# Research on Digital Economy Development Enabling the Transformation and Upgrading of Industrial Structure in Hebei Province

Yakun Wang[1], Mingyang Xu[2*], Qiqi Liang[3]

15345221@qq.com[1], 1114007717@qq.com[2*], 907311945@qq.com[3]

School of Economics and Management, Hebei University of Science and Technology, Shijiazhuang, China

**Abstract.** In the context of digital economy empowering the transformation and upgrading of traditional industries, based on the panel data of cities in Hebei Province from 2018 to 2022, the study is conducted to measure the level of digital economy development of cities in Hebei Province by using the entropy weighting method with linear weighting and explore the impact of the level of digital economy development on the transformation and upgrading of the industrial structure of the cities in Hebei Province based on the measurement results by using the bi-directional fixed-effects model. The study finds that there are large differences in the level of digital economy development and industrial structure transformation and upgrading among the cities in Hebei Province. Through the analysis of the multiple linear regression model, it is finally determined that the development of digital economy in the cities of Hebei Province is conducive to promoting the transformation and upgrading of industrial structure. The conclusion remains significant after introducing control variables as well as replacing the explanatory variables and controlling the endogeneity problem.

**Keywords:** Digital economy; industrial structure transformation and upgrading; two-way fixed effects

## 1 Introduction

Today's world is in the age of digitalisation, and the digital economy has become an important factor in driving high-quality economic development. China has seized the major opportunity of the development of the digital economy, and has made great efforts to develop the digital economy. Hebei Province is a province with a large scale of industrial enterprises in China, and the traditional industries in the province such as iron and steel, coal and other industries occupy a dominant position in the economy. In recent years, Hebei Province has been striving to promote the upgrading and transformation of traditional industries, and the digital economy industry in the province has shown a good development trend, and the structure of the digital economy has been continuously optimised. However, at the same time, there are also problems such as the large scale of traditional industries, insufficient innovation ability, and lack of market competitiveness due to low quality of industries. Therefore, in the new round of strategic choices, Hebei Province urgently needs to seize the new opportunities of the scientific and technological revolution and industrial change, and promote the deep combination of the digital economy and the real economy to give new vitality to the traditional industries.

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## 2 Literature Review

### 2.1 Ways to measure the level of development of the digital economy

The current method of measuring the level of digital economy development is mainly principal component analysis, and different scholars construct different evaluation index systems. Chen Ting [1] scores the level of digital economy development in Guangdong Province from the dimensions of digital users and digital outputs, while Guo Han et al. [2] used four-dimensional indicators on this basis, including digitalisation, networking, intelligence and platformisation. In terms of the object of measurement, it mainly focuses on the degree of digital economy development of national provinces and cities, Chinese city clusters, and a specific province and city in general[3].

### 2.2 Impact of the level of development of the digital economy

Studies have confirmed the positive effects of the digital economy at various levels, first, at the macro level, the development of the digital economy will promote the upgrading or optimisation of the industrial structure within the region, promote green technological innovation, promote economic development and high-quality development, and improve the quality of public services [4], as well as to promote the consumption of the population, alleviate the problem of closure, and promote the export trade [5], etc. Focusing on the urban perspective, many scholars have explored the impact of the digital economy on the overall development of the city, which can promote the city to improve the green total factor productivity, promote the green development of the city as well as promote urban innovation [6]; secondly, at the micro level, the development of the digital economy in the region will promote the technological innovation of the local enterprise and the green innovation [7], and increase the level of enterprise risk-taking as well as total factor productivity [8] and so on.

It is found that there are the following shortcomings in the existing studies: (1) Most of the existing studies measure the level of digital economy from the perspective of provinces and city groups, and there is a lack of research on the level of digital economy development of the cities in Hebei Province. (2) As a major manufacturing province, Hebei Province has outstanding industrial transformation problems, and the impact of digital economy development on the transformation and upgrading of the industrial structure of the cities in Hebei Province needs to be explored.

## 3 Research hypotheses

The transformation and upgrading of industrial structure is mainly reflected in two aspects, one is the rationalization of industry, which can reflect whether different industries can reasonably configure the resource elements [9], based on which to change the irrational industrial structure and increase the economic income of the enterprise; the second is the advanced industrialization, which reflects the process of dynamic adjustment of the labour-intensive industries to the knowledge- and technology-intensive industries, and it is the inevitable outcome of the evolution of the development trend of the economy [10]. The digital economy, as a major breakthrough in the transformation of the quality, efficiency and power of traditional industries, provides new ideas for the optimisation of industrial structure and the realisation of high-quality

economic and social development [11]. Firstly, the rapid development of the digital economy can effectively reduce the cost of using data resources, and the pre-investment funds for the digital transformation and upgrading of traditional industries will also decline, improve industrial efficiency, and promote industrial transformation and upgrading [12]. Secondly, manufacturing enterprises to improve their economic efficiency can use digital technology to improve the enterprise's resource allocation all-factor production efficiency, while promoting the transformation and upgrading of the traditional manufacturing industry in Hebei Province [13]. As a result, this paper proposes:

H1: The level of digital economy development has a positive impact on industrial structure transformation and upgrading

## 4 Research design and data testing

This paper selects the panel data of each prefecture-level city in Hebei Province from 2018 to 2022 for the study, and the data of each indicator are obtained from Hebei Provincial Statistical Yearbook, China Urban Statistical Yearbook, China Science and Technology Statistical Yearbook and China Electronic Information Industry Statistical Yearbook, and some of the missing data are calculated by the method of linear interpolation.

### 4.1 Variable design

The explanatory variables are measured in terms of two dimensions: rationalisation of industrial structure and heightened industrial structure. The formula for industrial structure rationalisation (R) is shown in (1):

$$R_{i,t} = 1/\sum_{j=1}^{n} \frac{Y_{i,j,t}}{Y_{it}} \ln\left(\frac{Y_{i,j,t}}{Y_{i,t}} / \frac{L_{i,j,t}}{L_{i,t}}\right) \quad (1)$$

**Ri,t** denotes the industrial structure rationalisation level of city **i** in Hebei province in period **t**; **Yi,j,t** denotes the output value of industry **j** in city **i** in Hebei region in period **t**; **Li,j,t** denotes the number of people employed in industry **j** in city **i** in Hebei province in period **t**.

The formula for calculating industrial structure heightening (IS) is shown in (2):

$$IS = \sum_{I=1}^{3} q_i \times i = q_1 \times 1 + q_2 \times 2 + q_3 \times 3 \quad (2)$$

**q1, q2** and **q3** represent the proportion of output value of the primary, secondary and tertiary industries, respectively.

The explanatory variables consist of 12 dimensions in four areas: digital infrastructure, digital industry development level, digital economy innovation capacity, and industry digitisation level; The control variables are selected as four indicators: degree of openness to the outside world (FDI), social consumption demand (SOC), degree of government intervention (GI), and science and education support (SE).

### 4.2 Model construction

In this paper, when constructing the econometric model of the impact of digital economic development on the transformation and upgrading of industrial structure in Hebei Province, it

is necessary to consider the degree of opening up to the outside world, social consumption demand and other influencing factors while giving full consideration to the development of the digital economy, and at the same time, it is also important not to neglect the government's role of government regulation in the transformation and upgrading of industrial structure. This paper sets up a two-way fixed-effects model as shown in (3), which on the one hand can avoid the result bias caused by the endogeneity problem of the model, and on the other hand will control the heterogeneity of different cities in terms of economic scale, enterprise income level, etc., as well as the heterogeneity of time caused by different economic policies and external environment in different time periods, to avoid the influence of individuals and time on the explanatory variables, and to improve the explanatory ability and estimation accuracy of the model. to avoid the influence of individual and time on the explanatory variables, and to improve the explanatory ability of the model and the accuracy of the estimation.

$$\mathrm{STR}_{it} = \propto_0 + \propto_1 \mathrm{DE}_{it} + \gamma \mathrm{Controls}_{it} + \mu_i + \varphi_t + \varepsilon_{it} \quad (3)$$

**4.3 Hypothesis testing**

1. Descriptive statistics

In terms of the level of transformation and upgrading of industrial structure, the extreme difference of each city is larger, showing a higher degree of dispersion, indicating that there are obvious differences in the advanced industrial structure of each city. In terms of the level of digital economy development, the sample has a larger extreme difference, indicating that the selected sample covers a wider range and is more representative. There are large differences in the degree of openness to the outside world, social consumption demand, the degree of government intervention, and scientific and educational support in each city in Hebei Province, and the economic environment of different cities has a large gap. Moreover, the correlation coefficients of the variables selected in this paper are less than 0.6, and it is considered that the possibility of the model's existence of multiple covariance is small, and multiple regression can be carried out.

2. Measurement results of industrial structure transformation and upgrading

The results of the quadrant analysis of the heightened and rationalised industrial structure of cities in Hebei Province are shown in Figure 1. The first quadrant represents that the degree of industrial structure intensification and rationalisation is higher than the average level, and the industrial structure transformation effect is better. The main cities are Shijiazhuang and Cangzhou. The second quadrant represents that the industrial structure is highly developed but not reasonable enough. The main cities are Qinhuangdao and Zhangjiakou. The third quadrant represents an industrial structure that is both highly developed and not rational enough, and is concentrated in the following cities: Handan, Hengshui, Xingtai and Chengde. The fourth quadrant represents an industrial structure that is more rationalised but less highly developed, with only Tangshan City in this quadrant. Taken together, Langfang and Shijiazhuang are doing better in terms of transformation and upgrading of their professional structures, while on the contrary, Chengde and Xingtai are underperforming in terms of both highly developed and rationalised industrial structures.

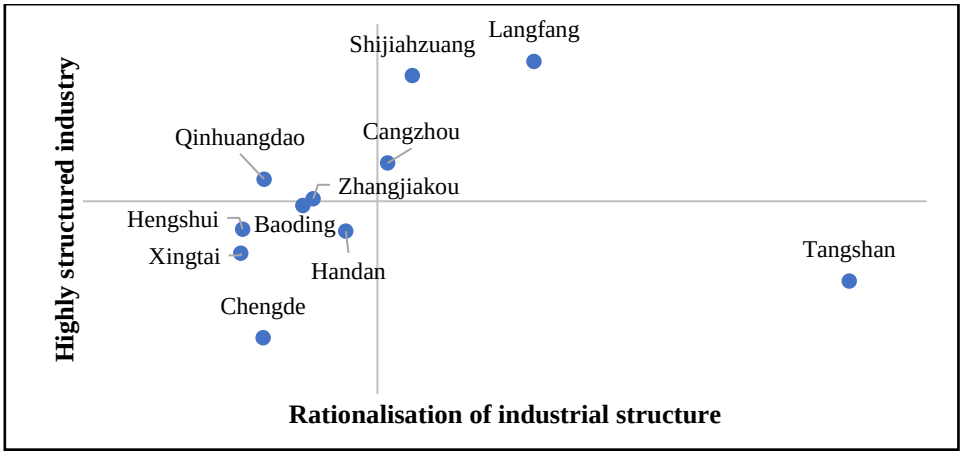


**Figure 1.** Quadrant map of industrial structure transformation and upgrading by city.

3. Regression analysis

Table 1 demonstrates the multiple regression results for the level of transformation and upgrading of the city's industrial structure. Column (1) shows the regression results without adding control variables under the dimension of industrial structure rationalisation, and the results show that the DE coefficient is significantly positive at the 5% level, and that for every unit increase in the level of digital economy development, the level of industrial structure rationalisation increases by 0.042 units. Column (2) shows the regression results of adding control variables under this dimension, and the results show that the R2 value of the model is significantly improved, proving that the model fits better after adding control variables. Column (3) is the regression result without adding control variables under the dimension of industrial organisation advancement, and the result shows that the level of digital economy development and industrial organisation advancement are significantly and positively correlated at 1% statistical level, and column (4) shows that the model fit improves with the addition of control variables, and for every unit increase in the development level of the digital economy, the industrial organisation advancement improves by 14.665 units. Hypothesis 1 is verified.

**Table 1**.Regression analysis results.

| VARIABLES | R(1) | R(2) | IS(3) | IS(4) | R(5) | IS(6) |
|---|---|---|---|---|---|---|
| DE | 0.042** | 0.047** | 23.269*** | 14.665** | 0.047** | 12.025** |
| FDI | | -0.001 | | -2.921 | -0.001 | -2.226** |
| SOC | | -0.001*** | | 0.027 | -0.001*** | 0.030 |
| GI | | -0.001*** | | 0.262*** | -0.001*** | -0.756*** |
| SE | | -0.003*** | | 0.161 | -0.003*** | -0.548* |
| Constant | 0.026*** | 0.146*** | 233.030*** | 231.289*** | 0.146*** | 38.837*** |
| R-squared | 0.075 | 0.350 | 0.216 | 0.481 | 0.350 | 0.554 |
| Company FE | NO | NO | YES | YES | NO | YES |
| Year FE | NO | NO | NO | NO | NO | NO |
| r2_a | 0.058 | 0.283 | 0.015 | 0.281 | 0.283 | 0.508 |
| F | 4.323 | 3.363 | 11.83 | 7.225 | 3.363 | 4.517 |

4. Robustness testing

In order to test the stability of the above benchmark regression results, the replacement of the explanatory variable calculation method is regressed again, and the industrial structure rationalisation index calculation formula is shown in (4):

$$R = -\sum_{i=1}^{n}\left(\frac{Y_i}{Y}\right)\left|\frac{Y_i/L_i}{Y/L} - 1\right| \quad (4)$$

The regression results are shown in (5) (6) in Table1, indicating that at the 5% confidence level, the level of digital economy development in Hebei Province still has a significant contribution to the transformation and upgrading of industrial structure. After replacing the measurement of the explanatory variables, the hypothesis still holds, indicating that the benchmark regression results are accurate.

Meanwhile, in order to mitigate the endogeneity problem associated with the model's bidirectional causality, lagged variable regressions were used. As shown in Table 2, (1) (3) columns are the base regression results, and (2) (4) columns are the regression results after one period of lagging, indicating that the model significance improves at 1% confidence level after controlling the endogeneity problem, i.e., the level of development of the digital economy in Hebei Province has a significant impact on the transformation and upgrading of industrial structure.

**Table 2**.Lagged independent variable regression results.

| VARIABLES | R1 | R2 | IS1 | IS2 |
|---|---|---|---|---|
| DE | 0.047** | | 14.665** | |
| Controls | YES | YES | YES | YES |
| Constant | 0.026*** | 0.122*** | 231.289*** | 204.880*** |
| Observations | 55 | 44 | 55 | 44 |
| R-squared | 0.350 | 0.313 | 0.481 | 0.315 |
| Company FE | NO | NO | YES | YES |
| Year FE | NO | NO | NO | NO |
| r2_a | 0.283 | 0.254 | 0.281 | 0.225 |
| F | 3.363 | 2.555 | 7.225 | 3.497 |

## 5 Conclusion

Based on the panel data of the cities in Hebei Province from 2018 to 2022, this paper constructs the index system for measuring the level of digital economic development, and analyses the linear impact of digital economic development on the upgrading of the industrial structure of the cities in Hebei Province by using a two-way fixed-effects model. The following conclusion is finally drawn: the level of digital economy development has a positive impact on the transformation and upgrading of industrial structure in the cities of Hebei Province, and this conclusion holds in the introduction of control variables as well as in the robustness test.

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