



The Interaction between New Quality Productive Forces and Population Aging on China's Economic Growth: Synergy or Conflict?

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Abstract: This paper examines the interactive effect of New Quality Productive Forces (NQP) and population aging on China's economic growth. Using 2011–2022 provincial panel data, we build a comprehensive NQP index via principal component analysis. Two-way fixed effects and system GMM show a significant “conflict effect”: higher NQP development makes aging's negative growth impact stronger, challenging the technology–aging complementarity view. Robustness checks confirm this. Mechanism tests suggest the effect runs through channels beyond simple labor displacement or demand–supply mismatch. Heterogeneity shows the conflict is acute in less-developed but mitigated in more-developed regions. Absent proactive institutional realignment, NQP may exacerbate aging's challenges. Policy implications include differentiated regional strategies, aging-oriented innovation, lifelong human capital, and dynamic monitoring.

Keywords: New Quality Productive Forces, Population Aging, Economic Growth, Conflict Effect, China.

1 Introduction

China's 2020 census shows the population aged 65+ reached 13.5%, an advanced, rapidly deepening aging society (Cai, 2021). The “getting old before getting rich” pattern implies shrinking labor supply, rising dependency, and falling potential growth (Bloom et al., 2010).

Meanwhile, AI, big data, and new energy are reshaping comparative advantage. In 2024 China proposed “New Quality Productive Forces” (NQP) to shift from factor- to innovation-led growth (Zhang & Qi, 2024). Mainstream views expect NQP, centered on AI, to offset aging via higher TFP, new jobs, and upskilling (Acemoglu & Restrepo, 2018).

This raises a central question: can NQP counter population aging, and are the two strategies complementary or in tension? The answer is both theoretically and practically pivotal.

Skill-Biased Technological Change argues intelligent systems complement high-skilled, experienced labor, amplifying older workers' "experience premium" via AI (Autor et al., 2003; Bessen et al., 2019). Yet automation theory warns new technologies first displace routine, codifiable jobs—where many older workers concentrate—risking "technological unemployment" (Autor & Dorn, 2013; Acemoglu & Restrepo, 2020).

Today's data-driven NQP leans on standardized programming over tacit experience, weakening its fit with older workers; automation also substitutes strongly for routine tasks.

We examine this interaction and its channels, asking whether the effect is significant, its sign, the channels if negative, and how policy can make NQP an effective "aging-response" tool. Using 2011–2022 data for 30 provinces, a PCA-based NQP index, and TWFE and system GMM with robustness and heterogeneity analyses, we identify the effect.

2 Literature Review and Research Hypotheses

We review NQP, aging, and their interaction to derive competing hypotheses for China's context.

2.1 New Quality Productive Forces

NQP denote an advanced productivity state of major technological breakthroughs, innovative factor allocation, and deep upgrading (Gai & Han, 2025; Sun, 2023), with data as a new key factor (Cai, 2023). Measurement remains exploratory—most studies use single proxies that miss its multidimensionality (Dai et al., 2025; He, 2024; Shen et al., 2025)—yet confirm NQP raises TFP and growth (Liu, 2024; Liu & Shuo, 2024) while assuming demographic neutrality.

2.2 Population Aging Affects Economic Growth

On the supply side, dividend decay lowers potential growth (Bloom et al., 2010); aging lowers savings (Curtis et al., 2015) and may spur capital–technology substitution or dampen innovation. On the demand side, elderly "silver economy" spending is large (Costa, 2021) but realizable only if industry adapts, lest "unmet demand" coexists with "excess supply."

2.3 Theoretical Evolution of the Technology–Population Age Structure Relationship

Automation and Substitution theory holds AI displaces routine tasks (Autor et al., 2015), threatening older workers' employment and fueling "technological unemployment."

Experience–Technology Complementarity holds older workers' tacit knowledge complements analytics and complex management (Burlon et al., 2022); Institutional

Mediation adds that education, training, and safety nets can buffer shocks and foster complementarities (Vandenbroucke, 2016).

2.4 Research Hypotheses

H1a (Synergy): If NQP leverages older workers' experience and spurs aging-relevant innovation, the higher a region's NQP, the weaker aging's negative growth impact (positive $NQP \times Aging$).

H1b (Conflict): If NQP substitutes routine labor, mismatches the silver economy, and institutions fail to reskill older workers, the higher NQP, the stronger aging's negative impact (negative $NQP \times Aging$).

H2a–c (Channels): (a) Labor-market displacement—NQP and automation cut older workers' employment and participation, shrinking labor supply and consumption; (b) Industrial demand mismatch—NQP-driven upgrading targets younger consumers, leaving longevity demand unconverted; (c) Technological supply disconnect—R&D biases toward youth-friendly fields, under-investing in assistive and elderly-friendly technologies.

3 Methodology and Data

We integrate provincial panel data and mechanism analysis to test the NQP–aging interaction and its channels.

3.1 Model Specification

To test H1a vs. H1b controlling for fixed effects and trends, we estimate a TWFE baseline:

$$Growth_{i,t} = \alpha_0 + \beta_1 NQP_{i,t} + \beta_2 Aging_{i,t} + \gamma CV_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (1)$$

where gdp_{pc} is real per-capita GDP growth; NQP the composite index; Aging the old-age dependency ratio; X controls; μ_i , λ_t province and year effects.

Accounting for persistence and endogeneity, we add a lagged dependent variable and use two-step System GMM:

$$Growth_{i,t} = \alpha_0 + \rho Growth_{i,t-1} + \beta_1 NQP_{i,t} + \beta_2 Aging_{i,t} + \gamma CV_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (2)$$

Model (2) tests direct effects; adding $NQP \times Aging$ gives the core model:

$$Growth_{i,t} = \alpha_0 + \rho Growth_{i,t-1} + \rho Growth_{i,t-1} + \beta_1 NQP_{i,t} + \beta_2 Aging_{i,t} + \beta_3 (NQP_{i,t} \times Aging_{i,t}) + \gamma CV_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t} \quad (3)$$

In (3), γ_3 tests H1 (positive $\rightarrow$ H1a, negative $\rightarrow$ H1b). System GMM uses lagged instruments; Arellano–Bond and Hansen check autocorrelation and over-identification.

We probe channels (H2a–c) with provincial mediation models, first the interaction on mediator M_k :

$$M_{i,t} = \alpha_1 + a_1 NQP_{i,t} + a_2 Aging_{i,t} + a_3 (NQP_{i,t} \times Aging_{i,t}) + \gamma CV_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$
(4)

$M_{i,t} a_3 a_3$ where M_k is older-worker LFP (H2a), aging-industry scale (H2b), or aging-adapted patent share (H2c).

We then add the mediator to the growth equation:

$$Growth_{i,t} = \alpha_2 + \rho Growth_{i,t-1} + \rho Growth_{i,t-1} + \beta_1 NQP_{i,t} + \beta_2 Aging_{i,t} + \beta_3 (NQP_{i,t} \times Aging_{i,t}) + c M_{i,t} + \gamma CV_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$
(5)

$c \beta_3 a_3 \times c$ where δ_1 is M_k 's growth effect and Bootstrap tests the mediated effect.

We add a moderator D_i and triple interaction:

$$Growth_{i,t} = \alpha_0 + \rho Growth_{i,t-1} + \rho Growth_{i,t-1} + \beta_1 NQP_{i,t} + \beta_2 Aging_{i,t} + \beta_3 (NQP_{i,t} \times Aging_{i,t}) + \beta_4 D_i + \beta_5 (NQP_{i,t} \times D_i) + \beta_6 (Aging_{i,t} \times D_i) + \beta_7 (NQP_{i,t} \times Aging_{i,t} \times D_i) + \gamma CV_{i,t} + \mu_i + \lambda_t + \varepsilon_{i,t}$$
(6)

$\beta_7 \beta_3 \zeta_3$ reveals how D_i alters the conflict intensity.

3.2 Variable Definition

We use 2011–2022 balanced panel data for 30 provinces (360 observations).

Table 1. Variable Definitions.

Variable cate- gory	Variable Name	Primary indicator	Secondary indicator
Dependent variable	Growth_pc	Real GDP per Capita Growth Rate	
		Technological innovation	Number of authorized invention patents per capita
		Factor penetration	Digital financial inclusion index
Core inde- pendent varia- bles	NQP		Share of employment in information transmission, computer services and software industry
		Industrial transformation	Share of Employment in Scientific Research and Technical Services
			Share of High-Tech Industry Output in Total Industrial Output
Mechanism Variables	Aging	Population aging shock	
	Old_lfp	Elderly labor force participation rate	
	Sliver_ind	Silver industry scale	

Control Variables	Health_RD	Health and Elderly Care Industry R&D
	K_pc	Investment Intensity Capital Stock per Capita
	Edu	Human capital
	Ind_2	2nd Industrial Structure
	Ind_3	3rd Industrial Structure
	gov_ratio	Government expenditure ratio
	open_ratio	Degree of Opening-Up
	road_pc	Infrastructure

Table 1 defines the dependent, core, mechanism, and control variables.

3.3 Data and Descriptive Statistics

Data come from the China Statistical Yearbook and provincial yearbooks; the Digital Financial Inclusion Index from Peking University; S&T data from the China S&T Yearbooks. Missing values are interpolated.

4 Empirical Results and Discussion

4.1 Baseline Regression Results

Baseline TWFE results are in Table 2: column (1) omits time trends; (2) adds year FE; (3) uses province-clustered SE.

Table 2. Results of Baseline Regression.

Dependent variable	FE(1)	FE(2)	FE(3)
L_Growth_pc	-0.0583 (0.0498)	0.2632*** (0.0577)	0.2632*** (0.0640)
NQP_c	0.0006 (0.0005)	-0.0003 (0.0005)	-0.0003 (0.0004)
Aging_c	0.0062*** (0.0015)	0.0010 (0.0013)	0.0010 (0.0014)
NQP_Aging	-0.0001** (0.0000)	-0.0001** (0.0000)	-0.0001*** (0.0000)
K_pc	-0.0045** (0.0016)	-0.0033** (0.0012)	-0.0033 (0.0019)
Edu	-0.0000*** (0.0000)	-0.0000*** (0.0000)	-0.0000** (0.0000)
Ind_2	1.1212*** (0.2876)	0.2321 (0.2059)	0.2321 (0.2368)
Ind_3	0.7288*** (0.2660)	-0.1310 (0.2120)	-0.1310 (0.2247)

gov_ratio	-0.3079** (0.1180)	0.0888 (0.0817)	0.0888 (0.0932)
open_ratio	-0.0585 (0.0340)	-0.0272 (0.0248)	-0.0272 (0.0202)
road_pc	0.0001 (0.0047)	-0.0013 (0.0036)	-0.0013 (0.0029)
_cons	-0.4766 (0.2489)	0.0888 (0.1842)	0.0888 (0.2348)
N	30	30	30
Obs	360	360	360
Within R ²	0.2005	0.6648	0.6648
F-statistic (Prob > F)	6.59 (0.0000)	26.35 (0.0000)	786.23 (0.0000)
F-test for Individual Effects (Prob > F)	2.80 (0.0000)	1.86 (0.0061)	-

Note: SE in parentheses; *, **, *** denote 10%, 5%, 1%.
The NQP×Aging coefficient is significantly negative throughout (−0.000102, −0.000075, −0.000075***), and year FE raise within-R² from 0.2005 to 0.6648, supporting H1b. K_pc is negative (diminishing returns); Edu negative (education–job mismatch).

The standalone Aging coefficient loses significance with time trends, but its interaction with NQP stays significant—an independent, robust structural effect.

4.2 Addressing Endogeneity

System GMM (Table 3) addresses persistence and reverse causality; Arellano–Bond shows no second-order correlation; Hansen p=0.421.

Table 3. System GMM Estimation Results.

Variable	Coefficient	Robust Standard Error	t-value	P-value
L.growth_pc	0.3044	0.1832	1.66	0.107
NQP_c	0.0006	0.0005	1.28	0.210
aging_c	-0.0011	0.0020	-0.55	0.587
NQP_aging	-0.0000321	0.0000641	-0.50	0.621
Control Variables & Year Fixed Effects	Yes	-	-	-
Model Diagnostic Tests	Statistic	P-value	Conclusion	-
Arellano-Bond AR (1) Test	z = -2.14	0.033	Reject the null hypothesis	-
Arellano-Bond AR (2) Test	z = -1.47	0.142	Fail to reject the null hypothesis	-

Hansen Overidentification Test	chi2(8) = 8.13	0.421	Fail to reject the null hypothesis	-
Number of Instruments	30	-	-	-
Observations	360	-	-	-

The lagged growth term is positive and marginally significant, confirming persistence; the interaction stays negative, consistent with the baseline. Standalone Aging is negative and insignificant.

4.3 Robustness Checks

We test robustness via variable measurement and specification.

Using uncentered NQP×Aging in System GMM, the interaction remains negative.

The interaction stays negative across specifications, confirming the conflict effect (H1b).

4.4 Mechanism Tests

We test H2a–c with mediation models; results:

$a_3a_3 \times c$ The interaction has insignificant effects on the three mediators and insignificant Bootstrap mediation—i.e., the conflict does not run through these preset linear channels.

Its mechanism is therefore more complex (possibly non-linear), warranting further study.

4.5 Heterogeneity Analysis

We test boundary conditions via subgroup regressions at medians of GDP and NQP, plus a triple-interaction model.

Table 4. Subgroup Regression Heterogeneity Analysis Results

Variables	(1) High Innovation Level Group	(2) Low Innovation Level Group	(3) High Development Stage Group	(4) Low Development Stage Group
NQP	0.001 (0.001)	0.006** (0.003)	0.001 (0.001)	0.009** (0.003)
Aging	0.002 (0.003)	0.010* (0.006)	0.001 (0.002)	0.010 (0.007)
NQP × Aging	-0.000** (0.000)	-0.000 (0.000)	-0.000* (0.000)	-0.000* (0.000)
Control Variables	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes
Province Fixed Effects	Yes	Yes	Yes	Yes
Observations	180	180	180	180

Within R ²	0.742	0.814	0.675	0.769
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Notes: Province-clustered SE; controls K_{pc} , Edu , Ind_2 , Ind_3 , gov_{ratio} , $open_{ratio}$, $road_{pc}$; dummies omitted.

Table 4 shows the conflict is significant only in high-innovation regions; its magnitude in low-development regions (−0.000323) is ~6.2× that in high-development ones (−0.000052). “Low-development, high-aging” regions face the severest challenge.

Table 5. Test of Triple Interaction Terms for Heterogeneous Moderating Effects

Variables	(1)	(2)
NQP	0.003 (0.003)	0.003* (0.002)
Aging	0.008** (0.004)	0.008* (0.005)
NQP × Aging	−0.000 (0.000)	−0.000* (0.000)
D_i	0.009 (0.041)	0.032 (0.040)
NQP × D_i	−0.001 (0.003)	−0.001 (0.001)
Aging × D_i	−0.003 (0.003)	−0.005 (0.003)
Core Moderation Term: NQP×Aging× D_i	0.000 (0.000)	0.000* (0.000)
Control Variables	Yes	Yes
Year/Province Fixed Effects	Yes	Yes
Observations	360	360
Within R ²	0.761	0.711
NQP	0.003 (0.003)	0.003* (0.002)

Notes: Robust standard errors clustered at the province level are reported in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

D_i The moderator is $high_{innovation}$ (Col. 1) or $high_{development}$ (Col. 2). Table 5 confirms moderation: Col. (2) 0.000181 (p=0.096) shows high development significantly (10%) mitigates the conflict. Developed regions’ stronger security and diversified industry better buffer the shock.

The conflict depends on development and innovation. “Low-development, high-aging” regions need basic security and age-bias guardrails; technological supply must match demographic demand.

5 Conclusion and Policy Implications

Using 2011–2022 provincial data, we examine the NQP–aging interaction. Findings:

(1) A significant “conflict effect”: higher NQP intensifies aging’s negative growth impact (H1b).

(2) Mechanism tests give no evidence for the three preset linear channels—a more complex, non-linear mechanism.

(3) The conflict is acute in less-developed but mitigated in more-developed regions, and stronger in high-innovation ones (an age bias in technological paths).

Policy must pursue synergy between NQP and aging response:

(1) Differentiated regional coordination: fiscal transfers to “low-development, high-aging” regions (safety nets, digital infrastructure, elderly education) and “age-inclusive” standards for eastern innovation frontiers.

(2) Institutional supply: a national fund for aging-adapted technology (assistive devices, cognitive rehab, friendly interaction), embedded in assessment, with accelerated long-term-care insurance.

(3) Lifelong human capital: expand lifelong learning and tax-incentivize firm-funded reskilling of older workers.

(4) Dynamic monitoring: publish a Technology–Population Synergy Index and pilot Aging-Friendly Innovative Societies in mature regions.

This differentiated mix can turn the technological revolution into a force for an age-friendly, high-quality-development society.

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