Analysis on the Evolution of Comparative Advantage of Energy Industry in Northeast China

LIU Xiao-jing, YANG Ming-zhu, CAI Fei-xiang, WANG Zong-tian
Management School of Changchun University of Chinese Medicine, Changchun 130117, China
E-mail: 122219380@qq.com

Abstract: The traditional industrial theory is based on the assumption that the industrial space in a region is continuous and homogenous, while the regional industrial space is determined by the comparative advantages of each industry. The same is true for the energy industry, which has different comparative advantages. The technical and connectivity embodied are also different, and their future evolutionary paths are also different. Therefore, the future path of the industry is also different, not necessarily linear, continuous, and may also be bifurcated and blocked. Based on the comparative advantage characteristics of each energy industry in the country, this paper calculates its technical and connectivity, analyzes the trend of evolution of dominant comparative advantage that each industry has, and explores its future based on the respective technical level and connectivity level of the energy industry. The path of development and the possible emergence of "risk of interruption", indicating the direction for industrial development.

1. Introduction and Literature Review
The theory of comparative advantage holds that factor endowment plays an important supporting role in the process of industrial upgrading. Industrial upgrading should follow the comparative advantage, but no specific operational suggestions are given for the direction and magnitude of industrial upgrading. Hobday (1994) classified the production processes of enterprises as OEA (processing assembly), OEM (OEM), ODM (self design and processing), OBM (own brand production) and other activities from the perspective of global value chain. OEM, to ODM, to OBM industry upgrade, to cross-industry upgrade. Studies by Hidalgo, Hausmann, and Klinger (2007) found that initial division of labor is crucial to the economic development of a region and affects the economic structure of the region and the path of regional economic development. Zhang Qizai (2008) extends Hausmann et al.'s research and proposes an extended HK industry upgrade model theory, introducing the concept of industry degree. It believes that the more industrial development opportunities follow, the smaller the chance of being "stuck" and the easier The industry escalation, meanwhile, also explains the "surge" of large-scale investments that take place worldwide. Deng Xiangrong (2013) further studied the HK model and added product innovation triggered by the accumulation of regional production capacity to the expanded HK model, putting forward an innovative model of expanding HK industrial upgrading. In short, the industrial upgrade path under the product space structure is a complicated network with linear and nonlinear upgrades, intra-industry upgrades and inter-industry upgrades, and linear or non-linearities also exist in intra-industry upgrades and inter-industry upgrades. Industry upgrades, according to upgrade the need to upgrade the technological distance across the path of choice, if the technical upgrading of the industry distance is less than the technical distance between the industry upgrade, give priority to intra-industry
upgrade; the other hand, if the technical distance between the industry to upgrade Less than the technological distance within the industry to upgrade, will give priority to inter-industry upgrade.

2. indicators of measurement and calculation

2.1 Connectivity measurement and calculation
Connectivity is the sum of similarities between other industries in the industry and the surrounding industries, reflecting the ability to upgrade the diversification path of industries. The higher the connectivity, the smaller the technological distance between the industry and other industries; The more interlinked industries, the more closely linked with the surrounding industries, the easier it is to exchange their products with the surrounding industries, and the stronger the capacity to absorb the surrounding industrial technology spillovers, the more opportunities for future upgrades.

\[
PATH_i = \sum_j \phi_{i,j} \quad (\phi_{i,j,t} = \min \left\{ p(x_{i,t} / x_{j,t}), p(x_{j,t} / x_{i,t}) \right\})
\]  

Where, \(PATH_i\) indicates industrial connectivity; \(\phi\) said industrial similarity; \(P\) said conditional probability; \(X\) said dominant comparative advantage; \(i, j\) said the industry; \(t\) said time. When the industry does not have a comparative advantage, the dominant comparative advantage \(X\) takes 0; when the industry has a comparative advantage, the dominant comparative advantage \(X\) takes 1.

2.2 Technical measurement and calculation
Industrial technical reflects the complexity of regional economy, and the complexity of the economy is directly reflected in the regional economic growth rate or per capita income level. This article uses per capita GDP and industrial comparative advantage indicators \(PRODY\) to calculate the regional economic complexity and technical, as follows:

\[
PRODY_t = \sum_c \left[ \frac{\sum \text{income}_c / \sum \text{income}_t}{\sum \text{income}_t / \sum \text{income}_i} \right] \times GDP_{pc_c}
\]  

Where, \(PRODY_t\) said that industrial technology; \(GDP_{pc}\) said the regional per capita GDP; \(\text{income}_c,\text{income}_t\) said the main business income; \(c\) said the region; \(i\) said that the industry; \(t\) said time.

2.3 Measurement of the type of industry
The measure of connectivity is the diversification of industries. The technical measure is the degree of industrial complexity. These two types of indicators reflect the accumulation of industrial knowledge and the represented capabilities. According to the connectivity and technical characteristics of industries, this paper reclassifies the types of industries in our country. (HH), High Technology - Medium Connectivity (HM), High Technology - Low Connectivity (HL), Medium Technology - High Connectivity (MH), Medium Technology - Medium Connectivity (MM), Medium Technology - Low Link (ML), Low Link - LH, Low Link - LM, Low Link - LL.

| Industry type   | High connectivity | In connectivity | Low connectivity |
|-----------------|-------------------|-----------------|-----------------|
| High-tech       | H-H               | H-M             | H-L             |
| In technology   | M-H               | M-M             | M-L             |
| Low technology  | L-H               | L-M             | L-L             |

3. Northeast China energy industry market share analysis

3.1 northeast energy industry market share overall trend analysis
This section examines the evolution of energy industry in northeast China trend, namely, oil and natural gas mining industry, coal mining and washing industry, petroleum processing coking and nuclear fuel
processing industry, thermal power generation and supply industry, gas production and supply industry five major energy industries in the northeast Regional market share of each year of each year.

![Figure 1. Northeast energy industry overall market share analysis](image)

According to the market share of energy industry in Northeast China in each year, the market share of energy industry in northeast China shows a significant downward trend, with the market share declining by 16% from 35% and its downward trend in the "11th Five-year Plan" period Especially, in a short period of 5 years, the market share dropped from 35% to 20%, indicating that the economic development strategy and layout of northeast China in recent years is to gradually shift the energy industry outward and improve the technological level of the whole industry in northeast China. Promote industrial upgrading.

3.2 Northeast China's energy market share of the national ranking analysis

According to the national rankings of the market share of various energy industries in Northeast China, the market share of the oil and natural gas exploration, petroleum processing, coking and nuclear fuel processing industries in Northeast China ranks the top three in the country. However, The market share of petroleum and natural gas mining declined from No. 1 to No. 3 and the petroleum processing, coking and nuclear fuel processing industries dropped from No. 2 to No. 3 ; Coal mining and washing industry's market share in the middle reaches of the country level, but the ranking is also gradually declining, from the third gradually dropped to fifth place; thermal power generation and supply, gas production and supply market share In the lower reaches of the country, and its market share in the country for many years has been in the 7th position, indicating that the northeastern region of the thermal power gas production and supply levels did not change much, the industry has maintained its original state produce.

| Table 2. Northeast China's national energy industry rankings |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
|                 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 |
| Coal mining and washing    | 3    | 4    | 5    | 5    | 5    | 5    | 5    | 5    | 5    | 6    | 5    |
| Oil and gas exploration   | 1    | 1    | 1    | 1    | 2    | 2    | 2    | 2    | 3    | 3    |      |
| Petroleum Processing, Coking and Nuclear Fuel Processing | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 2    | 3    |      |
| Thermal power production and supply | 8    | 7    | 7    | 7    | 7    | 7    | 7    | 7    | 7    | 7    | 7    |
| Gas production and supply      | 6    | 7    | 7    | 7    | 7    | 7    | 7    | 7    | 7    | 7    | 7    |

4. Trend of Energy Industry Comparative Advantage in Northeast China

From the perspective of the comparative advantages of the energy industry in northeast China, the comparative advantages of the two industries of coal mining and washing, oil and natural gas mining are relatively high, with the highest in the oil and natural gas mining industry, followed by the coal mining and washing industry, and the other The gap between the advantages of the three industries is not very clear; from the evolution trend of the level of advantages, the comparative advantage of Northeast China's energy industry as a whole is on the decline, and the absolute advantage of the coal mining and
washing industry, oil and gas mining industry, especially the downward trend. Obviously, it shows that in the past, the energy industry in northeast China that had been transferred to the outside made its industry, which used to be an absolute predominance, shift its focus of development in the future.

Figure 2. Comparative advantages evolution of various energy industries in Northeast China

5. Energy Industry Type Analysis

According to the level of industrial technology and connectivity, this article classifies the 37 industries in China into nine types according to the classification method of high, medium and low one-third of each.

| Industry type | High connectivity | In connectivity | Low connectivity |
|---------------|-------------------|-----------------|-----------------|
| High-tech     |                   |                 |                 |
| Furniture manufacturing | Rubber and plastic products | Other manufacturing / handicrafts | General equipment manufacturing |
| Textile and garment footwear manufacturing |
| Transportation equipment | Culture, education and sporting goods manufacturing | Instrumentation manufacturing made from metal |
| Electrical machinery and equipment manufacturing | Computer communications and other electronic equipment manufacturing |
| Chemical fiber manufacturing |
| In technology |                   |                 |                 |
| Printing and recording media reproduction | Water production and supply | Special equipment manufacturing |
| Food manufacturing | Paper and paper products | Thermal power production and supply |
| Chemical raw materials and chemical products | Gas production and supply | Black metal smelting and rolling processing |
| Petroleum Processing Coking and Nuclear Fuel Processing |
| Textile | Leather fur feathers and their products |
| Abandoned resources comprehensive utilization |
| Low technology |                   |                 |                 |
| Non-metallic mineral mining and dressing | Non-metallic mineral manufacturing | Black metal ore mining election |
| Agricultural food processing | Beverage manufacturing | Coal mining and washing |
| Medicine manufacturing | Wood processing and wood products | Non-ferrous metal smelting and rolling processing |
| Tobacco products | Oil and gas exploration |

In terms of types of industrial technologies, energy industries are mainly distributed in low-tech and medium-tech industries. From the perspective of industrial connectivity, energy industries are mainly distributed in low connectivity and high connectivity. Among them, the oil and natural gas mining industry has the lowest technical and connectivity level, with low-tech-low connectivity level. The connectivity of the coal mining and washing industry is slightly higher but the technology level is still relatively low. Processing coking and nuclear fuel processing industry is in the middle of technology,
but the connectivity is still low, in low technology connectivity; thermal power generation and supply and
gas production and supply industry is the energy industry, the highest technical and connectivity of
the two industries, In technology - in connectivity. This shows that China's energy industry is still
relatively backward in terms of its technological level. The level of its connection with other industries
is still relatively low. Its follow-up industrial upgrading has some difficulties and is prone to fall into the
trap of comparative advantages.

6. Northeast Energy Industry Upgrading Analysis

Table 4. Similarities among industries

| Industry type | H-H | H-M | H-L | M-H | M-M | M-L | L-H | L-M | L-L |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| H-H           | -   | -   | -   | -   | -   | -   | -   | -   | -   |
| H-M           | 0.574 | 0.400 | 0.292 | 0.200 | 0.337 | 0.226 | 0.134 | 0.097 |
| H-L           | 0.471 | 0.239 | 0.202 | 0.289 | 0.165 | 0.109 | 0.134 |
| M-H           | 0.546 | 0.376 | 0.283 | 0.462 | 0.389 | 0.181 |
| M-M           | 0.511 | 0.234 | 0.202 | 0.289 | 0.165 | 0.109 | 0.134 |
| M-L           | 0.394 | 0.226 | 0.210 | 0.163 |
| L-H           | 0.646 | 0.490 | 0.254 |
| L-M           | 0.629 | 0.332 |
| L-L           | 1.000 |

Combining the comparative advantage level of energy industry in Northeast China, the level of
technical connectivity of energy industry and the similarity level among industries, we find that the
energy industry with the highest market share in Northeast China is also the predominant industry in
northeast China, namely, oil and Natural gas mining industry, coal mining and washing industry, the two
industries, the lowest level of technology, the level of connectivity is the lowest, respectively, in
low-tech - low connectivity and low-tech - connectivity industry. Among them, the oil and natural gas
exploration industry in the industrial upgrading, the similarity within the group has reached 1, the
maximum similarity between groups was only 0.332, industrial upgrading is difficult, easy to fall into
the "comparative advantage trap" among the Northeast recently The gradual transfer of the industry to
the year, but also to a certain extent, reduce the possibility of falling into the "comparative advantage
trap" in the northeastern region; while the coal mining and washing industry in the industrial upgrading,
the intra-group similarity was 0.629, The similarity degree is the highest for low-tech-high-connectivity
industries, which has a similarity of 0.429, indicating that the industry needs to upgrade its industry
without the need to upgrade to a higher-technology level. The most effective and reasonable upgrade
direction is to continuously increase the matching degree among industries. With its adjacent high
connectivity upgrade is the future direction of development. Petroleum processing coke and nuclear
fuel processing industry, thermal power generation and supply industry, gas production and supply
industry which are distributed in the medium technology - low connectivity and medium technology -
connectivity, the similarity within the group are larger, less similarity between groups , It is more
difficult to upgrade the industry. In the future when upgrading the industry, we must rely on
 technological innovation to catch up with the technology.

7. Conclusion

(1) The energy industry in northeast China that had been transferred to the outside made its industry,
which used to be an absolute predominance, shift its focus of development in the future. Indicating that the
northeastern region of the thermal power gas production and supply levels did not change much, the industry has maintained its original state produce.

(2) China's energy industry is still relatively backward in terms of its technological level. The level of
its connection with other industries is still relatively low. Its follow-up industrial upgrading has some
difficulties and is prone to fall into the trap of comparative advantages.

(3) The energy industry in northeast China must consider the technical and connectivity of
the industry when upgrading its industry. If it wants to get out of the situation of upgrading and stopping the
file, it must take into consideration the influence of the technical distance between industries when upgrading its industry.

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