



Study on the Impact of Informatization on Industrial Structure Upgrading in Northeast China

Dapeng Dong^(✉)

School of Economics and Management, Heilongjiang Bayi Agricultural University,
Daqing, China
64719202@qq.com

Abstract. There is an important correlation between informatization and industrial structure change. Therefore, on the basis of existing research, the paper tries to prove the influence of informatization on the upgrading of industrial structure in Northeast China, in order to provide quantitative scientific basis for promoting the process of informatization development and the upgrading of industrial structure in Northeast China. This paper uses quantitative indexes to measure the evolution trend of industrial structure upgrading, uses entropy method to measure the development of informatization, and uses regression model to study the effect of informatization on industrial structure upgrading based on panel data of the three provinces in Northeast China. Liaoning Province has the highest level of industrial structure upgrading and informatization, while Heilongjiang Province has the lowest. Similarly, the industrial structure upgrading and informatization show a trend of first improvement and then decline. Regression results show that informatization plays an important role in promoting the industrial structure upgrading in Northeast China.

Keywords: Informatization · Industrial Structure Upgrading · Entropy Method · Regression Model

1 Introduction

The application of information network technology has not only changed the technological basis of social economic activities, but also brought about profound changes in the market environment such as information structure, market scope and competitive situation. It has further changed the mode of production and operation at the enterprise level, enhanced the efficiency of resource allocation at the industrial level, triggered a major change in the mode of production, and reshaped the regional and industrial competitive advantages in the era of globalization [9]. Relevant studies have found that there is a significant positive correlation between the level of informatization development and the upgrading of industrial structure [1, 13]. Some studies have pointed out that informatization promotes the adjustment of industrial structure by promoting the change of labor structure. Informatization can promote the optimization and upgrading of regional

industrial structure by optimizing the regional leading industry, improving the auxiliary industry and infrastructure structure, and promoting the emergence of emerging industries [2, 6]. Starting from the characteristics of informatization, the process of informatization contains the characteristics of high-tech industry such as rapid growth mechanism, efficient industrial resource allocation efficiency, and increasing industrial added value, which can directly transform and upgrade traditional industries, to promote the upgrading of the entire industrial structure [10, 11]. At the same time, from the perspective of the related structural model and organizational evolution, informatization can improve the efficiency of knowledge flow among industries, improving inter-industry linkages [8] accelerates knowledge production and diffusion and promotes positive evolution of Industrial Organization structure. In the process of information technology merging into other industries, the intra-industry spillover effect and inter-industry spillover effect of information technology can effectively upgrade the technological level of other industries and change their backward production and operation mode [5]. Some scholars have pointed out that the integration of informatization and industrialization can reduce the proportion of primary industry, promote the transfer of primary industry to secondary sector or tertiary sector of the economy, and improve the overall industrial structure [12].

Under the strategy of rejuvenating the old industrial bases, Northeast China has experienced a rapid economic growth in ten year [3]. However, the problems of low industrial level, structural convergence, excess production capacity, weak technological support and independent innovation capacity in northeast China have not been fundamentally solve. a When the external environment of economic development changes, the deep-seated contradictions previously concealed by high-speed growth will focus on breaking out. There are many reasons for the economic decline of Northeast China and the “new Northeast Phenomenon”, and the deep-seated reason lies in the fossilized, solidified and low-level industrial structure that has not been adjusted for a long time. At present, China’s economy has shifted from a stage of high-speed growth to a stage of high-quality development. It is now in a crucial period of transforming its development mode, optimizing its economic structure and transforming its growth momentum. Under the strategy of revitalizing the old industrial base, the key way to realize the high-quality development of the northeast economy is to upgrade the industrial structure, cultivate the new economic growth power and change the economic development mode. Based on the above analysis, it is of great theoretical value and practical significance to study the effect of informatization on industrial structure upgrading in Northeast China.

2 Measurement of Informatization

2.1 Entropy Method

On the basis of the existing research of informatization evaluation, considering the actual situation of informatization development in Northeast China and the availability of relevant data, two evaluation objects of informatization infrastructure and informatization application are established. Among them, the level of informatization infrastructure directly reflects informatization hardware conditions and development status, including the length long-distance optical cable, internet broadband access port, and the employees of information transmission, software and information technology service industry.

The level of informatization application can effectively reflects the penetration degree of informatization to other industries, including the penetration rate of mobile phones, users of internet broadband, and the total amount of telecom services.

When there are more than one index in an evaluation system, it is difficult to integrate because of different dimensions and orders of magnitude. In this paper, the original data of each year are standardized before data analysis, and then the entropy method is used to objectively weight each index to get the weight matrix. Finally, the comprehensive index of informatization development of each province is obtained by multiplying the weight of each indicator by the standardized value. The specific method is as follows.

First, the original data were standardized. Assuming that the evaluation index is x_{ij} and the standardized index is y_{ij} , the positive index is:

$$y_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (1)$$

The negative index is:

$$y_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})}, i = 1, 2, \dots, m; j = 1, 2, \dots, n \quad (2)$$

Next, determine the weight. Calculate the specific gravity p_{ij} of the evaluation index as:

$$p_{ij} = y_{ij} / \sum_{i=1}^m y_{ij} \quad (3)$$

The entropy value E_j is calculated as:

$$E_j = -\frac{1}{\ln m} \sum p_{ij} \times \ln p_{ij} \quad (4)$$

The entropy value of each index was used to calculate its difference coefficient $d_j = 1 - E_j$, and normalized the difference coefficient to obtain the weight index:

$$w_j = d_j / \sum_{j=1}^n d_j \quad (5)$$

Finally, the overall score is calculated:

$$g_i = \sum_j (w_j \times y_{ij}) \quad (6)$$

2.2 The Calculation Results

According to the above formula of entropy method, the comprehensive development level of informatization in the three northeastern provinces is shown in the Table 1. The horizontal comparison shows that Liaoning Province has the highest level of informatization development, while Heilongjiang Province has the lowest level of informatization

Table 1. Measurement of informatization development.

Year	Provinces		
	<i>Liaoning</i>	<i>Jilin</i>	<i>Heilongjiang</i>
2011	0.8491	0.0562	0.3304
2012	0.8101	0.0581	0.3735
2013	0.7950	0.0390	0.3284
2014	0.7826	0.0467	0.3603
2015	0.7747	0.0463	0.3581
2016	0.7592	0.0678	0.3844
2017	0.7710	0.0813	0.3971
2018	0.8517	0.1732	0.3355
2019	0.7977	0.0854	0.3514
2020	0.6891	0.1154	0.4602

development. From the perspective of vertical development trend, the level of informatization development in Liaoning Province showed an obvious downward trend before 2018, gradually decreasing from 0.849 to 0.771. It showed a significant increase in 2018, but then decreased significantly, and dropped to 0.689 in 2020, the lowest level in the province. The level of informatization development in Jilin Province showed an obvious upward trend before 2018, and reached the highest level of 0.173 in 2018, followed by a slight decline. The level of informatization development in Heilongjiang Province shows a steady upward trend from 0.33 to 0.46, but the overall level of informatization development is low.

3 Analysis of Industrial Structure Upgrading

3.1 Method of Measurement

The traditional method takes the proportion of non-agricultural output as the measurement index according to the Petty-Clark theorem. Although according to The Petty-Clark theorem, the increase in the proportion of non-agricultural output value is the general law of the evolution of industrial structure, since the 1970s, due to the development of information technology, economic servitization has become the main trend of the development of industrial structure, and the traditional measurement indicators cannot reflect the trend of economic structure servitization. Relevant studies can scientifically measure the degree of industrial structure advancement by the ratio of three industrial structures, such as structure similarity coefficient, Moore value and other indicators. However, the above indicators only simply reflect changes in industrial structure. For example, Jiao Yong (2015) [7] used the ratio of added value of tertiary industry and secondary industry to reflect the trend of “economic structure servitization” driven by informatization, but failed to reflect the degree of industrial structure optimization. In order to better reveal the

degree of advanced industrial structure, the advanced change value of industrial structure defined by Fu Linghui (2010) is selected as the measurement index to reflect the degree of advanced industrial structure of three provinces in Northeast China [4]. The advanced change value of industrial structure is defined as follows:

First, the proportion of the added value of the three industries in GDP is taken as a component respectively to form a set of three-dimensional vectors $x_0 = (x_{1,0}, x_{2,0}, x_{3,0})$.

Next, calculate the angle $(\theta_1, \theta_2, \theta_3)$ between x_0 and the vector of the industry from lower to higher, that is:

$$\theta_j = \arccos \left(\frac{\sum_i^3 x_{i,j} x_{i,0}}{\sqrt{\sum_i^3 x_{i,j}^2 \sum_i^3 x_{i,0}^2}} \right) (j = 1, 2, 3) \quad (7)$$

Finally, the advanced change value of industrial structure is calculated as follows:

$$W = \sum_{k=1}^3 \sum_{j=1}^k \theta_j \quad (8)$$

3.2 The Calculation Results

According to the above calculation formula, the calculation results of industrial structure upgrading are shown in Table 2. The horizontal comparative analysis shows that Liaoning Province has the highest degree of industrial structure upgrading, while Heilongjiang Province has the lowest degree of industrial structure upgrading. The vertical development trend shows that the industrial structure of Liaoning Province presents a significant trend of upgrading before 2018, and the upgrading level of the industrial structure is steadily improving, but it has a slight decline after 2018. The trend of industrial structure upgrading in Jilin Province is basically the same as that in Liaoning Province. Heilongjiang Province has an obvious development trend of industrial structure upgrading before 2018, which also slows down after 2018, but shows a significant improvement in 2020.

4 Analysis of Regression Model

4.1 Regression Model

In order to verify the influence of informatization on the upgrading of industrial structure in the three northeastern provinces, relevant influencing factors should be incorporated into the empirical analysis framework for testing. Therefore, this paper constructs the following econometric model:

$$str_{it} = \alpha_i + \beta \inf_{it} + \gamma_i X_{it} + \varepsilon_{it} \quad (9)$$

Table 2. Measurement of industrial structure upgrading.

Year	Provinces		
	<i>Liaoning</i>	<i>Jilin</i>	<i>Heilongjiang</i>
2011	6.5152	6.3628	6.3423
2012	6.5388	6.3711	6.3649
2013	6.5536	6.3924	6.3216
2014	6.6358	6.4251	6.4277
2015	6.7177	6.4641	6.5534
2016	6.7907	6.5782	6.6659
2017	6.8639	6.7424	6.7075
2018	6.8623	6.8153	6.3990
2019	6.8560	6.8065	6.3491
2020	6.8553	6.7234	6.8560

Table 3. The statistical description of relevant variables.

Variable	Mean	Sd	Mix	Max
<i>str</i>	6.5953	0.1925	6.3216	6.8639
<i>inf</i>	0.4110	0.2997	0.0390	0.8517
<i>pgdp</i>	10.7731	0.1912	10.3988	11.0876
<i>gov</i>	0.2420	0.0571	0.1563	0.3978
<i>road</i>	8.4508	0.3858	7.8726	9.0378

The explained variable *str* is the advanced change value of the industrial structure calculated in the previous paper and represents the upgrading of the industrial structure. The core explanatory variable *inf* is the level of informatization, which is calculated by entropy method in the previous paper. The other control variables are represented as *X*. The control variables mainly include other factors that may affect the industrial structure upgrading and include three variables. One of the control variables is Per capita GDP (*pgdp*) and that is used to measure the level of economic development in a region. The industrial development of the three provinces in Northeast China has obvious characteristics of government intervention, so government intervention(*gov*) is chosen as one of the control variables and is measured by the ratio of government fiscal expenditure to GDP. The improvement of transportation infrastructure is conducive to the free flow of production factors, thus influencing regional industrial upgrading, so the transportation infrastructure (*road*) is chosen as one of the control variables and is measured by the density of highway. In the model, GDP per capita and transportation infrastructure are logarithmic. The statistical description of relevant variables is shown in Table 3.

Table 4. The results of Regression.

Variable	Coefficient	SE	T	P > T
<i>inf</i>	0.1773**	0.0844	2.1016	0.0458
<i>pgdp</i>	0.2823	0.2446	1.1540	0.2594
<i>gov</i>	2.0966***	0.4379	4.7883	0.0001
<i>road</i>	0.2509*	0.1226	2.0464	0.0514
<i>_cons</i>	0.8535	1.8800	0.4540	0.6537

Note: ***, ** and * respectively indicate that the estimated coefficient value is significant at the level of 1%, 5% and 10%

4.2 Results of Regression

The regression results are reported in Table 4. The fitting degree R^2 of the regression model was 0.6803, indicating that the part of explained variables explained by all explanatory variables was very high. Therefore, the fitting of the model is better on the whole.

Regression analysis results show that the coefficient of informatization is positive and passes significance statistical test at the level of 5%, that is, the informatization has a positive effect on the upgrading of industrial structure. The improvement of informatization development and the penetration and integration of information technology will enhance the fluidity of production factors, change the ratio structure of production factors, improve the allocation efficiency of production factors among the three industries and within the industry, and promote the coordinated development of industries. At the same time, the technological progress brought by the development of information technology will guide the redistribution of capital or labor factors among different industries, promote the flow of factors to high-return industries, realize the optimal allocation of factors among different industries, further lead to the change of the ratio structure between capital and labor factors, and finally promote the upgrading of industrial structure. Therefore, the northeast region should improve the application efficiency of informatization in industry, in order to promote the upgrading of industrial structure with the improvement of informatization.

The per capita GDP coefficient is positive but fails to pass the statistical significance test, indicating that the improvement of regional economic development has no impact on the upgrading of industrial structure statistically. The coefficient of government intervention is positive and passes the significant statistical test at the level of 5%. Promoting the upgrading of industrial structure is one of the main objectives of the revitalization policy of the old industrial base in Northeast China. In this process, the government makes reasonable industrial development policies and guides the rational allocation of production factors in the industry, which is conducive to the upgrading of industrial structure. When the coefficient of transportation infrastructure is positive and the statistical significance test is carried out at the level of 10%, it shows that the improvement of transportation infrastructure and the improvement of transportation network density

promote the free flow of production factors, facilitate the optimal allocation of regional production factors, and further promote the upgrading of industrial structure.

4.3 Policy Implications

Based on the above research results, informatization has a significant role in promoting the upgrading of industrial structure in northeast China. Therefore, in the process of revitalizing the old industrial base in Northeast China, we should seize the historic opportunity of the global information revolution, fully develop the new generation of information and communication technologies, and further promote the integration of information into the industrial development system in northeast China, then speed up the promotion of regional industrial development level of information, promote the overall transformation and upgrading of industrial structure. At the same time, we should continue to deepen the construction of informatization, strive to improve the application of informatization, and promote the qualitative improvement of industrial structure through the innovation and application of information technology.

5 Conclusions

In this paper, the quantitative method is used to study the evolution trend of industrial structure upgrading in the three northeast provinces. The entropy method is used to calculate the development level of informatization, and the effect of informatization on industrial structure upgrading is studied by regression model with panel data of three northeastern provinces. Using the above research methods, this paper has drawn the following conclusions.

First, the evolution trend of industrial structure upgrading in the three northeastern provinces is similar on the whole, but there is a gap in the degree of industrial structure upgrading between the three northeastern provinces. The horizontal comparison shows that Liaoning Province has the highest degree of industrial structure upgrading, while Heilongjiang Province has the lowest degree of industrial structure upgrading. The development trend shows that, taking 2018 as the cut-off point, the upgrading of industrial structure in the three northeastern provinces shows a trend of first improvement and then decline.

Secondly, the entropy method is used to measure the level of informatization development and a similar conclusion is drawn. Liaoning Province has the highest level of informatization development, while Heilongjiang Province has the lowest level of informatization development. And from the perspective of information development trend, it also presents a trend of first improvement and then decline. Therefore, the northeast region should strengthen the information infrastructure construction, and push forward the information construction to obtain the new breakthrough.

Thirdly, the regression analysis results show that the coefficient of informatization is positive and passes the statistical significance test at the level of 5%, that means informatization plays an important role in promoting the industrial structure upgrading in Northeast China. In addition, The regression coefficients of other control variables also accord with the research expectation. Therefore, the Northeast China should improve the

application efficiency of informatization in industry, in order to promote the upgrading of industrial structure with the improvement of informatization.

Acknowledgment. This paper is supported by the Philosophy and Social Science Planning Project of Heilongjiang Province, China (Grant No. 20JYE271).

References

1. Cha, H. W., Zuo, P. F.(2017). The Impacts of informatization on industrial structure upgrading in China:spatial econometric analysis based on province's panel data, *Economic Review*, 1, 80–89.
2. Chen, Q. J., Zhao, M. L., Geng, X.(2018). Informationization, market segmentation and rationalization of industrial structure, *On Economic Problems*, 7, 14–19.
3. Chu, M., Zong, J.F.(2017). Why Economy Grow in Northeast China so Difficult:Institutional Barriers or Structural Distortions, *Research on Financial and Economic Issues*, 4, 114–121.
4. Fu, L. H.(2010). An empirical research on industry structure and economic growth, *Statistical Research*, 27(8), 3–8.
5. Han, X.F., Hui, N., Song, W.F.(2014). Can Informatization Improve the Technology Innovation Efficiency of Chinese Industrial Sectors, *China Industrial Economics*, 12,70–82.
6. Jiang. D. B., Ye, C. L.(2021). Informatization influences industrial structure: The mediating role of innovation, *Economic Vision*, 8, 1–14.
7. Jiao, Y.(2015). Does geographic agglomeration of production factors influence industrial structure change, *Statistical Research*, 32(8),54–61.
8. Kim, M.S., Yongtae, P.(2009). ICT Co-evolution and Korean ICT Strategy:An Analysis Based on Patent Data, *Telecommunications Policy*, 33(5),253–271.
9. Li, P., Liu, X. Y.(2015). The influence of market-oriented institutional change on technology progress in China, *Economic perspective*,4, 42–50.
10. Liu, H.T.,Jing, J.P.(2002). Analysis on the Impacts of Information Technology on Structure of Conventional Industries, *Information Science*, 20(3), 333–336.
11. Xiao, F.(2011). Informatization of Industry and Industrial Informationism, *Journal of Northeastern University(Social Science)*, 13(3), 4–8.
12. Xie, k., Xiao, J.H.,Zhou, X.B., Wu, J.P.(2012). Quality of Convergence between Industrialization and Informatization in China, *Economic Research Journal*,1, 4–16.
13. Zhao, X., Cha, H. W.(2015). Correlation analysis of industrial structure evolution and informatization development level, *China Population, Resources and Enviroment*, 25(7),84–88.

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

