

## New Quality Productive Forces and High-Quality Economic Development: Evidence from Shaanxi Province

Weiru Qi<sup>1,2</sup>, Muhammad Faliq Abd Razak<sup>1,\*</sup> and Sufian Jusoh<sup>1</sup>

<sup>1</sup>Institute of Malaysia and International Studies, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia

<sup>2</sup>School of Economics and Management, Xi'an Jiaotong University City College, Xi'an, Shaanxi, China

\*Corresponding Author: [faliqrazak@ukm.edu.my](mailto:faliqrazak@ukm.edu.my)

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**Abstract.** China's regional economies are at a critical stage of transition from factor-driven growth to innovation-driven and green development. New quality productive forces, centered on technological innovation, digitalization, and green development, provide an important driving force for high-quality economic development. Based on panel data from ten prefecture-level cities in Shaanxi Province from 2009 to 2022, this study examines the impact of new quality productive forces on high-quality economic development and its underlying mechanisms. The results show that new quality productive forces significantly promote high-quality economic development, with industrial structure upgrading and energy utilization efficiency serving as important mediating channels. Heterogeneity analysis indicates that this promoting effect is significant in the Guanzhong region but not statistically significant in Northern and Southern Shaanxi. The findings suggest that Shaanxi should strengthen enterprise innovation and industry-university-research collaboration, promote industrial upgrading and energy efficiency improvement, and adopt differentiated policies based on the development conditions of Guanzhong, Northern Shaanxi, and Southern Shaanxi to promote coordinated regional economic development.

**Keywords** New quality productive forces; high-quality economic development; industrial structure upgrading; energy utilization efficiency; Shaanxi Province.

### Introduction

With the continuing advancement of technological revolution and industrial transformation, the global growth paradigm has gradually shifted from factor-driven expansion to innovation-led development. Digitalization, intelligent transformation, and green transition are reshaping the allocation of production factors and the mechanisms of value creation. Technological progress has long been regarded as a fundamental source of productivity improvement (Solow, 1957), while innovation plays a central role in economic transformation and long-term growth (Schumpeter, 1934). In this context, new quality productive forces (NQPF) have emerged as a key concept for understanding productivity transformation. They represent advanced productive forces driven by technological innovation, improved factor allocation, industrial upgrading, and green transformation. Existing studies generally define NQPF from the perspectives of technological innovation, digital transformation, and institutional change, emphasizing their role in improving development quality through more efficient factor allocation (Xu et al., 2025; Pu & Huang, 2023). Han and Ma (2024) further argue that the effectiveness of NQPF depends on the alignment between technological innovation and institutional supply.

High-quality economic development (HQED) marks a shift from scale-oriented growth to quality-oriented development. It emphasizes economic expansion, structural optimization, innovation capacity, green transformation, openness, and shared development. Previous studies have moved beyond single indicators such as GDP growth and industrial output, constructing multidimensional evaluation systems that cover

economic, social, and ecological dimensions (Leng, 2008; Xu, 2013; Lai et al., 2011; Wu, 2014). Recent research further measures HQED through five dimensions: innovation, coordination, green development, openness, and sharing (Shi, 2024). From this perspective, NQPF and HQED are closely linked. NQPF provide new growth momentum through innovation and factor reallocation, while HQED reflects the quality and sustainability of this transformation.

China's economy has entered a stage in which traditional factor-driven growth is increasingly constrained by diminishing marginal returns, resource pressure, and regional imbalance. Although digital technology, advanced manufacturing, new energy, and green industries have created new opportunities for regional transformation, differences in innovation capacity, industrial structure, factor allocation efficiency, and resource-use efficiency remain evident across regions. These differences are particularly prominent in inland provinces, where industrial transformation and green development face stronger structural constraints. Shaanxi Province provides a suitable case for this study because it combines a strong industrial base, resource-dependent sectors, and growing innovation capacity, while still facing challenges in technology diffusion, industrial coordination, energy efficiency, and regional balance. Fig 1 further illustrates Shaanxi's recent progress in innovation input and digital transformation, as reflected by the growth of granted invention patents and the rising share of the digital economy. However, whether this progress can be effectively transformed into HQED still requires empirical examination.

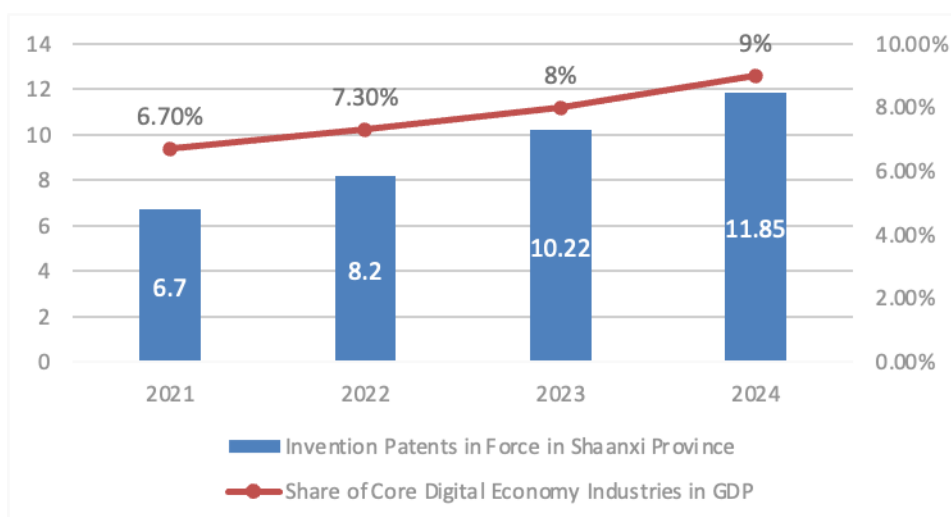


Figure 1. Trends in invention patents & digital economy share in Shaanxi 2021-2024 (Shaanxi Statistical Bulletin on National Economic & Social Development, 2024)

Existing studies have provided useful insights into the relationship between NQPF and economic development. Cheng and Chen (2023) argue that NQPF facilitate structural upgrading by accelerating the transformation of traditional industries and expanding the development space for emerging sectors. Chen (2022) finds that the digital economy supports high-quality development through productivity gains, industrial upgrading, and resource integration. Related evidence also suggests that the expansion of new industries and digitalization promotes high-quality development by improving factor allocation and green transformation (Wang et al., 2025). At the regional level, NQPF are often associated with stronger innovation capacity and structural adjustment (Li & Li, 2024). These studies help clarify how innovation-driven transformation supports HQED. Nevertheless, several important research gaps remain to be addressed. First, existing studies mainly discuss NQPF from macro or conceptual perspectives, while city-level empirical evidence remains limited. Second, although prior research has examined the economic effects of innovation, digitalization, and industrial upgrading, the mechanisms through which NQPF affect HQED require further clarification, especially the roles of industrial structure upgrading and energy efficiency. Third, insufficient attention has been paid to regional heterogeneity within inland provinces, where differences in industrial foundation, innovation capacity, and resource endowment may shape the economic effects of NQPF. These gaps are

particularly relevant to Shaanxi Province, where Guanzhong, northern Shaanxi, and southern Shaanxi differ substantially in economic foundation, industrial structure, and innovation capacity.

To address these gaps, this study examines the impact of NQPF on HQED using panel data from ten prefecture-level cities in Shaanxi Province from 2009 to 2022. Specifically, this study aims to answer three questions. First, do NQPF significantly promote HQED? Second, do industrial structure upgrading and energy efficiency serve as mediating mechanisms between NQPF and HQED? Third, does the effect of NQPF on HQED differ across regions within Shaanxi Province? To answer these questions, this study applies a two-way fixed effects model and mediation models to examine the direct effect, transmission mechanisms, and regional heterogeneity of NQPF. This study contributes to the literature in three ways. First, it provides city-level evidence on the relationship between NQPF and HQED, enriching empirical research on innovation-driven and quality-oriented regional development. Second, it identifies industrial structure upgrading and energy efficiency as two important transmission mechanisms, clarifying how NQPF are translated into improvements in development quality. Third, by focusing on Shaanxi Province and comparing Guanzhong, northern Shaanxi, and southern Shaanxi, this study reveals the regional heterogeneity of NQPF effects and provides targeted policy implications for inland provinces undergoing industrial transformation and green development.

### Theoretical Analysis and Research Hypotheses

#### *Mechanisms Through Which New Quality Productive Forces Drive High-Quality Economic Development*

NQPF are not confined to technological advancement; they are also reflected in shifts in factor allocation and changes in industrial organization. These transformations reshape both the sources of economic growth and the structure of efficiency. Endogenous growth theory highlights that knowledge accumulation and technological diffusion underpin long-term growth, while the notion of “creative destruction” implies that the introduction of new technologies is often accompanied by the displacement of existing production modes, prompting the reallocation of resources across sectors (Romer, 1990; Aghion & Howitt, 1992).

Under conditions of shifting growth dynamics and tightening resource constraints, technological progress does not necessarily translate into improvements in development quality. Its effects depend on whether production modes are transformed and whether resource allocation becomes more efficient (Rodrik, 2016). From this perspective, NQPF influence HQED through two closely related channels. They raise productivity levels and, at the same time, alter the way the economy operates. As innovation activities deepen, growth becomes less reliant on traditional factor inputs and increasingly driven by efficiency gains, which contributes to improvements in development quality. On this basis, the following hypothesis is proposed:

H<sub>1</sub>: NQPF exert a significant positive effect on HQED.

#### *New Quality Productive Forces, Industrial Structure And High-Quality Economic Development*

Changes in industrial structure reflect the reallocation of resources across sectors, which directly affects the efficiency of economic growth. Structural transformation theory suggests that shifting resources from low-productivity sectors to high-productivity sectors constitutes a key source of economic growth (McMillan & Rodrik, 2011). Under the influence of NQPF, technological innovation and factor mobility reshape existing patterns of production and division of labor. Capital, labor, and technology tend to move toward higher value-added industries, accompanied by adjustments in the technological composition and value distribution within sectors. This process promotes the upgrading of industrial structure.

Over the long term, economic development is often associated with structural transformation, typically reflected in an increasing share of the service sector (Kuznets, 1966). Technological progress also alters the allocation of resources and influences the distribution of economic activities across industries (Acemoglu, 2008). Empirical evidence further indicates that the digital economy enhances development quality through industrial upgrading (Chang et al., 2023), while improvements in NQPF are likewise associated with structural upgrading (Shao et al., 2024). In this context, NQPF influence HQED through industrial structure upgrading.

By facilitating the reallocation of resources toward more productive sectors, they contribute to improvements in overall economic efficiency. On this basis, the following hypothesis is proposed.

H<sub>2</sub>: NQPF promote HQED through industrial structure upgrading.

#### *New Quality Productive Forces, Energy Efficiency And High-Quality Economic Development*

Under increasingly stringent resource and environmental constraints, energy utilization efficiency has become a key dimension in assessing the quality of economic development. Technological progress improves resource utilization by refining production processes and input structures, which enhances economic performance (Porter & van der Linde, 1995). The emergence of NQPF has altered patterns of energy use. Advances in technology shift production away from energy-intensive inputs toward more technology-intensive modes, reducing energy consumption per unit of output. The diffusion of digital technologies improves information transmission and strengthens production coordination, allowing energy to be allocated more efficiently across production stages. As a result, energy use gradually shifts from extensive input toward efficiency-oriented utilization (Hsieh & Klenow, 2009).

More efficient resource allocation helps sustain higher output under given constraints while accommodating environmental considerations (Stern, 2007). Existing studies have examined the link between digitalization and energy efficiency from multiple perspectives, including firm-level digital transformation (Wang et al., 2024), digital technological innovation (Lu et al., 2024), and digital economy agglomeration (Zhao et al., 2025). NQPF, driven by technological innovation, influence development quality through changes in production modes and improvements in factor allocation (Xie et al., 2025). NQPF influence HQED through improvements in energy utilization efficiency. Higher efficiency reduces resource dependence and supports more sustainable growth. On this basis, the following hypothesis is proposed.

H<sub>3</sub>: NQPF exert a positive effect on HQED through improvements in energy utilization efficiency.

### **Methodology**

This study employs a quantitative research design using panel data from ten prefecture-level cities in Shaanxi Province over the period 2009-2022. A two-way fixed effects model is applied to examine the impact of NQPF on HQED while controlling for unobserved regional and temporal heterogeneity. In addition, mediation models are used to test whether industrial structure upgrading and energy utilization efficiency serve as transmission mechanisms between NQPF and HQED. Heterogeneity analyses are further conducted across different regions and levels of economic development to examine whether the effect of NQPF varies under different development conditions.

#### *Study Area*

Shaanxi Province is located in inland northwestern China and comprises ten prefecture-level cities, including Xi'an, Baoji, and Xianyang, as shown in Fig. 2. The province has distinct regional characteristics: northern Shaanxi is dominated by the Loess Plateau, central Shaanxi is centered on the Guanzhong Plain, and southern Shaanxi is characterized by mountainous and hilly terrain. Central Shaanxi, with Xi'an as its core, concentrates population, infrastructure, innovation resources, and economic activity. By contrast, northern Shaanxi is more dependent on energy and chemical industries, while southern Shaanxi has a less developed industrial base and stronger ecological constraints. These internal differences make Shaanxi a suitable case for examining how NQPF affect HQED and whether this effect varies across Northern, Central, and Southern regions.

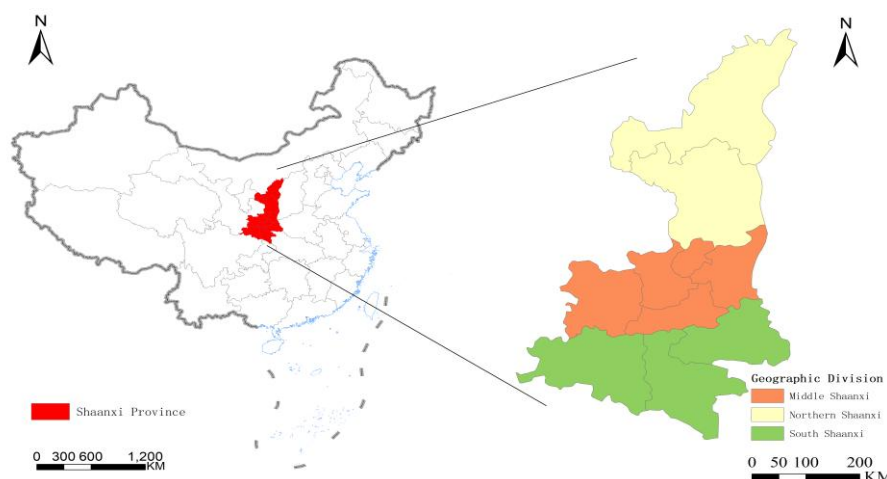


Figure 2. Study area

### Baseline Regression Model

The relationship between NQPF and HQED may be affected by unobserved regional characteristics and time-varying factors. Regional characteristics, such as industrial structure, resource endowments, and institutional conditions, may differ across prefecture-level cities. Time-varying factors, such as economic cycles, policy adjustments, and changes in the external environment, may also influence the estimation results. To address these potential sources of heterogeneity, this study employs a two-way fixed effects model that controls for both region-fixed effects and year-fixed effects. The baseline model is specified as follows:

$$HQED_{it} = \beta_0 + \beta_1 NQPF_{it} + \sum Control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (1)$$

In this model,  $i$  denotes the region and  $t$  denotes the year.  $NQPF_{it}$  represents the level of new quality productive forces, and  $HQED_{it}$  represents the level of high-quality economic development.  $Control_{it}$  refers to the set of control variables.  $\mu_i$  and  $\gamma_t$  capture region-fixed effects and time-fixed effects, respectively, while  $\varepsilon_{it}$  is the error term. The coefficient  $\beta_1$  measures the effect of NQPF on HQED.

### Mediation Model

To further examine the transmission mechanisms through which NQPF affect HQED, this study constructs mediation models by introducing industrial structure upgrading and energy utilization efficiency as mediating variables. Industrial structure upgrading reflects the adjustment and optimization of the industrial system, while energy utilization efficiency captures the efficiency of resource use under environmental constraints. Following the two-step approach proposed by Jiang (2022), the mediation model is specified as follows:

$$Mid_{it} = \alpha_0 + \alpha_1 NQPF_{it} + \sum Control_{it} + \mu_i + \gamma_t + \varepsilon_{it} \quad (2)$$

In this equation,  $Mid_{it}$  denotes the mediating variable, while the definitions of the remaining variables are consistent with those in equation (1).

### Variable Definition

This study takes the level of high-quality economic development (HQED) as the dependent variable. HQED refers to a development pattern that has emerged during the transition from rapid growth to quality-oriented growth. Its core lies in improving development quality and efficiency, with greater emphasis on innovation-driven dynamics and structural optimization (Huang et al., 2022).

In terms of its conceptual scope, HQED is commonly defined across five dimensions, namely innovation, coordination, green development, openness, and sharing. Following Liu et al. (2021), this study

selects 20 specific indicators from these five dimensions to construct an evaluation index system for HQED, as shown in Table 1. The entropy-weighted TOPSIS method is then applied to measure the level of HQED across prefecture-level cities in Shaanxi Province, in order to enhance the objectivity and comparability of the results.

Table 1. Evaluation index system for high-quality economic development

Dimension	Tertiary indicator	Description
Innovation	Science and technology input	R&D expenditure / fiscal expenditure Education expenditure / fiscal expenditure
	Patent level	Number of granted patents
	Financial development	Deposits of financial institutions / loans of financial institutions
Coordination	Living standards	GDP per capita Non-real estate investment / fixed asset investment
	Industrial structure	Share of tertiary industry
	Pollution emissions	Industrial wastewater emissions / industrial output Industrial SO <sub>2</sub> emissions / industrial output Industrial smoke (dust) emissions / industrial output
Green Development	Waste treatment	Comprehensive utilization rate of general industrial solid waste Centralized sewage treatment rate Harmless treatment rate of domestic waste
	Foreign investment	Actual utilized foreign capital
	Foreign-funded enterprises	Number of foreign-funded enterprises
Openness	Social welfare	Number of licensed physicians / resident population
	Sharing	Green coverage rate of built-up areas
Sharing	Consumption level	Total retail sales of consumer goods / GDP
	Government burden	Fiscal expenditure / fiscal revenue

### Core Explanatory Variable

This study takes new quality productive forces (NQPF) as the core explanatory variable. Unlike traditional productive forces, NQPF is driven by technological innovation and is reflected in changes in the forms of labor, means of production, and objects of labor, as well as in the application of new technologies and the participation of data as a production factor (Cheng & Cen, 2024). Based on this definition, and following Han et al. (2024), this study constructs an evaluation index system for NQPF by selecting indicators from multiple dimensions, including labor inputs, technological research and innovation output, digital development, and infrastructure and development conditions, as illustrated in Table 2.

### Control Variables

To control for confounding factors, this study includes the following variables. (1) The level of openness (Open) is used to capture the degree of regional economic openness and is measured by the ratio of actual utilized foreign direct investment to regional gross domestic product (GDP). A higher level of openness facilitates capital flows and technological spillovers, which contributes to improvements in the quality of economic growth. (2) The level of urbanization (Urban) reflects the extent of population urbanization and is measured by the proportion of the non-agricultural population to the registered population. The process of urbanization supports industrial restructuring, improves the efficiency of resource allocation, and strengthens

endogenous growth momentum. (3) Government intervention (Gov) is measured by the ratio of local general public budget expenditure to regional GDP, capturing the extent of government involvement in economic activities. Moderate intervention can improve resource allocation and the provision of public services, while excessive intervention may weaken market incentives. (4) Fiscal investment intensity (Fin) is measured by the ratio of fixed asset investment to general public budget expenditure, reflecting the role of government investment in driving economic development. Appropriate fiscal investment helps expand domestic demand and improve infrastructure conditions. (5) Education expenditure (Edu) is measured by the share of education spending in general public budget expenditure, indicating the importance attached by local governments to human capital investment. Education investment not only improves labor quality but also enhances innovation capacity and regional competitiveness. (6) Human capital (Hum) is measured by the proportion of students enrolled in higher education institutions to the total population at year-end, capturing the educational attainment of the labor force. Higher levels of human capital improve labor productivity and strengthen the capacity for technology absorption, thereby supporting HQED.

Table 2. Measurement index system for new quality productive forces

Dimension	Component	Indicator description	Direction
Advanced labor	Emerging industry workforce	Total number of employees in listed companies in strategic emerging industries and future industries, aggregated to the prefecture-level city based on the place of registration	+
	Individual capability	Average wage of on-the-job employees (yuan), reflecting the average skill level of the local workforce	+
	Human capital quality	Number of higher education institutions, reflecting local capacity for cultivating high-skilled labor	+
Advanced objects of labor	Infrastructure	Number of broadband internet subscribers per 1,000 households	+
		Total volume of telecommunications services (100 million yuan)	+
	Future development	Robot installation density	+
	Ecological environment	Investment in environmental pollution control (100 million yuan)	+
		Total transaction value of carbon trading, energy-use rights trading, and emission rights trading (100 million yuan)	+
Advanced means of production	Technological R&D	Ratio of science and technology expenditure to local fiscal expenditure	+
	Greening	Number of green invention patent applications in the current year	+
		Number of green utility model patent applications in the current year	+
	Data factors	Logarithm of (data asset-related word frequency) of listed companies, aggregated by registration location and averaged at the prefecture-level city	+
		Dummy variable indicating the presence of a data trading platform (1 = yes, 0 = no)	+

Source. construction based on Cheng and Cen (2024) and Han et al. (2024)

### Data Sources

This study uses panel data for ten prefecture-level cities in Shaanxi Province from 2009 to 2022 to examine the mechanisms through which NQPF affect HQED. Data on HQED are obtained from the China City Statistical Yearbook, supplemented by the Shaanxi Statistical Yearbook and statistical bulletins on national

economic and social development at the prefecture level. An evaluation index system is constructed based on five dimensions, namely innovation, coordination, green development, openness, and sharing, with 20 indicators used to measure the level of HQED.

Data for NQPF are drawn from multiple sources, including the China Science and Technology Statistical Yearbook, the China Urban Construction Statistical Yearbook, and the Chinese Research Data Services Platform database, with additional information from the International Federation of Robotics database and related studies. Indicators such as technological innovation, R&D investment, and invention patents are derived from science and technology statistics. Measures of industrial intelligence, informatization, and infrastructure are compiled using data from the Ministry of Industry and Information Technology and urban construction statistics. Regional variables, including energy utilization efficiency, fiscal expenditure, and infrastructure investment, are obtained from local statistical bulletins. Missing observations for a small number of cities or years are addressed using linear interpolation to maintain data continuity and completeness. Descriptive statistics of the main variables are presented in Table 3.

Table 3. Descriptive statistics

Variable	Obs	Mean	SD	Min	Max	Median
HQED	140	0.198	0.140	0.089	0.870	0.163
NQPF	140	0.103	0.134	0.004	0.698	0.053
Open	140	0.001	0.002	0.000	0.008	0.000
Urban	140	0.334	0.170	0.159	0.979	0.274
Gov	140	0.220	0.070	0.102	0.392	0.217
Fin	140	6.611	5.298	1.555	30.512	4.866
Edu	140	0.192	0.039	0.048	0.289	0.187
Hum	140	0.017	0.025	0.003	0.104	0.009

Table 3 reports the descriptive statistics of the main variables. HQED ranges from 0.089 to 0.870, while NQPF ranges from 0.004 to 0.698, indicating substantial cross-city and intertemporal differences. The control variables also show variation, especially in fiscal investment intensity and urbanization. These differences support the use of panel regression models that control for regional and temporal heterogeneity.

## The Findings

This section presents the empirical findings on the relationship between NQPF and HQED in Shaanxi Province. In line with the research hypotheses, the findings are organized into four parts. The first part examines the direct effect of NQPF on HQED through baseline regression and robustness tests. The second and third parts examine the mediating effects of industrial structure upgrading and energy utilization efficiency. The final part presents additional heterogeneity analyses across regions and levels of economic development.

### *Direct effect of NQPF on HQED: Testing H<sub>1</sub>*

H<sub>1</sub> proposes that NQPF exert a significant positive effect on HQED. To test this hypothesis, this study employs a two-way fixed effects model based on the results of the Hausman test and the model specification. The baseline regression results are shown in Table 4. All specifications control for both region-fixed effects and year-fixed effects. Column (1) includes only the core explanatory variable, NQPF. The estimated coefficient is positive and statistically significant at the 1% level, providing initial evidence that improvements in NQPF contribute to HQED. Columns (2) to (4) progressively incorporate control variables to mitigate potential omitted variable bias. The results remain robust across specifications. The coefficient on NQPF is consistently positive and significant at the 1% level, indicating that NQPF promote HQED. These findings provide empirical support for Hypothesis H<sub>1</sub>.

Table 4. Baseline regression results

	(1)	(2)	(3)	(4)
NQPF	0.966*** (29.06)	0.506*** (9.45)	0.728*** (19.90)	0.600*** (10.85)
Open		29.107*** (6.71)		7.432** (2.06)
Urban		0.051** (2.10)		-0.036 (-1.21)
Gov		-0.016 (-0.27)		0.025 (0.28)
Fin		0.000 (0.16)		0.001 (1.60)
Edu		-0.153 (-1.37)		-0.045 (-0.48)
Hum		0.086 (0.23)		-0.673 (-1.11)
Pop		0.014* (1.96)		0.197* (1.85)
FE_region	NO	NO	YES	YES
FE_year	NO	NO	YES	YES
_cons	0.099*** (17.68)	0.053 (1.49)	0.124*** (30.13)	-0.898 (-1.56)
N	140	140	140	140
R <sup>2</sup>	0.860	0.937	0.984	0.986
Adj. R <sup>2</sup>	0.86	0.93	0.98	0.98

Note: t-statistics are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

To further assess the reliability of the baseline results, robustness tests are conducted from four aspects: data treatment, sample selection, time period, and variable measurement. Specifically, the main variables are winsorized at the 1st and 99th percentiles to reduce the influence of extreme values. At the sample level, Shangluo City, which has a relatively weaker economic foundation, is excluded to mitigate the potential impact of regional disparities. The year 2020 is also removed to avoid abnormal fluctuations associated with the pandemic shock. In addition, an alternative measure of NQPF is constructed using a Baidu News search-based approach to examine the stability of the results under different measurement strategies. The results of all tests indicate that the main conclusions remain robust. The corresponding results are shown in Table 5.

#### *Winsorization Test*

The results after winsorization are presented in Column (1). After trimming extreme values at the 1st and 99th percentiles, the coefficient of NQPF is 0.475 and remains positive and statistically significant at the 1% level. Compared with the baseline regression, both the sign and significance remain unchanged. Although the magnitude of the coefficient varies after adjusting the sample distribution, its direction remains stable, indicating that the estimated effect is not driven by extreme observations.

#### *Excluding Less Developed Cities*

To account for potential bias arising from regional heterogeneity, Shangluo City is excluded from the sample and the model is re-estimated. The results, reported in Column (2), show that the coefficient of NQPF is 0.489 and remains significant at the 1% level. Its sign and statistical significance are consistent with the baseline estimates, suggesting that the effect is not confined to less developed regions.

#### *Excluding the Abnormal Year*

Given the substantial impact of the COVID-19 pandemic on economic activities, the year 2020 is excluded

and the regression is re-estimated. The results in Column (3) show that the coefficient of NQPF is 0.628 and remains positive and significant at the 1% level. This indicates that the promoting effect of NQPF on HQED persists after excluding pandemic-related disturbances.

*Alternative Measurement of the Core Explanatory Variable*

To further examine robustness, the core explanatory variable is replaced using a Baidu News search-based index (Li et al., 2020). This approach constructs an alternative proxy by counting news reports containing keywords such as “digital economy”, “technological innovation”, and “intelligent manufacturing”, capturing regional activity related to innovation and digital transformation. The results, presented in Column (4), show that the coefficient remains positive and statistically significant at the 5% level. The direction of the effect remains unchanged, confirming the robustness of the findings under alternative measurement strategies.

Table 5. Robustness test results

	(1) Winsorization	(2) Excluding less developed city	(3) Excluding abnormal year	(4) Alternative measure of NQPF (Baidu News index)
NQPF	0.475*** (8.28)	0.489*** (6.77)	0.628*** (10.07)	0.012** (2.41)
Open	9.141*** (3.33)	27.163*** (3.14)	6.797* (1.84)	23.498 (1.68)
Urban	-0.076** (-2.06)	-0.023 (-0.75)	-0.036 (-1.14)	-0.001 (-0.01)
Gov	-0.082 (-1.03)	-0.007 (-0.07)	-0.002 (-0.02)	0.119* (1.97)
Fin	0.001 (0.98)	0.001 (1.49)	0.001 (1.41)	0.003 (1.68)
Edu	-0.103 (-1.20)	-0.018 (-0.17)	-0.016 (-0.17)	0.096 (0.84)
Hum	-1.326** (-2.51)	-0.880 (-1.40)	-0.758 (-1.22)	-1.013 (-0.93)
Pop	0.011 (0.12)	0.139 (1.22)	0.188* (1.69)	0.733** (2.51)
FE_region	YES	YES	YES	YES
FE_year	YES	YES	YES	YES
_cons	0.162 (0.32)	-0.597 (-0.96)	-0.851 (-1.41)	-3.790** (-2.39)
N	140	126	130	140
R <sup>2</sup>	0.990	0.986	0.985	0.971
Adj. R <sup>2</sup>	0.99	0.98	0.98	0.96

Note: t-statistics are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

*Mediating effect of industrial structure upgrading: Testing H<sub>2</sub>*

H<sub>2</sub> proposes that NQPF promote HQED through industrial structure upgrading. To test this hypothesis, industrial structure upgrading is introduced as a mediating variable. Following Du et al. (2021), industrial structure upgrading is measured by the ratio of value added in the tertiary industry to that in the secondary industry. The mediation results are reported in Table 6.

In Column (1), the coefficient of NQPF on HQED is 0.600 and is statistically significant at the 1% level, indicating a positive effect of NQPF on development quality. In Column (2), the coefficient of NQPF on industrial structure upgrading is 1.164 and remains significant at the 1% level, suggesting that

improvements in NQPF increase the relative share of the tertiary industry compared with the secondary industry and promote structural upgrading. An increase in the share of the tertiary industry is associated with a reallocation of resources toward higher value-added sectors, which improves resource allocation efficiency (Herrendorf et al., 2014). Structural upgrading also enhances total factor productivity and supports HQED (Pan et al., 2021). The results from Columns (1) and (2) indicate that NQPF exert both direct and indirect effects on HQED. Industrial structure upgrading functions as a mediating channel, supporting Hypothesis H<sub>2</sub>.

Table 6. Mediation analysis: industrial structure upgrading

	(1) HQED	(2) Industrial structure upgrading
NQPF	0.600*** (10.85)	1.164*** (3.66)
Open	7.432** (2.06)	58.142*** (2.81)
Urban	-0.036 (-1.21)	0.100 (0.58)
Gov	0.025 (0.28)	3.945*** (7.71)
Fin	0.001 (1.60)	-0.011** (-2.43)
Edu	-0.045 (-0.48)	0.510 (0.96)
Hum	-0.673 (-1.11)	-9.995*** (-2.88)
Pop	0.197* (1.85)	-2.787*** (-4.53)
FE_region	YES	YES
FE_year	YES	YES
_cons	-0.898 (-1.56)	14.607*** (4.40)
N	140	140
R <sup>2</sup>	0.986	0.939
Adj. R <sup>2</sup>	0.98	0.92

Note: Standard errors are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

*Mediating Effect Of Energy Utilization Efficiency: Testing H<sub>3</sub>*

H<sub>3</sub> proposes that NQPF promote HQED through improvements in energy utilization efficiency. To test this hypothesis, energy utilization efficiency is introduced as another mediating variable. Following Shi and Li (2020), this study measures energy utilization efficiency using a super-efficiency DEA model with undesirable outputs. The mediation results are presented in Table 7.

In Column (1), the coefficient of NQPF on HQED is 0.600 and is statistically significant at the 1% level, indicating a positive effect of NQPF on development quality. In Column (2), the coefficient of NQPF on energy utilization efficiency is 0.734 and is also significant at the 1% level, suggesting that improvements in NQPF enhance energy utilization efficiency. Higher energy utilization efficiency is generally associated with lower energy consumption per unit of output and is closely related to improvements in economic development quality. Under environmental constraints, gains in green total factor energy efficiency help

reconcile the relationship between energy conservation, emission reduction, and economic growth (Shao & Wang, 2023). The results from Columns (1) and (2) indicate that NQPF exert both direct and indirect effects on HQED. Improvements in energy utilization efficiency act as a transmission channel, supporting Hypothesis H<sub>3</sub>.

Table 7. Mediation analysis: energy utilization efficiency

	(1) HQED	(2) Energy utilization efficiency
NQPF	0.600*** (10.85)	0.734*** (3.71)
Open	7.432** (2.06)	26.210** (2.04)
Urban	-0.036 (-1.21)	-0.665*** (-6.28)
Gov	0.025 (0.28)	-1.068*** (-3.36)
Fin	0.001 (1.60)	0.001 (0.48)
Edu	-0.045 (-0.48)	0.218 (0.66)
Hum	-0.673 (-1.11)	-1.750 (-0.81)
Pop	0.197* (1.85)	-0.297 (-0.78)
FE_region	YES	YES
FE_year	YES	YES
_cons	-0.898 (-1.56)	2.456 (1.19)
N	140	140
R <sup>2</sup>	0.986	0.846
Adj. R <sup>2</sup>	0.98	0.80

Note: Standard errors are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

*Additional Analysis: Heterogeneity Across Regions and Development Levels*

Additional analysis is conducted to examine whether the effect of NQPF on HQED varies across regions and levels of economic development. This analysis helps identify the conditions under which NQPF are more likely to generate significant improvements in development quality.

*Regional Heterogeneity*

The sample is divided into three regions based on Shaanxi’s regional economic classification: Northern Shaanxi, the Guanzhong region, and Southern Shaanxi. Northern Shaanxi comprises Yan’an and Yulin. The region is characterized by abundant resource endowments, with the energy sector playing a dominant role. The development of NQPF is closely linked to energy structure optimization, industrial chain extension, and technological upgrading. The Guanzhong region is the economic and technological center of Shaanxi Province, with a strong industrial foundation and concentrated innovation resources. In this region, NQPF development is mainly reflected in the integration of the digital economy, advanced manufacturing, and technological innovation. Southern Shaanxi has stronger ecological endowments, with industries more

oriented toward green manufacturing, ecological economy, and culture-tourism integration. This classification reflects regional differences in resource endowments, industrial structure, and innovation capacity, providing a basis for differentiated policy design.

The regression results are shown in Table 8. In the Guanzhong region, the coefficient of NQPF is 0.330 and significant at the 1% level, indicating that NQPF significantly promote HQED in this region. This result may be related to the stronger industrial foundation, higher concentration of innovation resources, and more complete factor agglomeration conditions in Guanzhong. In Northern Shaanxi, the coefficient of NQPF is positive but not statistically significant. The dominance of the energy sector and a relatively homogeneous industrial structure may limit the transformation of innovation into development quality. In Southern Shaanxi, the coefficient is also positive but does not reach statistical significance, suggesting that a smaller industrial base and weaker innovation capacity may constrain the formation of stable growth effects. These results indicate that the promoting effect of NQPF on HQED is more evident in the Guanzhong region, while the effects in Northern and Southern Shaanxi remain statistically insignificant.

Table 8. Regional heterogeneity analysis

	(1) Northern Shaanxi	(2) Guanzhong	(3) Southern Shaanxi
NQPF	0.215 (0.43)	0.330*** (3.12)	0.288 (1.07)
Open	-48.267 (-1.13)	25.505** (2.25)	-3.145 (-0.84)
Urban	-0.252 (-0.92)	0.004 (0.10)	-1.057** (-2.83)
Gov	0.175 (0.84)	-0.036 (-0.21)	-0.097 (-0.62)
Fin	0.004 (0.51)	-0.000 (-0.13)	-0.004 (-1.04)
Edu	0.018 (0.23)	-0.105 (-0.42)	-0.468** (-2.85)
Hum	0.773 (0.48)	-0.189 (-0.21)	4.745* (2.00)
Pop	-0.498 (-0.69)	0.415** (2.35)	0.615 (0.98)
FE_region	YES	YES	YES
FE_year	YES	YES	YES
_cons	2.275 (0.72)	-2.263** (-2.16)	-2.570 (-0.85)
N	28	70	42
R <sup>2</sup>	0.966	0.990	0.964
Adj. R <sup>2</sup>	0.81	0.98	0.92

Note: Standard errors are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

#### *Heterogeneity by Economic Development Level*

To further examine whether the effect of NQPF differs across stages of development, the sample is divided into high- and low-development groups based on the median level of economic development in Shaanxi Province. The results are shown in Table 9.

In regions with higher levels of economic development, the coefficient of NQPF is 0.482 and is statistically significant at the 1% level. This indicates that NQPF have contributed to improvements in the quality of economic development. Such effects can be attributed to relatively well-developed industrial systems, a higher concentration of innovation factors, and the rapid incorporation of new technologies into production processes. These conditions facilitate industrial upgrading and efficiency gains, which are reflected

in improved development quality (Zhang, 2023). In regions with lower levels of economic development, the coefficient of NQPF is -0.169 and is not statistically significant. These regions are characterized by weaker industrial foundations and limited accumulation of innovation factors. Constraints in technology diffusion and the transformation of innovation outcomes may hinder the formation of stable growth effects (Comin & Mestieri, 2018). As a result, NQPF have not yet translated into sustained improvements in economic development quality.

These findings suggest that the effects of NQPF vary across stages of development. Regions with stronger economic foundations are better positioned to absorb and transform NQPF, whereas less developed regions remain in a stage of factor accumulation and capacity building.

Table 9. Results of heterogeneity analysis by economic development level

	(1)	(2)
	High-development group	Low-development group
NQPF	0.482*** (4.56)	-0.169 (-1.04)
Open	42.735*** (2.81)	1.387 (0.51)
Urban	-0.107 (-0.93)	-0.125*** (-2.71)
Gov	0.059 (0.33)	0.139 (1.41)
Fin	0.001 (0.80)	0.006** (2.43)
Edu	0.072 (0.41)	-0.289** (-2.24)
Hum	-0.324 (-0.35)	0.025 (0.02)
Pop	0.115 (0.44)	-0.346 (-1.30)
FE_region	YES	YES
FE_year	YES	YES
_cons	-0.492 (-0.35)	2.020 (1.42)
N	69	67
R <sup>2</sup>	0.990	0.943
Adj. R <sup>2</sup>	0.98	0.90

Note: Standard errors are reported in parentheses. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5%, and 10% levels, respectively.

## Discussion

The findings show that NQPF significantly promote HQED in Shaanxi Province. This result indicates that technological innovation, digital development, and green transition have become important drivers of regional development quality. Technological change reshapes production modes and the role of production factors, thereby influencing development performance (Schwab, 2016; Brynjolfsson & McAfee, 2014). Innovation also affects economic outcomes by promoting industrial restructuring and resource reallocation (Aghion et al., 2014). In this sense, NQPF should not be interpreted only as technological progress. They also involve changes in production conditions, factor allocation, industrial organization, and development efficiency.

This finding extends existing discussions on quality-oriented economic development. Atkinson and Andes (2010) emphasize the role of continuous innovation and technological progress in economic transformation, while Ghosh and Parab (2021) show that technological progress and human capital accumulation can improve development quality by strengthening productivity and innovation capacity. The city-level evidence from Shaanxi shows that NQPF can be transformed into improvements in HQED in an inland provincial context. Compared with studies that examine innovation, digitalization, or green transformation separately, this study connects technological progress, factor reallocation, industrial upgrading, and green transformation in explaining changes in development quality.

The mediation results show that industrial structure upgrading and energy utilization efficiency are two channels through which NQPF affect HQED. With the development of NQPF, technological innovation and factor mobility encourage resources to flow toward higher value-added and more service-oriented sectors, which is consistent with the logic of structural transformation. Technological progress can also generate long-term economic effects by changing production modes and factor structures (Acemoglu & Restrepo, 2020). In addition, NQPF improve energy utilization efficiency by supporting cleaner production, more efficient energy allocation, and better resource use. This finding is consistent with studies that regard green total factor productivity and resource-use efficiency as important dimensions of development quality (Wang et al., 2024). For Shaanxi, where traditional and energy-intensive industries still account for a considerable share of the economy, these two mechanisms are particularly relevant. They suggest that NQPF contribute to HQED not only through innovation capacity, but also through structural adjustment and green efficiency improvement.

The heterogeneity results indicate that the effect of NQPF varies across regions and development stages. The promoting effect is significant in the Guanzhong region and in areas with higher levels of economic development, but it is not statistically significant in Northern and Southern Shaanxi or in the low-development group. This pattern suggests that the transformation of NQPF into HQED depends on regional absorptive capacity, industrial foundation, innovation accumulation, and institutional conditions. Egbeleo and Sodokin (2025) argue that the productivity effect of digital transformation is shaped by institutional quality and innovation capacity. This helps explain why regions with stronger economic foundations are more likely to convert NQPF into development quality. By contrast, regions with weaker industrial linkages, lower innovation capacity, or stronger resource dependence may need a longer period of capacity building before the benefits of NQPF can be fully released.

This study contributes to the literature in three ways. First, it provides city-level empirical evidence on the relationship between NQPF and HQED, extending previous studies that mainly discuss NQPF at the conceptual, national, or provincial level. Second, it identifies industrial structure upgrading and energy utilization efficiency as two transmission channels, explaining how innovation-driven productivity transformation is converted into development quality. Third, it shows that the effect of NQPF is shaped by regional conditions and development stages. The added value of this study lies in linking technological progress, factor reallocation, industrial upgrading, and green transformation within one empirical analysis, and in examining this relationship in inland cities where industrial transformation and green development face stronger structural constraints. This perspective helps deepen the understanding of how NQPF operate in regions with uneven development foundations.

## Conclusion

Using panel data from ten prefecture-level cities in Shaanxi Province from 2009 to 2022, this study examines the impact of NQPF on HQED and its transmission mechanisms. The results show that NQPF significantly promote HQED, with industrial structure upgrading and energy utilization efficiency serving as important transmission channels. This effect is more evident in the Guanzhong region and in areas with higher levels of economic development. These findings suggest that improving regional development quality requires the coordinated promotion of NQPF cultivation, industrial upgrading, energy efficiency, and regional integration.

Technological innovation remains the foundation for cultivating NQPF. In Shaanxi, policy efforts should strengthen enterprise participation, market-oriented factor allocation, and collaboration among

industry, universities, and research institutions. Greater emphasis should be placed on transforming scientific and technological achievements into industrial applications, especially in high-end equipment manufacturing, aerospace, new materials, intelligent manufacturing, artificial intelligence, new energy, and semiconductors. At the same time, industrial upgrading and energy utilization efficiency should be advanced together. Given the high share of traditional, resource-based, and energy-intensive industries, Shaanxi should shift from scale expansion toward value-chain upgrading, digital technology application, and cleaner production. Carbon emission trading, energy consumption rights trading, green credit, fiscal interest subsidies, and energy-efficiency programs can further guide enterprises toward cleaner and more efficient production. Regional differentiation is also necessary. The Guanzhong region should strengthen innovation agglomeration and spillovers to surrounding areas. Northern Shaanxi can use its energy base to move toward higher value-added segments of the industrial chain and accelerate energy structure adjustment. Southern Shaanxi may develop green industries and related services based on ecological and cultural resources. At the provincial level, better factor mobility and improved transport, energy, and information infrastructure can enhance regional connectivity and support coordinated development.

This study has several limitations. First, the analysis is based on panel data from ten prefecture-level cities in Shaanxi Province. Although this setting is suitable for examining the role of NQPF in an inland provincial context, the generalizability of the findings to other regions requires further examination. Second, the measurement of NQPF is constrained by data availability. As the concept continues to evolve, some dimensions, such as data factors, artificial intelligence applications, and digital industrial integration, may not be fully captured by the current indicator system. Third, this study focuses on industrial structure upgrading and energy utilization efficiency as mediating mechanisms, while other possible channels, such as green technological innovation, human capital accumulation, marketization, and institutional quality, remain to be further explored.

Future research can be extended in several directions. Cross-regional comparative studies can examine whether the mechanisms identified in Shaanxi also apply to other provinces or regions with different industrial structures and development conditions. More refined indicators and micro-level data, such as firm-level innovation, digital transformation, and energy-use data, may improve the measurement of NQPF and its economic effects. Future studies may also incorporate institutional and policy variables to better explain how local governance, market mechanisms, and innovation environments influence the transformation of NQPF into HQED outcomes.

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