Big Data Analysis on Upgrading Listed Enterprises in China

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Abstract: *The concept definition and measurement of enterprise upgrading is a great concern practically and theoretically. Firstly, the concept of enterprise upgrading is defined in combination with the new development stage and concept. Then an index system is constructed based on the level of efficiency and added value. The entropy method is used to weight the index system. Finally, taking the A-share entity enterprises from 2008 to 2018 as the research sample, we analyzed the development trend of enterprise upgrading level and compared the development status of enterprises from the perspective of property rights heterogeneity, regional differences, and fixed asset scale heterogeneity. The research results provide a reference for the reasonable measurement of enterprise upgrading levels.*

Keywords: *entropy method, enterprise upgrading, index system*

1. Introduction

China's labor costs have continued to rise, while land supply and environmental constraints have been further strengthened. The extensive development has brought a series of problems, such as waste of resources, environmental pollution, low added value, low efficiency, and so on. The above problems show that the traditional growth model has been unable to meet the requirements of high-quality economic development. Shifting from traditional resource-driven factors to innovation-driven ones, optimizing the allocation of factors, improving production efficiency, promoting economic growth with green development, and realizing industrial transformation and upgrading are inevitable requirements for China's economic development and show important directions for accelerating China's transformation. The implementation of the national economic growth model is for industrial transformation and upgrading enterprises. Enterprise upgrading is not only a strategic choice at the national level but also an inevitable choice for enterprises to maintain core competitiveness in complex situations. Thus, answering the following questions is the focus of this study: what is enterprise upgrading, how to measure the level of enterprise upgrade, and is there any difference in the upgrading level of Chinese enterprises from the perspective of heterogeneity for diverse Chinese enterprises.

2. Concept of Enterprise Upgrading

There is an urgent need for enterprises to contribute to high-quality economic development through transformation and upgrading into the new development stage. From the perspective of the value chain, enterprise upgrading refers to the process to create higher value-added products, which is manifested by the evolution of the low end of the value chain to a high value-added state [1−5]. Small and medium-sized enterprises and private enterprises play an irreplaceable role in promoting the rapid economic development and personnel employment of China. Transforming production and operation capabilities and improving efficiency are the main goals of the transformation of small and medium-sized enterprises [6]. The definition of enterprise upgrading has not yet been acknowledged, but it is accepted by scholars that enterprise upgrading is a dynamic process, often accompanied by enterprise innovation activities to ultimately improve the position in the product value chain. In 2007, the People's Bank of China, the CBRC, and the State Environmental Protection Administration (SEPA) issued the "Green Credit Guidelines", which pointed out that the blind expansion of high energy consumption, high pollution, and overcapacity industries should be curbed. In 2012, the "Twelfth Five-Year Plan for Energy Conservation and Emission Reduction" emphasized transforming China's industrial development pattern and achieving

energy conservation and emission reduction through the upgrading of pollution-intensive industries. Therefore, reducing energy consumption and implementing supply-side structural reforms are important for Chinese enterprises to transform and upgrade [7]. Combined with China's development requirements in the new era and guided by the "Five Development Concepts", we define enterprise upgrading as the action and process of progressive improvement in external operation and internal management. The aim is to improve production efficiency, reduce costs, increase the added value of products, and achieve innovation-driven green development and spiraling up of enterprise value.

3. Enterprise Upgrading Index Measurement Based on Improved Entropy Method

According to the definition of the enterprise upgrade, the comprehensive evaluation method is used to measure the level of enterprise upgrading at two levels: efficiency and high value-added. In this paper, the entropy method based on mathematical theory is used to objectively weight each index to determine the weight of the evaluation index and the comprehensive level of enterprise upgrading [8,9]. The specific calculation process is as follows.

3.1. Construction of index system

The results of enterprise upgrading are expressed in the improvement of production efficiency and the increase of product added value. The indicators are selected by considering the specific result performance of the efficiency level and value-added level of enterprise upgrading. The indicators are combined with the literature analysis method with the principles of systematicity, consistency, independence, and comparability. The final enterprise upgrading index system is shown in Table 1.

3.2. Entropy method to weight the index

3.2.1. Dimensionless processing of data

All indicators in the evaluation index system of enterprise upgrading are positive. In order to eliminate the impact of different dimensions on evaluation results, Eq. (1) is adopted for dimensionless processing.

$$A_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \tag{1}$$

where x_{ij} is the i-th observed value under the j-th index in the sample, $\min(x_{ij})$ is the minimum, $\max(x_{ij})$ is the maximum, and A_{ij} is the value after dimensionless processing of the original value.

3.2.2. Proportion of i-th observation value under the j-th index in this index

$$P_{ij} = \frac{A_{ij}}{\sum A_{ij}} \tag{2}$$

3.2.3. Calculate the entropy value of the j-th index, where n represents the number of samples.

$$E_j = -\frac{1}{\ln(n)} \sum_{i=1}^{n} P_{ij} \ln(P_{ij}) \tag{3}$$

3.2.4. Calculate the difference coefficient of the j-th index.

$$G_j = 1 - E_j \tag{4}$$

3.2.5. Calculate the weight of the j-th index

$$w_j = \frac{G_j}{\sum G_j} \tag{5}$$

3.3. Finally, EUi, the result of upgrading level of listed companies, is calculated on the basis of:

$$EU_i = \sum_{i=1}^{n} w_i A_i \qquad (6)$$

Table 1: Enterprise upgrading evaluation index system

Target layer	Criterion layer	Index layer	Variables	Indicator descriptions
Enterprise upgrading	Efficiency level	Energy saving and emission reduction	x_1	If the energy consumption or waste discharge decreases in the production process, take the value of 1, otherwise take 0
		Per capita output of employees	x_2	(Sales revenue + Inventory change) / Number of employees
		Fixed Assets Turnover	x_3	Operating revenue/ Average net fixed assets assets; Average net fixed assets = (Ending balance of fixed assets + 0pening balance of fixed assets) / 2
	Value added level	Product structure adjustment	x_4	If the product category has been adjusted in the current year, take the value of 1, otherwise take 0
		High quality innovation	x_5	Effective number of enterprise invention patents
		Brand competitiveness	x_6	The value is 1 if the brand entered the top 500 most valuable brands list, otherwise it is 0
		Market coverage	x_7	Enterprise sales/Industry sales
		Sales value added per 100 yuan	x_8	Value added / Total operating income
		Investor attention	x_9	Total annual reading of stock forum posts

4. Analysis of Current Situation of Enterprise Upgrading

Taking all A-share listed companies from 2008 to 2018 as the samples, we performed the analysis according to the following standards: (1) according to the industry classification of CSRC in 2012, financial and real estate enterprises are excluded, (2) eliminating ST and *ST companies, (3) eliminating companies with missing data, and (4) excluding the sample observations whose property right attribute is not determined. Finally, the annual observations of 15807 companies are obtained. Among them, the data on product structure adjustment comes from the WIND database, the data on brand competitiveness comes from "China's 500 most valuable brands" released by the World Brand Lab, the data on investor attention comes from the CNRDS database and the remaining index data comes from CSMAR database. Finally, the annual observations of 19043 companies are used.

4.1. Analysis of overall situation of enterprise upgrading

Table 2: Directly reflects the change trend of the upgrading level of real enterprises.

Year	2008	2009	2010	2011	2012	2013
Average value of enterprise upgrading level	7.38%	5.67%	5.33%	5.37%	5.01%	4.85%
Year	2014	2015	2016	2017	2018	
Average value of enterprise upgrading level	5.06%	5.38%	5.07%	4.68%	4.43%	

From 2008 to 2018, the upgrading level of real enterprises generally decreased (Table 2). The upgrading level of the enterprises was 7.35% in 2008, and dropped by 23% in 2009, reaching a level of

5.67%. The upgrading level of enterprises showed smaller fluctuations in 2010 and 2011, while it decreased during 2012 and 2013, reaching 4.85% in 2013 (the lowest level since 2008). In 2014, the trend was reversed, showing a slight increase, reaching 5.38% in 2015. However, the enterprise upgrading level has shown a significant downward trend since 2016, reaching 4.43% in 2018 (the lowest level in recent ten years).

The possible external factors of the above phenomena include the following.

4.1.1. Economic growth factors:

In 2008, the international financial crisis triggered by the US subprime mortgage had an inestimable impact on the world's major economies. China's economic growth gradually decreased, and the economic development entered the "new normal" and "L-shaped" trend after 2012. Its important characteristics were the gradual slowdown of market growth, the continuous rise of comprehensive factor costs, the increasing resource constraints, and the development of the real economy has fallen into a downturn. This factor led to a decrease in the overall upgrading level of real enterprises.

4.1.2. National development strategy and macroeconomic policy support:

To accelerate the transformation and upgrading of the manufacturing industry, China has launched development plans and strategies. In May 2015, the State Council issued "Made in China 2025", pointing out that "manufacturing is the main body of the national economy, the foundation for building a country, the tool for rejuvenating the country, and the foundation for strengthening the country". Transforming from a large manufacturing country is the core goal of "Made in China 2025". Improving technological innovation is a key element to helping enterprises become a manufacturing power through transformation and upgrade. In recent years, "tax and fee reduction" is an important tool for the government to encourage enterprises to improve their innovation, including the reform of value-added tax rates, additional deductions for R&D expenses, and so on. In addition, under the background of the new economic normal, General Secretary The Chinese government proposed the construction of the "Silk Road Economic Belt" and the "21st Century Maritime Silk Road" (the "One Belt and One Road" initiative) during his visits to Central Asia and Southeast Asia in 2013. With the promotion of the "One Belt and One Road" construction, the national space for transformation and upgrading of real enterprises is further expanded and the internationalization level of transformation and upgrading is improved, which significantly promotes the upgrading of Chinese enterprises [10]. The implementation of national development plans and strategies and macroeconomic policy support the trend of upgrading the decline in business.

4.1.3. Imbalance between the development of financial industry and real economy:

The transformation and upgrading of the real economy is facing strong pressure and constraints, while China's banking-led financial industry, including the real estate industry, has developed rapidly. A financial system deviates from the development of the real economy and increasingly shows the characteristics of "profit-seeking". On the one hand, compared with enterprise credit, banks are more inclined to housing loans. On the other hand, the financial industry has formed a relatively independent "M-M" monetary capital self-circulation process, which accelerates the accumulation of financial assets, hinders the flow of financial capital to industrial capital, and further weakens the function of financial services to the real economy and aggravates the development contradiction of the real economy. The imbalance between the development of the financial industry and the real economy and the problems of "financing difficulty" and "expensive financing" of real enterprises (especially small and medium-sized enterprises) have not been well solved, leading to a downward trend in enterprise upgrading.

4.2. Comparative analysis of enterprise upgrading from perspective of heterogeneity

4.2.1. Property heterogeneity

The heterogeneity of property rights causes enterprises with different ownership to have significant differences in business objectives, resource acquisition, and government support. Therefore, it is necessary to compare and analyze the differences between state-owned enterprises and non-state-owned enterprises at the average level of enterprise upgrading from the perspective of property right heterogeneity. According to the nature of actual controllers of listed companies, listed companies are divided into state-owned enterprises and non-state-owned enterprises. The results of the enterprise upgrading level are shown in Table 3.

Comparative analysis of enterprise upgrading level was carried out from the perspective of property right heterogeneity. Firstly, the average upgrading level of state-owned enterprises was 6.63% and that

of non-state-owned enterprises was 4.11% from 2008 to 2018. The t-test of the average difference between the two types of enterprises was -30.0758, showing a significant difference at the level of 1%. This indicates that the upgrading level of state-owned enterprises was significantly higher than that of non-state-owned enterprises. Secondly, after the global crisis, the upgrading level of state-owned enterprises decreased by 20% in 2009, while the upgrading level of non-state-owned enterprises decreased by 30%, which was much higher than that of state-owned enterprises. When facing systemic financial risks, the anti-risk ability of non-state-owned enterprises is generally lower than that of state-owned enterprises, which have congenital "vulnerability". Finally, to boost the transformation and upgrading of real enterprises and improve competitiveness, China has successively launched a series of stimulus policies to encourage enterprises to drive development, transformation, and upgrade enterprises through innovation. State-owned enterprises began to reverse the declining trend of enterprise upgrading in 2011 and maintained a higher level of rising in their enterprise upgrading level between 2013 and 2015. The non-state-owned enterprise had been in a declining trend after 2009 and rose in 2013 and 2014. However, their rising trend has not been maintained for a long time. Compared with non-state-owned enterprises, state-owned enterprises have high sensitivity to national policies and can make full use of state-supported policies to promote their development.

Table 3: Comparative analysis of financial asset allocation and enterprise upgrading status of listed companies with different ownership nature

Year	State-owned enterprises		Non-state-owned enterprises	
	Sample size	Average value of enterprise upgrading level	Sample size	Average value of enterprise upgrading level
2008	561	7.83%	350	6.66%
2009	620	6.31%	405	4.70%
2010	669	5.92%	527	4.58%
2011	722	6.31%	855	4.58%
2012	759	6.28%	1053	4.09%
2013	725	6.55%	1112	3.74%
2014	668	6.89%	1098	3.94%
2015	637	7.34%	1164	4.31%
2016	735	7.09%	1383	3.99%
2017	755	6.52%	1631	3.83%
2018	769	6.21%	1845	3.69%
Total	7620	6.63%	11423	4.11%

Note: The above data are the original data processed by winsorise.

4.2.2. Perspective of regional differences

Table 4: Comparative analysis of financial asset allocation and enterprise upgrading of Listed Companies in different regions

Year	Eastern region		Central and western Regions	
	Sample size	Average value of enterprise upgrading level	Sample size	Average value of enterprise upgrading level
2008	585	7.63%	326	6.94%
2009	646	5.91%	379	5.26%
2010	770	5.63%	426	4.79%
2011	1057	5.45%	520	5.20%
2012	1219	5.05%	593	4.91%
2013	1269	4.82%	568	4.91%
2014	1224	5.02%	542	5.13%
2015	1282	5.39%	519	5.35%
2016	1487	5.12%	631	4.95%
2017	1688	4.75%	698	4.51%
2018	1896	4.46%	718	4.37%
Total	13123	5.17%	5920	5.01%

Note: The above data are the original data processed by winsorise.

Although the economy has generally maintained a momentum, there is a long-term imbalance in the

development of different regions in China. Therefore, it is necessary to understand the status of enterprise upgrading in different regions. We divided the sample enterprises into eastern, central, and western regions, where the eastern region includes Beijing, Tianjin, Liaoning, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan; the central region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan Hubei, Hunan; the western region includes Chongqing, Sichuan, Guizhou, Yunnan, Guangxi, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang, Inner Mongolia.

Table 4 shows that the average level of enterprise upgrading in the eastern region was 5.17% and that in the central and western regions was 5.01%. The differences was statistically significant with a t-value of -1.6973 at the 10% level. This indicates that the enterprise upgrading level of physical enterprises in the eastern region is higher than that in the central and western regions. From 2008 to 2012, the upgrading level of enterprises in the eastern region was higher than that in the central and western regions, but the gap between the two decreased. From 2012 to 2015, the upgrading level of enterprises in the eastern region was equivalent to that in the central and Western Regions. However, from 2016 to 2018, the upgrading level of enterprises in the eastern region was higher than that in the central and western regions, but the gap between them was small. It shows that the inter-regional industrial transfer, the rapid development of the Internet economy, and the continuous improvement of transportation infrastructure are conducive to promoting the upgrading of enterprises in central and western China and shortening the upgrading gap between enterprises in eastern and central China.

4.2.3. Perspective of fixed asset scale differentiation

Table 5 presents that the average enterprise upgrading level of listed companies with small fixed assets was 5.10%, that of listed companies with medium fixed assets was 4.39%, and that of enterprises with large fixed assets was 5.52%. There is a "U" relationship between the enterprise upgrading level and the enterprise fixed assets scale. In terms of specific years, in 2009 after the financial crisis, the upgrading level of enterprises with small fixed assets decreased by 16.91%, the upgrading level of enterprises with medium fixed assets decreased by 28.67%, and the upgrading level of enterprises with large fixed assets decreased by 19.35%. The impact of systemic financial risk on enterprises with a large scale of fixed assets is higher than that of enterprises with a small scale of fixed assets under the macro adverse environment. The upgrading level of enterprises with large fixed assets was lower than that of enterprises with small fixed assets from 2008 to 2010. However, this trend was reversed and the upgrading level of enterprises with large fixed assets was also higher than that of enterprises with small fixed assets after 2011.

Table 5: Financial asset allocation and enterprise upgrading level of fixed asset enterprises of different sizes

Year	Small scale enterprises	medium-sized enterprises	large-scale enterprises
2008	7.98%	7.08%	7.39%
2009	6.63%	5.05%	5.96%
2010	5.79%	5.26%	5.03%
2011	5.24%	5.16%	5.90%
2012	4.69%	4.94%	5.45%
2013	4.62%	4.77%	5.24%
2014	5.22%	4.81%	5.36%
2015	5.12%	5.28%	5.84%
2016	4.95%	4.84%	5.65%
2017	4.46%	4.48%	5.29%
2018	4.31%	4.25%	4.93%
Total	5.10%	4.93%	5.52%

Note: The above data are the original data processed by winsorise.

5. Conclusion

Statistical analysis is used to analyze the current situation of enterprise upgrading of Chinese A-share enterprises during 2008−2018. Firstly, the concept of enterprise upgrading is defined. Secondly, the index system is constructed from the efficiency level and the value-added level, and the entropy method is used to assign weights. Finally, an in-depth analysis of enterprise upgrading is conducted from four aspects: overall distribution, heterogeneity of property rights, regional differences and differences in fixed asset size. From the result, the following conclusions are obtained: the upgrading level of entity

enterprises generally showed a downward trend from the overall distribution from 2008 to 2018. From the perspective of property heterogeneity, the upgrading level of state-owned enterprises is significantly higher than that of non-state-owned enterprises. From the perspective of regional differences, the upgrading level of entity enterprises in the eastern region is higher than that in the central and western regions. From the perspective of the difference in the scale of fixed assets, the relationship between the scale of fixed assets and the upgrading level of enterprises presents a "U" shape.

Acknowledgments

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