Monitoring Indicator System for Digital Transformation and Statistical Research of Sectors in China

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Abstract. At present, promoting digital transformation of sectors has become the worldwide common choice to drive sectors’ innovative development and realize sustainable economic growth. In this thesis, we firstly construct an indicator system for monitoring digital transformation of sectors which consists of five key aspects and fifteen key indicators. Then, we collect and make statistical analysis of digital transformation assessment data from 75137 enterprises in China, get an overview of China’s digital transformation of sectors, and conduct quantitative monitoring and overall analysis for process and effects of China's transformation and upgrading of sectors. Finally, we prospect and predict the future trend of China's digital transformation of sectors, and analyze digital transformation’s promoting effect on sectors’ value creation and benefit improvement based on data from enterprises’ market value and economic benefits.

1. Introduction
In recent years, new generation of ICTs (information and communication technologies), represented by the internet, big data, artificial intelligence have developed rapidly and integrated quickly with traditional industries, having ignited a systematic and holistic industry innovation and technology revolution with data-driven as core characteristics and economic development mode changing from material production and services dominated to information production and service dominated. According to a survey conducted by the well-known research institution IDC to 2000 CEOs from multinational enterprises, 67% of the global top 1000 enterprises and 50% of China's top 1000 enterprises will take digital transformation as their strategic core by the year 2018 [1].

Promoting digital transformation has gradually become the common choice and necessary path for sectors worldwide to grasp opportunities of industrial revolution and lead innovated development of economy.

Centering on the connotation, definition and theoretical framework of digital transformation, government departments and research institutions at home and abroad have carried out a series of researches [2, 3]. Recently, most of major countries in the world have taken digital transformation as the strategic choice to drive transformation and upgrading of sectors and to lead innovative development of economy. They have formulated national strategies, national planning and policies to support the promotion and implementation of digital transformation in their country [4-6]. However, promoting the
digital transformation of sectors is a complex and systematic project, which involves technology innovation, management optimization, organizational change, data mining and utilization, etc. At the same time, it is a long-term project, which requires continuous innovation, iterated improvement and long-term evolvement of the government and sectors. Formulating a set of indicator system for all-around monitoring the transformation process and effect is especially necessary for the practices of exploring digital transformation, so as to quantify transformation level, evaluate transformation effect and define transformation priorities. Aiming to solve this problem, we have set up a scientific and comprehensive monitoring indicator system based on previous theoretical results and industrial practices at home and abroad, carried out data collection from vast amounts of enterprises and made statistical analysis. We have quantitatively monitored the process and effects of digital transformation of sectors from multi-angles and all-round perspectives, so as to recognize the status and base of digital transformation of sectors, analyze the development trend and characteristics of sectors, and make clear of priorities and path for digital transformation of sectors. We hope this thesis can give guidance for studying the overall status, development trend, key features and future direction of China’s digital transformation of sectors, and provide a reference for formulating strategic policies and planning suggestions on future development.

2. Related Researches
A series of studies and discussions on the implementation path, promotion methods and influencing factors of digital transformation of sectors have been carried out in academia and industry circles. At the enterprise level, Berman, Saul J et al. proposed strategies and methods for enterprises to use digital technologies to transform their businesses so as to flexibly respond to rapidly changing customer needs based on the researches of IBM research [7]. Kevin Zhu et al. developed an integrative model to study the determinants of post-adoption stages of innovation diffusion [8]. Li Jun et al. analyzed the key points such as strategic control, organizational form innovation and data value mining during the process of enterprises’ promotion of digital transformation [9]. Besides, some experts put forward thinking and suggestions on the digital transformation of enterprise’s business based on the current development and application of new generation ICTs [10, 11]. Other experts contributed thoughts on the transformation and upgrading of traditional industries’ application of new generation ICT from different aspects [12, 13], or carried out relevant researches on the digital transformation of specific industries such as health care, media, financial banking [14-16].

Promoting digital transformation of sectors is a process of dynamic optimization and continuous evolution. Quantitative monitoring and comprehensive evaluation for the level and effect of digital transformation are the key measures to promote digital transformation and upgrading of sectors. Some research institutions have made efforts for primarily construct systematic evaluation methods and models to quantitatively evaluate the process and effects of digital transformation of sectors [17, 18]. Generally speaking, for the researches on evaluation and assessment for digital transformation of sectors, systematic research achievements have not been made at home and abroad. However, in related fields such as Industry 4.0, Digitalized Industry System, Integration of informatization and industrialization, many researchers from industry and academia circles have already made some achievements. RWTH Aachen University, and several other institutions jointly launched Industry 4.0 Maturity Index Report, in which they evaluated the capability of industry 4.0 from four aspects, including resources, informatization system, organization management and culture focusing on the IoT information system [19]. Researchers in China including Geng Chao et al. [20] and Zhou Jian et al. [21] made efforts in building evaluation framework of digital transformation evaluation. In addition, some scholars have also carried out a series of studies in the fields of manufacturing capacity evaluation, enterprise informatization evaluation, influencing factors of intelligent transformation of manufacturing industry, and sectors’ efficiency evaluation [22-26].

Seen from current literature, research and exploration on method and practice for digital transformation has made primary achievements. However, research on evaluation and assessment for digital transformation of sectors is still in its infancy, and there still exists a series of problems, including
lack of evaluation system which can comprehensively indicate digital transformation trends of sectors, and practices in empirical analysis of evaluation systems based on big-sample data.

3. **Assessment framework for digital transformation of sectors**

With rapid development and innovative application of new generation ICTs, promoting digital transformation of sectors has gradually become a common choice for countries around the world to seize the opportunity to develop advanced technologies and realize industrial upgrading. Digital transformation involves the transition of ideas, the transformation of modes and the innovation of paths, for which top-level design is very necessary for the promotion, so that we must constantly transit development ideas, clearly define view of development status and find scientific path, continuous innovation of promoting mode. Through continuous explorations and practices, an evaluation framework for digital transformation was put forward in China, which was released as the national standard "Assessment specification on integration of informatization and industrialization for industrial enterprises" (GB/T 23020-2013[27]) in September 2013, and as an international standard "Assessment framework for digital transformation of sectors in smart cities"(ITU-T Y.4906 [28]) published by the international telecommunication union (ITU). This framework can provide a reference for get an overview of the current status of sectors’ digital development and clarifying the priority areas, development needs and appropriate paths for digital transformation of sectors.

The evaluation framework for digital transformation of sectors is divided into two parts: progress assessment and impact assessment. Progress assessment includes four aspects: basis and support, domain application, integration and interaction, innovation and disruption; impact assessment includes digital competitiveness and economic, environmental and social impacts (Figure 1).

![Assessment framework for digital transformation of sectors](image)

**Figure 1.** Assessment framework for digital transformation of sectors

Based on the assessment framework for digital transformation of sectors, third-level indicators and data collection items can be further detailed. (Figure 2)
Figure 2. Assessment indicator system for digital transformation of sectors

4. Indicator System for Monitoring Digital Transformation of Sectors

4.1. Overview
Digital transformation of sectors is a long-term and systematic project, which involves: 1) digital and software-based modification of sector’s manufacturing infrastructure and business activities, so as to solidify the foundation for digital transformation of sectors; 2) data resources interconnection and business integration in the whole lifecycle of product, on the upstream and downstream of supply chain, and at every layer of management and control, so as to realize dynamic allocation of manufacturing resources on demand within the sector; 3) intelligent upgrading and collaborative innovation of business activities in the whole life cycle of product, on the upstream and downstream of industry chain, and at all layers of management and control; 4) inside-out innovation and disruption of production mode, operation mechanism and business mode of sectors driven by digital transformation and upgrading.

Therefore, based on the evaluation indicators and detailed data collection items in the international standard ITU-T Y.4906 considering the different key points in the process of digital transformation of sectors, we have comprehensively designed a set of indicator system for monitoring digital transformation of sectors, which contains several key indicators and can be used for quantitative monitoring from all-round angles and aspects for transformation and development process of sectors such as the overall status, domain applications, integration and interconnection, collaboration and
interaction, mode innovation. The indicator system for monitoring digital transformation of sectors is shown in Table 1.

Table 1. Indicator system for monitoring digital transformation of sectors

| Monitoring Priorities | Monitoring Indicators | Explication of Indicators |
|-----------------------|-----------------------|---------------------------|
| **overall status**    |                       |                           |
| Level of digital transformation | Comprehensively indicates the general level of digital transformation of sectors, obtained through weighted average of the score of digital transformation level of sample enterprises according to personnel size. |
| Development process of digital transformation | Digital transformation of sectors is a process in which the digital level and competitive ability of sectors are constantly improving, which can be divided into four stages: -- Stage of start-up construction: constructions of infrastructures for digitalization and preparations for material conditions have been started in the sector, but digital application in specific business links has not been realized; -- Stage of domain coverage: basic requirements for digitalization of sectors have been preliminarily satisfied, and the coverage and penetration of digital applications in specific fields have been gradually strengthened; -- Stage of integrated upgrading: digital applications have been widely used in almost all the key business links and fields of the sector, and data interconnections and business integrations across links and fields have been realized; -- Stage of innovative breakthrough: construction of infrastructure for digitalization of sector has gradually been completed, domain applications and integrated applications have been quite mature, and intelligent development and collaborative innovation have been effectively realized. |
| **single-domain digitalization** |                       |                           |
| digitalization rate of production equipment | The proportion of number of digitalized production equipment in the total number of production equipment. Digitalized production equipment in process industry refers to independent equipment with automatic information collection functions. Digitalized production equipment in discrete industry refers to NC machines, CNC machine centers, industrial robots, electromechanical equipment with data interface, etc. |
| Application rate of digital R&D tools | Digital R&D design tools refer to software tools which can assist enterprises in product design, thus realizing digital modeling, digital simulation, digital verification and other functions. For discrete industries, this indicator means the proportion of enterprises having realized 2D or 3D digital modeling among all enterprises. For |
| Process Industries | The proportion of enterprises using digital means in R&D design.<br>**Numerical control (NC) rate in key processes**<br>The NC rate in key processes in process industries refers to the coverage rate of process control systems (such as PLC, DCS, PCS, etc.) in key processes. NC rate in key processes in discrete industries refers to the coverage rate of numerical control systems in key processes, such as NC DNC, CNC FMC, etc.<br>**E-commerce application rate**<br>The application of e-commerce means orders for purchasing or selling products or services have been completed through the internet, while payment and delivery of products or services can be done "online" or "offline". Orders completed through the internet does not include orders received or dispatched by phone, fax or E-mail.<br>**Proportion of enterprises achieved integration of design and manufacturing**<br>Proportion of enterprises in which management of product data covers business links such as product design, process design, production and manufacturing, etc., and automatic transmission of information between product design and process design as well as process design and manufacturing can be realized.<br>**Proportion of enterprises achieved integration of production, supply and marketing**<br>Proportion of enterprises which use integration of information system to realize the integrated operation between links on the internal supply chain, such as material procurement, raw materials and completed products warehouse, manufacturing, product sales, etc., and can seamlessly connect with the financial management (automatically obtain data from the business system without manual input).<br>**Proportion of enterprises realized integration of management and control**<br>Proportion of enterprises which use integration of information system to realize seamless connection (automatically obtain data from the business system without manual input) of information uploading, instructions sending, etc. between enterprise production management (plan layer), workshop manufacturing execution (execution layer), production and manufacturing process control (control layer) and which have realized business integration.<br>**Proportion of enterprises realized the whole lifecycle control of products**<br>Proportion of enterprises in which product data management covers business links such as product design, technological design, production and manufacturing, field installation and debugging, while automatic transmission of information between product design and technological as well as technological design and process information automatic transfer between design and manufacturing can be realized, unified definition of digitalized product can be applied at all stages of the whole product lifecycle, and the associated maintenance of digitalized product can be realized.<br>**Proportion of enterprises realized**<br>Proportion of enterprises using information system to realize the collaborative operation of key businesses.
collaboration in the industry chain such as R&D, procurement, production, sales, finance, etc. between enterprises with the upstream and downstream enterprises in the industry chain.

Proportion of enterprises where the NC rate in key processes exceeds 50% while integration of management and control as well as integration of production, supply and marketing has been mostly realized. NC degree of underlying equipment in these enterprises is high, where integration of management informationization and low-level automation as well as integration of procurement, production, sales, inventory and finance on the internal supply chain has been realized. These enterprises have already heading towards intelligent factory or intelligent enterprises where networked, flexible and intelligent manufacturing mode supported by integrated information system has been formed.

Proportion of above-scale manufacturing enterprises that realized networked collaboration among all above-scale manufacturing enterprises in discrete industries. At present, types of networked collaboration in our calculation include cross-enterprise networked collaborative product design, cross-enterprise networked manufacturing, etc.

Proportion of above-scale manufacturing enterprises that realized service-oriented manufacturing among all above-scale manufacturing enterprises in discrete industries. At present, types of service-oriented manufacturing in our calculation include remote monitoring, online operation and maintenance, precise networked marketing, innovative services to provision based on intelligent terminals, etc.

Proportion of above-scale manufacturing enterprises that realized personalized customization among all above-scale manufacturing enterprises in discrete industries. Enterprises that realized personalized customization can automatically arrange productions according to customer orders, make plans for material supply and be equipped with the ability of dynamic optimization.

4.2. Methods for calculation and analysis
Calculation of indicators for digital transformation of sectors are as follows:

4.2.1. Weight assignment. The weight of each indicator can be determined by Delphi method, analytic hierarchy process and network analysis.

Decompose an indicator into n sub-indicators, the weight of each sub-indicator is $W_i(0 < W_i \leq 1, \sum_{i=1}^{n} W_i = 1)$. 
4.2.2. Score of bottom-level indicators for a single sample enterprise. Score of indicators from different data collection methods are as follows:

For numerical questions, the following formula can be used for indicator scoring:
\[ X_i = \frac{V_i - V_{min}}{V_{max} - V_{min}} \times 100 \]

among them, \( X_i \) is the score of this indicator, whose value is within the range of \([0,100]\); \( V_i \) is the actual value of the data collection item corresponded to the \( i \)th indicator; \( V_{min} \) and \( V_{max} \) are the minimum and maximum thresholds respectively of this data collection item.

For single-choice questions, the following methods can be used for scoring of indicator: (i) set specific scores for each option, whose values are within the range of \([0,100]\); (ii) the score of this indicator is the score value corresponding to the selected option.

For multiple-choice questions, the following methods can be used for scoring of indicator: (i) set specific scores for each option, whose values are within the range of \([0,100]\) and the sum of which is 100; (ii) the score of this indicator is the sum of the score values corresponding to the selected options.

For the yes-or-no questions, the following methods can be used for scoring of indicator: (i) if the answer is "yes", the score is 100; (ii) if the answer is "no", the score is 0.

4.2.3. Weighted scoring for evaluation of digital transformation in key areas and different aspects of each sample enterprise. For a single sample enterprise, the scores for 24 key areas and 6 evaluation aspects of digital transformation can be calculated by weight using the score of sub-indicators below and the total score can be calculated by weight using the score of first-level indicators.

Suppose the score of a sub-indicator is \( X_i | i = 1,2,\cdots,n \), the scoring formula for this indicator is as follows:
\[ Y = \frac{\sum_{i=1}^{n} X_i \times W_i}{\sum_{i=1}^{n} W_i} \quad (i = 1,2,\cdots,n) \]  

4.2.4. Scoring for indicators and evaluation of digital transformation in key areas of the sector. The score of first-level indicators, second-level indicators, third-level indicators and total score of the sector can be obtained through arithmetic average calculation of scores of corresponding indicators and total score of all sample enterprises in the sector.

5. Introduction of data sources and samples

We select the evaluation data of digital transformation submitted by 75,137 enterprises in China by June 2017 through the Contemporary Service Platform for Integration of Informatization and industrialization (http://www.cspiii.com). The sample enterprises account for 19.6% of the total number of above-scale industrial enterprises included and monitored by China's National Bureau of Statistics, having covered 31 provinces and cities and among 101 industries of China. The distributions of samples in industries and different sizes are representative and can reflect the overall degree of China's digital transformation objectively. (Figure 3 and Figure 4).
6. Monitoring and analysis for China's digital transformation of sectors

6.1. Overview of China's digital transformation of sectors

The comprehensive score of China's digital transformation in 2017 is 51.8, with the depth and breadth of ICTs’ application in specific fields of sectors, integrated applications in multi-businesses and multi-links and intelligent collaborative applications are constantly expanding. From the perspective of enterprise’s sizes, the development foundation of digitalization, internetization and intelligentization of large and medium-sized enterprises in China has been gradually strengthened, while the low level of small-micro enterprises’ digitalization is the main constraint for the overall digital transformation of each sector. It is estimated that the digitalization rate of production equipment and application rate of digital R&D tools in small-micro enterprises are respectively 34.7% and 28.9%, which are 10 percentage lower than the national average level. From different monitoring perspectives, China has a strong digital application level in specific industrial fields, but weak data interconnection and business integration capabilities among various business links are important constraints hindering industrial intelligent development and model innovation. It is estimated that in 2017, less than a quarter of China's enterprises realized the integration of design and manufacturing,
production, supply and marketing, and management and control, respectively 18.8%, 20.0% and 15.5%. (See Table 2)

Table 2. Overview of China's digital transformation of sectors (2017)

| Monitoring Priorities | Monitoring Indicators | Large-sized enterprises | medium-sized enterprises | small-micro enterprises | overall level |
|-----------------------|-----------------------|-------------------------|-------------------------|-------------------------|--------------|
| overall status | Level of digital transformation | 60.3 | 49.2 | 38.1 | 51.8 |
| | Development process of digital transformation(start-up construction) | | | | 33.0% |
| | Development process of digital transformation(domain coverage) | | | | 47.7% |
| | Development process of digital transformation(integrated upgrading) | | | | 15.2% |
| | Development process of digital transformation(innovative breakthrough) | | | | 4.1% |
| single-domain digitalization | digitalization rate of production equipment | 50.2% | 44.3% | 34.7% | 44.8% |
| | Application rate of digital R&D tools | 82.6% | 74.1% | 57.0% | 63.2% |
| | Numerical control (NC) rate in key processes | 56.1% | 44.2% | 28.9% | 46.4% |
| | E-commerce application rate | 66.8% | 59.8% | 52.0% | 55.1% |
| integration and interconnection | Proportion of enterprises achieved integration of design and manufacturing | 36.6% | 23.3% | 14.8% | 18.8% |
| | Proportion of enterprises achieved integration of production, supply and marketing | 42.2% | 28.8% | 14.1% | 20.0% |
| | Proportion of enterprises realized integration of management and control | 30.7% | 20.7% | 11.8% | 15.5% |
| Collaboration and interaction | Proportion of enterprises realized the whole lifecycle control of products | 13.8% | 9.3% | 6.5% | 7.9% |
| | Proportion of enterprises realized collaboration in the industry chain | 12.1% | 8.7% | 5.2% | 6.6% |
| | Readiness rate of smart manufacturing | | | | 5.6% |
| Mode innovation | Proportion of enterprises realized networked collaboration | | | | 31.0% |
| | Proportion of enterprises realized service-oriented manufacturing | | | | 24.3% |
| | Proportion of enterprises realized personalized customization | | | | 7.3% |
6.2. **The level of China's digital transformation has kept continuous and rapid growth**

The level of China's digital transformation in 2017 has kept continuous and rapid growth in recent years, with the proportion of enterprises having realized comprehensive integration approaching 20%. From the perspective of development level, the level of China’s digital transformation reached 51.8 in 2017 with a growth rate of 2.3%, 0.2 percentage point less than that of 2016, but the general level has shown a trend of accelerated growth. From the perspective of development process, after many years of development, China's digital transformation process has been gradually promoted, with development effect becoming increasingly prominent and the general level of digital transformation heading towards the middle and advanced stage in an accelerated speed. In 2017, 19.3% of Chinese enterprises have reached the stage of integrated upgrading, with the proportion of enterprises having almost realized comprehensive integration doubled that of 2012 (10.9%). Among them, 4.1% of Chinese enterprises have reached the stage of innovative breakthrough, having realized intelligent development and mode innovation after realizing data interconnection and business integration. (Figure 5)

![Figure 5. Analysis of development level and development stage of China's digital transformation of sectors](image)

6.3. **Key industries have taken different paths of digital transformation**

China’s key industries have taken different paths of digital transformation, having shown different characteristics in R&D, manufacturing and industry chains. Seen from general, electricity industry, tobacco industry, electronics industry, transportation equipment manufacturing industry, petrochemical industry have higher levels of digital transformation, with proportion of enterprises realized comprehensive integration exceeding 20%. Generally speaking, energy industry is higher than manufacturing industries, which is higher than mine industry. For manufacturing industry, equipment manufacturing industry has higher level of digital transformation, while raw materials industry and consumer goods industry are almost at the same level. Seen from key indicators, equipment industry has carried out active explorations on R&D innovation centering on the whole product lifecycle, and the application rate of digital R&D tools of automobile industry and machinery industry is 83.5% and 77.3% respectively, far higher than the national average. Raw materials industry focuses on improving level of intelligentization in manufacturing, constantly promoting intelligent transformation in whole-process quality control, equipment preventive management, comprehensive energy management, supply chain integration, etc., building intensive, effective, real-time optimized new production system. According to calculation, readiness rate of smart manufacturing of petrochemical industry reached 7.4%, topping ahead among China’s key industries. Consumer goods industry is closely related with users and terminal consumers, which uses technologies such as the internet, big data to better track the status of the upstream and downstream on industry chain and analyze user’s personalized needs to gain obvious advantages of level of industry chain coordination based on network.
According to calculation, proportion of enterprises realized industry chain collaboration in food industry and pharmaceutical industry is 9.2% and 9.1% respectively, 2.6 and 2.5 percentage point higher than the national average. (Figure 6 and Figure 7)

![Figure 6](image1.png)

**Figure 6.** Overview of digital transformation of China’s key industries

![Figure 7](image2.png)

**Figure 7.** Key indicators of digital transformation of China’s key industries

### 6.4. Digital transformation of China’s different regions presents echelon-formed features

The comprehensive level of China’s digital transformation of different provinces has shown obvious echelon-formed distribution characteristics, which is closely related to the level of regional development. According to the level of digital transformation in each region, regions in China can be divided into four echelons on the whole, obviously echelon-formed distributed. **The first echelon (above 50 points)** includes provinces and cities such as Jiangsu, Guangdong, Shandong, Shanghai, Beijing, Chongqing, Zhejiang, Tianjin, Fujian and Sichuan, mainly distributed in China’s eastern coastal areas and formed southwest highland of China’s digital transformation circling on Sichuan Province and Chongqing. **The second echelon (45-50 points)** concentrate in China’s central and eastern regions, including provinces as Anhui, Liaoning, Inner Mongolia, Henan, Hubei, Hebei, Hunan, Shaanxi and Shanxi. **The third echelon (40-45 points)** is distributed in China’s northeast, north, central and western areas, including provinces as Jiangxi, Jilin, Ningxia, Huizhou, Hainan, and Guangxi, Heilongjiang. **The fourth echelon (under 40 points)** includes provinces as Gansu, Hainan, Xinjiang and Tibet. (Figure 8)
6.5. Digital transformation drives constant emerging of various innovations in sector modes

In the aspect of networked collaborative R&D and manufacturing, proportion of discrete manufacturing enterprises realized networked collaborative R&D and manufacturing in China reached 31.0% in 2017. It is calculated that the proportion of enterprises realized networked collaborative R&D has increased to 51.4% among manufacturing enterprises in discrete industries having applied open R&D communities or collaborative production platforms. In the aspect of service-oriented manufacturing, 24.3% of manufacturing enterprises in discrete industries in China have carried out service-oriented manufacturing in 2017. According to calculation, proportions of enterprises carried out service-oriented manufacturing have risen to 29.0% and 41.7% respectively in all manufacturing enterprises in discrete industries having realized data interconnection in the whole lifecycle of products and business integration. In the aspect of personalized customization, 7.3% of manufacturing enterprises in discrete industries in China have carried out personalized customization in 2017. According to calculation, proportion of enterprises realized personalized customization can rise up to 14.4% when manufacturing enterprises in discrete industries realize the application and associated maintenance of unified digital product definition in all stages of the product lifecycle. (Figure 9)
7. Trend forecast and performance analysis of China's digital transformation of sectors

7.1. Value creation: digital transformation has become the key path for value growth of China’s listed enterprises

The Shanghai Stock Exchange Main Board, Shenzhen Stock Exchange Main Board, Shenzhen Stock Exchange SME Board and Shenzhen Stock Exchange GME Board are the four main boards on China’s stock market, with the number of listed enterprises increasing successively in GME Board, SME Board, Shenzhen Stock Exchange Main Board and Shanghai Stock Exchange Main Board. Taking more than 1200 listed enterprises in China as samples, we organize correlation analysis between the market value of enterprises and their comprehensive level of digital transformation. Results show that there is a significant positive correlation between enterprise’s market value and its comprehensive level of digital transformation. Generally, there is a significant positive correlation between the total market value of listed enterprises and their level of digital transformation, with correlation coefficient being 0.4302. According to calculation, hypothesis test for correlation between the level of digital transformation and the market value of enterprises, that of GME Board is not significant while those of SME Board and the main board are significant, with P values of the GME Board, SME Board, Shenzhen Main Board and Shanghai Main Board being 0.4530, 0.0009, 0.0000 and 0.0000 respectively, and correlation coefficient increasing by 0.0526, 0.1787, 0.3582 and 0.5605 correspondingly. (Figure 10)

7.2. Efficiency improvement: competitiveness and benefits of sectors have accelerated improvements after their digital transformation realizes comprehensive integration

Comparatively analyzes data of enterprises’ competitiveness and economic and social benefit in different stages of digital transformation, results show that when digital transformation reaches the stage of integrated upgrading, competitiveness of sectors will have a big jump and have an exponential growth after that. Seen from the whole, digital transformation is a long-term process, which often requires high investment in the early stages while significant improvement of competitiveness difficult to show up in the short term, however, with the continuous promotion of digital transformation, competitiveness of sectors will increase significantly after data interconnection and business integration have been almost realized. It is calculated that the average competitiveness of enterprises in the stage of single-domain application is 62.7, 5.6% higher than that in the stage of start-up construction, while the competitiveness of enterprises after reaching the stages of integrated upgrading and innovative breakthrough has been further improved by 6.7% and 8.2% respectively, with

Figure 10. Correlation coefficient for level of listed enterprises’ digital transformation & market value
an obvious accelerated growth in competitiveness. **Seen from different sectors**, indicators of economic benefits such as product quality, customer satisfaction, resource utilization efficiency, financial efficiency, innovation ability have been improved in different degrees along with the elevation of digital transformation stages. (Figure 11)

![Figure 11. Competitiveness and social and economic benefits of enterprises realized digital transformation](image)

8. Conclusion

Based on the evaluation framework for digital transformation of sectors and its detailed data collection items put forward in the ITU-T Y.4906, we have comprehensively designed an indicator system for monitoring digital transformation of sectors. This indicator system is combined with different key points in the process of digital transformation of sectors, and contains several key indicators. Then we collected data from the digital transformation assessment of China's 75137 enterprise and carried out statistical analysis based on an online platform of big data. We have made three main achievements: (1) built up an indicator system for monitoring digital transformation of sectors; (2) got an overview of China's digital transformation of sectors based on quantitative monitoring and whole-view analysis; (3) analyzed the role of digital transformation in promoting the value creation and benefit improvement of the sectors combined with indicators as market value, economic benefits of enterprise. This indicator system will help the government departments and enterprises to get a clear view on the current status of development, locate the key points of transformation and choose the right path to change, so as to realize accelerate the development of the digital transformation.

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