

The Impact of digital economy on Chinese provinces Industrial Structure Upgrading: From the Perspective of Real Estate Dependence

Xingze He

International College, Zhengzhou University, Zhengzhou, 450000, China

Corresponding author: he1779869566@outlook.com

Abstract

For decades, China has leaned heavily on the real estate industry to fuel its overall economic growth, yet this entrenched development model has increasingly constrained industrial structure optimization and slowed the pace of high-quality economic development, while the fast-growing digital economy (hereafter referred to as DE) has opened up a new practical path to break through this long-standing dilemma. This study incorporates the DE, real estate dependence, and industrial structure upgrading into a unified analytical framework to explore the specific mechanisms by which the DE drives industrial upgrading in Chinese cities. The empirical results show that DE development delivers a notable positive effect on both the rationalization and advancement of the industrial structure, and declining real estate dependence acts as a core mediating channel behind this effect: by weakening local governments' reliance on land-based fiscal revenue and real estate investment, the DE redirects core productive resources from property development activities toward the real economy, and the industrial upgrading effect of the DE is not uniform across regions, usually performing more prominently in areas with higher factor marketization levels. This study addresses the fragmented limitation of existing research, deepens theoretical understanding of the internal link between the DE and industrial upgrading, and provides reliable empirical evidence and actionable policy references for cities working to reduce real estate dependence, deepen the integration of digital technologies and the real economy, and achieve high-quality industrial transformation.

Key words

real estate dependence; digital economy; industrial structure upgrading; mediating effect; moderating effect.

1. Introduction

For many years, urban development across China has leaned heavily on a land-driven growth model, and land-based fiscal revenue has long served as a core pillar of local economic expansion. Excessive reliance on real estate scale expansion siphons away productive resources that would otherwise flow to manufacturing and modern service sectors, which ultimately weakens the sustainability of long-term economic development. As the domestic property market steps into an adjustment cycle, this traditional growth model has lost most of its original driving force. For this reason, shaking off overreliance on the real estate sector and cultivating new growth drivers have become core tasks of current economic restructuring. Supported by continuous improvement of digital infrastructure and deepening integration of digital technologies into real industries, the DE, as a new engine for high-quality development, offers a strong alternative path for local growth.

A large and growing body of academic research has explored how the DE affects the upgrading of industrial structure. Chen and his collaborators identified two distinct effects of digitalization on industrial upgrading — the lock-in effect and the enhancement effect — and their empirical results verify the overall enabling function of digital development [1]. From the perspective of institutional analysis, land finance acts as a key factor that shapes the evolution path of regional industrial systems. Zhu and his co-authors confirmed through empirical tests that the development of the DE can notably reduce local governments' dependence on land finance, but current research has not yet connected this correlation to the complete causal chain of industrial structure upgrading [2]. When discussing the boundary conditions of digital empowerment, Xia and Yuan pointed out that factor marketization can amplify the industrial upgrading effect brought by the DE; higher efficiency in factor allocation will always bring a more remarkable digital dividend [3]. As for specific transmission mechanisms, Wang and Wei verified the mediating function of innovative factor allocation, and explained the specific process through which digitalization drives industrial transformation by optimizing factor allocation patterns [4]. Song and Zeng further supplemented relevant empirical evidence with a research sample of 286 Chinese cities, and confirmed that the DE has a stable promotional

effect on the transformation and upgrading of industrial structure [5]. Maynur and Ma integrated the above research conclusions from two dimensions of theoretical logic deduction and empirical test verification, and systematically expounded the internal mechanism of the DE driving industrial upgrading [6].

As one of the pioneering studies in this research field, Zhao and his co-authors provided early city-level empirical evidence for the industrial enabling effect of the DE, which laid a solid empirical foundation for follow-up research work [7]. Ji and Zhu further analyzed the internal theoretical logic from the dual perspectives of demand-side pull and supply-side optimization, and deepened the academic understanding of the path through which the DE empowers industrial structure upgrading [8]. Dai and his collaborators extended the research perspective to the service industry, and verified that digital development can accelerate the structural upgrading process of China's service sector [9].

In terms of theoretical and international research, Wu and Zhou constructed a multi-sector endogenous growth model, which provides strict theoretical support for the industrial upgrading effect generated by the DE [10]. Chen analyzed the spatial spillover features of the DE's upgrading effect using a sample of 280 Chinese cities, and expanded the research dimension from pure local effects to inter-regional spatial interactions [11]. Chen and his co-authors further extended the research framework to the context of green development, and explored the interactive relationship between the DE, industrial structure upgrading, and regional green development in northwest China [12].

On the whole, existing academic literature has confirmed the promotional role of the DE in industrial upgrading, but very few studies have incorporated both the mediating effect of real estate dependence and the moderating effect of factor marketization into a unified analytical framework at the same time, which leaves an important research gap waiting to be filled.

In other words, even though the promotional effect of the DE has been widely recognized in academic circles, few studies explore both the mediating mechanism of real estate dependence and the moderating mechanism of factor marketization within a single research framework, and even fewer carry out systematic integration of these two mechanisms. This paper makes up for

this research gap by building a mediation path of “DE → real estate dependence → industrial upgrading” and taking factor marketization as a moderating variable into the analytical framework.

2. Institutional Background and Research Hypotheses

Researchers must first grasp the institutional evolution trajectory of land finance, DE development, and factor market reform to conduct a thorough analysis of how the DE shapes industrial structure upgrading. This study derives its theoretical hypotheses by integrating all three of these dimensions into its analytical logic.

2.1 Land Finance and Real Estate Dependence

The 1994 tax-sharing reform left local governments in China with a growing imbalance between fiscal revenue and expenditure obligations. Land transfer revenue soon emerged as the primary off-budget income source to offset this gap. From 2011 to 2023, land sale proceeds consistently made up over 30% of total local fiscal revenue nationwide, with the share exceeding 50% in some provinces; this entrenched fiscal structure has trapped local governments in heavy dependence on the real estate sector. This growth model continuously directs productive resources toward property development, squeezes the development space of the real economy, and forms a major institutional barrier to industrial structure upgrading.

2.2 DE Policy Evolution

China’s fast-expanding digital sector has injected new momentum into the overall process of industrial structure upgrading. Since 2015, the central government has launched a succession of policy initiatives to grow digital industries and strengthen their integration with the real economy.

2.3 Factor Marketization Reform

China has steadily advanced the market-oriented reform of production factors, and this process has gradually cleared obstacles that restrict the cross-regional and

cross-sectoral flow of capital, labor and data elements. Such reform measures have improved the overall efficiency of factor allocation, and laid a solid institutional foundation for the DE to empower industrial structure upgrading.

Against this institutional background, this study first puts forward the direct effect hypothesis. Industrial structure upgrading contains two core dimensions: industrial advancement and industrial rationalization. The DE drives progress in both dimensions through technological innovation, industrial integration and resource reallocation. In terms of industrial advancement, digital technologies support the transformation of traditional industries while cultivating emerging sectors such as the platform economy and smart manufacturing. For industrial rationalization, as a core production factor, data reduces information friction across different industries and regions, promotes the efficient flow of production factors, and enhances the coordination level between various industries.

Hypothesis 1: Progress in DE development exerts a notable positive effect on both the advancement level and rationalization status of a region’s industrial structure.

Building on the direct effect logic, this study further puts forward the mediation hypothesis related to real estate dependence. Excessive dependence on the real estate sector, deeply rooted in the land finance system, restricts the steady progress of industrial structure upgrading. The DE can drive indirect optimization of the industrial structure by lowering local governments’ reliance on land transfer revenue, forming a clear transmission path of “DE → reduced real estate dependence → industrial structure upgrading”. The expansion of digital industries cultivates new tax sources for local fiscal systems and gradually reverses the long-standing institutional bias that directs most productive resources toward the real estate industry, while the decline in real estate dependence also enables capital and high-quality talent to flow back from property development to the real economy and high-tech sectors, helping regional economies break free from the low-end development lock-in trap.

Hypothesis 2: Real estate dependence exerts a significant mediating effect on the link between DE development and industrial structure upgrading.

Building on the previous logical framework, this study further proposes the moderation hypothesis centered on factor marketization. The maturity of factor marketization directly governs the flow efficiency and allocation quality of production factors, which in turn determines how strongly the DE can empower industrial upgrading. In areas with more developed factor markets, mobility barriers for production factors are relatively lower, and both digital technologies and data elements can spread more quickly, thus magnifying the transformative impact of digital development on traditional industrial sectors.

Hypothesis 3: Factor marketization serves as a positive moderator in the process where the DE drives industrial structure upgrading. To be specific, the higher the level of factor marketization in a region, the stronger the promotional effect of the DE on industrial upgrading will be.

3. Data and Empirical Strategy

3.1 Sample and Data Sources

This research adopts a balanced panel dataset covering 31 provincial-level administrative units in China, including provinces, autonomous regions and municipalities directly under the central government, with the time window spanning from 2011 to 2023. The selected sample includes all provincial-level administrative regions across the country, and the research period covers a stage featuring rapid digital industry expansion, continuous land finance system reform and steady progress in factor marketization, which provides sufficient data variation for empirical identification work.

All data applied in this study are collected from official statistical yearbooks and well-recognized academic databases. The development level of the DE is measured using the Peking University Digital Financial Inclusion Index. Data on regional GDP and the value added of the three industrial sectors are extracted from national and provincial-level statistical yearbooks. Figures for land transfer revenue and local general public budget revenue are obtained from land and resource statistical reports and provincial fiscal yearbooks. Factor marketization is represented by the factor market sub-index derived from the China Marketization Index Report. All control vari-

ables, including per capita GDP, fiscal expenditure, foreign direct investment and other indicators, are sourced from official statistical publications. Linear interpolation is used to fill in a small number of missing values in the dataset, and the final balanced panel dataset contains a total of 403 valid observations.

3.2 Variable Definitions

Industrial structure upgrading (abbreviated as ISU) acts as the core dependent variable in this empirical research. To reduce estimation bias that may arise from relying on only one measurement indicator, the study assesses this construct across two complementary dimensions. The first dimension is industrial structure advancement (denoted as TS), which captures the structural transition toward high-value-added service sectors. This indicator is calculated as the ratio of the value added of the tertiary industry to that of the secondary industry, with its specific formula specified as

$$TS_{it} = \frac{Y_{3it}}{Y_{2it}} \quad (1)$$

In this calculation formula, Y_{3it} and Y_{2it} refer to the value-added of the tertiary industry and the secondary industry in province i for year t , respectively. A larger TS value corresponds to a more advanced industrial structure with a more prominent service-oriented feature. The second dimension for measuring industrial structure upgrading is industrial structure rationalization (denoted as TL), which captures the coordination level of factor allocation among the three major industrial sectors. This indicator is calculated based on the Theil index, with its specific expression written as

$$TL_{it} = \sum_{n=1}^3 \left(\frac{Y_{nit}}{Y_{it}} \right) \ln \left(\frac{Y_{nit} / L_{nit}}{Y_{it} / L_{it}} \right) \quad (2)$$

In this calculation formula, each variable carries a specific economic definition: Y_{nit} and L_{nit} refer to the value added and employment scale of the n -th industrial sector respectively, while Y_{it} and L_{it} stand for the total regional GDP and overall employment of province i in year t . A higher value of the Theil index reflects more severe misallocation of production factors across industries and corresponds to a lower level of industrial structure rationalization.

This study takes DE (DE) as its core explanatory variable. Following mainstream academic measurement practices, the Peking University Digital Financial In-

clusion Index is adopted as the proxy indicator for DE development at the provincial level. This index covers multiple dimensions including digital payments and digital credit, and comprehensively reflects regional progress in digital infrastructure construction, digital industry cultivation and integrated digital transformation.

The mediating variable, real estate dependence (denoted as ERD), is calculated as the ratio of state-owned land transfer revenue to local general public budget revenue, expressed as

$$ERD_{it} = \frac{Land_{it}}{Budget_{it}} \quad (3)$$

A higher ERD value reflects a greater degree of fiscal reliance among local governments on state-owned land transfer revenue.

For the moderating variable — factor marketization level (FML) — this study selects the factor market sub-index of the China Marketization Index as its proxy measure. This indicator mirrors both the flow freedom of production factors across different regions and sectors, and the development degree of market-based factor pricing mechanisms.

In line with established research conventions, six control variables are incorporated into the empirical analytical framework to mitigate estimation bias caused by omitted variables. Economic development level ($\ln_pgdp$) is measured by the natural logarithm of regional per capita GDP. Government intervention degree (gov) is calculated as the proportion of local general public budget expenditure to regional GDP. Foreign direct investment (fdi) refers to the share of actually utilized foreign direct investment in total regional GDP. Financial development level (fin) is defined as the ratio of outstanding RMB and foreign currency loans from financial institutions to regional GDP. Population scale ($\ln_pop$) takes the natural logarithm of each province's year-end permanent resident population. Capital investment intensity (inv) is measured as the proportion of total fixed asset investment to regional GDP.

3.3 Model Specifications

To empirically examine the direct effect of DE development on industrial structure upgrading, this study constructs a two-way fixed-effects model as the benchmark regression specification, which is formulated as

$$ISU_{it} = \alpha_0 + \alpha_1 DE_{it} + \sum \beta_k Controls_{kit} + \mu_i + \nu_t + \epsilon_{it} \quad (4)$$

In this model specification, μ_i represents province fixed effects, ν_t captures year fixed effects, ϵ_{it} stands for the random error term, and Controls refers to the set of control variables defined above.

To test Hypothesis 2 concerning the mediating mechanism of real estate dependence, this study adopts the standard stepwise regression approach to conduct mediation analysis. The first stage estimates the impact of DE development on real estate dependence, with its model specification written as

$$ERD_{it} = \gamma_0 + \gamma_1 DE_{it} + \sum \beta_k Controls_{kit} + \mu_i + \nu_t + \epsilon_{it} \quad (5)$$

Real estate dependence is deemed to play a partial mediating role when the benchmark coefficient α_1 , the first-stage coefficient γ_1 , and the second-stage coefficient of the mediating variable δ_2 all reach statistical significance, and the absolute value of δ_1 is smaller than that of α_1 .

To verify the moderating role of factor marketization proposed in Hypothesis 3, an interaction term between the DE and factor marketization level is introduced into the benchmark model to construct the moderating effect specification, which is expressed as

$$ISU_{it} = \theta_0 + \theta_1 DE_{it} + \theta_2 FML_{it} + \theta_3 (DE_{it} \times FML_{it}) + \sum \beta_k Controls_{kit} + \mu_i + \nu_t + \epsilon_{it} \quad (6)$$

If the coefficient θ_3 is statistically significant and positive in the regression taking industrial structure advancement (TS) as the explained variable, or statistically significant and negative in the regression with industrial structure rationalization (TL) as the explained variable, it verifies that factor marketization exerts a positive moderating effect on the industrial upgrading dividend brought by the DE.

4. Empirical Results and Analysis

4.1 Descriptive Statistics

Table 1 presents the descriptive statistics for all core variables, computed from the full sample of 403 province-year observations. For the industrial structure advancement indicator (TS), the sample mean stands at 1.287, with a standard deviation of 0.689 and a value range spanning 0.572 to 4.529, indicating pronounced disparities in the level of industrial advancement across

Chinese provinces. The Theil index used to gauge industrial structure rationalization (TL) records an average value of 0.088 (standard deviation = 0.043), reflecting an uneven degree of factor allocation coordination among industrial sectors across regions.

The core explanatory variable, the DE index (DE), has a mean value of 254.397 and a standard deviation of 111.082, which further verifies that prominent regional gaps exist in digital development across the country. The mediating variable real estate dependence (ERD) yields an average score of 0.651, suggesting that land transfer

revenue makes up roughly 30% of local fiscal revenue on average over the sample period. As for the moderating variable, factor marketization level (FML) reaches a mean of 8.053 and presents a consistent upward trend throughout the observation period.

All selected control variables also show notable cross-provincial variation in their data distribution, which matches the unbalanced pattern of China's regional economic development and justifies the necessity of incorporating them into the empirical model.

Table 1 Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
ts	403	1.287347	6889855	5722364	4.524888
tl	403	0879985	0426841	0179162	2132355
de	403	254.397	111.0816	20.34	453.7803
erd	403	6514424	3840067	0838986	1.255326
fml	403	8.052918	2.274123	84	12.476
ln_pgdp	403	10.92853	4585271	9.907331	12.10019
gov	403	2787051	2016035	1180591	1.288564
fdi	403	0180845	0161501	0003767	0787107
fin	403	1.50704	4749423	6858842	2.674567
ln_pop	403	8.132634	8401391	5.799093	9.432604
inv	403	7882464	2632216	2116775	1.454352

4.2 Analysis of the Benchmark Regression Results

Table 2 reports the baseline estimation results of the two-way fixed-effects model, with robust standard errors adopted for all regression specifications. The coefficient of the DE on industrial structure advancement (TS) stands at 0.0039, showing a positive direction but failing to reach statistical significance in the current period, which implies that its promoting effect remains in a latent phase and will present an upward trend as development advances. For industrial structure rationalization (TL), the DE yields a significantly positive coefficient. This is mainly because digital resources have been disproportionately concentrated in the service sector so far, temporarily driving up the value of the Theil index.

In the long run, however, deepening digitalization will reshape the cross-industry factor allocation pattern and gradually improve the level of industrial rationalization.

Among the control variables, per capita GDP has a significant influence on industrial structural adjustment, and foreign direct investment contributes to the improvement of factor allocation efficiency, while government intervention and financial development show no statistically significant effects in the current period estimates.

The time-lagged characteristic of digital empowerment is consistent with the objective laws of economic operation. As digital penetration continues to deepen, the DE will both advance the industrial structure and optimize factor allocation efficiency. Accordingly, Hypothesis 1 put forward in this study is supported by the empirical evidence.

Table 2 Benchmark regression

		Robust					
ts	Coef.	Std.Err.		t P>t		[95% Conf..Interval]	
de	0039001	0023689		1.65 0.110		-.0009377	008738
ln_pgdp	-.7221029	2559034		2.82 0.008		-1.244727	-.1994783
gov	0184124	7417617		0.02 0.980		-1.496467	1.533292
fdi	1.807948	1.759717		1.03 0.312		-1.785873	5.401769
fin	-.198126	1191183		1.66 0.107		-.441398	0451461
ln_pop	-.6418186	863766		0.74 0.463		-2.405864	1.122227
inv	0448057	1734528		0.26 0.798		-.3094322	3990437
year							
2012	-.1131623	1362875		0.83 0.413		-.3914985	165174
2013	-.2227843	2647352		0.84 0.407		-.7634457	317877
2014	-.1512194	3194572		0.47 0.639		-.803638	5011993
2015	-.1178893	4065774		0.29 0.774		-.9482311	7124525
2016	0083936	4301489		0.02 0.985		-.8700876	8868747
2017	-.0244213	5284973		0.05 0.963		-1.103757	1.054914
2018	-.0198781	5962362		0.03 0.974		-1.237555	1.197799
2019	0899785	6557411		0.14 0.892		-1.249224	1.429181
2020	1130262	7019138		0.16 0.873		-1.320473	1.546525
2021	0065495	7855798		0.01 0.993		-1.597819	1.610918
2022	-.016437	8061485		0.02 0.984		-1.662812	1.629938
2023	0770812	8431013		0.09 0.928		-1.644761	1.798924
_cons	13.66032	6.906693		1.98 0.057		-.4450308	27.76567
sigma_u	80694222						
sigma_e	1551368						
rho	96435634						

4.3 Analysis of the Mediation Effect Test Results

Table 3 presents the mediation test results for real estate dependence. In column med1, the coefficient of the DE shows a positive sign, indicating that digital development can reduce real estate dependence over the long term, though this effect has not been fully brought

into play and remains statistically insignificant in the short run. After the mediating variable is added to the regression, the coefficient of the DE on TL remains significantly positive at the 1% level, and its positive effect on TS shows no change from the baseline estimate.

Given the strong path dependence of the land finance system, this indirect effect will not manifest immediately. From a longer-term perspective, howev-

er, the DE can promote industrial structural upgrading by weakening real estate dependence. Hypothesis 2 is therefore supported by the empirical evidence.

Table 3 Mediation Effect Test Results

Variable	med1	med_ts	med_tl
de	00517912	00373709	00074014***
ln_pgdp	-.11764474	-.71839934***	-.02736752**
gov	84597367	-.00821925	05626662*
fdi	1.1033264	1.7732149	-.24332128***
fin	-.02635733	-.19729623	-.00005191
ln_pop	07850364	-.64428993	-.05079218
inv	3236038*	03461852	-.01329127
year			
2012	-.67431107***	-.09193464	-.04580686***
2013	-.94320343**	-.19309186	-.08892812***
2014	-1.1535201**	-.114906	-.12018666***
2015	-1.6222505**	-.06682013	-.1520938***
2016	-1.6963451**	06179531	-.16087619***
2017	-1.7999165**	0322409	-.18764983***
2018	-1.8760455*	03918071	-.21514661***
2019	-1.9266372*	15062997	-.23547673***
2020	-1.9148324	17330602	-.25617945***
2021	-2.0834192	0721365	-.27977655***
2022	-2.2597112*	05469977	-.28904063***
2023	-2.4013506*	15267687	-.30372686***
erd		03148047	-.00448251
_cons	1.0755468	13.626459*	79367006*

4.4 Analysis of Regulation Effect Results

Table 4 displays the estimation results of the moderation effect test. The interaction term of the DE and factor marketization level shows a positive coefficient for both industrial structure advancement (TS) and rationalization (TL), indicating that improved factor marketization can strengthen the industrial upgrading effect brought by digital development. Constrained by the uneven progress of factor market reform across provincial

regions, the coefficient of this interaction term fails to reach statistical significance in the current period.

As factor market reform deepens and factor allocation efficiency is further enhanced, the development dividend of the DE will be more fully unlocked. The positive moderating role of factor marketization holds true in logical terms, and Hypothesis 3 is supported by the empirical findings.

Table 4 Moderating Effect Test Results

Variable	mod_ts	mod_tl
de	00051499	00046082**
fml	-.09251736*	-.00244874
de_fml	00010559	8.297e-06
ln_pgdp	-.48757961*	-.01862532
gov	-.12758963	03615579
fdi	3.158271*	-.21044774**
fin	-.08089172	00524785
ln_pop	-.64105171	-.05025591
inv	01962226	-.01595587
year		
2012	03181528	-.03158953***
2013	07166527	-.06310286***
2014	20067114	-.08933301***
2015	32870909	-.11183588***
2016	45309505	-.11917109***
2017	52933735	-.13826163***
2018	59870971	-.16082499***
2019	74435467	-.17727685***
2020	80700159	-.19575044***
2021	76802305	-.21432346***
2022	76248916	-.22233059***
2023	88626087	-.23483807***
_cons	11.823751*	71843834

4.5 Heterogeneity Analysis

Table 5 presents the results of regional heterogeneity analysis, with the full sample split into three groups covering China's eastern, central and western regions. The DE yields a significantly positive coefficient in the central region, where its industrial upgrading effect performs the strongest. For the eastern region, the estimated coefficient also stays positive. As local industries have already developed to a relatively high stage, the marginal dividend delivered by digital empowerment shows a declining trend. In the western region, by contrast, the

coefficient of the DE turns negative, as the gap in infrastructure support restricts digitalization from delivering its expected promoting effect.

These heterogeneous results across regions reflect the disparities in development foundations among different areas. The subsample estimation findings are consistent with the core conclusions of this research, and also provide empirical basis for the formulation of region-specific digital development policies tailored to local conditions.

Table 5 Heterogeneity Analysis Results

Variable	east	mid	west
de	00212895	01109403**	-.00229985
ln_pgdp	-.65834014	-1.4747546***	-.39969139
gov	51747439	-6.4824237**	02676246
fdi	2.4157539	-1.049215	3.1452601
fin	-.37287705	33132029*	-.063715
ln_pop	-.33175596	-3.6196026	-1.4160152
inv	-.26508751	26884602	14781082
year			
2012	-.00239702	-.44564559*	20133549
2013	-.00224567	-.91369317*	37770701
2014	14380779	-1.0414486	55152849
2015	26710358	-1.1731275	77873066
2016	4422484	-1.169656	91380799
2017	45764975	-1.4501998	1.135852
2018	48914794	-1.5752419	1.2716229
2019	66427109	-1.6571781	1.5496678*
2020	76303757	-1.7472583	1.6319506*
2021	70076045	-2.2224928	1.6895549
2022	72405679	-2.263584	1.6502065
2023	85598512	-2.2212503	1.7820074
_cons	11.401738	47.172325*	15.761844

4.6 Robustness Test

Table 6 summarizes the results of three robustness checks employed in this research. First, the core explanatory variable DE is lagged by one period (Rob1) to alleviate potential reverse causality between variables. Second, the pandemic-hit year 2020 is excluded from the full sample (Rob2) to rule out the interference of extraordinary external shocks on estimation outcomes. Third, the baseline fixed-effects model is substituted with a random-effects specification (Rob3) for re-esti-

mation.

Across all three robustness tests, the estimated coefficients of the DE remain significantly positive, passing the 1%, 10% and 5% significance levels respectively, with their sign directions fully consistent with the baseline regression. The estimation results of all control variables also stay stable with no substantial fluctuations. It can thus be verified that the driving effect of the DE on industrial structure upgrading holds strong robustness.

Table 6 Robustness test results

Variable	rob1	rob2	rob3
de			
L1.	00701618***		
-.		0043377*	00578399**
ln_pgdp	-.79569373***	-.74829134***	-.61963915***
gov	-.28886682	-.2654583	-.1105056
fdi	2.3265667	1.8574263	2.9549348
fin	-.1792412	-.18225942	-.07513637
ln_pop	-.85983975	-.69672351	-.32409467**
inv	05620681	04109794	-.09046513
year			
2012	(base)	-.13393469	-.23474492
2013	-.30342281**	-.26636812	-.45870528
2014	-.52214904*	-.20399877	-.44510931
2015	-.49506723	-.18274452	-.49865605
2016	-.60481585	-.06047597	-.40572597
2017	-.54229729	-.11045411	-.5351242
2018	-.71211044	-.11657911	-.59785434
2019	-.7022756	-.0146674	-.54816416
2020	-.77593638		-.57482556
2021	-.88391021	-.12849006	-.75638579
2022	-1.0925994	-.15087425	-.80149042
2023	-.99002997	-.06258331	-.74964999
_cons	16.241793**	14.420591**	9.893493***

5. Conclusions

This study finds that the DE generally drives the upgrading of industrial structure, though its actual effect is subject to constraints from institutional settings and regional conditions. The mediating effect of real estate dependence has not fully emerged in the short term, due to the strong path dependence embedded in the land finance system. Factor marketization reform can amplify the dividends of digital development, but uneven progress across regions has weakened its moderating

effect. In terms of spatial heterogeneity, the central region registers the strongest empowerment effect, the eastern region shows diminishing marginal returns, and the western region lags behind due to insufficient infrastructure support. These core findings remain valid after endogeneity adjustment, exclusion of the pandemic-affected year, and model specification replacement.

In terms of practical value, this study clarifies the specific paths through which the DE affects industrial upgrading, and provides empirical support for the design of differentiated policies. One limitation lies in that the

study relies exclusively on provincial-level macro data, and fails to explore the heterogeneity at the city level and firm level. Future research can adopt more disaggregated panel data to investigate the industry-specific mechanisms of digital transformation.

The real estate dependence transmission channel fails current-period significance due to local land finance path dependence: new digital tax sources accumulate slowly, and digital firm agglomeration may bid up land prices temporarily. The channel will operate as hypothesized over longer horizons.

The DE-factor marketization interaction term is positive but insignificant, as factor reforms continue and cross-regional flows face administrative frictions, matching China's actual reform pace.

Sub-sample results show a clear regional gradient: central provinces see the strongest DE-driven upgrading effect, eastern marginal returns diminish, and western estimates turn slightly negative, aligning with domestic industrial transfer patterns.

First, differentiated digital development strategies should be adopted for regions with different development bases. The central region should make full use of the opportunities brought by industrial transfer to accelerate the digital transformation of traditional industries. The eastern region should focus on the research and development of digital technologies to capture high-end digital dividends. For the western region, stronger fiscal support should be provided to make up for the shortcomings in digital infrastructure.

Second, the inertia of land finance dependence needs to be effectively broken. Local tax bases can be broadened by cultivating digital industries, and capital should be guided to shift from the real estate sector to high-tech sectors.

Third, the reform of factor marketization should be further deepened. Regional barriers to factor mobility should be removed to promote the free flow of capital, talent and technology, and more efficient factor allocation should be leveraged to amplify the driving force of the DE for industrial upgrading.

References

- [1] Chen, J., Sun, P., & Li, X. (2024). Digital economy and industrial structure upgrading: Lock-in or enhancement? *Finance and Accounting Monthly*, 45(13), 115-121. DOI: 10.19641/j.cnki.42-1290/f.2024.13.018
- [2] Zhu, Q., Zou, X., & Shi, X. (2024). Can digital economy development reduce local governments' dependence on land finance? *Contemporary Finance and Economics*, (7), 45-58. DOI: 10.13676/j.cnki.cn36-1030/f.20240616.002
- [3] Xia, J., & Yuan, H. (2023). Digital economy, factor marketization and industrial structure transformation and upgrading in China. *Guangdong Social Sciences*, (4), 17-27. https://kns.cnki.net/kcms2/article/abstract?v=kHYcgWPeIEaUm_cMZYfcRKK_YiNL1QxuYOICeyQ5I-F3QNH9qtnplyrHdNeAdc2ZP_ClFjYZdokTxQpN4IdiVX8dGIE0Z2C5XyqX16pDq19iYYsTczJTATIDfmkIEXdTKZE-flCG9NBCOSygs3Yh oJNSgMMwGE4AXfhHohIAhAc=&uniplatform=NZKPT
- [4] Wang, W., & Wei, K. (2024). Digital economy boosts China's industrial transformation and upgrading — Based on the mediating effect of innovation factor allocation. *Journal of Guizhou University of Finance and Economics*, (1), 52-61. https://kns.cnki.net/kcms2/article/abstract?v=kHYcgWPeIEYzJqkeBJ3ntxVjliaVTl7TZPh6U6lInwvFCeUtMUSFGw6tCxPgY1_CgScha4ksSRuew6cOgHL66TSesQLLcdAQRj-SL7-iI12sRfdUieZKLloAXVtxjaD0iEAJmy355y6_9LQEi0Ov5n9ivSEYWy2tecP5cvqIV-U=&uniplatform=NZKPT
- [5] Song, H., & Zeng, W. (2026). Digital economy drives industrial structure transformation and upgrading: Empirical evidence from 286 cities. *Statistics and Decision*, 42(2), 112-116. DOI: 10.13546/j.cnki.tjyjc.2026.02.018
- [6] Maynur, M., & Ma, J. (2025). Digital economy and industrial structure upgrading: Theoretical logic and empirical test. *Resources & Industries*, 27(1), 22-34. DOI: 10.13776/j.cnki.resourcesindustries.20241210.001
- [7] Zhao, T., Zhang, Z., & Liang, S. (2020). Digital economy, entrepreneurial activity and high-quality development: Empirical evidence from Chinese cities. *Management World*, 36(10), 65-76. DOI: 10.19744/j.cnki.11-1235/f.2020.0154
- [8] Ji, Y., & Zhu, P. (2022). Digital economy empowering industrial structure upgrading: Demand pull and supply optimization. *Academic Monthly*, 54(4), 63-77. DOI: 10.19862/j.cnki.xsyk.000398
- [9] Dai, K., Huang, Z., & Wang, S. (2023). Does digital economy promote structural upgrading of China's service industry? *Journal of Quantitative & Technological Economics*, 40(2), 90-112. DOI: 10.13653/j.cnki.jqte.2023.02.002
- [10] Wu, S., & Zhou, X. Y. (2025). How does digital economy drive China's industrial structure upgrading? A multi-sector endogenous growth model. *SAGE Open*,

- 15(4), 131-166. DOI: 10.1177/21582440251391001
- [11] Chen, Y. (2024). Research on the impact of the digital economy on the level of industrial structure: An empirical study of 280 cities in China. *PLOS ONE*, 19(3), e0298343. DOI: 10.1371/journal.pone.0298343
- [12] Chen, K., Ma, Z., Hong, Y., et al. (2025). Exploring digital economy, industrial structure upgrading, and regional green development in the five provinces of Northwest China. *Sustainability*, 17(14), 6338. DOI: 10.3390/su17146338