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RESEARCH ARTICLE

# The Impact of Digital Finance on Industrial Structure Upgrading and its Heterogeneity Analysis

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## Abstract

In this paper, we use provincial panel data from China's30 provinces spanning the years 2011 to 2021 to calculate the indices of industrial structure rationalization and advancement. Employing a fixed-effects model that accounts for fixed effect of year and province, we examine the impact of digital finance on the upgrading of industrial structures.The findings reveal that digital finance promotes both the rationalization and advancement of industrial structures.The regional divergences analysis reveals that digital finance significantly boosts industrial structure upgrading in the eastern region. However, its impact on the central and western regions is much less obvious.The analysis of region with varying financial development levels reveals that digital finance has a more pronounced effect on industrial structure upgrading in areas with high financial development.Through the mechanism analysis and empirical test, it is found that digital finance facilitates industrial structure upgrading through promoting the technology market development.

**Keywords:** Digital Finance, Rationalization of Industrial Structure, Advancement of Industrial Structure, Technology Market Development.

## 1. Introduction

Currently, China's economy has reached a key phase of high-quality development, withindustrial structure serving as a vital ofeconomic progress and a key element in driving economic structural adjustment. However, China's industrial structure is still facing many problems that restrict its optimization and enhancement.The industrial structure upgrading is closely linked to the specific external environment, especially the robust support provided by the financial system, and the financial sector is an essential force to promote the of industrial structureupgrading(Qian & Zhou, 2011).Led by the strategy of "Internet+" and "industrial digitization", digital finance matured significantly. As a new financial model, digital finance leverages digital technology through financial institutions and internet platforms to carry out various financial business, including payment, settlement, financing, and investment(Huang & Huang, 2018). Digital finance effectively reduce information asymmetry of the traditional financial model and alleviate the phenomenon of financial exclusion by lowering the threshold of service as well as realizing the convenience of service(Du et al., 2020), and digital finance provides richer and more convenient financial products and services, which is the main trend for the development of the financial business in the future(Li & Ran, 2021). Therefore, how to build a digital financial system to provide support for industrial restructuring is an issue worth studying.

Scholars have varied opinions regarding the influence of traditional financial development on optimizing and advancing industrial structures. However, most agree that financial development is a significant boosting force for industrial restructuring(Greenwood & Jovanovic, 1990).Financial development accelerates

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capital flows and improves capital allocation, making it easier for productive and efficient firms to access capital, thus optimizing and enhancing the industrial structure(Xu & Tan, 2020). Financial development can accelerate industrial structural reorganization and promote economic increaseby the "horizontal effect" and "structural effect" of technological innovation (Yi & Liu, 2015).Some scholars also believe that the relationship of financial development and the upgrading of industrial structure is non-linear, the level of regional financial development positively influence industrial restructuring, exhibiting a U-shape pattern between financial development and industrial structure (Zhuang & Wang, 2020);At different financial developmentlevels, itsimpacton industrial structureupgrading shows an inverted "U" trend, initially increasing before subsequently decreasing (Tao & Xu, 2016).

The beneficial effect of digital finance on industrial restructuring is manifested in promoting the construction of digital infrastructure, all eviating difficulties faced in financing process, and further transforming technology into actual productivity, enhancing the industry core competitiveness, and achievingthe industrial structure adjustment (Pradhan et al., 2015; Sasidharan et al., 2015). Through scientific and technological innovation, digital finance can consistently strengthen its booster effect in facilitating industrial structural transformation. (Watanabe et al., 2018).However, some researchers considert hat utilizing digital financial services requires financing subjects to have a high level of knowledge as well as the ability to operate skilled equipment, which results in economically disadvantaged SMEs being at a disadvantage, suppressing effective demand, and to some degree causing distortions inindustrial structure, which is hindering its advancementand prevent the process of industrial structure upgrading (Tang et al., 2020; Tu & He, 2021). Tang et al. (2019) constructs a threshold model and found non-linear relationship between the two factors as well as regional heterogeneity.

To summarize, the existing studies provide important theoretical foundation and empirical experience for thearticle, nevertheless, the following limitations continue to exist: First, most existing studies primarily examine the impact of traditional finance on industrial structure, there are fewer reviewon how digital finance influences industrial structure. Secondly, existing studies usually use a relatively simple measureof industrial structure upgrading, and this research utilize both rationalization and advancement of industrial structure to evaluate the optimization and enhancement of industrial structure in a more comprehensive way. Thirdly, the analysis of existing related literature on the intermediary mechanism through which digital finance influence industrial structure mainly centers on technological innovation and resource distribution, and seldom involves technology market development.So, the possible innovations of this paper are: first, using more reasonable metrics to evaluate the industrial structure upgrading, and conduct amore comprehensively analyzing of how digital finance influences industrial structure upgrading. Secondly, using the mediation effect model, the impact mechanismwill be empirically tested, focusing specifically on the development of technology markets.Thirdly, the heterogeneity analysis will becarried out,exploring the factorsthat may lead to this different impact are analyzed, enriching the heterogeneity study of industrial structure upgrading.

The remainder of the paper is organizedas follows. The next section will provide theoretical analysis and research hypotheses. Section 3 will explain variable and data sources, and empirical model of the study. Section 4 will presentthe empirical results and analyses of the study, including the regression analysis, heterogeneity analysis, and the test of the mechanism of action. Finally, section5 will summarize the study and discusses its recommendations.

## 2. Literature Review and Research Hypothesis Development

### 2.1 Digital Finance and Industrial Structure Upgrading

Digital finance, as a trend transformation shift in financial sectorin the future, characterized by features and benefits that distinguish it from the traditional financialclearly.It serves to enhance the effectiveness of financial services, minimizing transaction expenses, and realizing financial inclusive sharing and precise services, etc.At the same time, it can also well alleviate the problems of slow development, uneven development and inefficiency of the financial industry caused by information inequity and knowledge barriers. Digital finance, as a service for all social classes and groups, has been closely integrated with big data and so on.It can better show overall financial development ofsociety, and take this as the starting point to extend and combine to various industries, and influence the adjustmentof industrial structure.

Firstly, resource allocation effects. Improving the efficiency of resource utilization has consistently

been a crucial factor in promoting China's economic progress. Enhancing the efficiency of resource allocation efficiency is even regarded as the main focus point for promoting industrial restructuring and fostering new engines of economic growth (Wang & Liu, 2017). Liu et al. (2019) found that the lowutilization rate of emerging industries capacity is primarily caused by resource mismatch and repetitive investment.

It can be seen that resource mismatch not only affects production efficiency, but also hinders the adjustment of industrial structure to more innovative high-tech sector. Digital finance helps address misallocation of resources through directly complementing traditional finance and indirectly enhancing the overall quality of financial services, optimize labor allocationby promoting employment and enhancing the cross-regional mobility of labor Chang Jianxin. It can also accelerate the process of digitalization of local and foreign infrastructure with sufficient capital accumulation, and realize the improvement of cross-regional payment efficiency and resource allocation efficiency. Financial resources allocation effect, because digital finance can form a convenient and fast transaction network, so it can better serve buyers and sellers and simplify and speed up the whole transaction process. Consequently, digital finance can accelerate the market capital flow. Digital financial centers can realize digital financial elements through more advanced digital technology to achieve cross-time and location allocation, this process enhances the exchange of financial elements between domestic and international.That is, digital finance improves the distribution of financial resources across different sectors, there by supports the development of industrial structure (Bruhn & Love, 2014). Moreover, digital finance can timely and effectively supply capital for industrial progress as well as deeply fit digital financial service support (Huang & Huang, 2018). This further encouragesthe reasonable and efficient distribution of financial resources, which in turn may promote industrial optimization and upgrading.

Secondly, the technological progress effect. First of all, digital finance can ease the funding limitationsfaced by enterprises, innovative technology initiatives are often marked by high risk, extended investment timelines, substantial capital investment, which is in conflict with the high transaction costs of traditional financial institutions and the credit discrimination of SMEs. While digital finance effectively use information technology to bridge the gap ininformation imbalance between the capital supply and demand force, it can better assess the risks and optimize the risk management system, so as to effectively reduce the transaction costs to support enterprise innovation activities, so that capital flows to innovative enterprises at a reasonable cost, easing the constraints of the traditional credit market on the supply of funds to innovation enterprises and technological advancement, thus tilting investment to high-tech industries. Secondly, digital finance has the ability to improve enterprise innovation financing environment and enhance innovation vitality through financial product innovation, which can force companies to enhance the industrial chain and stimulate the growth of high-tech sectors. Thus, digital finance can gradually improve the industrial compositionby promoting innovation (Yi & Liu, 2015).

Finally, the consumer demand effect. The development of digital finance has offered consumers more convenient ways of transaction, payment and credit, stimulating consumer demand, and the rise of the digital industry has greatly facilitated the learning, acceptance and use of products, alleviating to the adverse effects of the information inequality, and also greatly slowing down consumer costs. In addition, the variation in consumer preferences will also facilitate the realization of industrial structure upgrading. By expanding consumer demand, digital finance helps drive this transformation, supporting the growth and refinement of industries (Du et al., 2020). Consequently, this paper proposes the following hypothesis:

*Hypothesis 1.* Digital finance is conducive to improving rationalization of industrial structure

*Hypothesis 2.* Digital finance is conducive to promoting advancement of industrial structure

### 2.2 Mediating Effects of Technology Market Development

Advancements in science and technology play a key role in driving the improvement and evolution of the industrial structure.which firstly improves the production efficiency of some industries, makes the production factors converge, and then drives the other industries to achieve rapid development through the role of industrial correlation and ultimately triggers the industrial structure optimization. Mou (2013) combed the influence of successive scientific and technological revolution, and found that the significant adjustments of industrial structure in history were all triggered by scientific and technological revolutions.

The technology market is a trading market for scientific and technological achievements, as well as an important trading market for production factors, including the production, exchange and circulation of technological commodities. The technology market serves as a market platform and mechanism that supports the industrialization of scientific and technological achievements,the movement of technological resources, and the growth of technology-driven companies in China. It significantly supports the linkage and integration of scientific and technological with economic structures(Lu & Zhu, 2006).Digital finance helps to build an efficient platform for the development of capital and technology markets. Digital finance eases restrictionsto accessing financial services, maximizes the effectiveness of capital supply, guidesresources toward highly efficient enterprises, and indirectly promotes the technology market development. Digital finance enhances the interoperability between technology markets and facilitate the construction of network technology market platforms. Therefore, digital finance has the potential to promote the technology marketdevelopment. whichin turn facilitates the progression of China's real industrial structure.

Firstly, the development of technology market has a direct promotion effect on technological innovation. Distinguished from the capital market, labor market and other factor segments, the technology market serves as a key place of aggregation, flow and allocation of important innovation resources, exerting a more direct and more important impact on innovation activities (Dai, 2018).The technology market can improve regional innovation capacity and enhance labor productivity, and from the level of external knowledge introduction, it can effectively transfer information on technology and products.The realization of innovation drives the regional industrial structure fromprimary industry tothe secondary and tertiary industries in a gradual ,sequential evolution, and the technology market is a bridge for the realization of knowledge innovation (Ye & Liu, 2018).As the technology market evolves, the continuous optimization of the market environment and improvement in market vitality can lead to concentrationof human capital, this can accelerate the dissemination and diffusion of new knowledge, generate a wide range of positive externalities, and increase labor productivity.which will help to realize the industrialization of technological achievements, and achievehigher efficiency adjustment of the industrial structure (Ngai & Pissarides, 2007).

Secondly, the technology market is an important production factor market, which plays a significant role a significant role indistribution of resources, and the technology market is centered on the industrialization of scientific and technological innovation "results transformation" to effectively allocate resources. When the regional technology market is relatively underdeveloped, the lack of market mechanism leads to the phenomenon of mismatch of production resources is more common (Ye & Liu, 2018).China's technology market has been gradually improving, and its ability to rationalize allocate resources and production factors of production has been steadily rising. The function of the technology market in integrating factors is conducive to lowering the replacement cost of factors, reducing blind investment in the development of industries and the resulting problem of overcapacity, and enhancing the efficient distribution of resources acrossdifferentindustries. In addition, the construction oftechnology market system can strengthen the capitalization, industrialization and marketization of scientific and technological achievements, help to reshape traditional and emerging industries, rationally deploy the innovation chain, and enhance inter-industry balance and facility the enhancement and refinement of the industrial structure by sharing information and resources and improving the allocation of technological factors.

Finally, the technology market serves as a crucial pathway for industrialization and application of innovation outcomes. Scientific and technological achievements will appear in the form of products and be promoted to the whole industry via the technology market. Itcan effectively solvesuch problems as new technologies are difficult to be integrated into key equipment and products, new technologies are difficult to be embedded in mainstream industries, and technological achievements are difficult to be transformed and transferred,providing reliable basic guarantee,accelerating the spread of new technologies, optimizing the distribution of production factors,and thus facilitating industrial structuremodification. Consequently, this paper proposes the following hypotheses:

*Hypothesis 3.* Digital finance improves the rationalization of industrial structure by improving technology marketdevelopment

*Hypothesis 4.* Digital finance facilitates the advancement of industrial structure by improvingtechnology marketdevelopment

## 3. Methodology

### 3.1 Model

Building on the preceding theoretical framework, this paper develops the following econometric modelto assess the effects of digital finance on industrial structure upgrading.

$$TL_{i.t} = a_0 + a_1 DF_i + aControl_{i.t} + \lambda_i + \mu_t + \varepsilon_{i.t} \quad (1)$$

$$UG_{i,t} = b_0 + b_1 DF_{i,t} + bControl_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t} \quad (2)$$

In Equation (1), (2), *i*denotes province, *t* denotes year, $TL_{i,t}$, $UG_{i,t}$ arerationalization and advancement of industrial structure, which aredenote the industrial structure upgrading, $DF_{i,t}$ is thedigital finance, and $Control_{i,t}$ represents a set of control variables, $\lambda_i$ and $\mu_t$ are provinceand year fixed effects, respectively, $\varepsilon_{i,t}$ represents error disturbance.

To further validate the transmission mechanism through which digital finance influences industrial structure upgrading and to test *Hypotheses 3 and Hypotheses 4*, a system of recursive equations is set up on the basis of equations (1) and (2), and the specific model is established as follows.

$$M_{i,t} = \gamma_0 + \gamma_1 tech_{i,t} + \gamma Control_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t} \quad (3)$$

$$TL_{i,t} = c_0 + c_1 DF_{i,t} + c_2 M_{i,t} + cControl_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t} \quad (4)$$

$$UG_{i,t} = d_0 + d_1 DF_{i,t} + d_2 M_{i,t} + dControl_{i,t} + \lambda_i + \mu_t + \varepsilon_{i,t} \quad (5)$$

In the above equations, $M_{i,t}$ is the mechanism variable technology market development (tech) which influences the rationalization of industrial structure (TL) and the advancement of industrial structure (UG). Thisstudy will empirically test the mediation effect equationexpressed in (3)-(5), and if $\gamma_1$ in Eq. (3) is notable, it suggests that digital finance stimulates the technology marketdevelopment. Continuing to explore in equation (4) and equation (5), if $c_2$ is also significant, it indicates that digital finance enhances the rationalization of industrial structure through its influence on technology market development; If $d_2$ is also notable, it implies that digital finance facilitates the advancement of industrial structure by influencing technology marketdevelopment.

### 3.2 Variablesand Data Sources

#### *3.2.1 Variables and Indicators*

*ExplainedVariable*

Industrial structure upgrading serves as theexplained variable, and most of the existing studies choose the ratio of the third sector to GDP (Wu & Liu, 2013) or the industrial structure upgrading index as an indicator(Xu & Jiang, 2015).However, this paper believes that this cannot fully characterize the industrial structure upgrading. It should be considered from two levels: first, the industrial structure layout should be scientific, which can be expressed by the rationalization of the industrial structure indicators; The second is the upgrading of industrial structure.Thesecond is the upgrading of industrial structure.By referencing the common patterns of industrial structure evolution in developed country and the characteristics of the economic transition toward the service sector in the advanced stages of industrialization, and the ratio of the tertiary and secondary industries in the industrial structure more accurately expresses t forthcoming enhancement and refinement of the industrial structure.

Rationalization of industrial structure: This paper adopts the approach outlined by Gan et al. (2011), and uses a redefined Theil Index to quantify this indicator. The detailedequationis as follows:

$$TL = \sum_{k=1}^{n} \left(\frac{Y_i}{Y}\right) \ln\left(\frac{Y_i}{L_i} / \frac{Y}{L}\right) \quad (6)$$

In equation (6), $Y$ denotes the gross national product, and $Y_i$ represents the value added by industry *i*; L refers tosum of employed, and $L_i$ signifying the number of employed in industry $i$; n stands for the full quantity of industries, and k denotes each specific industry. The redefined TL index adequately represents the distribution of each industry in the overall structure, and moreover characterizes the discrepancy of the actualfrom the optimal industrial structure in the equilibrium state. the TL is v to 0, the smaller thedeviation, indicating that the industrial structure is more balanced and efficient.

Advancement of industrial structure: This paper will adopt to comparing the proportion of value added by the tertiary sector to that of the secondary sector (Zhao, 2018; Zhou & Chen, 2021), the specific equation is as follows:

$$UG = Y_3 / Y_2 \quad (7)$$

In equation (7), UG indicates the advanced industrial structure, $Y_3$ indicates the value-added by the tertiary sector, $Y_2$ indicates the value-added bythe secondary sector. Ahigher UGvalue signifies a more advanced industrial structure.

*Explanatory Variable*

Digital finance: In this study, the key explanatory variable is the total digital finance index (DF). This index consists of three components: The total digital finance index contains the breadth of digital finance coverage (DF_coverage), which reflects how widely digital finance services are accessible; the depth of digital finance usage (DF_usage), which measures the extent of usage among consumers and businesses; and the level of financial digitization (DF_digitization), which indicates how advanced and integrated digital technology is within financial services. Tostreamline analysis, digital finance and its each sub-index is divided by 100. This index is calculatedbased on the Analysis HierarchyProcess (AHP).

*Control Variable*

The adjustment of industrial structure can be influenced by various additional factors, drawing on some previous research theories and experiences,the followingcontrol variables will be included in the analysis:

Government intervention (gov): the proportion of local government general public budget expenditures compared to gross domestic product; Economic development (ln_Pgdp): Per capita GDP; FDI: the ratio of actualforeign direct investment to the province's GDP; Level of infrastructure development (traffic): logarithmic number of miles of roads in each province; Human capital level (hum): the percentage of students enrolled in higher educationrelativeto the total population of that province; Informatization level (infor): the proportion oftotal volume of postal and telecommunication services to the regional GDP.

*Mediating Variable*

Technology market turnover is the driving force of the technology market, and it is the various trading activities formed in the market by the main players in the technology market. Technology market turnover reflects the actual state of a region regarding transfer and advancements in innovation. Specifically, the level of technology market turnover can indirectly indicatea region's overall strength, such as the quantity of innovative companies, value of innovation. Through transactions within this market, both the government and enterprises can achieveeffective utilization of technological resources, speeds up the dissemination and utilization of technological advancements,facilitate the integration and enhancement of the industrial chain(Zhou & Zhang, 2022). Therefore, this study will measuretechnology market development by examining the transaction value within the technology market.

Technology market development (tech): the turnover of the technology marketto GDP of a region.

### *3.2.2 Data Sources*

Since the available period for the Digital Finance Index is 2011-2021, consequently, this study focuses on data collected from 30 provinces in China (excluding Tibet, Hong Kong, Macau and Taiwan), covering the years 2011-2021. For the indexes measured by GDP, the year 2000 is used as the base period for deflating each index uniformly, logarithmic processing is performed for aggregate-type data, and to address gaps in the statistical data, this study adopts the linear interpolation method to fill in the missing values. The digital finance index comes from the Peking University Digital Inclusive Finance Index (2011-2021) (Guo et al., 2020). The information regarding industrial structure upgrading is sourcedfrom the China Statistical Yearbook. Other data are from China Statistical Yearbook, National Bureau of Statistics, China Demographic Statistical Yearbook, China Trade and Foreign Economic Statistics Yearbook, and China Science and Technology Statistical Yearbook. The descriptive statistics are shown in Table 1.

**Table 1.** *Descriptive Statistics*

| Variable Type | Variable | Obs | Mean | Std.Dev. | Min | Max |
|---|---|---|---|---|---|---|
| Explained Variable | TL | 330 | 0.213 | 0.198 | -0.099 | 1.042 |
| | UG | 330 | 1.342 | 0.731 | 0.527 | 5.244 |
| Explanatory Variable | DF | 330 | 2.315 | 1.033 | 0.183 | 4.59 |
| Moderating Variable | tech | 330 | 0.016 | 0.029 | 0 | 0.175 |
| Control Variable | gov | 330 | 0.249 | 0.103 | 0.107 | 0.643 |
| | ln_Pgdp | 330 | 9.325 | 0.463 | 8.542 | 10.781 |
| | hum | 330 | 0.02 | 0.006 | 0.008 | 0.042 |
| | FDI | 330 | 0.02 | 0.018 | 0 | 0.121 |
| | infor | 330 | 0.07 | 0.145 | 0.015 | 2.513 |
| | traffic | 330 | 11.692 | 0.85 | 9.4 | 12.896 |

## 4. Results and Discussion

**Table 2.** *Baseline Regression Results*

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Variable** | **TL** | **UG** | **TL** | **UG** |
| DF | -0.2814*** | 0.3923*** | -0.2680*** | 0.4444*** |
| | (0.0752) | (0.1104) | (0.0913) | (0.1281) |
| gov | | | 0.5553 | 3.6114*** |
| | | | (0.3454) | (0.4847) |
| ln_Pgdp | | | 0.1352 | 0.6899*** |
| | | | (0.1142) | (0.1602) |
| hum | | | -2.7947 | -8.2917 |
| | | | (4.7699) | (6.6937) |
| FDI | | | 1.5116*** | -2.4773*** |
| | | | (0.5266) | (0.7390) |
| infor | | | 0.0032 | -0.0521 |
| | | | (0.0375) | (0.0527) |
| traffic | | | 0.4198*** | 0.1416 |
| | | | (0.1021) | (0.1433) |
| _cons | 0.4043*** | 0.8562*** | -5.8328*** | -7.8493*** |
| | (0.0351) | (0.0516) | (1.5286) | (2.1452) |
| Obs. | 330 | 330 | 330 | 330 |
| R-squared | 0.3438 | 0.7270 | 0.4216 | 0.7803 |
| Province Fixed | Yes | Yes | Yes | Yes |
| Year Fixed | Yes | Yes | Yes | Yes |

**Note:** ****, **, * Significant at 1%, 5%, and 10% confidence levels, respectively Standard errors are in parentheses. Same as below*

Table 2 reports the baselineregression results of digital finance on the rationalization andadvancement of industrial structure.Specifically, the data of model (1), (3) reflect the effects of digital finance on Theil index of the industrial structure, with one excluding control variables and the other withincludingthem. Theestimated coefficient values of which are -0.2814 and -0.268, both statistically significant at the 1% level. This finding indicates that digital finance exerts a notable negative effect on Theil index of the industrial structure, there by promoting a transition towards rationalized industrial structure, which confirmed *Hypothesis 1*. Meanwhile, the data of models (2) and (4) present the regression outcomes of digital finance on advancement of industrial structure, both without and with control variables.The estimated coefficients are 0.3923 and 0.4444, both statistically significant at the 1% level,suggests that digital finance positively facilitatethe advancement of industrial structure, and the *Hypothesis 2* is confirmed.

### 4.1 Endogeneity and Robustness Test

**Table 3.** *Lagged One-period Regression of the Digital Finance Index on Industrial Structural Upgrading*

| | (5) | (6) | (7) | (8) |
|---|---|---|---|---|
| | first | second | first | second |
| **Variable** | **DF** | **TL** | **DF** | **UG** |
| L_DF | 0.889*** | | 0.889*** | |
| | (0.00947) | | (0.00947) | |
| DF | | -0.592*** | | 0.783*** |
| | | (0.156) | | (0.194) |
| gov | -0.0312 | 0.918*** | -0.0312 | 3.515*** |
| | (0.111) | (0.339) | (0.111) | (0.422) |
| ln_Pgdp | 0.0280 | 0.416*** | 0.0280 | 0.483*** |
| | (0.0366) | (0.120) | (0.0366) | (0.150) |
| hum | 2.370 | 9.263* | 2.370 | 3.724 |

| | | | | |
|---|---|---|---|---|
| | (1.743) | (5.065) | (1.743) | (6.315) |
| FDI | | 1.257** | | -2.416*** |
| | | (0.562) | | (0.701) |
| infor | -0.277* | -0.330* | -0.277* | -0.449* |
| | (0.146) | (0.194) | (0.146) | (0.242) |
| traffic | 0.0148 | 0.305*** | 0.0148 | 0.254* |
| | (0.0149) | (0.110) | (0.0149) | (0.137) |
| Constant | 0.0916 | -6.414*** | 0.0916 | -5.405*** |
| | (0.478) | (1.559) | (0.478) | (1.944) |
| Obs. | 300 | 300 | 300 | 300 |
| R-squared | 0.983 | 0.810 | 0.983 | 0.979 |
| Province Fixed | Yes | Yes | Yes | Yes |
| Year Fixed | Yes | Yes | Yes | Yes |
| First Stage F | 142.92 | | 142.92 | |

**Note:** ****, **, * Significant at 1%, 5%, and 10% confidence levels, respectively Standard errors are in parentheses. Same as below*

To minimize potential endogeneity issues between digital finance and industrial structure upgrading, this study employs the two-stage least squares (2SLS) methods. The lagged one-period digital finance index is used as an instrumental variable,as the progression of digital finance is continuous. This prior level can predict the current level of digital finance, which satisfies of exogeneity assumption.

Table 3 displays the regression findings,wheremodels (5) and (7) indicate that the estimated coefficient for the lagged digital finance indicator is 0.889, significant at the 1% level, satisfying the correlation requirement. Additionally, the F value is 142.92, which shows that the regression results are not affectedby issues related to weak instrumental variable.The results from model (6) and (8) reveal that estimated coefficient values of digital finance concerning rationalization and advancement of industrial structure are -0.592 and 0.783, both are significant at 1% level, supporting *Hypothesis 1* and *Hypothesis 2*, which also verifies the baseline regression result's reliability.

**Table 4.** *Digital Finance Sub-Index Regression on Industrial Structure Upgrading*

| | (9) | (10) | (11) | (12) | (13) | (14) |
|---|---|---|---|---|---|---|
| Variable | TL | TL | TL | UG | UG | UG |
| DF_coverage | -0.2088* | | | 0.1482 | | |
| | (0.1225) | | | (0.1631) | | |
| DF_usage | | -0.1646*** | | | 0.2210*** | |
| | | (0.0486) | | | (0.0644) | |
| DF_digitization | | | -0.0168 | | | 0.0933** |
| | | | (0.0323) | | | (0.0425) |
| hum | 0.3362 | -6.5041 | -0.6959 | 1.4113 | 10.3429 | 5.1933 |
| | (5.1042) | (5.3718) | (5.2630) | (6.7957) | (7.1222) | (6.9259) |
| open | 0.1439 | 0.0863 | 0.1282 | -0.7774*** | -0.7097*** | -0.7638*** |
| | (0.0882) | (0.0874) | (0.0882) | (0.1174) | (0.1158) | (0.1160) |
| infor | 0.0010 | -0.0036 | 0.0036 | -0.0441 | -0.0366 | -0.0479 |
| | (0.0383) | (0.0378) | (0.0385) | (0.0510) | (0.0501) | (0.0506) |
| traffic | 0.4814*** | 0.4042*** | 0.4664*** | 0.1743 | 0.2777** | 0.2553* |
| | (0.1027) | (0.1037) | (0.1069) | (0.1368) | (0.1375) | (0.1407) |
| _cons | -8.4945*** | -6.8682*** | -7.5537*** | -3.6803* | -5.3616*** | -5.0598** |
| | (1.5362) | (1.4633) | (1.4975) | (2.0452) | (1.9401) | (1.9706) |
| Obs. | 330 | 330 | 330 | 330 | 330 | 330 |
| R-squared | 0.3979 | 0.4154 | 0.3923 | 0.7942 | 0.8018 | 0.7970 |
| Province Fixed | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed | Yes | Yes | Yes | Yes | Yes | Yes |
| **Note:** ****, **, * Significant at 1%, 5%, and 10% confidence levels, respectively Standard errors are in parentheses. Same as below* | | | | | | |

We conduct robustness tests through substituting explanatory variables, regressing industrial structural upgrading on each sub-index of digital finance.Table 4 reports the regression outcomesforeach sub-index of digital finance,focusingon the breadth of coverage of digital finance (DF_coverage), depth of use of digital finance (DF_usage), and digitization of digital finance (DF_digitization). Models (9), (10) and (11) show the regression outcomes of the three sub-indexes on the rationalization of industrial structure, with estimated coefficient values are -0.2088, -0.1646 and -0.0168, respectively. Notably, DF_coverage and DF_usage aresignificant at the1%, 10%levels, while the estimated coefficientforDF_digitizationnot significant. This indicates that digital finance influences the rationalization of industrial structure is primarily realized through the two channels: its breadth of coverage and depth of use.Models (12), (13), (14) are the regression results for the three sub-indices on the advancement of industrial structure, yielding estimated coefficient values are 0.1482, 0.2210, 0.0933. The findings indicate that DF_usage and tDF_digitization are significant at the level of 1% and 5%, respectively, while DF_coveragedoes not demonstrate statistical significance. Which indicates thatdigital finance influences the advancement of industrial structure is mainly realized through the depth of usage and degree of digitization.The results in Table 4 are largely closely with those of the baseline regression, which verifies the reliability of the initial results and supports *Hypothesis 1* and *Hypothesis 2*.

## 5. Further Analysis

### 5.1 Heterogeneity Analysis

**Table 5.** *Regional Heterogeneity Regression Results*

| | (15) East Region | (16) Middle Region | (17) West Region | (18) East Region | (19) Middle Region | (20) West Region |
|---|---|---|---|---|---|---|
| **Variable** | **TL** | **TL** | **TL** | **UG** | **UG** | **UG** |
| DF | -0.0887*** | 0.0221 | 0.0745 | 0.1727*** | 0.3723 | 0.3762** |
| | (0.0279) | (0.1076) | (0.0620) | (0.0302) | (0.3839) | (0.1420) |
| gov | 2.1644* | 0.0203 | -0.2320 | 2.8472** | 1.3081 | 3.4632*** |
| | (1.1994) | (0.5210) | (0.2292) | (1.2998) | (1.8578) | (0.8055) |
| ln_Pgdp | 0.1558 | -0.1272 | -0.1925*** | 0.8172** | -0.2946 | 0.8364** |
| | (0.3450) | (0.1421) | (0.0567) | (0.3739) | (0.5067) | (0.2795) |
| hum | -21.1957* | -5.9953 | -11.4204** | -28.2670** | -21.7730 | 20.3761* |
| | (12.3037) | (5.2991) | (4.3717) | (13.3336) | (18.8976) | (11.1120) |
| FDI | 1.0444 | -0.0160 | -2.1323** | -3.1174** | -6.8625* | -0.7095 |
| | (1.1525) | (1.0929) | (0.7149) | (1.2489) | (3.8974) | (3.8987) |
| infor | -0.2094 | 0.0057 | 0.0621 | 0.1720 | -0.0323 | -0.5686 |
| | (0.4352) | (0.0159) | (0.0553) | (0.4716) | (0.0566) | (0.3874) |
| traffic | 0.6771*** | 0.2891*** | 0.1346 | 0.8591*** | -0.1473 | -0.4030 |
| | (0.2494) | (0.0800) | (0.0761) | (0.2702) | (0.2851) | (0.3484) |
| _cons | -8.5997** | -1.9788 | 0.7094 | -16.2196*** | 5.3827 | -3.3346 |
| | (3.8188) | (1.7473) | (0.9531) | (4.1384) | (6.2312) | (5.0023) |
| Obs. | 121 | 88 | 121 | 121 | 88 | 121 |
| R-squared | 0.3592 | 0.7032 | 0.9052 | 0.7723 | 0.8268 | 0.8560 |
| Province Fixed | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed | Yes | Yes | Yes | Yes | Yes | Yes |
| **Note:** ****, **, * Significant at 1%, 5%, and 10% confidence levels, respectively Standard errors are in parentheses. Same as below* | | | | | | |

To understandhow digital finance affects the industrial structure across various regions, this study carries out group regression analysis for the eastern, central, western areas respectively.Table 5 reports the regression results. According to regression results from models (15), (16) and (17), the estimated coefficient value forthe effect of digital finance on the Theil index of the eastern region's is -0.0887, significant at the 1% level. Which indicates that digital finance is effectively to the promotion of the rationalization of industrial structure in the eastern region, while its impact in the central and western region is not

obvious.The regression results from models (18), (19), (20) reveal that the estimated coefficient values of digital finance on the index of industrial structure advancement is 0.1727in the eastern and western regions (significant at the 1% level) and 0.3762 in the western region (significant at the 5% level). which indicates that digital finance fosters the advancement of industrial structure in both eastern and western regions, while its impact in the central region is not obvious.

Overall, digital finance significantly contributes to enhancing the industrial structure of the eastern region. This is primarily because digital finance builds upon traditional finance, relying on both it and technological innovation to enhance industrial structurethe development.There isa better economic foundation and an inherent development advantage in traditional finance and technological innovation in eastern region.Consequently, after the implementation of digital finance, financial institutions in this area provide diversified financial products to enterprises and individuals. With the increased utilization of digital finance, these institutions are able to effectively allocate resources (Tan & Lu, 2021), thereby facilitating the upgrading of the eastern region's industrial structure.

**Table 6.** *Regression Results on Financial Development Heterogeneity*

| | (21) High Financial Level | (22)Low FinancialLevel | (23) High Financial Level | (24) Low FinancialLevel |
|---|---|---|---|---|
| **Variable** | **TL** | **TL** | **UG** | **UG** |
| DF | -0.5930*** | 0.1481*** | 0.5992*** | 0.2586 |
| | (0.1684) | (0.0364) | (0.1991) | (0.1731) |
| gov | 0.9543* | 0.1893 | 3.0144*** | 1.5016* |
| | (0.5758) | (0.2527) | (0.6806) | (0.8080) |
| ln_Pgdp | 0.3692* | -0.0645 | 0.6377*** | 0.2632 |
| | (0.2015) | (0.0658) | (0.2381) | (0.2514) |
| hum | 1.6183 | -11.6867*** | -7.4735 | 18.3412** |
| | (11.8703) | (2.2377) | (14.0292) | (7.8759) |
| FDI | 1.3459 | -1.8914*** | -2.1318** | 3.6309 |
| | (0.8547) | (0.3474) | (1.0101) | (2.1654) |
| infor | -0.2737 | -0.0037 | -1.3323*** | -0.0104 |
| | (0.3407) | (0.0027) | (0.4026) | (0.0066) |
| traffic | 0.5954*** | 0.0939* | 0.4735** | -0.0081 |
| | (0.2013) | (0.0459) | (0.2379) | (0.0906) |
| _cons | -9.8782*** | -0.1553 | -10.9137*** | -2.2634 |
| | (2.8137) | (1.0038) | (3.3254) | (2.6223) |
| Obs. | 164 | 166 | 164 | 166 |
| R-squared | 0.5104 | 0.8718 | 0.7913 | 0.9057 |
| Province Fixed | Yes | Yes | Yes | Yes |
| Year Fixed | Yes | Yes | Yes | Yes |

**Note:** ****, **, * Significant at 1%, 5%, and 10% confidence levels, respectively Standard errors are in parentheses. Same as below*

Table 6 reports the results across various levels of financial development. The regression results from models (21), (22) reveal that the estimated coefficientson Theil indexfor industrial structureare -0.5930 and 0.1481, both significant at the 1% level in areas with high level of financial development. In contrast, the coefficients for areas withlow financial development is positive but non-significant.This suggests that digital finance effectively fosters the rationalization of industrial structure in regions with high financial development, whereas it does not support such rationalizationin regions with low financial development. Models (23), (24)exhibit thatthe regression coefficient on the advancement of industrial structure are 0.5992, significant at the 1% level, and 0.2586, which is not significant. Thisindicates that digital finance significantly drives the advancement of industrial structure in the regions with high financial development, while its effect is less pronounced in regions with lowfinancial development.

In general, digital finance is more effective in facilitating industrial structure upgrading in regions with high traditional financial development.Since digital finance builds upon traditional financesystems, areas with a well-established traditional finance infrastructure have a higher development foundation, a greater acceptance of digital finance (Guo & Wang, 2020), resulting in more obvious effect on industrial structure upgrading.

## 5.2 The Mediating Role of Technology Market Development

**Table 7.** *Mediating Effect Regression Result*

| | (25) | (26) | (27) |
|---|---|---|---|
| **Variable** | **tech** | **TL** | **UG** |
| DF | 0.0367*** | -0.1604* | 0.1504*** |
| | (0.0065) | (0.0944) | (0.0168) |
| tech | | -2.9302*** | 4.8485*** |
| | | (0.8222) | (1.0556) |
| ln_Pgdp | -0.0261*** | 0.0586 | 0.8832*** |
| | (0.0081) | (0.1139) | (0.1296) |
| hum | 0.0089 | -2.7687 | -6.5579 |
| | (0.3380) | (4.6742) | (4.7482) |
| FDI | -0.0594 | 1.3375** | -2.1560*** |
| | (0.0373) | (0.5184) | (0.7734) |
| infor | 0.0000 | 0.0033 | -0.0334 |
| | (0.0027) | (0.0368) | (0.0552) |
| traffic | -0.0203*** | 0.3602*** | -0.0096 |
| | (0.0072) | (0.1014) | (0.0781) |
| _cons | 0.4721*** | -4.4495*** | -7.9223*** |
| | (0.1083) | (1.5475) | (1.8878) |
| Obs. | 330 | 330 | 330 |
| R-squared | 0.5710 | 0.4466 | 0.7487 |
| Province Fixed | Yes | Yes | Yes |
| Year Fixed | Yes | Yes | Yes |

**Note:** ****, **, * Significant at 1%, 5%, and 10% confidence levels, respectively Standard errors are in parentheses. Same as below*

Table 7 This study refers to stepwise regression method for testing mediation effect (Wen et al., 2004). According tothe theoretical insights and mathematical formulas of mediation effect,the two-way fixed effect model is employedto investigatehow thetechnology market development as a mediating variable in the relationship between digital finance andindustrial structure upgrading, which is utilized for testing *Hypothesis 3* and *Hypothesis 4*.

Models (25), (26), and (27) are the empirical tests done on equations (5), (6), and (7) in Table 7. The model (25) reveals the estimated coefficient valueon technology market development is 0.0367, significant at 1% level, indicates that digital finance positively influences technology market development, serving as a mediating variable for further testing. Model (26) shows that the estimated coefficient of digital finance on industrial structure Theil index is -0.1604, significant at 10% level. Meanwhile, the estimated coefficient value of technology market development on industrial structure Theil index is -2.9302, significant at 1% level. This indicates a mediation effect, meaning that digital finance can enhance the industrial structure development towards rationalization through technology market development, Hypothesis 3 is confirmed. Model (27) show that the estimated coefficient for digital finance on the advancement of industrial structure index is 0.1504,significant at 1% level. Meanwhile, the estimated coefficient for technology market development on the advancement of industrial

structureindex is 4.8485, also significant at 1% level. which indicates that the digital finance supportsthe development the advancement of industrial structure through technology marketdevelopment, Hypothesis 4 is confirmed.

Overall, digital finance has contributed in varying degrees to both the rationalization and advancement of industrial structurethrough the intermediary mechanism of technology market development.

## 6. Conclusion and Recommendations

This paper analyzes panel data from 30 Chinese provinces spanning from 2011 to 2021 to investigate how digital finance influences the upgrading of industrial structure. It employs fixed- effects models and mediation analysis to validate and explore the effects and mechanisms involved. Thestudy's findings reveal that: (1) The results of the baseline regression demonstrates that digital finance positively influences both rationalization and advancement of industrial structure. The conclusion remains consistenteven after conducting robustness test,including regression analyses with a one-period lagged digital finance and assessments of each digital finance sub-index. (2) Heterogeneity analysis highlights that both regional and financial development differences in the effect of digital finance on industrial structure upgrading. Specifically, the positive effect of digital finance on industrial structure upgrading is more pronounced in China'seastern region and areas with high financial development level. (3) The analysis of mediation effect indicates that digital finance can realize industrial structure upgrading through technology market development. Based on these findings, the following suggestions are proposed:

1. Strengthen and enhancedigital finance infrastructure

The government should promote digital finance development and financial innovation. It should improve the construction of digital financial system to local conditions, maximizing the effectiveness of digital finance to deliver optimized services that are accessible and affordable, High-quality, convenient financial services should be provided to support the development of enterprises, especially those that are innovative and high value-added enterprises, so as to boost the realization of industrial structure upgrading.

2. Accelerating the role of science, technology and innovation in digital finance

Addressing the challenges of costly and in accessible financing for SEMs is essential, especially innovative ones, digital finance has energized the enthusiasm and enthusiasm of enterprises for innovation and acceleratedindustrial structure upgrading. Encourage the innovation of traditional financial institutions through financial support and policy guidance,and promote collaboration between traditional financial institutions and technology firms, to achieve the benign interactive of traditional financial institutions and digital finance, which in turn leads to healthy growth of the whole financial system. It invigorates the economic market, promote the economy from traditional industry sector to development of higher-end and smarter industries, and realize industrial structure upgrading.

3. Utilizingdigital finance to enhance the industrial structure in the central and western regions

The central and western regions, which lag behind in economicand financial development, possess a late-comer's advantage. By adjusting the distribution of production factors more effectively, these regions can enhance the efficiency of their industrial structure adjustments.Specifically, the central and western regions can Utilize digital finance to provide more flexible financial services. This approach will foster the growth of new industries, enhance their economic vitality and competitiveness, and then better realize industrial structure upgrading. In the central and western regions, it is essential necessary to enhance awareness of financial tools and improve the local education level to establish a foundation for the growth of digital finance.

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