

Impact of Digital Synergy of Industrial Chain on Regional Technological Innovation

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Abstract: The transformation of the industry chain digital collaboration makes each subject in the industry chain can rely on real-time three-dimensional data information to form a more efficient and scientific management decision-making system. However, at present, there are still obstacles that hinder the modernization level of the industry chain, such as the existence of short boards in core technology and low value-added industry in China. Therefore, this paper takes provincial panel data as the main data source for empirical analysis, focuses on the pain point problems in the digitization process, and provides scientific and reasonable new suggestions and new ideas for technological innovation. This paper mainly uses the fixed effects model to explore whether the digitalization synergy of the industrial chain can promote regional technological innovation to a certain extent, and to identify the main driving factors.

Keywords: Industrial chain digitization; Technological innovation; Digital-real integration.

1. Literature review

The report of the 20th CPC National Congress proposes to "accelerate the development of the digital economy, promote the deep integration of the digital economy with the real economy, and create internationally competitive digital industry clusters". Yuan Chun[9] and others emphasize that, if you want to build a new development pattern and promote the domestic economic cycle, it is necessary to realize the deepening of the collaboration between domestic regions and industries, and the digital-real fusion is an important development path to enhance economic efficiency. Based on this, this paper argues that industrial chain digital synergy refers to the digitization and intelligence of each link in the industrial chain through the integration and application of big data, Internet of Things and other emerging information technologies. Thus, it strengthens the collaborative industrial division of labor and information interoperability and sharing, and improves the efficiency and quality of the industrial chain.

1.1. Digital Synergy in The Industry Chain

On the macro level, scholars focus on the role of digital transformation in international competition. Intelligent infrastructure construction plays a supporting role in the transformation and upgrading of the manufacturing industry, in which the construction of industrial Internet should be put in the first place[4]. Xiong Lei[8] et al. put forward the guarantee system for the integrated development of manufacturing and the Internet from the three dimensions of financial and tax support, talent support, and basic environment, which indicates that the modular regionalized production will replace the centralized large-scale production in the future, and the influence of the scale effect will gradually diminish. And Yang Danhui[10] pointed out that the industrial chain has appeared the trend of regionalization and short chain synchronization, which has widened the division between countries. This will make developing countries, especially the less developed countries that are deep in the digital divide, have fewer opportunities to use their comparative advantages to obtain the dividends of

globalization, and exacerbate the contradiction of unbalanced development of the world economy. Although scholars' views point out the necessity and importance of promoting the digital transformation of the industrial chain in China, these studies are stuck at the level of theoretical analysis and lack of research on empirical issues, and there is little data support to prove that the intervention of intelligence directly promotes the development of regionalization of the industrial chain.

At the micro level, most scholars believe that it is necessary to focus on building a data integration platform, and study new initiatives to promote intelligence and digitization from the perspective of enterprises. Chen Xiaodong[0] and others believe that the digital economy mainly enhances the resilience of the industrial chain through four aspects: promoting the flow of factors, building a digitalization platform, advancing industrial technological innovation, and cultivating leading enterprises. Song Hua and Yang Yudong[7] emphasize that enterprises should independently realize the integration of business, logistics, information and capital flows among themselves through the benefit mechanism. However, in this process, public administration should also play an important safeguard role. The above literature does not further indicate what development paths should be adopted for different enterprises, nor does it explore the extent of positive and negative effects of change for enterprises at different positions in the industry chain.

1.2. Industrial Chain Digitization and Regional Technological Innovation

For the industrial chain digital development on the regional technological innovation of the impact of the path of research literature is less, the research perspective is also more focused, mainly the following two entry points:

The industry chain of different industries, such as agriculture and manufacturing, is differentiated to explore the innovation performance. Ren Baoping[6] believes that the implementation of the strategy of "digital technology + high-end intelligent manufacturing" should be promoted in the new type of industrialization, to promote China's real economy to realize the transformation from the low-end manufacturing to

the high-end manufacturing of the value chain[2]. Guo Yanfeng et al.[3] believe that industrial digitization has a direct role in promoting the resilience of the agricultural industry chain, and at the same time improves the level of agricultural industry chain innovation.

Digital industrialization and industrial digitization, as two ways to promote new industrialization in the context of digital economy, are both interconnected and differentiated from each other, and they synergistically promote the construction of modern industrial system[6]. Pang Lei and Ding Wenli[5] prove that digital technology innovation assumes part of the mediating effect of digital economy, digital industrialization, industrial digitization and the control ability of the key links of the industrial chain, and the intensity of the mediating effect of enhancing the centrality of the industrial chain is higher than the mediating degree of the industrial chain, by using the level of digital technology innovation, measured by the digital technology patent granting rate, as a mediating variable.

In conclusion, the above studies focus on the introduction of new technologies to the industry and the reconstruction of enterprise production process, management mode, and business process to adapt to the digitalization demand, but the industrial chain digitization focuses more on the digital transformation of all the links in the whole chain, as well as the enhancement of the efficiency of the whole industrial chain and the sharing of resources.

2. Theoretical Analysis and Research Hypotheses

2.1. Mechanism of Action: Digital Connectivity - Knowledge Reorganization - Innovation Emergence

In the era of digital economy, the digital collaboration of industrial chain has reconstructed the traditional knowledge flow and innovation mode through digital technology. This paper constructs a transmission model of "digital connection-knowledge reorganization-innovation emergence", which aims to reveal the internal mechanism of how digital synergy promotes regional technological innovation through technological empowerment and organizational change. Digital connectivity refers to the efficient connection of upstream and downstream enterprises in the industrial chain, research institutions, government and other innovation subjects through digital technology. It can break down information silos, reduce transaction acquisition costs, and enhance the real-time and precision of cross-organizational collaboration. Relevant data are the number of connected devices on the industrial Internet platform, the number of cross-enterprise data interfaces, and the coverage rate of supply chain collaboration systems. Knowledge reorganization refers to the formation of a new knowledge system through knowledge integration, reconstruction and re-creation on the basis of digital connectivity. It can transform dispersed tacit knowledge into explicit knowledge and generate new knowledge through collaborative R&D. For example, Huawei builds joint laboratories with universities and research institutions, generating an average of 1000+ patents per year, which shows the high efficiency of its innovation. Specific indicators include the number of cross-field joint patent applications, the amount of technology transaction contracts, and R&D investment. Innovation

emergence refers to the generation of breakthrough technological innovations through non-linear interactions on the basis of knowledge reorganization. The result is the formation of new technological tracks or even the development of disruptive products and the reconstruction of business models, such as the development of smart grid-connected vehicles and the emergence of shared manufacturing platforms. Measurement indicators include the number of invention patents authorized per 10,000 people and the conversion rate of technological achievements.

2.2. Formulation of Hypotheses

2.2.1. Basic situation of digital synergy in the industry chain

Digitization provides impetus for improving the resilience of the industrial chain and the reliability of the supply chain, and can provide strong support for China's position in the global industrial chain. However, at present, the integrity of China's industrial chain and the coordination of the industrial system are lacking, and the autonomy rate of important production links in some industries is low. The popularization of emerging general technology in the modernized industrial system is not widespread enough, and the application of digital technology in different regions is unbalanced. This has led to a poor effect of digitalization in promoting the synergy of the modernized industrial chain.

2.2.2. Basic situation of regional technological innovation

Technological proximity has a significant positive impact on the quality of technological innovation. Higher levels of technological proximity between regions provide similar technological knowledge, which makes it easier for regions to reach a consensus on common interests and promote in-depth exploration in the same field to expand the depth of knowledge, thus making innovative technologies more refined and complex, and thus improving the quality of innovation. Digital collaboration in the industrial chain can simultaneously empower the supply and demand sides, alleviate the problem of information asymmetry, effectively reduce the transaction costs of innovation, talent and other key factors in the flow process, and contribute to the further expansion of scientific and technological openness and cooperation and the enhancement of regional innovation efficiency.

In this case, this paper proposes hypothesis 1: the digital synergy of industrial chain can promote regional technological innovation to a certain extent.

3. Variable Selection and Model Construction

3.1. Modeling

In order to verify the impact of industrial chain digital synergy on regional technological innovation, this paper constructs an individual fixed effect model and conducts empirical tests, and the model is set as follows:

$$NVP = a_0 + a_1EI + a_2\log(FI) + RD + \varepsilon_i \quad (1)$$

NVP is the explanatory variable of this paper, which refers to the number of effective patents in each province, and EI, FI and RD are the explanatory variables of this paper. EI denotes the development data of the integration of dualization, specifically refers to the informatization and e-commerce situation of enterprises in the sub-region (the number of websites owned by enterprises), which can reflect the

penetration rate of enterprises' digital R&D and design tools and the application rate of Internet platforms. FI refers to the number of foreign investment. RD denotes the intensity of enterprises' R&D investment in each province. ε_i RD denotes the R&D investment intensity of enterprises in each province. is a random error term, because the actual labor human capital

stock HC is not significant in the preliminary regression effect, so the influence factor is removed and subsumed in the random error term.

3.2. Variable Selection and Measurement

Table 1. Variable Description

Level 1 indicators	Secondary indicators	Specific indicators	Indicator characteristics
Regional technological innovation	Number of innovation patents	Number of active patents by province	+
Indicators of digital synergy in the industry chain	Digitization rate	Degree of enterprise informatization	+
	Financial support	Number of foreign investments	+
	microcost	Intensity of corporate R&D investment	+

The variables selected in this paper are all from the statistical yearbooks of Inner Mongolia, Zhejiang, Guangdong and Sichuan from 2014 to 2024, and the two major directions of "digitization" and "synergy" are considered comprehensively from multiple dimensions, and

the missing variables are made up by interpolation.

4. Empirical Results and Analysis

4.1. Descriptive Analysis

Table 2. Descriptive analysis of variables

	EI	FI	NVP	RD
Mean	39493.409	6274.681	116835.977	9713426.477
Median	35869.5	2904.5	45506	6280892.5
Maximum	94392	24141	66500	34266367
Minimum	3320	264	1444	1004406
Std. Dev.	29687.114	7691.167	165305.567	9206441.794
Skewness	0.375	1.403	1.873	1.026
Kurtosis	1.948	3.468	5.606	3.173
Jarque-Bera	3.059	14.846	38.182	7.782
Probability	0.216	0.001	5.113	0.020
Sum	1737710	276086	5140783	427390765
Observations	44	44	44	44

Based on the tabular data provided in Table 2, we can characterize the four variables (EI, FI, IMP, and RD). The EI standard deviation is 29687.11, skewness is 0.375 (right skewed), kurtosis is 1.949, which is flatter as compared to a normal distribution, the Jarque-Bera statistic is 3.06 with a probability of 0.217, and the result is not significant, the data may obey a The FI standard deviation is 167530.17 The skewness is 403485392.1 for extreme right skewness, the kurtosis is 468009980.5 image for extreme spiking, the Jarque-Bera statistic is 84657086.38, the probability is 0.0006, the result is significant, the data does not obey a normal distribution. the IMP standard deviation is 5570.92. Skewness is 873166573.1 the image is extreme right skewed, kurtosis is 606137048.3 the image is also extreme spiky, Jarque-Bera statistic is 18292202.7, probability is 0.113, the result is not significant. RD standard deviation is 794, skewness is 025529755, the image is right skewed, kurtosis is 173714987 extreme spiky, the Jarque-Bera statistic is 782922135, probability 0.020, the result is significant and does not obey normal distribution. The data distribution of EI and IMP is relatively more centralized, the data distribution of FI and RD is extremely skewed with very high kurtosis, there are extreme values or outliers in the data, and the number of observations for all variables is 44.

4.2. Correlation Analysis

Table 3. Variable Correlation Analysis

Correlation Probability	EI	FI	RD
EI	1.0000	----	----
FI	0.900126	1.0000	----
RD	0.951258	0.939637	1.0000
	0.0000	0.0000	----

Table 3 shows a highly positive and statistically significant correlation between these three explanatory variables, which suggests that there is an intrinsic link or common influencing factor for these variables. 0.900 indicates that the number of corporate websites is significantly positively correlated with the scale of foreign investment, and it is speculated that regions with more foreign investment tend to have a high degree of economic openness, and that enterprises tend to set up websites in order to adapt to the demands of international competition and cooperation, and are more inclined to establish websites in order to enhance their digital image. Foreign-invested enterprises may push local enterprises to improve their informatization level through the technology spillover effect. 0.951 shows that the number of websites and

the intensity of R&D investment are highly synchronized. Regions with high R&D investment usually have stronger innovation capability, and enterprises need to display their technological achievements and attract cooperation resources through websites. Digital tools are an important channel for the transformation of R&D results, such as online technology trading or intellectual property display. The correlation coefficient between foreign investment and R&D investment intensity is 0.940, indicating that foreign investment is closely related to regional R&D investment intensity. Foreign investment tends to enter regions with well-developed R&D infrastructure and strong innovation policy support. Meanwhile, foreign enterprises may push local governments and enterprises to increase R&D investment through direct investment or technical cooperation.

4.3. Smoothness Test

The p-value of the joint test based on the chi-square distribution and the standardized test based on the Z-statistic

are both less than 0.05, which indicates the rejection of the original hypothesis, suggesting that the residual series is overall smooth, i.e., there is no unit root. Meanwhile, there is a significant difference in the smoothness of residuals in different cross-sections (different regions). The main reasons may lie in the following three aspects: first, there may be structural breakpoints in cross-section 2 (cross-section data of Zhejiang Province), leading to a decrease in the test validity. Second, there are only 10 observations in each cross-section, and the small sample amplifies the random fluctuations and affects the test results. Third, the lag order is 0, which may not fully capture the dynamic characteristics of the series, leading to the failure of the test in some cross-sections.

Table 4. ADF test results

Method	statistic	Prob**
ADF - Fisher Chi-square	26.6549	0.0008
ADF-C h oi Z-stat	-3.31268	0.0005

Table 5. Cross-section Breakdown Results

Cross-section	P-value	Conclusion ($\alpha=0.05$)	implied meaning
1	0.0355	Rejection of the original hypothesis	The residuals of this cross section are smooth
2	0.3174	No rejection of the original hypothesis	The residuals of this cross-section may be non-stationary
3	0.0696	No rejection of the original hypothesis	Close to the significance boundary, need to be interpreted with caution
4	0.0021	Rejection of the original hypothesis	Strong evidence in favor of residual smoothing

In conclusion the ADF test results indicate that the residual series show smoothness ($p<0.05$) at the overall level, supporting the possible existence of a cointegrating relationship between the variables. However, the heterogeneity between cross sections suggests the need to be alert to grouping differences in the data or model setting issues. For the follow-up study, we will also use robust standard errors that make the model less sensitive to heteroskedasticity.

4.4. KAO test

Table 6. KAO test results

ADF	t-Statistic	Prob.
	-1.572138	0.058
Residual variance	2.17E+08	
HAC variance	1.91E+08	

The ADF statistic corresponds to a p-value of 0.0580 (here we choose $\alpha=0.05$), accepting the original hypothesis that there is no cointegration relationship between the variables. However, the cointegration relationship is at the edge of statistical significance, and we need to combine the economic theory with the practical background to judge it carefully and explore it further. The reason for this may be that non-stationarity is not completely eliminated, and although the preliminary ADF test shows that the residuals are overall stable ($P<0.05$), the cross-sectional heterogeneity weakens the robustness of the cointegration relationship to a certain extent. Secondly some important variables may have been omitted, such as not controlling for potential covariates such as human capital (HC) and regional policies, which may lead to the residuals containing systematic information and

interfering with the cointegration relationship. At the same time, the absence of cointegration relationship has some implications for our policy making, and the government should formulate targeted policies according to the characteristics of different provinces, e.g., Guangdong focuses on the linkage between foreign investment and innovation, while Inner Mongolia needs to strengthen local R&D.

4.5. F-test

Table 7. F-test results

	sum of squares of the residuals
Sum of squares of residuals for mixed effects models	14725362407.35931
Fixed effects model residual sum of squares	105294985569.5951

The F-test formula yields an F-value much greater than 0.05, and a fixed-effects model is chosen over a mixed-effects model.

4.6. Hausman Test

Table 8. Hausman test results

Test Summary	Chi-Sq. Statistic	Chi-Sq.d.f	Prob.
Cross-section random	227.571720	3	0.0000

The specific results of Hausman's test showed a chi-square statistic of 227.57, a degree of freedom of 3, and a p-value much less than the level of significance, so the original hypothesis was rejected and the fixed effects model was more appropriate than the random effects model.

Table 9. Analysis of Variance of Variable Coefficients

variant	fixed-effects coefficient	random effects coefficient (REC)	variance (statistics)	P-value	reach a verdict
EI	4.851	-1.261	0.908	0.0000	Significant difference in coefficients
LOG (FI)	-27694.28	-29707.00	3.0e+7	0.7135	The difference in coefficients is not significant
RD	0.0168	0.0248	0.000002	0.0000	Significant difference in coefficients

We specifically analyze the coefficient difference analysis of the variables and learn that the difference between the fixed and random effect estimates of the number of enterprise websites and the R&D investment intensity of enterprises in each province is significant, which is a necessity to support the fixed effect model. Secondly, the difference in the logarithm of foreign investment is not significant, probably due to its weak correlation with individual effects, but the overall test is still dominated by the fact that most of the variables are significantly different.

4.7. Regression Results

Table 10. Fixed effects model regression results

Variable	Coefficient	Std. error	t-Statistic	Prob.
C	-18095.34	73967.57	-0.244639	0.8081
EI	4.851144	1.074119	4.516392	0.0001
LOG (FI)	-27694.28	9875.513	-2.804338	0.0080
RD	0.016800	0.001808	9.292313	0.0000

$$NVP = -18095.34 + 4.851144EI - 27694.28\log(FI) + 0.016800RD + \varepsilon_i \quad (2)$$

Using the PLS method to regress the panel data on the fixed-effects model, we get the coefficient of the constant term is -18095.34, which is insignificant, indicating that after controlling for other variables, the explanatory power of the intercept term on the explanatory variable "effective number of patents" is insufficient, which suggests that most of the differences in the intercept are absorbed by the individual fixed effects. The t-test results for the explanatory variables EI and RD show that they are highly significant, indicating that the digital transformation of enterprises has a positive impact on innovation output, and that the positive impact of enterprise R&D investment on the number of patents exists stably, but the marginal effect may be limited by the efficiency of the inputs or specific problems in the process of policy implementation. Secondly, the adjusted decidable coefficient is 0.985436, which indicates that the goodness of fit is extremely high and the fit is better. The F-statistic is 485.90, which also further indicates that the joint independent variables have significant explanatory power on NVP. However, the coefficient of $\log \log(FI)$ of foreign investment in the independent variables is significantly negative, indicating that the number of effective patents decreases by 276.94 patents for every 1% increase in foreign investment, a result that may be related to the crowding-out effect of technological monopoly of foreign firms or innovation in the region, and will not be explored here.

4.8. Heterogeneity Test

This study examined the heterogeneous effects of industrial chain digital synergy (EI) on regional technological innovation (NVP) through group regression and interaction term analysis. The results show that there are significant regional differences in the impact of digital synergy on technological innovation.

Specifically, as shown in Table 11, the impact of digital synergy on technological innovation in Inner Mongolia is significantly negative (coefficient = -1.411, $p < 0.01$), which may be due to the fact that Inner Mongolia's economic structure is dominated by resource-based industries and the marginal effect of digital synergy is low. The impact of digital synergy on technological innovation in Zhejiang, Guangdong, and Sichuan are all insignificant, indicating that the role of digital synergy has not yet fully emerged or has been fully tapped in these provinces. Regarding the control variables, the intensity of R&D investment (RD) is significantly positive ($p < 0.01$) in all provinces, indicating that R&D investment is a key factor driving technological innovation. Foreign investment (FI) is not significant in some provinces, but is significantly positive in the national sample (coefficient = 8.542, $p < 0.01$).

In addition, to further test for regional heterogeneity, this study introduces an interaction term between region and digital synergy (EI_region). The results in Table 12 show that the coefficient of the interaction term is 1.057 ($p < 0.001$) and the t-statistic is -6.06, indicating that the interaction between region and digital synergy has a significant positive effect on technological innovation. This result suggests that there is significant regional heterogeneity in the impact of digital synergy on technological innovation. Specifically, in regions with higher levels of digital synergy, the positive impact of digital synergy on technological innovation is stronger, while in regions with lower levels of digital synergy, the impact of digital synergy on technological innovation is weaker and may even be negative.

Combined with the grouped regression results, the effect of digital synergy on technological innovation is significantly negative in Inner Mongolia (coefficient = -1.411, $p < 0.01$), while it is not significant in Zhejiang, Guangdong, and Sichuan. This suggests that inter-regional technological gaps and economic fundamentals are important factors contributing to heterogeneity.

Table 11. Heterogeneity analysis of districts

	(1) Inner Mongolia	(2) Zhejiang	(3) Guangdong	(4) Sichuan
EI	-1.411** (-4.52)	2.400 (1.84)	-1.051 (-0.72)	-3.617 (-0.62)
RD	0.00495*** (8.78)	0.0181** (3.81)	0.0231*** (14.07)	0.0133 (1.74)
FI	1.423 (0.59)	-15.14 (-1.65)	3.837 (2.20)	0.362 (0.03)
_cons	3669.0 (1.41)	-184511.3** (-3.50)	-143436.9 (-2.15)	73982.3 (0.67)
N	11	11	11	11

Note: t statistics in parentheses, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 12. Further regional heterogeneity tests

variable	statistic
EI	-5.740*** (-9.12)
RD	0.0187*** (-10.11)
FI	8.542*** (-4.86)
EI_region	1.057*** (-6.06)
_cons	-7334.5 (-1.03)
N	44

Note: t statistics in parentheses, * p<0.05, ** p<0.01, *** p<0.001

4.9. Robustness Tests

By performing manual assisted regression on the panel data and constructing an auxiliary regression equation for the sum of squares of residuals on the explanatory variables, we find that the joint significance of their explanatory variables is poor, and therefore there is no heteroskedasticity. Subsequently, by adjusting the standard errors, comparing the ordinary standard errors with the clustered robust standard errors and re-estimating the model, we find that the coefficient significance changes are small, and therefore we consider the model to be more robust.

5. Conclusions and Outlook

5.1. Conclusion of the Experiment

Promoting the digital transformation of enterprises, such as website construction subsidies and digital training, can significantly enhance innovation capacity and promote patent output, thus boosting regional technological innovativeness. Significant differences in foreign investment in different regions may distort the coefficients, but the foreign investment variable has a certain technological crowding-out effect, with foreign firms occupying a technological dominant position and inhibiting local original innovation to a certain extent.

5.2. Policy Recommendations and Implications

5.2.1. Government digital transformation support

First, governments at all levels should provide financial subsidies for the construction of enterprise websites. Tiered subsidies can be adopted to provide tax credits or additional deductions for research and development expenses for large enterprises to encourage them to establish digital research and development platforms. A special digital transformation fund should be set up for small and medium-sized enterprises, and subsidies should be provided in grades according to enterprise size. Second, the promotion of digital tools. Build a national "enterprise digital innovation platform", integrated patent database, technology trading market and online collaboration tools, while carrying out the "1,000 enterprises digital training program", joint colleges and universities and technology enterprises to provide customized training courses. Third, deepen the application of technology. Encourage enterprises to adopt artificial intelligence and big data analytics to optimize the R&D process, and provide demonstration incentives for successful cases. It is worth noting that the application of blockchain technology in intellectual property

protection should be promoted and a tamper-proof patent depository system should be established.

5.2.2. Foreign investment guidance and regulation

First, the establishment of a negative list and access mechanism. The Negative List for Foreign Investment Access has been dynamically updated to restrict the entry of foreign investment in low-tech and high-pollution industries. It also implements "green channel" approval for foreign investment in high-tech fields. Second, strictly enforce anti-monopoly and fair competition. Strengthen the national security review of foreign mergers and acquisitions to prevent the loss of core technologies. Step-by-step fines have been imposed on monopolistic behavior, and foreign enterprises with excessive market shares have been forced to split up.

5.2.3. Improving R&D efficiency

First, improve the performance evaluation system. A third-party organization has been introduced to conduct a full-cycle evaluation of R&D projects, focusing on the patent conversion rate. Second, vigorously promote the market-oriented transformation mechanism. Establishing a national patent trading platform and supporting the pilot of patent pledge financing and securitization. It also encourages enterprises to set up "open innovation laboratories" and share experimental equipment and data resources with universities. Third, promote the deep integration of industry, academia and research. Pilot "innovation enclaves" in key cities to attract research institutions to set up branches in industrial parks. Moreover, the supervision of R&D funds should not be relaxed, and the strengthening of industry-university-research cooperation should avoid "heavy investment and light transformation", so as to ensure that the investment flows to the core technological innovation.

5.2.4. Implementing regional differentiation strategies

For eastern provinces, such as Zhejiang and Guangdong, they can build on their natural advantages to construct "international innovation corridors", attracting the world's top R&D centers to settle there, and supporting international talent communities and cross-border data free ports. At the same time, promote the pilot "digital free trade zone", allowing foreign-funded R&D data to flow across borders on the premise of meeting national security standards. For the western provinces, such as Inner Mongolia can rely on the advantages of clean energy, the establishment of "zero-carbon technology research and development base", subsidizing the integration of wind and storage patents. Sichuan can create a "military-civilian integration innovation demonstration zone" to promote the transformation of dual-use technologies in aerospace, nuclear energy and other fields. Most importantly, differentiation does not mean isolation of the two sides, the state can strengthen inter-regional coordination and linkage, the establishment of "cross-regional innovation fund" to support the transfer of technology from the east to the west, according to the amount of technology output to the eastern enterprises tax concessions. At the same time, an "innovation enclave economic zone" should be established to encourage western enterprises to set up research and development outposts in the east and share innovation resources and development results.

5.3. Shortcomings

The study has some limitations, firstly a dynamic panel model has not been introduced to control for the path dependence of the number of patents. Secondly, human

capital and policy dummy variables can be added to enhance the explanatory power. Finally, the operability of the policy recommendations needs to be explored, and their effectiveness will be combined with the actual situation of the region, and present different forces.

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