Research on the Evaluation Indicator System of the Integration of Enterprise Informationization and Industrialization

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Abstract

It has become quite significant for the enterprises to enhance the competitiveness through promoting the integration of informationization and industrialization: informationization has played a great role in the product design, production and operation and marketing of the enterprises. How to establish the indicator for the integration degree of informationization and industrialization? How to evaluate the informationization construction level of enterprise? In terms of information construction, how can the enterprise make adjustment and improvement? In this paper, the thought course of "discover the problem – analyze the problem – solve the problem" has been abided by. It adopts Analytic Hierarchy Process (AHP), and constructs the corresponding evaluation indicator system from the aspects of infrastructure, single application, comprehensive integration and collaboration and innovation; this system has also been adopted to evaluate enterprise informationization level in Shandong in 2012, to provide reference for the enterprises to appraise their integration degree of informationization and industrialization, and provide theoretical support for the government to formulate supportive policy.

Keywords: Informationization; Industrialization; Integration; Indicator system; Indicator

In the process of global economic integration, the development of information technology has led to fundamental change of survival and competition environment of enterprises. "Two-oriented (informationization and industrialization) integration" is an important stage in the social and economic development process, and also the only way for the industry to change from independent development to integrative development, and from quantitative change to qualitative change. "Two-oriented integration" means to drive industrialization by informationization, and promote informationization by industrialization. New industrialization road is the inevitable result for the overlapping development of informationization and industrialization process. In terms of the enterprise, the connotation of "two-oriented integration" is to innovate the product research and development, production

and design, and realize the upgrading of product and technology, strengthen the management on production process, product testing, product sales and service through information technology and informationization, and then lead the enterprise to take the new industrialization road, pursue the sustainable development mode, and promote the transformation and development of the enterprise.

1. Introduction

To put it simple, "two-oriented integration" is to integrate industrialization and informationization by use of the engineering. To have a deep understanding of "two-oriented integration", we shall first have adequate awareness of industrialization and informationization.

Informationization refers to the historical process to cultivate and develop the new productive force represented by intelligent tools and bring benefit to the society with these tools. TadaoUmesao, a Japanese scholar, has suggested that "informationization is the generic terms of communication modernization, computerization and behavior rationalization" in his paper Discussion on Information Industry. Definition of informationization given by famous economists including Lin Yifu is: "the so-called informationization is a process to transform the traditional economic and social structure by IT, which is established on the basis of IT industry development and IT expansion to various economic sectors". While the professors of Renmin University of China represented by Zhao Ping think that: "informationization refers to the historical process during which the application of modern information technology by people has reached relatively high degree, and so facilitating the broad sharing of information resource within the whole society, promoting the full exertion of the potential of human intelligence and social material resources, and leading the social economy to develop in the direction of high efficiency and good quality".

Industrialization refers to the process during which the proportion of industry (especially manufacturing industry) or the secondary industry output value (or income) in the Gross National Product (national income) has been on continuous increase, and the industrial employment proportion in total employment has also ascended constantly.

Industrialization is the core content of modernization, and also the process for the transformation from agricultural society to the modern industrial society. "Industrialization" has dual concept in Chinese (which refers to the industrial sector and manufacturing production) but the same spelling in English. As learning from its English concept, the industrialization demands on the development of both the secondary industry or manufacturing industry, and the primary industry and tertiary industry. Globally, not only the manufacturing industry, energy industry and metallurgical industry of the secondary industry, but also many industries of the primary and tertiary industry have been advanced towards the industrialized direction. The authentic industrialization can only be achieved through the coordinated development of agriculture, industry and service industry.

Based on the above, informationization and industrialization can be deemed as a process or a historical process, which is composed of several stages, whose contents are shown by varied expression forms in different fields. In the process of industrialization, it mainly pursues the rapid economic development and constant accumulation of material resources; while the informationization is realized by adopting advanced scientific and technologic manners to improve the production efficiency, production technology and optimize the industrial structure. Industrialization and informationization are mutually integrated and promoted, and have internal connection.

The integration process of informationization and industrialization has been followed by the integration of products, business and industrial extension, whose contents have been

reflected to many fields of economic development. In the great revolution of information age, two-oriented integration has become the important drive for the economic development of enterprises, and so many enterprises have invested a great amount of money on information construction. It's quiet difficult for most of the enterprises to answer the questions such as how about the benefit of information investment, and how to evaluate if the information investment is successful. It shall attribute to that the enterprises cannot make accurate evaluation of their two-oriented integration degree. Therefore, the construction of scientific evaluation system of two-oriented integration degree will be good for the enterprises to accurately evaluate their integration level, and also help to lead the scientific information investment of enterprises.

At present, in terms of guiding the information investment decision-making of enterprises, the evaluation system for two-oriented integration level we have known mainly has the following defects: 1. it is difficult to show the integration degree of enterprise information process and other important aspects through the horizontal analysis of the impact of two-oriented integration on enterprise development and refining relevant indicators, i.e. "readiness degree-application degree-performance degree" framework system; 2. partial indicator system contains a variety of indicators unrelated to the development of enterprise, for example: per capita GDP growth rate and unemployment rate index.

In this paper, two-oriented integration development process has adopted horizontal analysis; in the construction of indicator system, the evaluation framework for the two-oriented integration development level raised by Liu Jiuru and Zhou Jian in 2012 in Analysis on the Industrial Enterprise Two-oriented Integration Development Level and Key Problems has been applied. In this framework, the process for two-oriented integration has been divided into totally four hierarchies, namely "infrastructure", "single application", "comprehensive integration", "coordination and innovation". Centering on the above four hierarchies, the evaluation indicators have been refined and the two-oriented integration evaluation system has been established.

2. Construction of Two-Oriented Integration Evaluation Indicator System for the Enterprises

### 2.1. Construction Principle of Indicator System

In this paper, while constructing two-oriented integration evaluation indicator system, the following principles have been abided by in order to ensure the scientificity and efficiency of indicator system: 1. orientation, "two-oriented integration" indicator system is mainly used for self-evaluation of the enterprise, and guide the two-oriented integration construction; 2. qualitative and quantitative indicators shall supplement each other; 3. reasonability and completeness shall be combined, the indicator system shall have clear hierarchies and logics, the refined indicators shall be mutual independence; 4. scientificity, the construction of indicator system shall be built on sound theoretical basis and actual situation of the enterprise.

2.2. Selection of Evaluation Indicator

The evaluation framework for the two-oriented integration development level raised by Liu Jiuru and Zhou Jian in 2012 has been adopted in this paper, which is centered on competitiveness, and divides the process of two-oriented integration into four hierarchies, namely "infrastructure", "single application", "comprehensive integration", "coordination and innovation". Refer to the following figure for details:
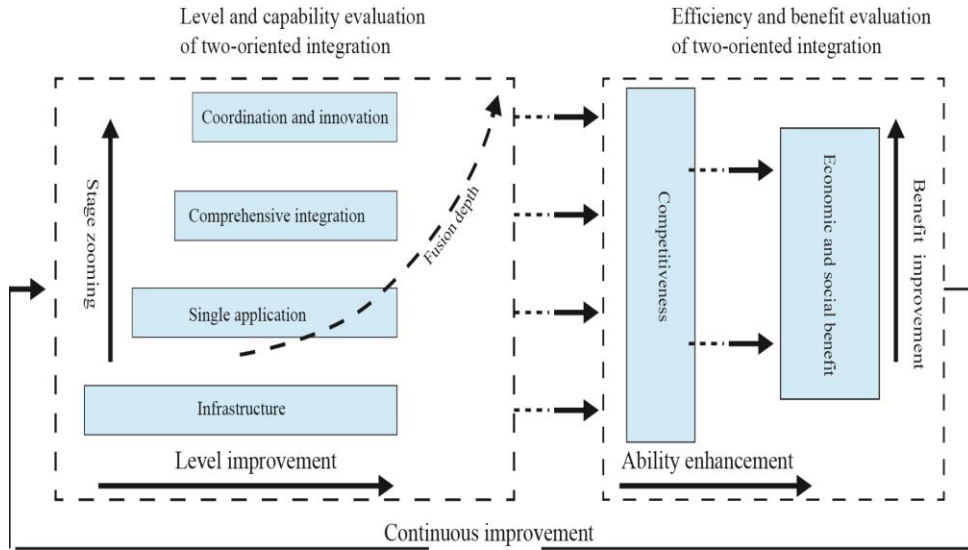
Evaluation framework raised by Liu Jiuru and Zhou Jian is constructed around enterprise competitiveness, "coordination and innovation" and "comprehensive integration" raised by them have also authentically reflected the actual situation of informationization development at present, which agree with the research scheme of this paper; therefore, the paper adopts the evaluation framework as the primary hierarchy of indicator system and enriches the refined indicators (which have been acquired by repeated discussion with information workers, enterprise managers, professional information scholar and through screening) basing on it, and the two-oriented integration evaluation system of this paper has been established as shown in figure below:
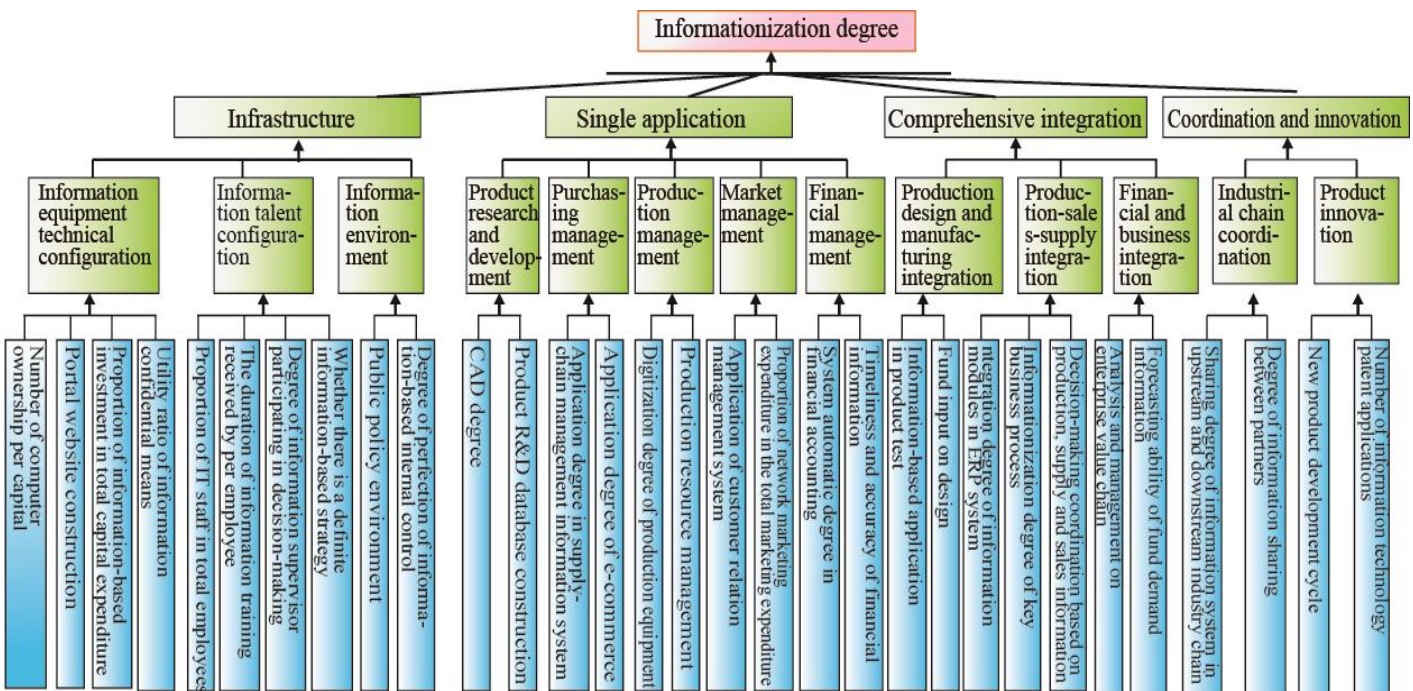
Meanings of each refined indicators are shown in table below:

No.	Level-III Indicator	Basic Meaning and Data Structure of the Indicator
1	Number of computer ownership per capital	Reflect the hardware basis of enterprise informationization
2	Portal website construction	Reflect the enterprise resource integration condition, service object coverage scope and available service content; evaluate according to the intactness of functions, i.e. staff entrance, online sales, information distribution, online self-service for customers;
3	Proportion of information-based investment in total capital expenditure	Reflect the enterprise's attention on informationization
4	Utility ratio of information confidential means	Reflect the information secrecy degree, mainly including equipment construction, system improvement, secrecy system updating and software upgrading.
5	Proportion of IT staff in total employees	Reflect the employee amount of enterprise information research and application
6	The duration of information training received by per employee	Reflect the information knowledge and skill improvement of enterprise employees
7	Degree of information supervisor participating in decision-making	Reflect the influence of informationization on enterprise decision-making, which is mainly related to the role of information principal played in decision-making
8	Whether there is a definite information-based strategy	Reflect if the informationization construction has long-term planning
9	Public policy environment	Reflect the degree that informationization has been supported by external policies.
10	Degree of perfection of information-based internal control	Reflect the internal control process and system environment corresponding to the informationization
11	CAD degree	Reflect the information application condition in enterprise product design
12	Product R&D database construction	Reflect the saving and management of informationization on enterprise R&D data, experience and intelligence
13	Application degree in supply-chain management information system	Reflect the management and maintenance of informationization on the upstream industrial chains of the enterprise
14	Application degree of e-commerce	Reflect the proportion of e-commerce purchasing in general purchasing during the purchasing management
15	Digitization degree of production equipment	Reflect the automatic production degree for equipment, and the informationiztaion integration degree
16	Production resource management	Reflect the influence degree of informationization for optimal distribution and waste reduction of production resources
17	Application of customer relation management system	Reflect the management and maintenance of information on downstream industrial chain, mainly including: customer material management, potential customer management and customer order management.
18	Proportion of network marketing expenditure in the total marketing expenditure	Reflect a series of marketing activities for the communication and transaction between enterprise and customers through the Internet
19	System automatic degree in	Reflect the supporting degree of information to the

	financial accounting	generation, settlement, formulation, analysis and excavation of financial information
20	Timeliness and accuracy of financial information	Reflect the supporting degree of information to the processing speed of financial information
21	Information-based application in product test	Reflect the participation degree of informationization in product test, i.e. applying the information methods for the simulated test for new products
22	Fund input on design	Reflect the proportion of information investment related to product R&D design in the total investment for product design and manufacturing
23	Integration degree of information modules in ERP system	Reflect the connection tightness of various modules in ERP, generally, the more data interfaces between the information modules in ERP, the higher integration level of information.
24	Informationization degree of key business process	The solidification degree of main business process and internal control system through information system shall be balanced with the business process proportion covered by information system.
25	Decision-making coordination based on production, supply and sales information	Reflect the consideration degree for relevant information of other departments and mutual coordination degree for decision-making of different departments under the process of informationization, while the decision-making among departments and trans-departments.
26	Analysis and management on enterprise value chain	Reflect the supporting degree of informationization on data query and analysis in each link of enterprise value chain
27	Forecasting ability of fund demand information	Reflect the financial information on various aspects of the comprehensive information enterprises, in order to make reasonable capital arrangement and avoid the crisis of capital chain
28	Sharing degree of information system in upstream and downstream industry chain	Reflect the information sharing degree of informationization between the enterprises and within the upstream and downstream industrial chains.
29	Degree of information sharing between partners	Reflect the sharing degree of relevant information for business coordination with strategic cooperative partners
30	New product development cycle	Reflect the information application degree in the process of product and service extension (i.e. after-sales service assurance, visiting installation and regular maintenance)
31	Number of information technology patent applications	Reflect the innovation speed of informationization

2.3. Calculation of Indicator Weight

Detailed indicator weight actually reflects the psychological sorting of degree of importance of detailed indicators of evaluation system designers. So the assignment of detailed indicator weight is a process of subjective judgment by evaluation system designer. In order to convert the value judgment of experts and scholars to exact figures, this paper adopts Analytic Hierarchy Process (AHP). Analytic Hierarchy Process (AHP) is a decision-making method combining qualitative and quantitative analysis based on dividing relevant elements into target, norm, scheme, etc. Analytic Hierarchy Process (AHP) realizes the mathematization of decision-making thinking process with less quantitative information, and

provides simple and convenient decision-making methods for complex decision making problems with multiple target, multi-criteria or no structural characteristics. It is especially suitable for conditions in which the results of decision are hard to be measured directly and accurately.

This paper collects judgments of 10 experts and scholars on the importance of detailed indicators through software Yaahp, and has obtained Level-I indicator weight matrix and Level-III indicator weight details, in which "Wi" representing indicator weight. See the following chart and table for details:

Judgment Matrix

Informationization degree	Infrastructure	Single application	Comprehensive integration	Collaboration and innovation	Wi
Infrastructure	1.0000	2.0000	5.0000	6.0000	0.5364
Single application	0.5000	1.0000	2.0000	3.0000	0.2535
Comprehensive integration	0.2000	0.5000	1.0000	2.0000	0.1305
Collaboration and innovation	0.1667	0.3333	0.5000	1.0000	0.0796

Level-I Indicator	Level-II Indicator	Level-III Indicator	Level-III Indicator Weight
Infrastructure	Technical configuration of information-based equipment	Average number of computer ownership per one hundred people	13.88%
		Portal website construction	2.68%
		Proportion of information-based investment in the total capital expenditures	6.21%
		Utility ratio of information confidential means	1.61%
	Information-based talents resource	Proportion of information technology talents in the total	2.44%
		The duration of information training received by per employee	7.31%
		Degree of information supervisor participating in decision-making	7.31%
		Whether there is a definite information-based strategy	7.31%
	Information environment	Public policy environment	3.66%
		Degree of perfection of information-based internal control	1.22%
Single application	Product R&D	CAD Degree	2.09%
		Product R&D database construction	2.07%
	Procurement management	Application degree in supply-chain management information system	2.09%
		Application degree of e-commerce	1.05%

	Production management	Digitization degree of production equipment	4.75%
		Productive resource management	1.19%
	Marketing management	Application of customer relation management system	2.50%
		Proportion of network marketing expenditure in the total marketing expenditure	7.49%
	Financial management	System automatic degree in financial accounting	2.09%
		Timeliness and accuracy of financial information	1.05%
Comprehensive integration	Product design and manufacturing integration	Information-based application in product testing	1.07%
		Fund input on design	1.07%
	Production-supply-marketing integration	Integration degree of information modules in ERP system	1%
		Informationization degree of key business processes	1%
		Decision-making coordination based on production, supply and sales information	5.02%
	Financial and business integration	Analysis and management on enterprise value chain	1.29%
		Forecasting ability of fund demand information	2.59%
Collaboration and innovation	Industrial chain synergy	Sharing degree of information system in upstream and downstream industry chain	2.65%
		Degree of information sharing between partners	2.65%
	Product innovation	New product development cycle	1.33%
		Number of information technology patent applications	1.33%

2.4. Check Consistency of Indicator Weight

This paper carries out check consistency of indicator of different levels in the indicator system with software Yaahp, consistency ratio of the first, second and third level are respectively CR1=0.0092, CR2=0.0019, and CR3=0.011. All consistency ratios of different levels are under 0.1, which indicates the indicator weight sorting of different levels meets the satisfied consistency, and we can make totaling of detailed indicator according to above-mentioned weight vector.

3. Data Analysis

In this paper, questionnaires are designed based on corresponding above-mentioned indicator system for interviewee/respondents to fill in. Then we can obtain the scores of detailed indicator; by multiplying the detailed indicator score by detailed indicator weight, we can get weighting scores of detailed indicator. Summarizing the weighting scores, we will get scores of informationization and industrialization degree of the enterprise on the whole. 190 copies of questionnaires are sent out for enterprises (mainly in manufacturing industry) in Shandong Province, and 172 questionnaires are returned and 146 questionnaires are valid.
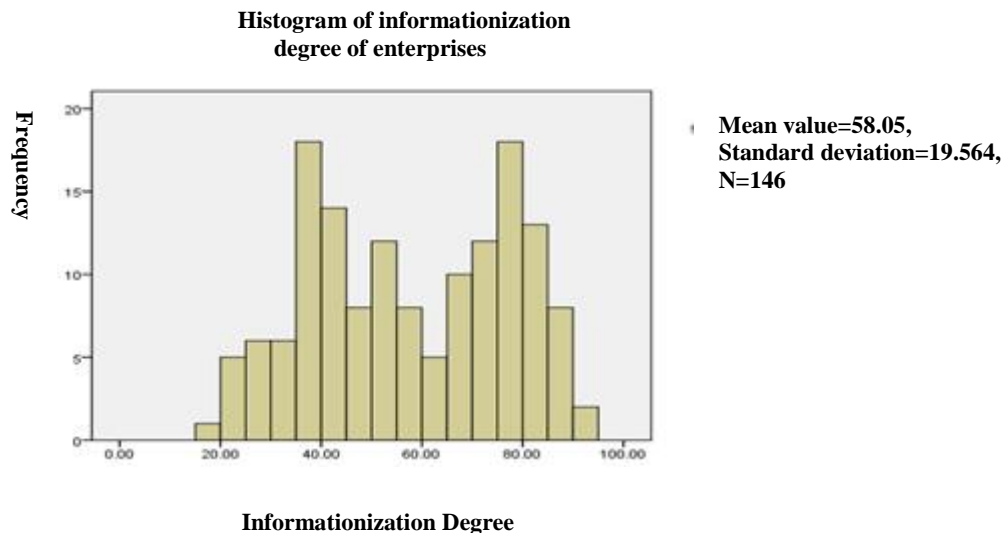
3.1. Data reliability analysis

This paper takes "Cronbach's Alpha" as the statistical magnitude of reliability analysis, and carries out reliability test on relevant data collected. Through SPSS 17.0 software package - > analysis - > metrics - > reliability analysis, the paper measures and calculates Cronbach's Alpha value of consistency statistical magnitude of competitiveness level and the degree of the informationization of enterprises. Under normal conditions, if Alpha coefficient reaches 0.7-0.8, it indicates that there are considerable reliabilities of indicators; if Alpha coefficient reaches 0.8-0.9, it indicates strong reliability of indicator. Through the tests, Cronbach's Alpha values of 31 detail indicators in the questionnaire exceed 0.8, therefore informationization level data collected in this paper has a higher reliability.

3.2. Evaluation Result

The paper has arranged and calculated the f collected informationization level data of enterprises in Shandong Province in 2012. For descriptive statistics status of informationization level of local enterprises, please see details in the following chart:

Histogram of informationization degree of enterprises

Mean value=58.05, Standard deviation=19.564, N=146

Informationization Degree

We can learn from the chart above that, many enterprises in Shandong Province have made great achievements on information construction. Integration degrees of informationization and industrialization in 26 enterprises score over 80, but the horizontal differentiation on informationization between enterprises is quite obvious, with a dumbbell shape distribution on the whole. And many enterprises still have lower informationization level, and there are few enterprises with medium information level. In the process of investigation and interview, we have learned that the distribution of informationization level is related to bottlenecks of information construction: 1. For most of the enterprises, after the information hardware has upgraded to a certain level, further information construction, such as organization adjustment and business process optimization will face higher hurdles, which will lead to the stagnation of further improvement of the information level. 2. Some enterprises are short of ample funds and talents for information construction in the next step after entering into the information construction on system integration phase.

4. Conclusions and Policy Recommendations

This paper constructs two-oriented integration evaluation indicator system for enterprises, centered on enterprise competitiveness and based on infrastructure, single application, comprehensive integration, and collaboration and innovation. Through the evaluation of two-oriented integration degree of enterprise in Shandong Province, the indicator system has been applied with rather satisfactory practical results. During the measurement of two-oriented integration degree of enterprise in Shandong Province, we have found that, a considerable number of enterprises meet with relatively large obstructions after entering into the system integration phase of information construction: 1. From the point of inner-enterprise, information construction for system integration phase influences the interests of the departments of enterprises, and some management staffs. So the informationization will halt if senior managers do not propel it forward. 2. From external environment of the enterprises, since price and consulting fees of information systems are expensive, and high-end information market is in short supply (mainly controlled by foreign ERP software vendors), it is hard for small and medium-sized enterprises to promote the informationization construction at system integration stage. Besides, sampling collection in this paper concentrates in large-scale listed companies, and lacks of samples from small enterprises, therefore, informationization level of enterprises in Shandong stated in the paper tends to be more optimistic that it really is.

Through scientific quantitative analysis with Analytic Hierarchy Process (AHP), the weight of each indicator is determined, and the corresponding proportion is concluded for the two-oriented integration of enterprise. In the process of improving the market competitiveness of enterprises, to promote the scientific management and sustainable development of enterprise, and provide strong theoretical basis and support tools for great-leap-forward development and competitiveness improvement of enterprises, the enterprise shall promote the two-oriented integration from the angle of products, and improve the information technology content, intelligent level and added value of products. Promote the two-oriented integration from the angle of industrial cluster, and improve the integral informationalized level of small and medium-sized enterprises, give full play to the leading role of leading enterprise towards small and medium-sized enterprises.

At present, China is still in the exploration and development period of two-oriented integration. Although Ministry of Industry and Information Technology has confirmed the overall thinking of "boost systematically and in multi dimensions and focus on key point", there are still many problems and difficulties in the specific progradation of "two-oriented integration". From the perspective of enterprises which are the main part of two-oriented integration, specific scheme shall be firstly made, but not all enterprises can make out two-oriented integration schemes suitable for their own development. From the perspective of soft environment of two-oriented integration, most schemes on two-oriented integration are formulated by traditional information technology professionals, but we must realize that, two-oriented integration means the integration on technology, products, business, industry, and so on, which will be never equal to informationization, therefore, high level talents for two-oriented integration schemes are quite limited, and this has restricted the process of integration to a certain extent.

"Two-oriented Integration" is not only systems engineering, but also creative work, and there is still a long way to go for the subsequent development. From the point of time, the development of "Two-oriented Integration" still needs a quite long time, and enterprises should speed up the informationization infrastructure construction, strengthen integrated application, and gradually develop to the stage of deep application. From the point of region,

eastern developed regions should guide the upgrading of industrial structure, reduce the gap with developed countries, while central and western regions should achieve leapfrog development, and gradually narrow the gap with eastern developed regions. From the point of the industry, we should pay attention to develop complete industry solutions, accelerate business synergies and resource integration, and promote the development of the whole industry. In addition, upstream and downstream enterprises of industry chain should also have synergetic development, so as to promote the competitiveness of the whole industry chain. All in all, reasonable scheme of informationization and industrialization development should be designed in different regions and industries according to the current situation of development, speeding up the further integration of informationization and industrialization.

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