and technological achievements into new product creation or the use of advanced technology, leading to the diffusion of innovation results and improving the market competitiveness of enterprises [36]. In fact, the commercialization activities of university–industry collaboration can not only promote the development and use of new products but also promote the application of new technologies by enterprises, optimize the utilization of resources to a certain extent, and achieve resource conservation and low consumption production.

Hypothesis 3b (H3b). Innovative climate positively affects regional sustainable development through UIC business activities.

2.3. Resource Endowments, UIC Activities, and Regional Sustainable Development

2.3.1. Resource Endowments, UIC S&T Innovation Activities, and Regional Sustainable Development

The development of the regional innovation system requires the joint efforts of innovation subjects and elements. Innovation activities are related to the ability of enterprises to absorb external information, knowledge, and technology. The rational use and allocation of resources affect the efficiency and quality of university–industry collaboration S&T innovation activities. R&D investment can improve researchers’ grasp of new technology trends, promote researchers’ learning, and enable researchers to absorb external knowledge [37]. The functions of universities have been expanded from education and research to knowledge transfer to perform social service functions. Universities are often referred to as “the power source behind growth” because the knowledge, experience, and skills they produce are innovative. The company has obtained technology and expertise from high-quality human resources such as researchers [38]. With the help of researchers’ experience, they can learn more about cutting-edge knowledge and gain more innovation capabilities and intellectual capital [39]. Furthermore, cooperation involves technical consultations, contract research, scientific research, and technological development to promote the transformation of scientific and technological achievements by universities [40]. Through cooperation, enterprises not only obtain innovative technologies but also gain learning opportunities, talent reserves, and relationship capital. These are helpful for the long-term innovation and development of enterprises.

At present, under the conditions of environmental changes and resource constraints, enterprises are frequently considering introducing innovative products and services to solve the adverse effects of production activities on the environment. Universities are increasingly transcending their organizational boundaries, exerting their social service functions, and pursuing sustainable social transformation. In the process of regional sustainable development, more relevant knowledge and technologies need to pass through school–enterprise cooperation, the market, and the social interactions of cooperation [3].

Hypothesis 4a (H4a). Resource endowments positively affect regional sustainable development through UIC S&T innovation activities.
2.3.2. Resource Endowments, UIC Business Activities, and Regional Sustainable Development

The cooperation and exchange between the main bodies in the regional innovation system is an important driving force to promote the development of regional innovation, and university–industry collaboration is a reservoir for the active development of the regional innovation system [41]. Regional development needs to use many resources to be maintained, and UIC business activities can promote economic restructuring, transformation, and upgrading, so as to further promote the overall development of the region [42]. Through university–industry collaboration, enterprises can use human, financial, and material resources, such as R&D personnel, research funds, and laboratory equipment; improve the technical content of products; promote the development and utilization of new materials, processes, and products; and follow up technical reserves to promote the development of regional technology [43]. In the investment of resources, universities can become suppliers of regional sustainable-development-related knowledge. The ability of researchers is a booster for the development of university–industry collaboration and innovation activities. R&D personnel themselves have the potential to discover new knowledge. School–enterprise cooperation can use the ability of researchers to identify business opportunities [44]. Under the guidance of opportunities, they can use new knowledge to transform them into new products or new process flows through commercialization behaviors, further bringing about economic growth [45]. Enterprises interact with universities through various channels, from cooperative research projects, cooperative patents, derivative product creation, consulting, and targeted specialized training [46] to commercialization, increasing the number of patent applications, and the creation of corporate value (generated by knowledge and technology products) to promote economic growth in its surroundings. In an environment of fierce market competition, rapid technological changes, and shortened product life cycles, the introduction of new technologies, products, or processes promotes the sustainable development of enterprises. This industrialization innovation can also promote regional innovation systems and steady economic development [47]. Based on the above literature, the following hypothesis was proposed:

**Hypothesis 4b (H4b).** Resource endowments positively affect regional sustainable development through UIC business activities.

To study the above hypothesis, we made the following arrangements. First, UIC activities were divided into two dimensions, namely UIC technological innovation activities and UIC business activities. We constructed a two-mode model to test the mediating effect of UIC with two types of activities on relationships between the innovation climate and resource endowments with regional sustainable development. We aimed to explore how two factors of regional resource endowments and innovation climate impact regional sustainable development through UIC activities. Second, in previous studies, Stata multiple regression analysis has been used to analyze influencing factors, but regression analysis limits the number of dependent variables. The PLS method combines principal component analysis and regression analysis and is mainly used to verify causal analysis and prediction. Latent variables were used to establish a research model applicable to the research in this study. Therefore, this study used the PLS method for analysis.

Under the above-mentioned structural arrangement, this study established two models of university–industry collaboration for analysis.

**Model 1:** Exploring the mechanism by which an innovation climate and resource endowments act on regional sustainable development through UIC S&T innovation activities. The model is as follows Figure 1:
To study the above hypothesis, we made the following arrangements. First, UIC activities can promote sustainable development through the active work of scientific researchers. This study used the number of publications as an indicator. Second, in previous studies, multiple regression analysis has been used to analyze influencing factors, but regression analysis limits the number of dependent variables. The PLS method combines principal component analysis and regression analysis and is mainly used to verify causal analysis and prediction. Latent variables were used to establish a research model applicable to the regional level analysis and regression analysis and is mainly used to verify causal analysis and prediction.

3. Methods

3.1. Data Sources and Research Methods

In terms of regional definition, we used provinces as the unit and 30 provinces (excluding Tibet) as the research sample. Due to the fact that schools and enterprises take advantage of factors to carry out university–industry collaboration activities, there are policies and measures lagging behind the impact of regional sustainable development. This study set the lag period as one year. The data on innovation climate and resource endowments are collected in 2016. Data on university–industry collaboration and regional sustainable development in 2016 and 2017 were collected, respectively. The sample selection of universities was based on the data of regional universities in the China Higher Education Statistical Yearbook. The data sources of the research were the China Higher Education Statistical Yearbook, China Science and Technology Statistical Yearbook, China Population and Employment Statistical Yearbook, and the website of the National Bureau of Statistics.

This research model focused on the analysis of long-term relationships. At the same time, the sample size was small, and the least squares method with robust standard errors was used to test the innovation climate and resource endowments through different types of university–industry collaboration activities to study the impact of regional sustainable development.

3.2. Variable Measures

3.2.1. Innovation Climate

The innovation climate (IC) is the common perception of an environment and ability that affects the active work of scientific researchers. This study used the number of pub-

Figure 1. Model diagram of the S&T activities of university–industry collaboration.

Model 2: Exploring the mechanism of innovation climate and resource endowments on regional sustainable development through UIC business activities. The model is as follows Figure 2:

Figure 2. Model diagram of the business activities of university–industry collaboration.
lished academic papers (PAPNs) [21] and the number of regional published scientific and technological academic works (RPSTWs) [43] as proxy variables to measure the innovation climate. These variables can reflect that they are more willing to actively carry out challenging activities because of their innovative ability.

3.2.2. Regional Resource Endowments

Regional resource endowments are the basis for developing UIC technology and transforming results, which is mainly manifested in the research personnel, research institutions, and research funds that facilitate UIC activities [21]. The following indicators are used to measure it: (1) The number of R&D personnel (RDP) in regional universities: The main body of cooperation influences the creation, flow, and absorption of new knowledge. This study used the number of R&D personnel in regional universities as a proxy variable for measurement [48]. (2) Enterprise funds in internal expenditures of R&D funds: This mainly refers to the basic situation of corporate funding for R&D projects. The intensity of funding affects the innovation enthusiasm and initiative of researchers. This study used corporate funding as a proxy variable. Wu, Y.M. used the funding input of enterprise funds to measure the funding input of UIC when studying the relationship between university–industry collaboration and industrial enterprise innovation output [18].

3.2.3. UIC Scientific and Technological Innovation Activities

In the national innovation system, patents are an important indicator used to measure the core competitiveness of enterprises, industries, and even the country, as well as an important indicator that reflects the scientific research capabilities of universities [49]. Since invention patents are the most difficult and have the greatest practical value, this article uses the number of invention patents granted to measure UIC Scientific and Technological Innovation Activities (UIC_STIA). [50] In addition, the number of basic research projects in universities reflects the innovative ability of universities and enterprises to carry out basic research activities. Therefore, this article uses the number of invention patent grants [50] and the number of basic research projects [21] to measure UIC S&T Innovation Activities (UIC_STIA).

3.2.4. UIC Business Activities

Technology transfer is the basis for the transformation of technological achievements [25]. The sales revenue of new products of industrial enterprises above designated size illustrates the market value of innovation achievements [21]. Therefore, this article uses the number of technology transfer contracts and the sales revenue of new products of industrial enterprises above designated size to measure the UIC business activities (UIC_BA).

3.2.5. Regional Sustainable Development

Regional sustainable development (RSD) is a comprehensive concept that refers to the ability of a region to maintain sustainable development under the premise of coordinated economic, social, and environmental development. The core of regional sustainable development lies in the pursuit of the coordinated development of the economic, social, and environmental subsystems [51]. Sulfur dioxide emissions refer to the level of environmental pollution. This article uses carbon dioxide emissions to measure environmental subsystems [52]. GDP Per capita (PCGDP) represents the benefits of regional economic development and reflects regional economic development. Development ability and attractiveness reflect the economic subsystem [53]. The average number of years of education of the regional population (PEDU) represents the region’s human capital, reflects the vitality and potential of regional development, and represents the social subsystem [54]. The research targets illiteracy (Illiteracy), elementary school (PS), junior high school (JS), and high school (HS) and MV , specialist, undergraduate, and postgraduate were calculated based on 0, 6, 9, 12, 12, 15, 16, and 19 years, respectively. Finally, divided by the number of people aged six and over (PASAO), the specific calculation is as follows:
PEDU = (III × 0+ PS × 6+ JS × 9 + HS × 12 + MV × 12 + SPE × 15 + UND × 16 + POS × 19)/PASAO (1)

The specific content of the variable measurement index system of the thesis is shown in Table 1.

Table 1. UIC Activities and Regional Sustainable Development Measurement Index and Symbol.

| Variables                        | Metrics                                           | Variable Symbol | Data Sources                                |
|----------------------------------|--------------------------------------------------|-----------------|---------------------------------------------|
| Innovation climate               | Number of published academic papers               | PAPN            | China Higher Education Statistical Yearbook |
|                                  | University publication of scientific and         | RPSTW           | China Higher Education Statistical Yearbook |
|                                  | technological works                               |                 |                                             |
| Resource endowments              | Number of R&D personnel in regional universities | RDP             | China Higher Education Statistical Yearbook |
|                                  | Enterprise funds in internal expenditures of     | RDEF            | China Science and Technology Statistics Yearbook |
|                                  | R&D funds                                         |                 |                                             |
| UIC S&T innovation activities    | Number of patents granted                         | PGN             | China Higher Education Statistical Yearbook |
|                                  | Number of basic research projects                 | BRPN            | China Higher Education Statistical Yearbook |
| UIC business activities          | Sales revenue of new products of industrial      | NPR             | China Science and Technology Statistics Yearbook |
|                                  | enterprises above designated size                |                 |                                             |
|                                  | Number of technology transfer contracts           | TTCN            | China Higher Education Statistical Yearbook |
| Regional sustainable development | GDP per capita                                    | PCGDP           | China National Bureau of Statistics         |
|                                  | Average years of education of the population      | PEDU            | China Population and Employment Statistical Yearbook |
|                                  | in the region                                     |                 |                                             |
|                                  | Sulfur dioxide emissions                          | SDE             | China National Bureau of Statistics         |

4. Results

To eliminate the influence of dimensions on the analysis results, the research data were standardized. Since sulfur dioxide emissions are an inverse indicator, this article makes a reciprocal review of it. Due to the delay in reflecting some variables, a lag period was set up for the model based on the above considerations. The lag period was one year (generally, the lag period is 1–2 years). We collected the innovation climate and resource endowments data in 2016. The data related to the two activities of UIC were collected in 2016, and regional sustainable development data were collected in 2017.

4.1. Research Facet Reliability and Convergence Validity

This research adopted five dimensions: innovation climate, resource endowments, UIC scientific and technological innovation activities, UIC business activities, and regional sustainable development. Table 2 shows the Cronbach reliability coefficients, combined reliability, and average extraction variability of these dimensions. The effectiveness and reliability of the model can be seen through the above indicators. It can be seen from Table 2 that the reliability of each facet reaches 0.7, indicating that there is sufficient reliability and there is internal consistency in the facet. There was no need to exclude any indicators from the aspect.
Table 2. Reliability and convergence validity of model variables.

|                              | Loading | Cronbach’s α | CR  | AVE  | $R^2$ |
|-----------------------------|---------|--------------|-----|------|-------|
| **Model 1:**               |         |              |     |      |       |
| Innovation climate          |         |              |     |      |       |
| RPSTW                       | 0.960   |              | 0.966| 0.934|       |
| PAPN                        | 0.973   |              |      |      |       |
| Resource Endowment          |         |              |     |      |       |
| RDP                         | 0.935   |              | 0.912| 0.839|       |
| RDEF                        | 0.896   |              |      |      |       |
| UIC technology innovation activities |         |              |     |      |       |
| PGN                         | 0.969   |              |      |      |       |
| BRPN                        | 0.969   |              |      |      |       |
| Regional sustainable development |       |              |     |      |       |
| PCGDP                       | 0.916   |              | 0.922| 0.797| 0.470 |
| PEDU                        | 0.917   |              |      |      |       |
| SDE                         | 0.844   |              |      |      |       |
| **Model 2:**               |         |              |     |      |       |
| Innovation climate          |         |              |     |      |       |
| RPSTW                       | 0.963   |              | 0.966| 0.934|       |
| PAPN                        | 0.970   |              |      |      |       |
| Resource Endowments         |         |              |     |      |       |
| RDP                         | 0.893   |              | 0.912| 0.838|       |
| RDEF                        | 0.938   |              |      |      |       |
| UIC business activities     |         |              |     |      |       |
| NPR                         | 0.904   |              |      |      |       |
| TTCN                        | 0.883   |              |      |      |       |
| Regional sustainable development |       |              |     |      |       |
| PCGDP                       | 0.973   |              | 0.898| 0.748| 0.280 |
| PEDU                        | 0.869   |              |      |      |       |
| SDE                         | 0.737   |              |      |      |       |

At the same time, the combined reliability of each facet exceeded the required standard value of 0.7, and the average extraction variation (AVE) was greater than the required value of 0.5, indicating that the aspect has high convergence validity. The overall results of the confirmatory factor analysis show that the measurement model has strong applicability. In Model 1, the determination coefficient value of innovation climate and resource endowments on UIC scientific and technological innovation activities reached 0.885, which shows that innovation climate and resource endowments can fully explain the UIC’s scientific and technological innovation activities. Other coefficients of determination can be explained in the same way. The specific data are shown in Table 2.

Tables 3 and 4 are the discriminating validity analysis tables of Models 1 and 2, respectively. Below the diagonal is the Pearson correlation coefficient, and on the diagonal is the root value of the average extracted variance (AVE). From Tables 3 and 4, it can be seen that the root value of AVE in each aspect is greater than the correlation coefficient of that aspect and other structures, and it can be seen that both Model 1 and Model 2 have good discriminating validity.
Table 3. Model 1 correlation and discriminant coefficient table.

|       | IC    | RSD  | RE    | UIC_STIA |
|-------|-------|------|-------|----------|
| IC    | 0.966 |      |       |          |
| RSD   | 0.552 | 0.893|       |          |
| RE    | 0.857 | 0.593| 0.916 |          |
| UIC_STIA | 0.905 | 0.686| 0.907 | 0.969    |

Table 4. Model 2 correlation and discriminant coefficient table.

|       | IC    | RSD  | RE    | UIC_BA  |
|-------|-------|------|-------|----------|
| IC    | 0.967 |      |       |          |
| RSD   | 0.594 | 0.865|       |          |
| RE    | 0.828 | 0.640| 0.915 |          |
| UIC_BA | 0.755 | 0.529| 0.879 | 0.894    |

4.2. Model Path Coefficient Analysis

After evaluating the applicability of the measurement model, we analyzed the relationship between the variables in the model. We applied the PLS algorithm to 30 samples and used bootstrapping for 500 repeated sampling for analysis.

4.2.1. Structural Model 1 Direct Effects

Model 1: Exploring the mechanism of innovation climate and resource endowments on regional sustainable development through UIC S&T innovation activities.

Table 5 shows the direct and indirect effects between latent variables. From the perspective of direct effects for the impact of UIC scientific and technological innovation activities on regional sustainable development ($\beta = 0.686$, $t = 5.389$, $p = 0.000 < 0.05$), Hypothesis 1 is valid. This is due to UIC S&T innovation activities developing new technologies and processes, reducing resource consumption and environmental pollution, improving resource utilization efficiency, and positively promoting regional sustainable development [30].

Table 5. Overall results of the model.

| Hypothesis | Relationship | Coefficient | Mean   | SD    | t-Value | p-Value | Decision |
|------------|--------------|-------------|--------|-------|---------|---------|----------|
| Direct effect | IC $\Rightarrow$ UIC_STIA | 0.481 | 0.460 | 0.160 | 3.000 | 0.003 | Supported |
|             | RE $\Rightarrow$ UIC_STIA | 0.495 | 0.514 | 0.161 | 3.073 | 0.002 | Supported |
|             | IC $\Rightarrow$ UIC_BA | 0.088 | 0.086 | 0.196 | 0.449 | 0.654 | Rejected |
|             | RE $\Rightarrow$ UIC_BA | 0.806 | 0.821 | 0.185 | 4.352 | 0.000 | Supported |
| H1          | UIC_STIA $\Rightarrow$ RSD | 0.686 | 0.705 | 0.127 | 5.389 | 0.000 | Supported |
| H2          | UIC_BA $\Rightarrow$ RSD | 0.529 | 0.606 | 0.101 | 5.226 | 0.000 | Supported |
| Indirect effect | IC $\Rightarrow$ UIC_STIA $\Rightarrow$ RSD | 0.330 | 0.322 | 0.132 | 2.492 | 0.013 | Supported |
|             | RE $\Rightarrow$ UIC_STIA $\Rightarrow$ RSD | 0.340 | 0.365 | 0.126 | 2.705 | 0.007 | Supported |
|             | IC $\Rightarrow$ UIC_BA $\Rightarrow$ RSD | 0.047 | 0.057 | 0.126 | 0.368 | 0.713 | Rejected |
|             | RE $\Rightarrow$ UIC_BA $\Rightarrow$ RSD | 0.427 | 0.493 | 0.128 | 3.343 | 0.001 | Supported |

On the one hand, the innovation climate is positively correlated with the S&T innovation activities of university–industry collaboration ($\beta = 0.481$, $t = 3.000$, $p = 0.003 < 0.05$), consistent with the results of Yuan [55] research. As for resource endowments, the effect on UIC scientific and technological activities ($\beta = 0.495$, $t = 3.073$, $p = 0.002 < 0.05$) shows that resource endowments have a significant impact on UIC scientific and technological innovation activities. This is due to the ability of university researchers to affect the degree
of knowledge innovation, and funding affects the configuration of research infrastructure. More experimental equipment can be obtained if funding increases, which increases the resources available to researchers, thereby leading to better research endowments and more efficient innovation activities [56].

4.2.2. Structural Model 1 Mediating Effects

From the perspective of intermediary variables, the innovation climate has an impact on regional sustainable development through UIC scientific and technological innovation activities ($\beta = 0.330, p = 0.013 < 0.05$); therefore, Hypothesis 3a is established. The protection of the intellectual property rights of patents will help strengthen the mutual trust between the two parties of university–industry collaboration, stimulate the technology trading market, and carry out UIC scientific and technological innovation activities better. This is consistent with the views of Wang, X.H. and Hu, S.L. [57]. Resource endowments impact regional sustainable development through the scientific and technological innovation activities of UIC ($\beta = 0.340, p = 0.007 < 0.05$); therefore, Hypothesis 4a is established. Through the flow of personnel, funds, information, and other resources, UIC scientific and technological innovation activities are used to carry out research projects and improve the ability to serve society through technological upgrading. In addition, the technological innovation system is complex and is a subsystem that interacts with the environment and society. S&T innovation activities are the intermediate link. The social role of technology services in the region depends on the supply capacity of the technology source and the effective value provided [58]. The main results of the model are shown in Table 5.

4.2.3. Structural Model 2 Direct Effects

Model 2: Exploring the mechanism of innovation climate and resource endowments on regional sustainable development through UIC business activities.

For the impact of UIC business activities on regional sustainable development ($\beta = 0.529, t = 5.226, p = 0.000 < 0.01$), Hypothesis 2 holds. The main results obtained by comparing these two models show that these two types of university–industry collaboration activities have a significant positive impact on regional sustainable development. However, UIC scientific and technological innovation activities have a greater direct impact on regional sustainable development. For example, Tseng, Huang and Chen [25] believe that the development of technological innovation activities helps to improve the efficiency of resource utilization, enhance companies’ technological innovation performance by providing high-quality patents. The improvement of enterprise innovation performance further serves the regional innovation system.

In terms of innovation climate, for UIC business activities ($\beta = 0.088, t = 0.449 p = 0.654 > 0.05$), the innovation climate has no significant impact on university–industry collaboration business activities. This is because the transformation of scientific and technological achievements into new products requires technical capabilities, financial support, production capabilities, sales capabilities, and risk tolerance. Technical capabilities rely on stimulating the enthusiasm of university researchers and improving the capabilities of researchers. The remaining four items must rely on enterprises to promote the commercialization of scientific and technological achievements.

In terms of resource endowments, their effect on UIC Business activities ($\beta = 0.806, t = 4.352, p = 0.000 < 0.05$) shows that resource endowments have a significant impact on UIC technological innovation activities and commercial activities. However, from the path of coefficients, resource endowments play a more significant role in UIC business activities. This is because new products can only be benefited by investing resources from research and development to marketing the products, and technological achievements can only be benefited where the benefits are intuitive. This is consistent with Li, L.S.’s research [59] because attention should be paid to the input of industry–academy cooperation resources, and UIC can continue to carry out UIC activities.
4.2.4. Structural Model 2 Mediating Effects

The innovation climate cannot affect the region’s sustainable development through UIC business activities (β = 0.047, t = 0.368, p = 0.713 > 0.05); therefore, Hypothesis 3b is not established. The following explanation can be made: in the entrusted development model of university–industry collaboration, the enterprise assigns R&D tasks to the university according to market demand. The two parties form an entrusted agent relationship. Due to the difference in the goals of school–enterprise cooperation, researchers may be eager to publish results because of the difficulty of R&D output or a lack of time control of the project cycle and generate confidentiality issues to seek scientific truth [57]. Resource endowments impact regional sustainable development through UIC business activities (β = 0.427, t = 3.343, p = 0.001 < 0.05); therefore, Hypothesis 4b is established. This is because resource endowments need to work through the medium of university–industry collaboration activities. The transformation of technological achievements into new products must go through the five stages of “research–development–pilot test–production–market.” The result is consistent with Li, H.J. [45] that the technological radiation shaped the great economic and ecological benefits.

In terms of the importance of the indicators based on the load value, as shown in the model estimation diagrams in Figures 3 and 4, taking the regional sustainable development indicator as an example, resource endowments have a significant impact on both models. Therefore, R&D personnel (human resources) and enterprise funds (financial resources) are the primary resources for the development of university–industry collaboration activities. When analyzing the effect on regional sustainable development, take the business activity model estimate in Figure 4 as an example. The GDP per capita has the most significant load value of 0.973, indicating that UIC business activities have the most significant impact on regional economic development, followed by human capital, with a load value of up to 0.869, so the effect on the social subsystem is second. The impact of UIC business activities on reducing sulfur dioxide emissions reached 0.737, so its impact on the environmental subsystem is relatively small. Therefore, the short-term impact of UIC business activities on regional sustainable development is mainly in the intuitive benefits and significant results, which act on the regional economic growth. In a long term, UIC business activities will contribute to regional social and environmental development. The main results of the model are shown in Table 5.

![Figure 3. Estimated diagram of the UIC scientific and technological innovation model.](image-url)
5. Discussion and Conclusions

University is the main body of regional innovation system development, and its role in regional economic and social development is a complicated phenomenon. How to maximize and localize the benefits of university–industry interaction and improve regional development momentum and capabilities has attracted scholars’ attention [8]. Taking the regional innovation system as a research perspective, this paper explores the mediating role of university–industry collaborative activities based on innovation climate and resource endowment on regional sustainable development. The main contribution of this study was to divide the university–industry collaboration activities into two types—UIC scientific and technological innovation activities and UIC business activities—and use the PLS method to link the innovation climate and resource endowments with regional development through university–industry collaboration activities. The actual results of this study found through empirical research were that both innovation climate and resource endowments can impact regional sustainable development through UIC S&T innovation activities. However, the innovation climate has limited impact on regional sustainable development through UIC business activities. This shows that S&T innovation activities through UIC are the top priority of regional sustainable development. Universities have intellectual and technological resources, and enterprises have industrial capital and market demand. The collaboration between the two parties will help promote the construction of regional technological innovation systems, form a virtuous circle of UIC, and contribute to regional sustainable development [60].

First of all, UIC scientific and technological innovation activities and business activities between universities and industry play an important role in promoting regional sustainable development. UIC S&T innovation activities, however, have a greater impact on the sustainable development of the regions than business activities. The reason maybe the technological innovation is an endogenous driving force that can break through the constraints of resources, reduce resource consumption and environmental pollution, directly act on resource conservation and protect the environment, and then make a great contribution to promoting the coordinated development of the economy, society, and environment [51].

Second, resource endowments have a significant impact on both UIC technological innovation activities and business activities. However, they have a more significant impact on business activities. Universities provide R&D personnel, invention patents, enterprise supply funds, and technology demand orientation to promote the popularization and application of technological achievements through knowledge flow. They discover new technologies and enhance the innovation radiation effect of regional UIC activities [20].

Third, the innovation climate and resource endowments factors can promote regional sustainable development through UIC scientific and technological innovation activities. However, the innovation climate does not significantly impact regional sustainable development through UIC business activities. First of all, the high innovation climate of regional university–industry collaboration helps to absorb knowledge and innovation elements from outside universities, exert innovation demonstration effects in universities, stimulate
the internal motivation of R&D personnel, and promote the output of innovation results. Moreover, universities’ provision of R&D personnel has relatively reduced the requirements for R&D personnel of enterprises in scientific and technological innovation activities, thereby liberating the human resources of enterprises in the region and helping to invest in a new round of innovation. This point of view is roughly the same as Su, Y.’s in [20]. For the innovation climate, the impact of UIC business activities on regional sustainable development is not significant, because researchers may not apply for patents in time or extend the duration of industry–university projects due to the pursuit of academic status and other reasons, resulting in the poor development of UIC business activities, which reduces the driving force and radiation of the application of technological innovation achievements in regional economic development.

In general, university–industry collaboration activities are a strategic measure to promote the effective integration of regional technology with economic and social development, as well as a way to promote the development and transformation of regional innovative technologies. In the regional innovation system, universities and enterprises realize resource sharing and complementary advantages and absorb each other’s innovative knowledge and technology. Hence, micro-level organizational learning is sublimated to macro-level regional knowledge accumulation and diffusion, ultimately promotes the improvement of regional innovation capabilities, and then realizes the sustainable development of the region [61].

Based on the analysis of the conclusions, this study puts forward some suggestions for UIC. The triple helix theory means the interaction between the government, universities, and enterprises. These three main bodies are an important part of the regional or national innovation system. Therefore, in order to promote the sustainable development of the region, the joint efforts of universities, governments, and enterprises are necessary.

In the triple helix model, the role of the university is to form an innovation zone centered on the university through scientific research and technology transfer, and to provide the necessary intellectual resources for the regional innovation system [41]. University–industry collaboration activities meet the needs of universities. First, universities are one of the main bodies to carry out university–industry collaboration activities. In university–industry collaboration, universities should give full play to the social service function, encourage the combination of industry and competition, cultivate students’ innovative thinking through university–industry collaboration, build an applied talent training ecosystem integrating “industry, specialty, and entrepreneurship” [7], cultivate the research knowledge and skills needed to create sustainable development, and gradually improve the quantity and quality of university R&D personnel, ensuring that the direction of scientific research and personnel training in colleges and universities meets the needs of economic development.

The region should build an independent innovation system with the help of UIC technological innovation activities and business activities, such as introducing entrepreneurial elements in local universities, creating a positive entrepreneurial culture, and encouraging innovation and tolerating failure in a cultural climate in order to realize the close connection between knowledge dissemination and application practice; guide innovative talents to solve practical problems; cultivate the later supply of human capital; and provide human capital assistance for regional innovation activities. In addition, we should pay attention to the use of the regional resource endowments. Industrial agglomeration is the reservoir of knowledge and labor. Through the communication of personnel, knowledge, and technology, enterprises can improve the digestion and absorption capacity of advanced technology in the region with the help of the agglomeration effect in order to promote the effective diffusion of innovative technology and drive sustainable development in the process of serving regional innovation systems.

It is important to give full attention to the role of the government. The government should establish an information disclosure platform of the University–Industry Research Institute, where the government can release resource information and project information
and disclose the demand information of enterprises for green technology in order to realize a good docking of cooperation activities between universities and enterprises and improve regional economic and environmental benefits. In addition, the government should actively stimulate the vitality of university–industry collaboration, guide universities and enterprises to develop green technology and innovative technology, realize green manufacturing, and ensure the unity of economic and ecological benefits.

The regional innovation system is closely related to the regional resource endowment, scientific and technological strength, and cultural customs. In the university–industry collaboration activities, the creation, flow and commercialization of knowledge and technology all reflect the operation process and ultimate goal of the regional innovation system [62]. In the future, developing universities to carry out innovative research and promote the application of green technology in enterprises will not only help to promote the development of the regional economy but also ensure regional green development and realize the coordinated and healthy development of the region. Thus, it is necessary to strengthen mutual connection and coordinated development of subjects and elements of innovation, deepen university–industry collaboration activities, and accelerate innovation linkage and the achievement transformation. While deepening the regional UIC, paying attention to promoting inter-regional university–industry collaboration activities, and regarding the regions participating in the region’s sustainable development as a mutually beneficial, win–win community, in the long run, it is necessary to form material capital based on scientific knowledge and technological innovation; build a talent team with high-level innovation potential; promote regional technology development, technology promotion, and achievement transformation; explore regional sustainable development models; and form regional development trends with good production and excellent ecology.

6. Research Limitations

There are some limitations in our research. One limitation is that we only collected the data in China, and the samples used were not significant and were without comparisons to other countries. Future studies should use large samples to reduce the possibility of errors. Second, this research lacked the division of regions and researching on the basis of considering regional heterogeneity. Third, this study mainly used the innovation climate and resource endowments factors to explore the impact of UIC activities and sustainable development in the region. There was a lack of discussion on the relationship between the two areas. In the future, research will refine regional development, analyze the impact of heterogeneity, and continue to deepen research and guide practice based on existing results. Finally, we could extend the impact factors such as enterprise scale, local culture, etc., for discussing the influence on UIC.

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