Journal of Business and Green Innovation

E-ISSN: Pending
P-ISSN: Pending

Publisher Information

Publisher:

Institute of Advanced Technology and Green Innovation LLC (INATGI)

Location: 2807 N Parham Rd, Ste 320, Henrico, VA 23294, United States

Official Websites:

- www.inatgi.com
- www.inatgi.cn

Publishing Frequency:

Biannual (Two issues per year)

Contact Details:

- Phone: +1 (757) 407-6474
- Email: editorial@inatgi.com/editorial@inatgi.in

Publishing Statement

The ***Journal of Business and Green Innovation*** (***JBGI***) is published by the Institute of Advanced Technology and Green Innovation LLC (INATGI) as an open access academic journal. All content is freely available without charge to the user. Users are allowed to read, download, copy, distribute, print, search, or link to the full texts of the articles in this journal without asking prior permission from the publisher or the author, in accordance with the principles of the Budapest Open Access Initiative (BOAI).

DOI Registration

All published articles are assigned to a **Digital Object Identifier** (**DOI**) under the prefix **10.63646**, ensuring permanent and citable access.

Journal of Business and Green Innovation

Volume 1 Issue 2

December 2023

Virginia, USA

Institute of Advanced Technology and Green Innovation

E-ISSN: Pending

P-ISSN: Pending

Table of Contents

The Impact of University Knowledge Spillover on the Innovation and Development of Technology Enterprises

Linyue Wei[1], Lijuan Tong[2]*

[1]School of Management, Capital Normal University, Beijing 100084, China
[2]Capital Normal University, Beijing 100048, China
*Email: tonglijuan@cnu.edu.cn

Abstract

As technology enterprises continue to advance their role as core drivers within innovative systems, the impact of university knowledge spillover on their development remains unclear. Thus, this paper systematically explores the specific mechanisms and effects of knowledge spillover on technological innovation within enterprises. Through in-depth investigations in technology-intensive regions among universities, technology enterprises, and institutional personnel, this study categorizes university knowledge spillover into four core dimensions: the transformation of research achievements, the mobility of high-skilled talent, university-industry collaboration models, and innovative cultural atmospheres. Utilizing a linear regression model, this empirical research examines the impact mechanisms and effects of university knowledge spillover on the innovation and development capabilities of technology enterprises, while also considering transmission pathways and recommendations for sustainable development. The study finds that university knowledge spillovers make a significant positive contribution across all dimensions to enterprise innovation. This conclusion not only validates the applicability of knowledge spillover theory within the technological innovation system but also emphasizes the vital role of universities as sources of knowledge innovation. Practically, the research findings have significant implications for promoting deep integration between academia and industry and accelerating the efficient transfer of scientific achievements from university laboratories to enterprise production lines. Strengthening cooperation mechanisms between universities and enterprises and optimizing the environment for knowledge flow and sharing can effectively enhance the overall efficiency of the technology innovation system and drive high-quality economic and social development.

Keywords: Knowledge spillover from universities; university-enterprise relationship; Industry-University-Research Cooperation; Scientific Research Achievement Transformation

Article History:
Received July 23, 2023
Revised September 16, 2023
Accepted October 14, 2023
Available Online December 10, 2023

See: https://inatgi.in/index.php/jbgi/index for more information. https://doi.org/10.63646/HYCD9025

The Impact of University Knowledge Spillover on the Innovation and Development of Technology Enterprises

1. Introduction

In the context of increasingly fierce global technological competition, innovation in high-tech fields can enhance a nation's core competitiveness. Technology enterprise parks are often co-established with numerous universities and research institutions, and their close geographic proximity facilitates convenient and close collaborative sharing relationships. The presence of many universities within these parks provides abundant resources and conditions for knowledge spillover, while a multitude of high-tech enterprises and research institutions offer platforms for receiving technological spillover achievements. This collaborative relationship between universities and enterprises not only aids in the effective utilization and output of internal personnel, skills, and resources within universities but also enhances enterprise brand value, drives the iteration and upgrading of innovative products, stimulates innovation efficiency and potential, and supports regional industrial structure upgrading and the optimization of corporate internal innovation atmosphere and management models, securing a leading position in market competition.

Existing research indicates that companies with promising prospects for innovation and development potential often have close relationships and cooperation with universities, which are sources of outstanding talent. By engaging in scientific research collaboration with these universities, such as establishing cooperative projects and joint laboratories, technology enterprises can gain early access to cutting-edge technologies and priority use of the latest research achievements, patents, and equipment resources, thereby accelerating the transformation and application of scientific achievements, enhancing core competitiveness and market share, driving innovation-driven development in regional economies, and increasing their domestic and international reputation and influence. This knowledge spillover effect is often manifested in the transformation of university research achievements into enterprises, the flow of skilled talent from universities stimulating enterprise R&D transformation, the development of university-industry collaboration models, and the radiation of unique university innovation culture into enterprise innovation development. Therefore, this paper empirically analyzes the effects of university knowledge spillover from the perspective of its impact on enterprise innovation and development, further exploring the specific channels of influence and the variations in university knowledge spillover effects under different contexts and providing recommendations and outlooks(Cheng H;Huang SQ;,Yu YH;Zhang ZY;Jiang MF, 2011).

However, current literature examining whether and in what aspects universities can enhance corporate innovation performance yields inconsistent results, primarily due to differences in evaluation criteria. Furthermore, research specifically focused on university-industry collaboration remains scarce within this context. Consequently, the contributions of this study are primarily manifested in two aspects. Firstly, it enriches the theory of university knowledge and technology fostering enterprise innovation, elucidating how

 https://doi.org/10.63646/HYCD9025

universities can imbue targeted, universal, and stable knowledge into technological enterprises, thereby advancing related policies to support collaborative technological R&D and igniting the internal innovation potential of these enterprises. Secondly, universities' management research and case studies can offer enterprises fresh managerial insights and methodologies(Lundberg ,H; Öberg, C., 2020). Economists and management experts at universities often conduct profound analyses and forecasts of market trends. Such knowledge and information can spill over to enterprises through collaborative projects, seminars, lectures, and other forms, enabling enterprises to optimize internal management processes, enhance operational efficiency, mitigate management risks, and better grasp market dynamics. This, in turn, facilitates the formulation of target market strategies to avert market risks and achieve steady growth. Through collaborations with universities, enterprises can promptly access risk assessment and early warning information regarding technology, market, and management, thereby strengthening their risk prevention capabilities. Meanwhile, this research also holds practical significance. Thirdly, for enterprises, the research findings on innovation performance conducted by universities encourage them to prioritize R&D intensity and elevate their innovation capabilities, which is pivotal for building intelligent and modern industrial chains. For governments, the research outcomes provide a basis for optimizing support policies. Governments should adhere to market development patterns, dynamically adjust subsidy amounts and intensities, and facilitate rational resource allocation.

To address these issues, the second part of this study conducts a theoretical analysis. In the third part, the four dimensions of university knowledge spillover are further analyzed, and research hypotheses are proposed. In the fourth part, universities and technology enterprise institutions in various regions are selected as research samples, and the selection of variables is determined; an empirical analysis system is used to examine the impact of university knowledge spillover on enterprise innovation and development, and the potential pathways for enterprise development under different manifestations of university knowledge spillover are explored. The fifth part summarizes this paper and further provides policy recommendations and outlooks.

2.Theoretical Analysis and Research Hypothesis

2.1 The Impact of University Research Achievements on Corporate Technological Innovation

University research, both applied and fundamental, frequently generates new scientific technologies, patents, and intellectual property. These research outcomes, through technology transfer mechanisms such as technology licensing and intellectual property utilization, disseminate their knowledge resources to enterprises, where they are adopted and commercialized by high-tech companies. This process creates a knowledge spillover effect that drives industrial innovation and upgrading, thereby influencing the technological innovation capabilities of enterprises. Research by Cheng, H., et al. suggests that the transformation of university research outcomes should be effectively integrated with science, technology, and the economy to facilitate university-industry collaboration (UIC) and the transformation of research achievements. Moreover, a favorable policy

 https://doi.org/10.63646/HYCD9025

support environment can protect research outcomes and respect the intellectual property rights of researchers, reducing concerns about intellectual property theft and enhancing the scope and effectiveness of knowledge transfer. Incentive mechanisms by university administrators to encourage the transformation of research outcomes can promote a culture of knowledge sharing and broaden the reach of university research transformation. Based on the above analysis, we propose the first hypothesis:

H1. The transformation of university research achievements positively influences corporate technological innovation.

2.2 The Impact of University Human Resource Mobility on Corporate Technological Innovation

Universities and research institutions serve as talent cultivation centers, supplying high-quality talent to high-tech industries. The mobility of university human resources primarily refers to the career changes and employment choices of university faculty and students. When these individuals move, they transfer their rich knowledge, including personal experiences, technical expertise, and academic research findings, to individuals and organizations within enterprises(Yang, JJ; Li, SL; Li, CF., 2023; Liu, C., Cao, J. M., Wu, G. D., Zhao, X. B., & Zuo, J., 2022; Gao, X., Guo, X., & Guan, J. C., 2014). Research by Yang, JJ, et al. highlights the importance of a university education system oriented towards the labor market, demonstrating that enhancing human capital can significantly promote corporate innovation and development . When university faculty and students move due to positive motivations such as career advancement and personal growth, they are more inclined to share knowledge, facilitating the collision and diffusion of innovative ideas. This leads to increased knowledge spillover effects, driving technological innovation in enterprises(Lu, Y., & Yang, J. ,2024; Evans, N., Miklosik, A., & Du, J. T., 2024). The management and organization of high-quality talent by enterprises determine the value these individuals can contribute and influence the extent to which knowledge resources are maximized in production innovation. Based on the above analysis, the second hypothesis can be drawn:

H2. The mobility of university talent positively influences corporate technological innovation.

2.2 The Impact of University-Industry-Research Collaboration on Corporate Technological Innovation

Universities and enterprises exchange the latest academic research findings, professional knowledge, and technology, providing companies with innovative ideas and solutions. This process promotes the commercialization of knowledge, thereby enhancing the technological strength and innovative capacity of enterprises. If the knowledge produced by universities is relevant, and both parties are highly motivated to collaborate and possess strong knowledge absorption capabilities and technical expertise, the effectiveness of knowledge spillover will be further enhanced, facilitating knowledge renewal and

 https://doi.org/10.63646/HYCD9025

technological advancement in enterprises(Cheng, XF; Zhang, ZM; Yang, Y; Yan, ZH., 2019; Coutinho, C., Cretan, A., da Silva, C. F., Ghodous, P., & Jardim - Goncalves, R., 2016; Lu, Y.,2021). Research by Cheng, H, et al. demonstrates that university-industry collaboration (UIC) policies, through collaborative investments and knowledge output transformation, have a significant positive impact on university knowledge innovation and achievement transformation (Liang, LM;Chen, LX;Wu, YS;Yuan,JP.,2012). When universities and enterprises jointly participate in R&D projects and engage in in-depth exchanges and cooperation, this collaborative innovation mechanism accelerates the pace of innovation in enterprises, enhances innovation outcomes, improves R&D efficiency, and broadens the influence of knowledge spillover(Pittayasophon, S;Intarakumnerd, P., 2017). Especially when universities act as partners with specific relationships to enterprises, they exert every effort to assist companies in solving technical challenges, further generating novel knowledge, technology, and ideas. Based on the above analysis, we propose the third hypothesis:

H3. University-industry-research collaboration positively influences corporate technological innovation.

2.4 The Impact of University Innovation Culture Dissemination on Corporate Technological Innovation

The unique innovation culture of universities, with its inherent values and concepts, profoundly influences the recognition and acceptance of innovation within enterprises through widespread dissemination, thereby stimulating corporate innovation vitality(Lu, Y. ,2022). As core institutions of knowledge creation and dissemination, universities foster an innovative culture that not only facilitates the flow of knowledge between academia and industry but also significantly enhances the overall knowledge level within enterprises. Research by Pittayasophon, S. indicates that different campus environments and corporate operational models yield varying effects on collaboration and development (Jagdev, HS;Thoben, KD, 2001). The behavioral patterns inherent in the university cultural atmosphere—exploration, openness, inclusivity—exert a positive demonstrative effect on individual and organizational management within companies, guiding them to change traditional thinking and behavioral habits. The social attributes of corporate personnel determine their ways of functioning within specific environments, and such environments greatly influence group dynamics(Hou, BJ; Hong, J; Wang, H; Zhou, CY., 2019). Therefore, when the innovation culture of universities successfully spreads to enterprises, it fosters a positive internal atmosphere that encourages technological innovation and development. Based on the above analysis, we propose the fourth hypothesis:

H4. The dissemination of university innovation culture positively influences corporate technological innovation.

 https://doi.org/10.63646/HYCD9025

3. Research Design

3.1 Questionnaire Design and Sample Selection

In this survey, questionnaires were distributed to universities and technology enterprises in a technology-intensive area in Beijing, China (the Zhongguancun district). Using a sampling survey method, 432 questionnaires were collected, of which 405 were valid after excluding invalid responses, resulting in a response rate of 93.8%.

The design of this survey was divided into personal information and scale assessment. University knowledge spillover was examined across four dimensions(Caulfield, B.; Furszyfer, D., 2022). First, we asked whether enterprises had received technology licenses and transfers from universities, along with the frequency and quantity, to analyze the contribution of technology transfer to technological innovation and product upgrades. We also gathered data on the number and duration of collaborative projects between enterprises and universities to assess whether these collaborations improved work efficiency or promoted innovation. Furthermore, we examined whether universities provided enterprises with solutions and services for the transformation of research achievements, assessing their effectiveness and practicality, including the proportion and speed of transformation into technologies or products. This helped evaluate the transformation of university research achievements within enterprises.

Second, we assessed the participation of enterprise personnel in university talent mobility, academic activities, and conferences, as well as the impact on corporate talent development and technological innovation, to understand the flow of talent resources between enterprises and universities(Falk, M., 2012). By examining whether universities have provided necessary talent and intellectual support to enterprises, and whether universities and enterprises have conducted independent joint technological research and talent cultivation, such as whether both parties have jointly established research centers, institutes, laboratories, science and technology parks to conduct scientific research and incubate achievements, whether special funds for industry-university-research cooperation have been set up, or whether corporate and social funds have been absorbed to form a school board of directors to establish high-tech enterprises in universities. From the perspective of cooperation content, it is necessary to investigate whether universities provide technology transfer, technology development, joint construction of R&D institutions or laboratories, establishment of economic entities, joint talent cultivation, sharing of scientific and technological resources, technical consultation or services, etc. From the output level, the number of jointly researched topics, products, and authorized patent applications between universities and enterprises is examined, demonstrating the efficiency of scientific research capabilities and the results of scientific research achievements transformation in universities, and reflecting the number of scientific and technological achievements with independent intellectual property rights obtained through industry-university-research cooperation(Xu, R.; Shen, Y., 2023).

Third, we evaluated the effectiveness of university-industry-research collaboration by examining the economic, social, and environmental benefits of projects and assessing the

See: https://inatgi.in/index.php/jbgi/index for more information. https://doi.org/10.63646/HYCD9025

contribution of collaborative projects to technological innovation, product upgrades, and market expansion.

Finally, we assessed whether the content of university campus culture dissemination covered core values, management concepts, and innovation spirit of enterprises.Analyze the diversity of forms of campus culture dissemination, including lectures, seminars, cultural exchange activities, corporate internships and practical training, and whether these forms can effectively transmit the university's campus culture to enterprises. Furthermore, examine the attitudes and perspectives of enterprise personnel towards the dissemination of university campus culture, thereby demonstrating the extent to which the dissemination of innovative university culture influences the development of corporate culture(Lu, Y., Zheng, X., Li, L., & Xu, L. D. ,2020; David, P.A.; Hall, B.H., 2000 ;Safitri, V.A.; Sari, L., 2020)). We evaluated whether enterprises were willing to actively embrace university campus culture dissemination and assessed their understanding, recognition, and application of the content, including whether they could integrate university campus culture with corporate culture to promote development and innovation.

3.2 Data Analysis

Table 1. Reliability Analysis.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.649	.701	5

The results of the data analysis indicate that the alpha values for the university knowledge spillover variables are above 0.6, and the overall alpha value for the questionnaire is above 0.7, suggesting that the reliability of this scale is within an acceptable range

Table 2. KMO and Bartlett’s Test of Sphericity

Kaiser-Meyer-Olkin measure of Sampling Adequacy		.761
	Approx. Chi-Square	409.117
Bartlett's Test of Sphericity	df	10
	Sig.	.000

The Kaiser-Meyer-Olkin (KMO) value for the survey questionnaire is 0.761, indicating good validity. The significance level is 0.000, demonstrating highly significant results.

3.3 Model Setting

This study focuses on the impact of university knowledge spillover on corporate innovation and development. University knowledge spillover is categorized into four dimensions. To test the hypothesis, the transformation of university research achievements, human resource mobility, university-industry-research collaboration, and the dissemination of innovation culture are included in the regression model as explanatory variables, while the effects on corporate innovation and development are treated as explained variables (Ma, C.; Yang, H., 2021; Brink, T, 2017; Di Domenico, M; Tracey, P; Haugh, H, 2020). Furthermore, based on the different manifestations of these

 https://doi.org/10.63646/HYCD9025

four dimensions, we analyze the effects and extent of their impact on corporate innovation and development to determine whether university knowledge spillover can enhance corporate innovation efficiency. Consequently, the model is created as follows:

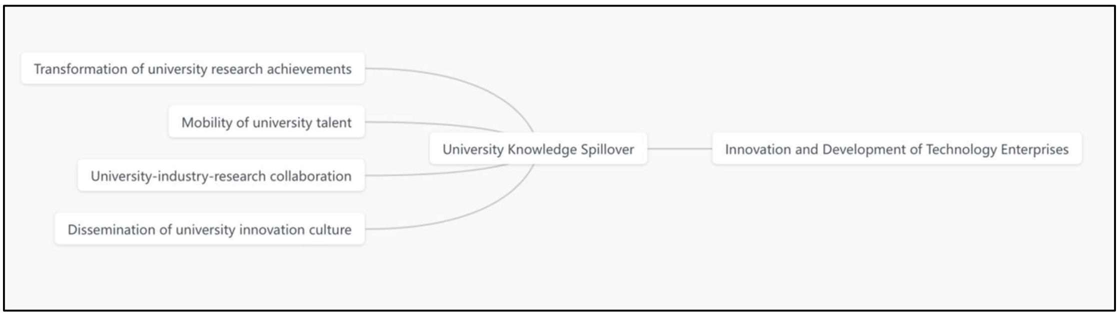

Figure 1. Research Model Setting

4. Empirical Results and Analysis

4.1 Descriptive Statistics

The statistical analysis of the relevant questionnaire yielded the following results. Among the survey respondents, enterprises accounted for 62.72%, universities for 17.78%, and research institutions for 19.5%, indicating a well-balanced representation of each type of institution. The high level of participation from technology enterprises in the surveyed area suggests a strong interest in university knowledge spillover and technological innovation, highlighting the significant reference value of this study's findings for technology enterprises.

Table 3. Statistics of Participants

Institution	Proportion
Universities	17.78%
Enterprises	62.72%
Research Institutions	19.51%

4.2 Correlation Analysis

This paper conducts data analysis using SPSS 26.0.

Table 4. Correlations

		Transformation of university research achievements	Mobility of university talent	university-industry-research collaboration	Dissemination of university innovation culture	University knowledge dissemination promotes innovative development of enterprises
Transformation of university research achievements	Pearson Correlation Coefficient	1	.179**	.179**	.073	.128**
	Sig. (2-tailed)		.000	.000	.142	.010
	Number of Cases	405	405	405	405	405

See: https://inatgi.in/index.php/jbgi/index for more information. https://doi.org/10.63646/HYCD9025

Mobility of university talent	Pearson Correlation Coefficient	.179**	1	.568**	.498**	.401**
	Sig. (2-tailed)	.000		.000	.000	.000
	Number of Cases	405	405	405	405	405
university-industry-research collaboration	Pearson Correlation Coefficient	.179**	.568**	1	.461**	.321**
	Sig. (2-tailed)	.000	.000		.000	.000
	Number of Cases	405	405	405	405	405
Dissemination of university innovation culture	Pearson Correlation Coefficient	.073	.498**	.461**	1	.380**
	Sig. (2-tailed)	.142	.000	.000		.000
	Number of Cases	405	405	405	405	405
University knowledge dissemination promotes innovative development of enterprises	Pearson Correlation Coefficient	.128**	.401**	.321**	.380**	1
	Sig. (2-tailed)	.010	.000	.000	.000	
	Number of Cases	405	405	405	405	405

Table 4 indicates that the significance values for variables such as human resource mobility and university-industry-research collaboration are 0.000, demonstrating a significant correlation between university knowledge spillover and corporate innovation and development. The Pearson correlation coefficients for the four variables of university knowledge spillover are 0.128, 0.401, 0.380, and 0.380, all greater than 0, indicating a positive correlation between university knowledge spillover—through research achievement transformation, human resource mobility, university-industry-research collaboration, and innovation culture dissemination—and corporate innovation and development. This suggests that university knowledge spillover plays a facilitating role in corporate innovation and development.

4.2.1 Regression Analysis

Table 5. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.141a	.020	.010	1.014	1.767

Table 5 provides a description of the regression equation's fit. The Durbin-Watson value should be close to 2, indicating that the samples are independent and suitable for regression analysis. The DW value is 1.767, which is close to 2, demonstrating that there is minimal autocorrelation among the samples, and they are indeed independent. The correlation coefficient (R) is 0.141, and the square of this coefficient, known as the coefficient of determination, is 0.020. This preliminary assessment suggests that the model has a good fit and is appropriate for regression analysis.

Table 6. ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	regression	9.580	4	2.395	21.623	.000b
	Residuals	44.306	400	.111		
	Total	53.886	404			

Table 6 illustrates the significance test of the regression equation, specifically the significance test of the univariate linear regression equation. The F-value is 21.623, indicating that the variance between groups is much larger than the variance within groups, and the contribution of the between-group variance to the total variation is substantial. The significance level, P, is 0.000, which is less than the significance level \(\alpha = 0.05\), indicating an extremely low significance level. Therefore, the null hypothesis should be rejected, suggesting that there is a significant difference between the regression coefficient and zero. This indicates that the linear relationship between the explanatory variables and the explained variable is significant. This finding demonstrates that the univariate linear regression model, established to assess the extent to which university knowledge spillover — through research achievement transformation, human resource mobility, university-industry-research collaboration, and innovation culture dissemination — promotes corporate development, possesses significant statistical meaning.

Table 7. Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	p
		B	Std. Error	Beta		
1	(Constant)	.543	.079		6.868	.000
	Transformation of university research achievements	.025	.022	.053	1.136	.257
	Mobility of university talent	.383	.068	.313	5.614	.000
	University-industry-research collaboration	.162	.064	.139	2.527	.012
	Dissemination of university innovation culture	-.011	.016	-.031	-.687	.493

As shown in Table 7, the output of the model includes estimates of partial regression coefficients, comprising non-standardized coefficients, standardized coefficients, and t-tests for the statistical significance of each partial regression coefficient (i.e., whether it differs significantly from 0, indicating a linear relationship with the dependent variable). Also, the significance tests for the regression equation and the regression coefficients serve the same purpose. The significance levels for the four dimensions and the constant are close to 0.000, all passing the significance tests. This indicates that the linear relationship regression equation between the four independent variables and the impact of university knowledge spillover on corporate development is as follows:

$$H = 0.025 \times (\text{Effect of Research Achievement Transformation}) + 0.383 \times (\text{Degree of Talent Exchange}) + 0.162 \times (\text{Effect of University-Industry-Research Collaboration}) - 0.011 \times (\text{Spread of Innovation Culture}) + 0.543.$$

Among these, Standardized Coefficients (Beta) remove the impact of different units among independent variables and are calculated using standardized data, where standardized data = (Original Data - Mean) / Standard Deviation. The constant term in the standardized regression equation is 0, and the standardized regression coefficient Beta is derived as Beta = β * (Standard Deviation of Independent Variable X / Standard Deviation of Dependent Variable Y). When statistically significant, a larger absolute value of the standardized regression coefficient indicates a stronger effect of the corresponding independent variable on the dependent variable Y. This implies that, with other independent variables held constant, a change of one standard deviation in the independent variable leads to a corresponding change in the number of standard deviations in the dependent variable. After standardization, all variables have a mean of 0 and a standard deviation of 1, and the constant term is 0. In this example, Beta = 0.383 (for Mobility of University Talent) > 0.162 (for University-Industry-Research Collaboration), indicating that, under the premise of both factors having a facilitating effect, the Mobility of University Talent exerts a greater influence on University Knowledge Dissemination Promoting Innovative Development of Enterprises compared to University-Industry-Research Collaboration.

In conclusion, this shows that university knowledge spillover has an overall positive linear correlation with corporate innovation and development and can promote the prosperity and growth of enterprises.

Table 8. Residual Statistics

	Min.	**Max.**	**Mean**	**S.D.**	**N**
Predicted Value	1.06	1.69	1.16	.154	405
Residual	-.694	.933	.000	.331	405
Std.Predicted Value	-.667	3.482	.000	1.000	405
Std.Residual	-2.086	2.805	.000	.995	405

In the context of linear regression analysis, the residual is a paramount concept, representing the discrepancy between the estimated value and the observed value. It encapsulates the variation in the dependent variable that arises from all factors not included in the model despite being analyzed as potential independent variables. The Durbin-Watson test outputs predictive values, residuals, standardized predictive values, and standardized residuals. The test statistics, the DW value, is displayed in the model summary table as a result of this analysis. In essence, the residual signifies the portion of the dependent variable that cannot be estimated or predicted by the analyzed independent variables. Graphically, the residual is depicted as the distance from an observed data point to the fitted regression line, offering a visual representation of the model's deviation from the actual observations.

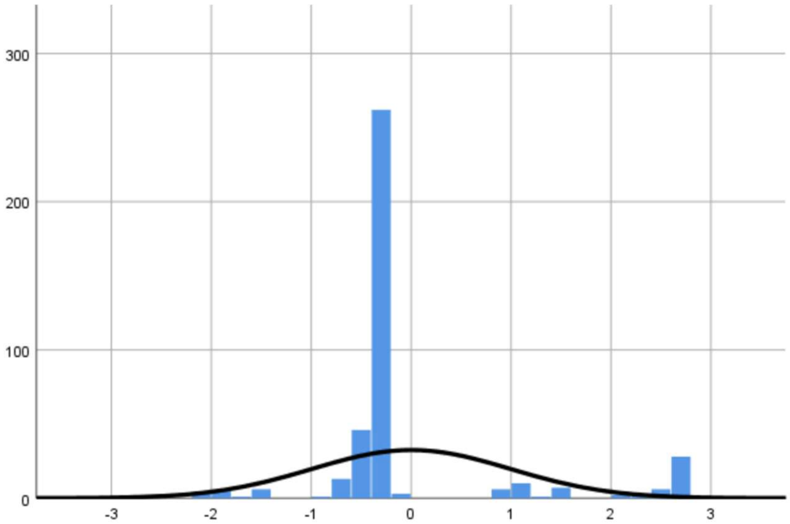

Figure 2. Standardized Residual Histogram

By outputting a Histogram alongside a normal distribution curve, one can examine whether the standardized residuals conform to a normal distribution through the histogram and P-P plot. Scatter plots of standardized residuals against standardized predicted values can be utilized to inspect linearity and homoscedasticity. Outliers can be detected using studentized residuals.

Under normal circumstances, the residuals follow a normal distribution with a mean of 0 and a variance of δ^2, while the standardized residuals follow a normal distribution with a mean of 0 and a variance of 1.

Outlier Examination: Residuals that exceed three standard deviations are considered outliers, and these can be visually identified on a residual plot. Additionally, the results of outlier analysis are also output in the case analysis.

Homoscedasticity Examination: Scatter plots of standardized residuals against standardized predicted values or individual independent variables can be constructed to assess homoscedasticity. If the standardized residuals are randomly and evenly distributed above and below the horizontal line at 0, it can be assumed that the variances are approximately equal. However, if the standardized residuals exhibit spreading or convergence as the standardized predicted values increase, it may indicate a lack of homoscedasticity.

Linearity Examination: If the standardized residuals exhibit a curved pattern, it suggests that the relationship between the dependent variable and the independent variables may not be linear, or that the residuals may not be independent.

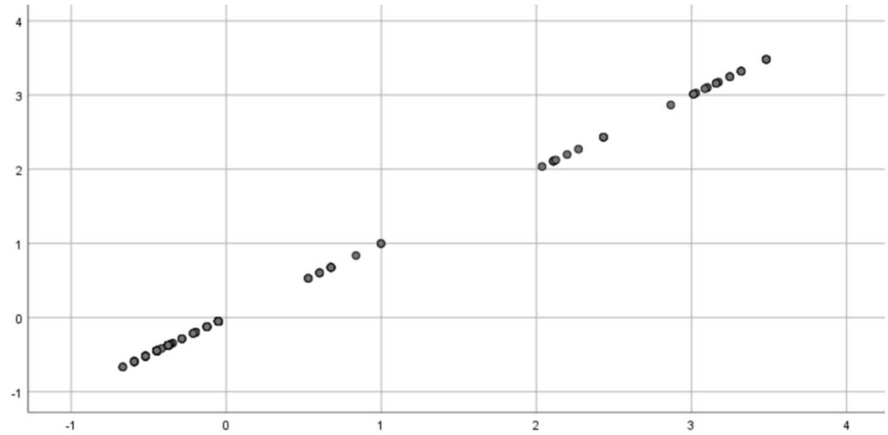

Figure 3. Standardized Residual Scatter Plot

Table 8 and Figures 2, 3 show that the standardized residual histogram is symmetrical on both sides. From the P-P plot of standardized residuals, it can be observed that the scatter points are mostly close to the diagonal line, indicating that the normality of the residuals is satisfactory. The model summary table shows that the residuals passed the Durbin-Watson (DW) test, confirming that the residuals are independent. In the standardized residual scatter plot, the majority of the scatter points fall within plus or minus two standard deviations, suggesting that the model fits the data well.

This paper first examines the linear trend, which assumes a linear relationship between the dependent variable and the independent variable. A preliminary assessment is made through a scatter plot (simple linear correlation) using Table10. to visualize the relationship. During the testing, it is observed that the observations of the dependent variable are mutually independent, indicating that the covariance between the residuals of any two observations is zero. The Durbin-Watson test can be employed to ascertain the absence of autocorrelation.

Subsequently, the normality is observed. For any linear combination of the independent variables, the dependent variable follows a normal distribution. Here, normality implies that when a particular independent variable takes multiple identical values, the corresponding observations of the dependent variable exhibit a normal distribution. However, in practical samples, a fixed value of an independent variable often corresponds to only a limited number of observations, sometimes even just one, making it impossible to directly assess the normality of the dependent variable's observations. Instead, the model shifts the focus to examining whether the residuals conform to a normal distribution(Preuveneers, D; Joosen, W; Ilie-Zudor, E, 2018; Johnston, A; Prokop, D, 2024; Abramo, G; D'Angelo, CA; Di Costa, F, 2011).

Additionally, the examination of homoscedasticity is conducted. Similar to normality, the model utilizes residual plots to assess whether the residuals satisfy the assumption of homoscedasticity. It is observed that there is no multicollinearity among the independent variables. The presence of multicollinearity can lead to various issues, including discrepancies between results and objective facts, as well as instability in the estimation equations(Kwong, C., Tasavori, M., & Cheung, C. W. M., 2017; Kurdve, M., Bird, A., & Lage - Hellman, J., 2020; Hu, J. W., Gao, S., Yan, J. W., Lou, P., & Yin, Y., 2020; Miao, Y., Shi, Y., & Jing, H., 2024). Stepwise regression can be employed to restrict the entry of

See: https://inatgi.in/index.php/jbgi/index for more information. https://doi.org/10.63646/HYCD9025

strongly correlated independent variables into the equation. In cases of multicollinearity, one can eliminate the independent variable responsible for the collinearity, combine independent variables, or alternatively utilize ridge regression, principal component regression, partial least squares regression, among other methods. Multicollinearity can be investigated using various methods, including tolerance, variance inflation factor (VIF), characteristic roots, condition indices, variance proportions, correlation coefficients, and residual plots(Li, X. B., & Tan, J., 2020; Wulan, M. Q., & Petrovic, D., 2012; Darabi, F., Saunders, M. N. K., & Clark, M., 2020; Lu, Y., & Williams, T. L., 2021; Gertner, D., Roberts, J., & Charles, D., 2011).

In this case, there are no outliers identified, but there may be a high leverage point present. Regardless of the changes in the predicted values of the dependent variable, the standardized residuals are randomly distributed above and below the horizontal line at 0, indicating no exceptional points and maintaining a relatively stable pattern, which can be considered as evidence of homoscedasticity. As Figure 10 shows, the residuals are generally randomly distributed on both sides of the 0 horizontal line, with no apparent positive or negative bias, suggesting that the four dimensions of university knowledge spillovers—Transformation of university research achievements, Mobility of university talent, University-industry-research collaboration, and Dissemination of university innovation culture—all exhibit a linear relationship with the innovative development of enterprises(Braziotis, C., & Tannock, J., 2011; Sun, T. T., & Cheng, X. H. ,2024; Yin, X. M., Li, F., Chen, J., & Zhai, Y. D., 2024; Savarese, C., Huybrechts, B., & Hudon, M., 2020; Lu, Y., Sigov, A., Ratkin, L., Ivanov, L. A., & Zuo, M. , 2023).

4.3 Research Results Analysis

The data analysis results indicate that university knowledge spillovers significantly impact the technological innovation and development of technology enterprises through four aspects: the transformation of scientific research achievements, human resource mobility, industry-university-research cooperation, and the dissemination of innovative culture. In particular, enterprises that advance in all four dimensions concurrently exhibit particularly robust innovation and development momentum.

As a crucial base for scientific research and innovation, universities directly contribute to the technological innovation of enterprises through the transformation of their research achievements. More than 90% of the enterprises located near universities have participated in the transformation of university research achievements or invited university personnel for training and technical support, indicating frequent interactions between the two parties in terms of knowledge and technology. By collaborating with universities, these enterprises have absorbed the universities' capabilities in intellectual property management and technology transfer mechanisms, enriching their technological options. This allows them to transform the latest research and development achievements into practical productivity, which better aligns with market demands, enhancing their technological level and market competitiveness.

The mobility of human resources between universities and enterprises is one of the significant avenues for knowledge spillovers. The survey revealed that many enterprises actively recruit talents from universities, particularly those with innovative spirits and R&D capabilities. The integration of these talents not only brings fresh ideas and creative resources to the enterprises but also promotes the updating and optimization of their

 https://doi.org/10.63646/HYCD9025

internal knowledge structures. Additionally, when university personnel enter enterprises, their academic backgrounds and professional expertise provide invaluable intellectual support to the companies.

Industry-University-Research (IUR) cooperation represents the most direct manifestation of knowledge spillovers. Through such collaboration, universities can apply their latest research achievements and ideas to actual production, while enterprises can leverage the research capabilities and resource advantages of universities for technological innovation and industrial upgrading. The fact that up to 91.89% of enterprises have collaborated with universities on projects and utilized university patents is a tangible indicator of the close cooperative relationship between universities and enterprises in the surveyed area. According to enterprise personnel, those who collaborate with universities have not only improved their work efficiency but also demonstrated stronger competitiveness and innovative capabilities in technological innovation and product development. Evidently, IUR cooperation enables both universities and enterprises to fully leverage their respective strengths, realize resource sharing and complementary advantages, and thereby promote technological innovation and industrial upgrading(Wang, Y. D., Hu, R. F., Li, W. P., & Pan, X. F., 2016; Paay, J., Kuys, B., & Taffe, S., 2021; Lei, X. P., Zhao, Z. Y., Zhang, X., Chen, D. Z., Huang, M. H., & Zhao, Y. H., 2012; Li, Q., Wang, Z. Y., Cao, Z. C., Du, R. Y., & Luo, H. , 2015; Kesting, T., Gerstlberger, W., & Baaken, T.,2018).

As a crucial source of cultural heritage and innovation, universities play a pivotal role in driving and fostering an innovative cultural atmosphere within technological enterprises. Overwhelmingly, 87.2% of enterprises acknowledge the influence of universities' innovative culture on them. Through collaboration and exchanges with enterprises, the innovative culture of universities can gradually permeate into corporate cultures, inspiring creativity and an innovative spirit among employees, enhancing corporate image and brand value, and strengthening corporate cohesion and centripetal force. This heightened enthusiasm among staff helps enterprises acquire new technological insights and solutions, boosting brand recognition. Consequently, it not only fosters technological innovation within enterprises but also assists them in enhancing their market influence and maintaining a leading position amidst fierce market competition

5. Discussion

5.1 Innovative Applications

This study analyzes the critical role of university knowledge spillovers in the development of technology enterprises. In technology parks, where enterprises are densely concentrated and information exchange is frequent, there are abundant opportunities and effective outcomes for university knowledge spillover. Through the dissemination of research findings, academic exchanges, and talent mobility, universities transfer new ideas, technologies, and knowledge to enterprises, stimulating their innovative vitality. Geographical advantages facilitate collaboration with universities and research institutions, enabling joint R&D activities and the use of each other's resources to enhance their innovation capabilities(Peng, C., & Meng, Y. J., 2016; Li, B., Xu, C. J., Wang, Y. C., Zhao, Y., Zhou, Q., & Xing, X. D., 2024). This close integration of academia, industry, and research further enhances the effects of knowledge spillover.

Moreover, existing successful cases demonstrate the significant advantages of university knowledge spillover in driving surrounding enterprises. The close interaction between Stanford University and companies in Silicon Valley has resulted in notable knowledge

 https://doi.org/10.63646/HYCD9025

spillover and innovation benefits for both parties. Stanford's breakthroughs in fields such as computer science and electrical engineering are shared with Silicon Valley companies through methods like patent transfers. The collaboration between Stanford University and surrounding enterprises is mutually beneficial, as companies gain access to external university knowledge while also contributing technological resources and development platforms back to the universities through their R&D activities and innovation outcomes. This bidirectional flow of knowledge and technology further promotes the development of renowned university-enterprise collaborative innovation ecosystems globally(Alpaydin, U. A. R., 2019).

As crucial bases for scientific research and innovation, universities play a direct role in driving technological innovation in enterprises through the transformation of their research achievements. Many companies actively recruit university talent with innovative spirit and R&D capabilities, bringing fresh ideas and creative resources that facilitate the updating and optimization of corporate knowledge structures. Through university-enterprise collaboration, universities leverage intellectual property management and technology transfer mechanisms to apply the latest research outcomes and concepts to practical production. At the same time, companies can use scientific research strengths and resource advantages to drive technological innovation and industrial upgrading. Furthermore, as the innovation culture of universities gradually permeates corporate culture, it inspires innovation among employees and strengthens organizational cohesion and alignment.

Companies collaborating with universities not only improve work efficiency but also demonstrate stronger competitiveness and innovative capacity in technology and product development. It is evident that university-industry-research collaboration effectively harnesses the respective advantages of universities and enterprises, achieving resource sharing and complementary strengths, thereby promoting technological innovation and industrial upgrading.

Based on the above analysis, this paper offers the following recommendations regarding the four dimensions of university knowledge spillover:

Universities should actively engage in various forms of academic exchanges and community service activities to promote the widespread dissemination of innovative culture and expand channels for knowledge dissemination, creating more opportunities for the transformation and application of knowledge. Fostering long-term stable partnerships between universities and enterprises can facilitate the continuous transfer and sharing of knowledge, enhancing overall collaborative innovation capabilities. To improve the efficiency of knowledge dissemination and transformation, we need to promote close cooperation between universities and enterprises, effectively enhancing corporate technological levels and R&D capabilities through training and talent recruitment, thereby strengthening product performance and market competitiveness. Additionally, governments should play a role by introducing policies such as tax incentives and financial support to encourage and support the transformation of university research outcomes and knowledge spillover, improving intellectual property protection systems, strengthening intellectual property application management, and ensuring that universities' legal rights are fully protected.

It is noteworthy that the research activities of universities do not necessarily yield significant positive spillover effects across all types of high-tech industries. The extent and effectiveness of these spillovers are often contingent upon factors such as the characteristics of the industry, technological maturity, market environment, and policy support. Consequently, in practical applications, it is imperative to devise tailored strategies and measures based on specific circumstances to maximize the innovative impetus of university research activities on high-tech industries.

6. Conclusions

As countries increasingly integrate university-industry collaborations in education and manufacturing, more regions are relocating industries to areas rich in high-quality talent, such as universities, to achieve better sustainable innovation development. Against this backdrop, this study uses the technology-intensive enterprises and university parks in Beijing's Zhongguancun district as research samples to empirically examine the impact of university knowledge spillover on corporate innovation and development. The research finds that university knowledge spillover primarily manifests in four aspects: research achievement transformation, high-skilled talent mobility, university-industry-research collaboration, and the dissemination of an innovative cultural atmosphere. Furthermore, each of these four dimensions of university knowledge spillover contributes significantly and positively to corporate development, and these conclusions remain robust even after testing with alternative variables and instrumental variables. Additionally, it is further revealed that the combined effect of the four dimensions of university knowledge spillover has a more pronounced impact on the sustainable development of high-tech enterprises.

References

Abramo, G., D'Angelo, C. A., & Di Costa, F. (2011). University - industry research collab oration: a model to assess university capability. Higher Education, 62(2), 163 - 181. DOI: 10.1007/s10734-010-9372-0.

Alpaydin, U. A. R. (2019). Exploring the spatial reach of co - publication partnerships of multinational enterprises: To what extent does geographical proximity matter? Regional S tudies Regional Science, 6(1), 281–298. DOI: 10.1080/21681376.2019.1583601.

Banaeianjahromi, N., & Smolander, K. (2019). Lack of Communication and Collaboratio n in Enterprise Architecture Development. Information Systems Frontiers, 21(4), 877 - 90 8. DOI: 10.1007/s10796-017-9779-6.

Braziotis, C., & Tannock, J. (2011). Building the extended enterprise: key collaboration f actors. International Journal of Logistics Management, 22(3), 349 - 372. DOI: 10.1108/09 574091111181363.

Brink, T. (2017). SME routes for innovation collaboration with larger enterprises. Industr ial Marketing Management, 64, 122 - 134. DOI: 10.1016/j.indmarman.2017.01.010.

Caulfield, B., & Furszyfer, D. (2022). Measuring the equity impacts of government subsi dies for electric vehicles. Energy, 248, 123588. DOI: 10.1016/j.energy.2022.123588.

Cheng, H., Huang, S. Q., Yu, Y. H., Zhang, Z. Y., & Jiang, M. F. (2011). The 2011 collab orative innovation plan, university - industry collaboration, and achievement transformati on of universities: Evidence from China. Journal of the Knowledge Economy, 14(2), 124 9–1274. DOI: 10.1007/s13132-022-00907-0.

Cheng, X. F., Zhang, Z. M., Yang, Y., & Yan, Z. H. (2019). Open collaboration between universities and enterprises: A case study on GitHub. Internet Research, 30(4), 1251–127 9. DOI: 10.1108/INTR-01-2019-0013.

 https://doi.org/10.63646/HYCD9025

Coutinho, C., Cretan, A., da Silva, C. F., Ghodous, P., & Jardim - Goncalves, R. (2016). Service - based negotiation for advanced collaboration in enterprise networks. Journal of Intelligent Manufacturing, 27(1), 201–216. DOI: 10.1007/s10845-013-0857-4.

Darabi, F., Saunders, M. N. K., & Clark, M. (2020). Trust initiation and development in SME - university collaborations: implications for enabling engaged scholarship. European Journal of Training and Development, 45(4 - 5), 320 - 345. DOI: 10.1108/EJTD-04-2020-0068.

David, P. A., & Hall, B. H. (2000). Is public R&D a complement or substitute for private R&D? A review of the econometric evidence. Res. Policy, 29, 497–529. DOI: 10.1016/S0048-7333(99)00087-6.

Di Domenico, M., Tracey, P., & Haugh, H. (2020). The dialectic of social exchange: Theorizing corporate-social enterprise collaboration. In Organizational Collaboration (pp. 100-118). Routledge.

Evans, N., Miklosik, A., & Du, J. T. (2024). University - industry collaboration as a driver of digital transformation: Types, benefits and enablers. Heliyon, 9(10). DOI: 10.1016/j.heliyon.2023.e21017.

Falk, M. (2012). Quantile estimates of the impact of R&D intensity on firm performance. Small Business Economics, 39, 19–37. DOI: 10.1007/s11187-010-9290-7.

Gao, X., Guo, X., & Guan, J. C. (2014). An analysis of the patenting activities and collaboration among industry - university - research institutes in the Chinese ICT sector. Scientometrics, 98(1), 247–263. DOI: 10.1007/s11192-013-1048-y.

Gertner, D., Roberts, J., & Charles, D. (2011). University - industry collaboration: a CoPs approach to KTPs. Journal of Knowledge Management, 15(4), 625 - 647. DOI: 10.1108/13673271111151992.

Hou, B., Hong, J., Wang, H., & Zhou, C. (2019). Academia-industry collaboration, government funding and innovation efficiency in Chinese industrial enterprises. Technology Analysis & Strategic Management, 31(6), 692-706. DOI: 10.1080/09537325.2018.1543868.

Hu, J. W., Gao, S., Yan, J. W., Lou, P., & Yin, Y. (2020). Manufacturing enterprise collaboration network: An empirical research and evolutionary model. Chinese Physics B, 29(8). DOI 10.1088/1674-1056/ab96a8.

Jagdev, H. S., & Thoben, K. D. (2001). Anatomy of enterprise collaborations. International Journal of Production Economics, 12(5), 437–451. DOI: 10.1080/09537280110042675.

Johnston, A., & Prokop, D. (2024). SME productivity and university collaboration: does past performance influence future performance? European Journal of Innovation Management. DOI: 10.1108/EJIM-12-2023-1043.

Kesting, T., Gerstlberger, W., & Baaken, T. (2018). A benefit segmentation approach for innovation - oriented university - business collaboration. International Journal of Technology Management, 76(1–2), 58–80. DOI: 10.1504/IJTM.2018.088702.

Kurdve, M., Bird, A., & Lage - Hellman, J. (2020). Establishing SME - university collaboration through innovation support programmes. Journal of Manufacturing Technology Management, 31(8), 1583 - 1604. DOI: 10.1108/JMTM-09-2018-0309.

Kwong, C., Tasavori, M., & Cheung, C. W. M. (2017). Bricolage, collaboration and mission drift in social enterprises. Entrepreneurship and Regional Development, 29(7 - 8), 609 - 638. DOI: 10.1080/08985626.2017.1328904.

Lei, X. P., Zhao, Z. Y., Zhang, X., Chen, D. Z., Huang, M. H., & Zhao, Y. H. (2012). The inventive activities and collaboration pattern of university - industry - government in China based on patent analysis. Scientometrics, 90(1), 231–251. DOI: 10.1007/s11192-011-0510-y.

Li, B., Xu, C. J., Wang, Y. C., Zhao, Y., Zhou, Q., & Xing, X. D. (2024). Digital transfor mation, supply chain collaboration, and enterprise growth: Theoretical logic and Chinese practice. European Research on Management and Business Economics, 30(2). DOI: 10.10 16/j.iedeen.2024.100249.
Li, Q., Wang, Z. Y., Cao, Z. C., Du, R. Y., & Luo, H. (2015). Process and data fragmenta tion - oriented enterprise network integration with collaboration modelling and collaborati on agents. Enterprise Information Systems, 9(5–6), 468–498. DOI: 10.1080/17517575.20 13.879742.
Li, X. B., & Tan, J. (2020). Exploring the Role of University - Run Enterprises in Techno logy Transfer from Chinese Universities. Management and Organization Review, 16(4), 9 07 - 943. DOI: 10.1017/mor.2019.55.
Liang, L. M., Chen, L. X., Wu, Y. S., & Yuan, J. P. (2012). The role of Chinese universiti es in enterprise - university research collaboration. Scientometrics, 90(1), 253–269. DOI: 10.1007/s11192-011-0503-x.
Liu, C., Cao, J. M., Wu, G. D., Zhao, X. B., & Zuo, J. (2022). Interenterprise collaboratio n network in international construction projects: Evidence from Chinese construction ente rprises. Journal of Management in Engineering, 38(2). DOI: 10.1061/(ASCE)ME.1943 - 5479.0001006.
Lu, Y. (2021). The current status and developing trends of Industry 4.0: A Review. Infor mation Systems Frontiers, 1–20. DOI: 10.1007/s10796-021-10156-2.
Lu, Y. (2022). Implementing blockchain in information systems: A review. Enterprise Inf ormation Systems, 16(12), 2008513. DOI: 10.1080/17517575.2021.2008513.
Lu, Y., & Williams, T. L. (2021). Modeling analytics in COVID - 19: Prediction, preventi on, control, and evaluation. Journal of Management Analytics, 8(3), 424 - 442. DOI: 10.1 080/23270012.2021.1946664.
Lu, Y., & Yang, J. (2024). Quantum financing system: A survey on quantum algorithms, potential scenarios and open research issues. Journal of Industrial Information Integration, 100663. DOI: 10.1016/j.jii.2024.100663.
Lu, Y., Sigov, A., Ratkin, L., Ivanov, L. A., & Zuo, M. (2023). Quantum Computing and Industrial Information Integration: A Review. Journal of Industrial Information Integratio n, 100511. DOI: 10.1016/j.jii.2023.100511.
Lu, Y., Zheng, X., Li, L., & Xu, L. D. (2020). Pricing the cloud: a QoS - based auction ap proach. Enterprise Information Systems, 14(3), 334 - 351. DOI: 10.1080/17517575.2019. 1669827.
Lundberg, H., & Öberg, C. (2020). Teachers, researchers, but not innovators? Rethinking university - industry collaboration. Journal of Business & Industrial Marketing, 36(13), 1 61–173. DOI: 10.1108/JBIM-03-2020-0126.
Ma, C., & Yang, H. (2021). Low - carbon consumption with government subsidy under a symmetric carbon emission information. J. Clean. Prod., 318, 128423. DOI: 10.1016/j.jcle pro.2021.128423.
Miao, Y., Shi, Y., & Jing, H. (2024). Effect of digital transformation on labor income sha re in manufacturing enterprises: insights from technological innovation and industry - uni versity - research collaborations. Kybernetes, 53(13), 24 - 46. DOI: 10.1108/K-08-2023-1 414.
Paay, J., Kuys, B., & Taffe, S. (2021). Innovating product design through university - ind ustry collaboration: Codesigning a bushfire rated skylight. Design Studies, 76. DOI: 10.1 016/j.destud.2021.101031.

Peng, C., & Meng, Y. J. (2016). Empirical study of manufacturing enterprise collaboration network: Formation and characteristics. Robotics and Computer - Integrated Manufacturing, 42, 49–62. DOI: 10.1016/j.rcim.2016.05.005.

Pittayasophon, S., & Intarakumnerd, P. (2017). University and industry collaboration in Japan and Thailand: Influence of university type. Asian Journal of Technology Innovation, 25(1), 23–40. DOI: 10.1080/19761597.2017.1302399.

Preuveneers, D., Joosen, W., & Ilie - Zudor, E. (2018). Policy reconciliation for access control in dynamic cross - enterprise collaborations. Enterprise Information Systems, 12(3), 279 - 299. DOI: 10.1080/17517575.2017.1355985.

Safitri, V. A., & Sari, L. (2020). Research and Development (R&D), Environmental Investments, to Eco - Efficiency, and Firm Value. Indones. J. Account. Res., 22, 377–396. DOI: 10.33312/ijar.446.

Savarese, C., Huybrechts, B., & Hudon, M. (2020). The Influence of Interorganizational Collaboration on Logic Conciliation and Tensions Within Hybrid Organizations: Insights from Social Enterprise - Corporate Collaborations. Journal of Business Ethics, 173(4), 709 - 721. DOI: 10.1007/s10551-020-04557-7.

Sun, T. T., & Cheng, X. H. (2024). Research on the cross - border collaboration agility of technology - based enterprises and its driving factors. Technology Analysis & Strategic Management. DOI: 10.1080/09537325.2024.2336551.

Wang, Y. D., Hu, R. F., Li, W. P., & Pan, X. F. (2016). Does teaching benefit from university - industry collaboration? Investigating the role of academic commercialization and engagement. Scientometrics, 106(3), 1037 - 1055. DOI: 10.1007/s11192-015-1818-9.

Wulan, M. Q., & Petrovic, D. (2012). A fuzzy logic based system for risk analysis and evaluation within enterprise collaborations. Computers in Industry, 63(8), 739 - 748. DOI: 10.1016/j.compind.2012.08.012.

Xu, R., Shen, Y., Liu, M., Li, L., Xia, X., & Luo, K. (2023). Can government subsidies improve innovation performance? Evidence from Chinese listed companies. Economic Modelling, 120, 106151. DOI: 10.1016/j.econmod.2022.106151.

Yang, J. J., Li, S. L., & Li, C. F. (2023). Graduate education and enterprise innovation. Applied Economics Letters. Advance online publication. DOI: 10.1080/13504851.2023.2272695.

Ye, Z., & Lu, Y. (2022). Quantum science: A review and current research trends. Journal of Management Analytics, 9(3), 383 - 402. DOI: 10.1080/23270012.2022.2089064.

Yin, X. M., Li, F., Chen, J., & Zhai, Y. D. (2024). Innovating from university - industry collaboration: the mediating role of intellectual capital. Journal of Intellectual Capital, 24(6), 1550 - 1577. DOI: 10.1108/JIC-10-2022-0207.