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The Impact of New Quality Productivity on High-quality Development of New Urbanization: An Empirical Analysis Based on Panel Data of Five Provinces and Regions in Northwest China

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Abstract

Based on the panel data of 31 prefecture-level cities in the five northwest provinces and regions from 2010 to 2024, this paper explores the impact and mechanism of new quality productivity on the high-quality development of new urbanization from the perspective of productivity transformation. The empirical results show that:(1)New quality productivity has a significant positive promotion effect on the high-quality development of new urbanization, and this conclusion is still valid after the robustness and endogenousness tests.(2)Entrepreneurial activity plays a positive mediating role between new quality productivity and high-quality development of new urbanization, and the business environment produces a positive moderating effect through new quality productivity.(3)The heterogeneity of new quality productivity has a nonlinear impact on the high-quality development of new urbanization in the five northwest provinces and regions. Through this study, it helps the five northwest provinces and regions to break through the bottleneck of new urbanization development and provides theoretical and practical reference for regional high-quality development.

Keywords: New-quality productivity; new urbanization; high-quality development; mediating effect

1. Introduction

The process of global urbanization has entered a critical stage of quality improvement and sustainable transformation. The academic community has abandoned the traditional model of simply pursuing urban scale expansion [1], and generally focused on core issues such as connotative growth of urbanization, optimization of living environment, equalization of public services and green low-carbon transformation. The theoretical systems such as sustainable urbanization and urban stock renewal [2]

have become the mainstream research framework of global urban governance, providing important theoretical support and practical reference for the transformation and upgrading of urbanization in various countries. In China, the high-quality development of new urbanization is the inevitable direction of urbanization development and a powerful engine for building socialist modernization in an all-round way [3]. By the end of 2025, China's urbanization rate has increased to 67.90 %, which is still in the stage of accelerated development of Northam curve, and is expected to reach 78 % by 2035. The 2026 Central City Work Conference clearly pointed out that China's urbanization is shifting from a period of rapid growth to a new stage of stock quality and efficiency improvement and connotative development, emphasizing the development of new productivity as an important engine to promote urban renewal with high quality. Different from the steady-state mature stage of urbanization in developed countries in Europe and the United States and the formation of a gradient-coordinated urban system, China's urbanization has the characteristics of rapid growth, large volume and heavy transformation tasks, and the phased structural contradictions are more prominent. At present, China's new urbanization still faces outstanding problems such as the imbalance between land and population urbanization, the pressure of environmental pollution control, the lag of industrial transformation and upgrading, and the insufficient supply of public services for the floating population [4]. The traditional scale expansion development path has encountered obvious bottlenecks. It is urgent to rely on new productivity to break the shackles of development, inject new momentum into the high-quality development of urbanization, and explore the transformation path of modern urbanization that suits China's national conditions.

At present, the research on the high-quality development of new urbanization mainly focuses on the dual carbon target [5], water environment quality [6], scientific and technological innovation [7], population flow [8], digital economy [9], public service supply [10]and so on. The research area is mostly the eastern developed provinces and urban agglomerations. At the same time, the research on new quality productivity is mainly carried out from both qualitative and quantitative aspects. Qualitative aspects include connotation interpretation [11], feature analysis [12], production logic [13] and so on. Some literature also expounds the influence of new quality productivity on rural revitalization [14], industrial structure [15], urban-rural integration [16]and puts forward development path selection and countermeasures from a quantitative perspective. These results provide a solid theoretical support and practical reference for the research on the high-quality development of new urbanization.

However, there are few studies on how new-type productivity affects new-type urbanization, and

there are few results on the interaction between the two. Although some studies have confirmed that new-type productivity has a significant role in promoting the high-quality development of new-type urbanization [17], this paper takes the whole country as the object and lacks specific regional targeted analysis. Northwest China is an important gateway for China to open to the west and an important channel connecting the East and the West. At the same time, the five provinces and regions are facing common problems such as weak ecological background, thin industrial foundation and lack of human resources. There is an urgent need and practical exploration in the development of new quality productivity and the construction of new urbanization. In view of this, based on the panel data of 31 prefecture-level cities in the five provinces of Northwest China from 2010 to 2024, this paper incorporates new productivity and high-quality development of new urbanization into a unified research framework, and uses entrepreneurial activity and marketing environment as intermediary mechanisms and regulatory mechanisms to analyze the interaction between the two and the path of action.

The possible marginal contribution of this paper is as follows : in terms of research content, it systematically tests the mediating role of entrepreneurial activity and the moderating role of business environment, which is in line with the deployment requirements of China's 2026 Central City Work Conference "relying on reform and opening up to enhance urban kinetic energy" ; in terms of research perspective, it breaks through the perspective of traditional productivity and re-emphasizes the impact of productivity on the high-quality development of new urbanization, which further broadens and enriches the research field. On the impact mechanism, it provides a benchmark analysis-heterogeneity test-mechanism analysis research framework, opens the mechanism black box between new quality productivity and new urbanization development, and provides a targeted reference for the five northwestern provinces to solve the contradiction between ecology and development and promote the development of connotative urbanization.

2.Theoretical Basis and Research Hypotheses

2.1New productivity and high-quality development of new urbanization

Marxist productivity theory holds that the change of production mode is the fundamental driving force of social development, and the leap of productivity has become the iterative evolution of the spatial form and governance mode of human society [18].

As an advanced productive force led by technological innovation and oriented toward high-quality development, new quality productive forces are highly aligned in both theoretical logic and practical

paths with the core essence of new urbanization: people-oriented, quality first, and green collaboration. Both forms a dynamic empowerment closed loop through factor restructuring, structural optimization, and governance upgrades. Specifically, new quality productive forces build a high-quality development driving system for new urbanization through four dimensions: population empowerment, economic quality improvement, public service upgrades, and ecological optimization, injecting momentum into their high-quality development.

Firstly, technological innovation empowerment drives high-quality population agglomeration and transformation [19]. Its core mechanism is to rely on core breakthroughs such as digital technology and artificial intelligence to promote the improvement of population quality through two major paths. On one hand, major industrial technological innovation gives rise to strategic emerging industries, creating a large number of high-skilled and high value-added jobs, creating a talent siphoning effect, and optimizing the age and skills structure of the urban population[20]; On the other hand, relying on institutional innovation to improve mechanisms for talent cultivation, introduction, and incentives, and activating individual innovation vitality; At the same time, by optimizing the equalization of public service allocation through intelligent technology, development opportunities are ensured, ultimately achieving a transformation from population concentration to quality improvement, aligning with the new urbanization goal of modernizing people.

Secondly, factor restructuring promotes high-quality urban economic development. The new productivity takes scientific and technological innovation as the core, and realizes the transformation of production factors from extensive investment to precise allocation by reshaping the flow of urban and rural factors, promoting the high-end upgrading of industrial structure, optimizing the layout of urban space and innovating the utilization of resources. It not only breaks the bottleneck of diminishing marginal benefits of land, capital and other factors in traditional urbanization, but also cultivates new growth points of urban economy through industrial digitization and digital industrialization, and provides sustainable economic support for promoting the high-quality development of new urbanization.

Thirdly, digital intelligence can improve the efficiency of urban public service supply. The digital and intelligent technology promoted by the new quality productivity promotes the transformation and upgrading of public services through a dual path [21]. One is to optimize the public service process and reduce the cost of public service supply by taking “Internet + government service” as the carrier [22] ; the second is to build a public service demand perception system based on big data and Internet of Things

technology, promote cross-regional and cross-disciplinary collaborative sharing of resources, realize the transformation from passive supply to active perception, improve the accuracy and inclusiveness of urban public services, promote residents' well-being and urban belonging, and facilitate high-quality and efficient development of new urbanization.

Fourthly, green and low-carbon optimization optimizes the carrying capacity of urban ecological environments. New quality productive forces promote the transformation of urbanization development models toward green and low-carbon through three-dimensional collaborative innovation through technological innovation, institutional improvement, and governance upgrades. On the technological front, innovation-driven efforts will promote the green and low-carbon transformation and upgrading of the economy, industry, and energy structure, forming green productive forces; At the institutional level, innovate mechanisms such as carbon trading and green finance to guide production factors toward green industry agglomeration; At the governance level, a digital ecological monitoring system is being built to improve the precision of environmental governance [23]. The three will work together to reduce resource consumption and environmental pollution, solve the traditional urbanization dilemma of pollution first, then remediation, and provide ecological security guarantees for high-quality development of new-type urbanization.

In summary, new productivity systematically empowers through the four dimensions of population, economy, public services and ecological environment, and injects core kinetic energy into the high-quality development of new urbanization. Therefore, the following assumptions are made:

H1: New quality productive forces have a significant positive and positive effect on the high-quality development of new-type urbanization.

2.2 Intermediary Mechanism

Entrepreneurial activity refers to the number and frequency of newly established enterprises within a certain region, and is a core indicator of market entity vitality [24]. Marxist reproduction theory emphasizes that [25] the rational allocation of production factors and the realization of value need to be completed through the practical activities of market players, and entrepreneurial behavior is an important path for the transformation of technological achievements and industrial opportunities generated by new productivity into realistic development momentum. Its logic of enabling entrepreneurial activity is mainly reflected in the following aspects : First, technological innovation breakthroughs have spawned new industries and new formats, providing diversified scenarios and market space for entrepreneurial

activities, and reducing technological thresholds and entrepreneurial costs [26] ; second, institutional innovation activates the entrepreneurial willingness of micro-subjects by optimizing the market environment, and promotes the development of entrepreneurial activities from sporadic dispersion to clustering.

At the same time, new quality productivity promotes entrepreneurial activity through multiple paths [27] : in the population dimension, the siphon effect of jobs formed by the agglomeration of entrepreneurial enterprises attracts high-quality talents, promotes the balanced flow of population between urban and rural areas, and optimizes the urban population structure ; in the economic dimension, entrepreneurial clusters cultivate urban characteristic industries through technology spillovers and industrial chains to enhance economic resilience ; in terms of public services, entrepreneurs participate in the construction of public service supply, enrich the types of service supply, and improve the efficiency of supply ; in the ecological dimension, scientific and technological innovation and entrepreneurship have spawned new technologies and business models, focusing on the development and application of green and low-carbon industries, and helping urban green and people-oriented development[28].

Therefore, this study argues that new quality productive forces, as a new form of production, activate entrepreneurial activity through empowerment through technology and institutions. Entrepreneurial activity empowers high-quality urbanization development through population agglomeration, economic efficiency, service quality improvement, and ecological optimization pathways, forming an intermediary transmission chain of "new quality productive forces—entrepreneurial activity—high-quality development of new urbanization." Based on this, hypotheses are proposed:

H2: New quality productive forces indirectly promote high-quality development of new urbanization by increasing entrepreneurial activity.

2.3Regulation Mechanism

Taking the public infrastructure environment, talent environment and economic environment as the core indicators to describe the business environment, it is believed that it can have a regulatory effect on the high-quality development of new urbanization through the transmission path of new quality productivity or the intermediary path of entrepreneurial activity.

Firstly, the optimization of the business environment strengthens the green and intensive empowerment of new quality productivity through green transformation [29]. Drive the upgrading of digital infrastructure industry with the help of new information infrastructure such as 5G network and

big data center. With the help of smart grid, energy storage facilities and advanced ecological infrastructure, we can reduce carbon emissions and improve resource utilization efficiency, and help the new urbanization development model to transform into green and intensive.

Secondly, the improvement of the business environment reshapes the empowerment path of new quality productivity to the high-quality development of new urbanization by optimizing the population structure and resource allocation. Through educational adaptation and policy incentives, we will build a high-quality talent ecology and cultivate high-quality talents with cross-border integration capabilities [30]; through data elements, we can optimize the efficient agglomeration of innovation elements between cities and between urban and rural areas, and promote the transition of new urbanization from scale expansion to people-oriented, green intensive and innovation-driven.

Thirdly, the improvement of the business environment promotes the deep integration of new quality productivity into the development of new urbanization by cultivating new drivers of social and economic growth [31]. Upgrading the urban commercial space structure with new business forms such as e-commerce and smart cultural tourism; the servitization of manufacturing industry, the linkage of digital agriculture and the extension of innovation chain can enable the integration of industry and city, and help the transformation of new urbanization from scale expansion to green intensive, innovation-driven and regional coordination mode.

In summary, a high-quality business environment can stimulate market vitality and development potential, accelerate economic restructuring and industrial upgrading, and thus support the high-quality development of new urbanization. Accordingly, this paper assumes that:

H3: Business environment plays a significant regulatory role between new productivity and high-quality development of new urbanization.

3Research Design

3.1 Model construction

3.1.1 Basic model construction

In order to study the impact of new productivity on the high-quality development of new urbanization, an empirical analysis model is constructed based on the panel data of 34 prefecture-level cities in the five northwestern provinces from 2010 to 2024, as follows [32]:

$$Haq_{it} = \alpha_0 + \alpha_1 Nmp_{it} + \sum_m \alpha_m Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (1)$$

Among them, i denotes the city, t denotes the year, Haq represents the high-quality development

index of new urbanization, Nmp represents the development index of new productivity, Contrals denotes the control variable, α_0 is a constant term, α_1 is the influence coefficient of new productivity on the high-quality development of new urbanization, αm is the coefficient of each control variable.

3.1.2 Mechanism test model

(1) Mediation effect model

In order to explore the mechanism of new-type productivity on the high-quality development of new-type urbanization, this paper introduces entrepreneurial activity as a mechanism variable to examine whether new-type productivity has a positive effect on the high-quality development of new-type urbanization by enhancing entrepreneurial activity, and constructs a mechanism test model. On the basis of stepwise linear regression, Bootstrap empirical test is carried out to verify the reliability of the intermediary mechanism. The specific model is as follows:

$$Mid_{it} = \beta_0 + \beta_1 Nmp_{it} + \sum_m \beta_m Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (2)$$

$$Haq_{it} = \lambda_0 + \lambda_1 Nmp_{it} + \lambda_2 Mid_{it} + \sum_m \lambda_m Controls_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (3)$$

Among them, Mid represents the intermediary variable entrepreneurial activity.

(2) Moderating effect model

In order to verify the moderating effect of marketing environment on the relationship between new productivity and high-quality development of new urbanization, referring to the method of Elamer et al.[33], the model is constructed as follows:

$$Haq_{it} = \beta_0 + \beta_1 Nmp + \beta_2 Be + \beta_3 Nmp \times Be + \beta_5 Controls_{it} + \sum Year + \sum City + \varepsilon_{it} \quad (4)$$

Among them, Nmp represents the new quality productivity index, Be is the business environment.

3.2 Variable selection and description

3.2.1 Explained variables

The measurement of high-quality development level (Haq) of new urbanization has not yet formed a unified standard [34]. Due to the vast territory and significant development heterogeneity of the study area. The urbanization rate in 2025 is characterized by Ningxia (69.10%) > Shaanxi (67.17 %) > Qinghai (64.70%) > Xinjiang (61.61%) > Gansu (58.08%). Therefore, based on the theory of sustainable development, the policy orientation of the Yellow River Basin Ecological Protection and High-quality Development Plan, combined with the core connotation of the people-oriented new urbanization, and

drawing on the practices of Xintao Wang [35], this paper constructs an evaluation index system from the four dimensions of population development, social economy, public service and ecological environment. In order to avoid the deviation of subjective weighting, the entropy weight TOPSIS is used to reduce the dimension, and the Haq level of 31 prefecture-level cities in the five northwestern provinces is measured. The specific indicators are shown in table 1.

Table.1 System of indicators for the level of high-guality New-type urbanization

System layer	Criterion layer	Indicator Layer	unit	Attribute	weight
High-quality New Urbanization	Population development	Number of students in institutions of higher learning per 100,000 population	person	+	0.0478
		Urbanization rate of resident population	%	+	0.0645
		Population density	km^2/ person	+	0.0874
		Employment ratio of the secondary and tertiary industries	/	+	0.1365
		The proportion of education fiscal expenditure	/	+	0.0433
		Urban registered unemployment rate	%	-	0.0304
	Social economy	Gross regional product per capita	yuan/person	+	0.0318
		The deposit and loan balance of financial institutions as a proportion of GDP	/	+	0.0431
		The proportion of tertiary industry output value	/	+	0.0539
		Number of authorized patents for inventions	unit	+	0.0292
	Public services	Internet penetration rate	%	+	0.0908
		Per capita urban road area	m^2/ person	+	0.0648
		Per capita possession of public library collections	volumes/ person	+	0.0262
		Number of practicing physicians per 10,000 people	person	+	0.0264
	Eco-environment	Harmless treatment rate of domestic waste	%	+	0.0496
		Centralized treatment rate of sewage centralized treatment plant	%	+	0.0247
		Per capita park green area	m^2	+	0.0356
		Green coverage rate of built-up area	%	+	0.0451
		Industrial sulfur dioxide emissions	t	-	0.0689

3.2.2 Core explanatory variables

In terms of the measurement of new qualitative productivity (Nmp), it is based on the core

framework of laborer-labor means-labor object in Marxist productivity theory [36]. Based on the existing research [37], an evaluation system including 12 secondary evaluation indicators is constructed from the three dimensions of new labor force, new labor materials and new labor objects, as shown in Table 2:

Table.2 System of indicators and calculation formula for new quality productive forces

Target Layer	Criterion layer	First-level indicators	Secondary indicators	Calculation method	weight
new quality productive forces	New type of workers	The quality of new workers	The employment situation of digital services	The proportion of employees in information transmission computer services and software industry	0.0463
			Intensity of education funding	The proportion of education expenditure to fiscal expenditure	0.0875
		New Labor Consciousness	The proportion of employees in the tertiary industry	The tertiary industry employment / total number	0.1432
	New type of labor tools	Tangible means of production	Internet access	The number of Internet broadband access users per 100 people	0.0593
			Mobile phone use	The number of mobile phones per 100 people	0.0571
		Intangible means of production	Renewable energy consumption	Electricity consumption of the whole society	0.1567
			Renewable energy efficiency	Power consumption per unit of GDP	0.0704
	New type of labor object	New industries	Digital finance level	Peking University Digital Inclusive Finance Index	0.0332
			The level of technological innovation	The number of patent authorizations per 10,000 people	0.0915
		Digital services	Telecommunications business communications	Telecommunications business volume	0.0592
			Total postal business	Total postal business	0.0191
			Digital infrastructure	Digital infrastructure index	0.1765

3.2.3 Mediator variable

Entrepreneurial activity (Entrep). Referring to the research methods of Widarko, Agus, and M. Khoirul Anwarodin [38], considering the characteristics of high proportion of small and medium-sized cities in Northwest China and large differences in population agglomeration, the urban resident population is used as the standardized base, and the number of new enterprises /100 people is used as an alternative indicator. This index eliminates the interference of urban scale heterogeneity, ensures the fairness of cross-regional comparison, and accurately characterizes the per capita entrepreneurial vitality, which strengthens the operability and credibility of the research results.

3.2.4 Regulating variables

This paper selects the business environment (Be) as a moderating variable, takes the infrastructure environment, talent environment and entrepreneurial environment as the basic indicators, and uses the business environment model to measure the quantitative representation of the index [39]. On the one hand, this method breaks through the bottleneck that traditional qualitative evaluation is difficult to quantify and compare. On the other hand, it can rely on the index to accurately implement policies, promote the regional business environment from passive rectification to active optimization, and help the high-quality development of new urbanization.

3.2.5 Control variables

Referring to the research of Chang, Xinfeng, Zihe Yang, and Abdullah, et al. [40], the indicators with significant interference effects on the core explanatory variables were selected as control variables (Table 3).

Table.3 Variable explanation of the indicator

Variable type	**variable name**	**Variable definition**	**Indicator explanation**
Variable being explained	Haq	High-quality development of new urbanization	High-Quality Development Index for New Urbanization
Explain variables	Nmp	New Quality Productivity Index	New Quality Productivity Index
Mediator variable	Entrep	Entrepreneurial activity	Number of newly established enterprises per 100 employees (per 100 people)
Adjust variables	Be	Business environment	An evaluation index calculated based on the Doing Business model
Control variables	Dig	Digital inclusive finance	Inclusive Finance Index
	Mar	Degree of marketization	The ratio of regional GDP to government spending
	Inst	Industrial structure	Tertiary industry output value / secondary industry output value
	Urb	Urbanization level	Urban population density (people/square kilometers)

Digital Inclusive Finance (Dig) is characterized by the Inclusive Finance Index of Peking University Digital Finance Research Center, which can fully reflect the coverage and use depth of regional digital financial services. The degree of marketization (Mar) is characterized by the ratio of regional GDP to government fiscal expenditure, which is in line with the influence mechanism of marketization reform on resource allocation efficiency. The industrial structure (Inst), which uses the proportion of the tertiary industry output value to the regional GDP is consistent with the theoretical logic of industrial structure

upgrading to promote the quality of urban development; the urbanization level is characterized by urban population density, which can directly reflect the supporting role of population agglomeration on urban development. Infrastructure construction (Con), using the ratio of total highway mileage to total number of people, reflects the basic guarantee function of transportation infrastructure for the development of new urbanization [41].

3.3 Data Source

2010 is the key node of China's urbanization from speed type to quality type. Combined with the needs of the western development strategy, it is easy to analyze the effects before and after the policy, and the provincial situation or regional situation in the northwest region is similar, with unique resources and location advantages. Therefore, this paper takes 34 prefecture-level cities in the five northwestern provinces from 2010 to 2024 as the initial sample of the study. In order to ensure the accuracy of the measurement, this paper eliminates some provinces and cities with missing data, and finally retains 31 prefecture-level cities and 11532 observations. It is difficult to obtain new quality productivity data. The digital inclusive financial index and digital infrastructure index are all derived from the Wukong data platform with high academic recognition. Other data are derived from the 2011-2025 《China Urban Statistical Yearbook》. The missing data of individual cities are supplemented by interpolation. In order to avoid the interference of outliers and extreme values on the research results, the original data of all variables are processed by 1 % tail reduction. Table 4 is the descriptive statistical results of the main variables.

Table.4 Descriptive statistics of main variables

variable	Sample size	Mean value	Variance	Maximum value	Minimum value
Haq	396	0.6479	0.1656	0.8890	0.0400
Nmp	396	0.5259	0.1551	0.7870	0.0230
Entrep	396	1.0939	0.3834	1.7453	0.5976
Dig	396	124.6678	53.5186	177.4715	32.7233
Mar	396	4.0653	0.6831	4.8502	2.0879
Be	396	0.7179	0.2092	0.9634	0.0312
Ins	396	1.0326	0.2840	1.5116	0.6917
Urb	396	113.2626	53.2626	2.0000	146.9091

4. Empirical Results and Analysis

4.1 Data Stability Testing

In order to avoid pseudo-regression and meet the model assumptions, LLC test and IPS test are used to test the stability of time series panel data (table 5). The results show that the core explanatory variable

new quality productivity and control variables digital inclusive finance, marketization degree, urbanization process itself are stable ; the initial test of the new urbanization high-quality development of the explained variable and the adjustment variable business environment inspection is non-stationary , but after the first-order split and the second-order split processing, they all achieve stationary through the unit root test at the 5 % significant level.

In order to further reveal the long-term stable relationship between non-stationary variables, Kao test and Pedroni were used to analyze the co-integration of explanatory variables and explanatory variables. In the KAO test, MDF, DP and ADF were all significant at the 1% level, rejecting the original hypothesis of no co-integration relationship; Pedroni test also supports the existence of cointegration relationship. Therefore, the panel time series data meet the requirements of short-term dynamic analysis and long-term equilibrium relationship conditions at the same time, which can take into account the statistical rigor of the model and the depth of economic interpretation, and lay a reliable measurement foundation for subsequent policy analysis.

Table.5 Results of panel data stationarity test

variable	**Unit root inspection method**				**Conclusion**
	LLC inspection	**P-value**	**IPS inspection**	**P-value**	
U1	1.077	0.854	-0.4453	0.3458	Not stable
▲	-0.9665	0.1669	-2.1150	0.0172	Not stable
▲▲	-8.4926	0.0000	-5.3341	0.0000	stable
U2	-9.7688	0.0000	-2.3186	0.0102	stable
Industrial structure	-4.4647	0.0000	-2.2807	0.0113	stable
Entrepreneurial activity	-3.1897	0.0007	4.0788	1.0000	Not stable
			-2.1407	0.0161	
Digital inclusive finance	-14.0429	0.0000	-4.6762	0.0000	stable
Degree of marketization	-6.7419	0.0000	-1.8016	0.0358	stable
Urbanization process	222.6520	1.0000	-4.3220	0.0000	stable
Business environment	14.9303	1.0000	10.8234	1.0000	Not stable
▲	8.5181	1.0000	3.3207	0.9996	Not stable
▲▲	1.3296	0.9082	-8.7491	0.0000	stable

Cointegration test method	Statistical name	Statistical values	P-value	Inspection results
KAO test	MDF	-18.2561	0.0000	Rejects the null hypothesis that cointegration relationships do not exist, and believes that cointegration relationships do
	DF	-28.9480	0.0000	
	ADF	-14.5973	0.0000	
Pedroni test	Modified Phillips–Perron t	11.8777	0.0000	
	Phillips–Perron t	-17.6286	0.0000	
	ADF	-9.0570	0.0000	

Note: ▲ Represents the first-order difference of the variable, ▲▲ Represents the second-order splitting of the variable. All the data sourced from Stata software calculations and compilation.

4.2 Empirical Analysis

4.2.1 Baseline Regression

In order to further explore the mechanism of new productivity on the high-quality development of new urbanization, a panel data regression model is constructed based on Formula (1), and the robust standard error of urban clustering is used for estimation, and the model is tested by Lagrange multiplier (LM) (Table6). Columns (1) -Column (5) in Table 6 are the regression results of gradually adding control variables. The data show that the influence coefficient of new quality productivity on the high-quality development of new urbanization is significantly positive regardless of whether the control variables are considered or not, and passes the 1% significance level test. It shows that the new quality productivity has a significant positive correlation with the high-quality development of new urbanization. The higher the development level of new quality productivity, the more it can promote the high-quality development of new urbanization. Hypothesis H1 is fully confirmed. This conclusion is consistent with the conclusion of Tian Jiaxin et al.'s research on new quality productivity has a positive driving effect on new urbanization in 2025, which further proves the reliability of the research results.

From the perspective of control variables, the influence coefficients of digital inclusive finance and marketization degree are-0.0305 and-0.1297, respectively, and both pass the 10% significance level test, indicating that the current stage of digital inclusive finance and marketization process has a certain negative impact on the high-quality development of new urbanization. The two have not yet formed an effective synergistic path with the high-quality development of new urbanization, and their internal mechanism still needs to be further optimized. On the contrary, the influence coefficients of industrial structure and urbanization level are 0.0785 and 0.0493 respectively, and are significantly positive at the

1% level. The conclusion shows that: on the one hand, the optimization and upgrading of industrial structure provides the core driving force for the high-quality development of new urbanization by promoting the qualitative change of economic structure transformation; on the other hand, the improvement of urbanization level realizes quantitative change by promoting the agglomeration of regional population and resource elements. The two jointly build a virtuous cycle of structural optimization-efficiency improvement-sustainable development, and become the twin engines driving the high-quality development of new urbanization.

Table.6 Basic regression results

variable	（1）Haq	（2）Haq	（3）Haq	（4）Haq	（5）Haq
Nmp	0.5120*** （9.37）	0.5120*** （4.56）	0.5120*** （9.37）	0.5120*** （9.37）	0.4771*** （7.63）
Dig		-0.0305* （-0.2.77*）	-0.1688* （-1.89）	0.1532** （3.19）	-0.4959** （-3.04）
Mar			-0.1297*（-1.65）	0.3909*** （3.68）	-0.5538** （-2.41）
Ins				0.0785*** （4.03）	0.4757*** （3.86）
Urb					0.0493*** （3.39）
Constant term con	0.3645	0.4710*** （7.62）	2.3917** （2.02）	-2.1226** （-3.19）	4.6030**（2.80）
Control variables	NO	YES	YES	YES	YES
Urban fixed	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES
Observations	396	396	396	396	396
Goodness of fit R^2	0.5950	0.5950	0.5950	0.5950	0.6216

Note: *,**and *** denotes levels of 10 %, 5 % and 1% respectively. The internal value of () is the coefficient regression T value. The same below.

4.2.2 Robustness Testing

The high-quality development and new productivity of new urbanization are affected by multi-dimensional factors, and the construction of its evaluation indicators is also in continuous development and improvement. In order to further ensure the rigor, reliability and replicability of the empirical analysis conclusions, the robustness test is carried out from the following four aspects. The results are shown in Table 7.

Table.7 Robustness check results

	Replace the new urbanization indicators	Analytic Hierarchy Process Method	Reconstruct new quality productivity indicators	Change the sample interval	
	（1）	（2）	（3）	（4）	（5）
Nmp	0.1902** （2.0500）	0.6389*** （15.5700）		0.9090*** （12.3300）	0.7170*** （11.9300）
Nmp1			0.2112** （1.3800）		
Constant	0.3656*** （6.4000）	0.3053*** （14.2600）	0.7474*** （8.4500）	0.116** （0.3500）	0.5840* （0.0400）
Control variables	YES	YES	YES	YES	YES
Year fixed	YES	YES	YES	YES	YES
Observations	396	396	396	396	396
Goodness of fit R^2	0.7441	0.7141	0.5828	0.5487	0.6110

First of all, in order to focus on the connotation of high-quality development more accurately, this study reconstructs the evaluation system of high-quality development of new urbanization : the innovation development dimension selects the number of invention patents and the proportion of non-agricultural industry output value ; the coordinated development dimension selects the number of buses per 10,000 people and the per capita road density ; the green development dimension selects energy consumption per unit of GDP and sulfur dioxide emission intensity ; in the dimension of openness and sharing, the total retail sales of social consumer goods and the per capita park green space area are selected.

From the regression results of column (1) in table 7, it can be seen that after reconstructing the high-quality development index system of new urbanization, the impact of new quality productivity on it is still robust. Secondly, in order to verify the sensitivity of the results to the weight setting, the analytic hierarchy process (AHP) is used to adjust the weight distribution of the model. Column (2) of Table 7 shows that the impact of new quality productivity on the high-quality development of new urbanization is still robust. At the same time, the calculation method of new quality productivity of explanatory variables is replaced and the index system of new quality productivity is reconstructed. In Column (3) of the table, referring to the research of Lingyu Li et al[42], and reconstructed the evaluation index system of new quality productivity (Nmp1) with core indicators

such as employment structure, economic output and technical basis. From the regression results, it can be seen that the verification conclusion is consistent with the above results. Finally, considering that policy shocks may have a phased impact on the relationship between variables, the original sample research period is divided into two sub-intervals of 2010-2015 (pre-policy) and 2016-2024 (post-policy) by changing the sample interval, and regression tests are carried out respectively. The results of Columns (4) and (5) of Table 7 further confirm the robustness of the above conclusions in different time dimensions.

4.2.3 Endogenous treatment

There may be a two-way causal relationship between new productivity and high-quality development of new urbanization, which leads to the problem of reverse causal endogeneity in the model results. In order to effectively alleviate the result bias caused by this problem, the panel instrumental variable method is used to test the research results, and the one-period lagged data of the digital infrastructure index (Digtial-1) is selected as the instrumental variable of new quality productivity (Table 8).

Table.8 Endogeneity Test Results

variable	**Phase One**	**Phase Two**
Digtial-1	-1.701131*** （-3.5500）	1.404591*** （4.2400）
Anderson canon. corr. LM statistic	x^2（1）=9.232，p=0.0024	
Cragg-Donald Wald F statistic	13.1410	
Control variables	YES	YES
Year fixed	YES	YES
Observations	396	396
Goodness of fit R^2	0.2323	0.2323

It can be seen from table 8 that the Anderson canon. corr. LM statistics and Cragg-Donald Wald F statistics of the one-period lag digital infrastructure index show that the one-period lag digital infrastructure index passes the weak instrumental variable test, the unrecognizable test and the over-recognizable test, indicating that the instrumental variable selection meets the requirements. At the same time, and it's fitting coefficient is 0.2323, and it is significantly positive at the 1 % level, which is completely consistent with the significance of the benchmark regression results, which fully shows that the above research results are robust and effectively avoids the interference of the inverse causal endogeneity problem on the estimation results.

4.3 Analysis of mediating effect

In order to verify the mechanism of new productivity in H2 on the high-quality development of new urbanization, the mediating variable entrepreneurial activity is introduced, and the mechanism test is carried out by using models (2) and (3) (Table 9).

Table.9 Results of mediation effect test

variable	（1）Haq	(2)Entrep	(3)Haq
Nmp	0.5120*** （4.8500）	0.2310* （1.8000）	0.7264* （20.4600）
Entrep			-0.0246* （-1.5400）
Constant	0.3645*** （0.0298）	0.3225*** （0.9451）	0.2688*** （3.9800）
Control variables	YES	YES	YES
City fixed	YES	YES	YES
Year fixed	YES	YES	YES
Observations	396	396	396
Goodness of fit R^2	0.5580	0.0168	0.5868
adj. R^2	0.5675	0.0292	0.5666
Bootstrap	Coef.	Bias	Std. err
_bs_1	0.0062	6.45e-0.5	0.143

Model (1) is the direct effect of new quality productivity on the high-quality development of new urbanization. The influence coefficient is 0.5120, which is significantly positive, indicating that new quality productivity has a significant direct promoting effect on the high-quality development of new urbanization, which lays a foundation for the subsequent intermediary mechanism test. Model (2) adds the mediating variable entrepreneurial activity on the basis of direct effect, and finds that the influence coefficient of new quality productivity on new urbanization is significantly reduced to 0.2310. At the same time, the coefficient of entrepreneurial activity is significantly positive, which indicates that there is a partial or complete mediating effect of entrepreneurial activity in the path of new quality productivity on the high-quality development of new urbanization.

Model (3) further tests the first half path of the influence mechanism of entrepreneurial activity on new-type productivity, and finds that the influence coefficient of new-type productivity on entrepreneurial activity is 0.7264, which is significantly positive, but the influence coefficient of entrepreneurial activity on the high-quality development of new-type urbanization is -0.0264, which is not significant, indicating that new-type productivity can effectively stimulate entrepreneurial activity. However, at present, entrepreneurial activity has not yet become an effective carrier to promote the high-

quality development of new-type urbanization in the five northwestern provinces, which means that the core driving role of new-type productivity should be given full play. It is also necessary to strengthen the transformation efficiency of entrepreneurial achievements, improve the precise matching of entrepreneurial resources and urbanization construction needs, rather than simply focusing on the entrepreneurial activity itself. In order to avoid the possible test errors of the stepwise regression method, the Bootstrap empirical sampling method is used to verify the mediating effect. The results show that the confidence interval of the mediating effect value of entrepreneurial activity does not contain 0, indicating that the mediating effect exists, which further confirms that entrepreneurial activity plays a partial mediating role between new productivity and high-quality development of new urbanization.

Based on the analysis results of models (1)-(3) and Bootstrap test, it can be seen that entrepreneurial activity plays a part of intermediary role between new productivity and high-quality development of new urbanization. New productivity indirectly promotes high-quality development of new urbanization by enhancing entrepreneurial activity, and research hypothesis H2 is fully verified. Innovation factors empower urbanization to improve quality by activating entrepreneurial activities, which further enhances the reliability of the conclusion of this study.

In order to verify Hypothesis H3, multiple linear regression is performed using Model (4), and the results are shown in Table 10. When only the core explanatory variable new productivity is included in Model (1), the influence coefficient is 0.5120, which is significant at the level of 1%, indicating that the new productivity has a significant positive effect on the development of new urbanization without considering the moderating variables, which is consistent with the conclusion that new productivity is the core driving force for the high-quality development of new urbanization in the previous research. After the adjustment variable business environment is added to Model (2), its influence coefficient is also significantly positive and significant at the 1% level, indicating that a good business environment plays a positive role in promoting the high-quality development of new urbanization.

In the model 3, the interaction multiplier (Nmp*Be) between new quality productivity and business environment is significantly positive at the 1% level, indicating that the business environment has a significant positive adjustment effect in the relationship between new quality productivity and high-quality development of new urbanization, and its promotion effect is: $\partial Haq/\partial Be = 0.6097 + 0.1563Nmp$, It shows that for every unit increase in the business

environment, the promotion effect of new quality productivity on the high-quality development of new urbanization can be increased by 15.63%. Therefore, the hypothesis H3 is verified. This further shows that the deep integration of scientific and technological innovation and industrial innovation, through technological iteration and efficiency improvement, injects core kinetic energy into the high-quality development of new urbanization ; at the same time, the improvement of the business environment can stimulate the vitality of the market, and the synergy between the two can increase the conversion efficiency of new productivity by 15.63%, becoming the accelerator for the high-quality development of new urbanization.

Table.10 Results of moderating effect test

variable	（1）	（2）	（3）
Nmp	0.5120***	0.3768***	0.6772***
	（4.8500）	（8.6800）	（7.7600）
Be		0.4449***	0.6097***
		（14.2400）	（11.7700）
Nmp*Be			0.1563***
			（3.9500）
Constant	0.3645***	0.1303***	0.0365***
	（0.0298）	（7.5900）	（0.12500）
Control variables	YES	YES	YES
City fixed	YES	YES	YES
Year fixed	YES	YES	YES
Observations	396	396	396
adj.R^2	0.5580	0.7140	0.7242

5 Conclusions and suggestions

5.1 Conclusion

Based on the panel data of 31 prefecture-level cities in the five provinces of Northwest China from 2010 to 2024, this paper incorporates new productivity and high-quality development of new urbanization into a unified analysis framework, and systematically reveals the mechanism and regional heterogeneity of the two by constructing a mediating effect and a moderating effect model. The conclusions are as follows:

(1) New productivity has a significant positive enabling effect on the high-quality development of new urbanization. The new productivity promotes the high-quality development of new urbanization through the four dimensions of population-economy-public service-ecological environment.

(2) Entrepreneurial activity plays a partial mediating role in the relationship between new

productivity and high-quality development of new urbanization, and the business environment has a positive moderating effect on the high-quality development of new urbanization enabled by new productivity.

(3) The heterogeneity of the non-linear impact of new productivity on the high-quality development of new urbanization. The higher the industrial structure and urbanization level, the stronger the marginal effect. The impact of digital inclusive finance and marketization is significantly negative, reflecting the current situation of insufficient sinking of digital financial services and insufficient market-oriented reform in the northwest region.

5.2 Recommendations

Based on the above research conclusions, the following suggestions are drawn:

(1) Strengthen the core driving role of new quality productivity and break the short board of northwest development. Strengthen scientific and technological innovation and achievement transformation. Focusing on advantageous industries such as new energy, photovoltaic power generation, and characteristic agriculture, a Special Fund for New Productivity was established to strengthen the co-construction of characteristic laboratories by universities, research institutes, and enterprises, and to focus on breaking through the R & D and application of key technologies in the industry. Make up for the shortcomings of digital infrastructure. We can give priority to the layout of 5G base stations, smart grids, big data centers and other new infrastructure facilities in key cities and towns, establish a regional coordination mechanism of east and west, and promote cooperation between regions with low and high new productivity. The government has increased training and support in key areas such as scientific and technological innovation, green environmental protection and digital skills, cultivated a group of high-quality new labor force, and empowered new quality productivity to promote the high-quality development of new urbanization.

(2) Activate the accelerator function of entrepreneurial activity and increase its mediating effect. We should strengthen the integration and development of entrepreneurship, public services and ecological governance, encourage entrepreneurs to support “Internet+” actions, actively participate in the supply of public services in remote areas of Northwest China, and guide entrepreneurial enterprises to participate in ecological projects such as soil and water conservation and desertification control, so as to realize the dual benefits of entrepreneurial income increase and ecological protection and stimulate entrepreneurial enthusiasm.

(3) Optimize the dynamic adjustment efficiency of the business environment and focus on the development pain points in the northwest. Improve the eco-friendly rule of law guarantee mechanism, promote the transformation of business environment policies into laws, establish a credit + ecology evaluation system, and enhance institutional stability and predictability. Deepen the reform of factor market allocation, strengthen the construction of digital infrastructure, build a government-to-local intelligent management platform, and stimulate the vitality of data factors; at the same time, a talent flow mechanism such as technology investment and flexible talent introduction can be established to promote the agglomeration of high-level talents into strategic emerging industries.

Declarations

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Code availability: The raw code cannot be publicly released due to the project has not been concluded yet. Readers may obtain the code from the corresponding author upon reasonable request after signing a confidentiality agreement.

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