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The Technological and Economic Logic for Intelligent manufacturing

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Abstract: Focusing on the difficulties that domestic industrial enterprises face while promoting intelligent manufacturing, this article introduces methods for facilitating the application of related technologies. Our in-depth investigation and comparative analysis show that the fundamental cause of these difficulties is the low economic efficiency of the technology used. Therefore, the key factor to promoting the application of a certain technology is to improve its economic efficiency. However, problems such as outdated management and low-quality requirements restrict the economic efficiency of technology. To counter this, strategic goals must be set for technological transformation and upgrading of the enterprise; further, a higher quality standard should be set. Meanwhile, technologies related to intelligent manufacturing can be adopted to promote better management and address the weaknesses of enterprises, thereby improving the economic efficiency of technology.
Keywords: intelligent manufacturing; industrial Internet; Industry 4.0; cyberspace

In recent years, intelligent manufacturing has become a hot topic in industrial society. Although most companies are trying to find a way to succeed in this field, few have made progress. Employing the perspective of the economic efficiency of technology, this article analyzes the real causes of the problems faced by enterprises.

1 Intelligent manufacturing and business confusion

One of the perspectives employed to observe intelligent manufacturing is the in-depth application of information and communication technology (ICT) to manufacturing and its subsequent integration. Introducing manufacturing execution systems and implementing enterprise resource planning systems may not bring about the expected economic gains; further, collecting huge amounts of data may not necessarily provide useful knowledge. Further, one may encounter the problem of the economic inefficiency of technology in all these cases.

Technological advancement and an efficient economy are two different things. Joseph Schumpeter emphasized that an invention is not an innovation until it is used in economic activities for gain. From his point of view, innovation reconfigures labor, equipment, and technology within an enterprise to provide better economic results. New technologies thus offer new options for resource reallocation; however, adopting a new technology does not necessarily lead to high economic efficiency until it is used in an appropriate manner.

China's competitiveness is generally linked to its cheap labor. For instance, BYD Co., Ltd., a Chinese automobile manufacturer, began to manufacture Ni-Cr batteries in the 1990s; despite its production lines being far less automated that those of rival Japanese companies, its total costs were still 40% lower because of its low-cost labor. One of the main motivations for enterprises to adopt intelligent manufacturing is to lower labor costs; however, if low-cost labor is available, one has less reason to do so.

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A number of the problems faced by enterprises arises from this contradiction in the Chinese market, especially when one compares it with those of developed countries.

2 Demand-driven and application scenarios

One of the primary principles of technology resource allocation is that one does it only when it helps improve business outcomes. Normally, businesses demand the economic efficiency of technology based on various real scenarios. Different scenarios generate different demand levels, which lead to different value-adding technology applications. For instance, industrial Internet and data analytics rapidly improve the operation and maintenance of a full-sized aircraft engine but yield little benefit if applied to a toy plane. Customization is a huge blessing in steel production, but of no interest to people in the petrochemical industry.

The key factor to adopting intelligent manufacturing technology is to find an economic fit with existing scenarios; for example, to replace a human job with a machine or robot, one needs to demonstrate the "value" that the replacement can directly create on its own or, indirectly, by helping raise human productivity. In these scenarios, the limitations are often physiological, especially the cognitive challenges of humans. Generally speaking, cognitive challenges increase with higher efficiency. Thus, higher quality demands, a larger business scope, greater complexity, and more frequent changes are scenarios that normally raise the adoption rates of advanced technologies. For this reason, most of these scenarios are observed in advanced enterprises.

Chinese companies often occupy the middle or low end of the industry value chain by producing low-quality products with cheap labor; they are involved in little R&D and offer few consulting services. These enterprises are, thus, more likely to face confusion when applying advanced intelligent manufacturing technologies because the economic fit exists for few business scenarios.

3 Transformation and upgrading, and technology application

Before intelligent manufacturing technologies are applied to the business scenarios of these enterprises, innovations in areas such as business processes, business models, and organizational structuring are needed to align the intelligent manufacturing technology with the business models of these enterprises; in other words, so-called "transformation and upgrading" is required. More R&D needs to be conducted, and resources must be reallocated to produce higher-quality products. This will proactively create more scenarios under which to adopt advanced intelligent manufacturing technologies, enabling companies to move up the industrial value chain.

The commonly understood goal of transformation and upgrading is to improve the core competitiveness of an enterprise; further, because related technologies are utilized to achieve this goal, transformation and upgrading can promote technology application. For any enterprise, transformation and upgrading is a strategic matter, whereas technology application is always a tactical issue. Although the development of ICT does make transformation and upgrading feasible, one cannot plan technology advancement until a clear business strategy has been defined. From another perspective, intelligent manufacturing is essentially an "in-depth integration" of ICT and manufacturing; this means that ICT is applied to promote innovations and changes to the existing business rather than to serve it. Without innovations, it would be difficult to proceed with applications of ICT and true "in-depth integration" will not be achieved. In this paper, we emphasize that transformation and upgrading creates the conditions for technology application based on the belief that only business innovations can drive the application of technologies related to intelligent manufacturing.

Treating intelligent manufacturing as a technical matter, rather than one involving transformation and upgrading, is the main cause of confusion among enterprises. In fact, it is something for entrepreneurs rather than technical leaders to consider. Entrepreneurs are responsible for the overall strategic vision and goals, whereas technical teams should provide specific solutions for each scenario. Only a clear and high-level strategic view can lead to a successful application of technology.

This has been proven by practical industry experience. REDCOLLAR Co., Ltd. produces personalized suits on an assembly line—a production model that makes management complex. By utilizing smart technologies, REDCOLLAR manages the entire workshop in a highly integrated manner; both material flows and worker operations are managed and configured dynamically, which leads to high operational efficiency. The relevant ICT is adopted to fit the business scenarios, resulting in high economic efficiency. A customized home production service brings huge challenges to production design and production. By leveraging advanced technology such as big data analysis, ShangPin Home Collection Co., Ltd. achieved a high level of knowledge sharing and design reuse, thereby improving the synergy between design and production. The use of related technologies was helpful in this case.

4 Development logic of intelligent manufacturing

The objective of intelligent manufacturing is to free humans by delegating boring, laborious, dangerous, dirty, and harmful work to machines; further, humans can then take up creative and fun-filled jobs for self-actualization. Thus, the adage that "work is becoming the first demand of human beings" will gradually come true. From a technical point of view, advancement depends on the gradual change in the human−machine relationship. By perfecting cyberspace, humans will spend more time building

and improving models in cyberspace rather than doing the controlling themselves [1].

Again, the above statements require a technical feasibility analysis that leads to economic viability; this requires more research to discover the inner logic between technologies and economic matters. We know that digitization is a prerequisite for information processing and transmission. Therefore, we need digitization to lay the technology feasibility foundation for the intelligence that we are aiming for. The Internet has overcome the limitation of physical space in terms of information transmission, thereby providing better ways to configure and perceive more usable resources. The more the resources one can allocate, the more the options one has and the greater the economic benefits possible. Introducing intelligent technologies to help humans with data collection and decision making at this point will certainly lead to higher economic potential. The China Academy of Engineering, in its Reports on China's Intelligent Manufacturing Development Strategy, has defined three paradigmatic evolutionary stages that reflect the process of this change: digitalization, connectivity, and intelligent manufacturing [2]. Digitalization is the foundation, connectivity increases the economic potential, and intelligence converts the potential into reality.

Industry 4.0 has demonstrated this logic [3] in its own way. The Internet enhances the connectivity between enterprises and their customers across the supply chain; further, it strengthens the coordination among departments, processes, and equipment. All these can be considered capability improvements for better resource allocation. Based on these improvements, more customization within production lines can occur. However, customization also introduces complexity to businesses, and this challenges the capabilities of the human brain to process a massive amount of information. In this case, intelligent technologies such as the cyber-physical system can play an important role.

Knowledge plays an important role when intelligence technologies are used in information collection and decision making. Modeling and digitizing human knowledge are the core tasks in this process, and industrial big data can significantly improve the technical and economic feasibility of knowledge-based production; hence, intelligence technologies have become the most important enabling technology in intelligent manufacturing.

The continuous expansion and improvement of cyberspace are facilitating the collection of industrial big data. The technical feasibility of knowledge production increases when data quality improves, model completeness is achieved, and more scenarios are covered. With the help of big data, some knowledge can be present in machines without human coding through machine learning; this would be a significant transformation, similar to that from "give a fish" to "teach to fish." As data quality improves and big data technologies mature, the efficiency and quality of knowledge production from data also improve; this leads to a wider scope and lower cost, further improving economic feasibility.

The General Electric practice of using the Industrial Internet for aircraft engine maintenance is essentially an application of knowledge sharing with big data [4]. Knowledge sharing in the Internet era rapidly increases the value of data and knowledge as well as improves the economic efficiency of knowledge-based production. Further, because intelligence is based on knowledge, it can, technologically speaking, boost the development of intelligence.

From digitalization to intelligence, the Internet is the key technology to ensure that an enterprise moves on the right track toward higher economic efficiency.

5 Chinese characteristics and policy expectations

It is economic efficiency, rather than an improvement in technology, that makes intelligent manufacturing a desirable technology. The most difficult part of adopting intelligent manufacturing technology is its introduction because the fit of the technology with the enterprise scenario is more important than the technology itself.

We need to identify scenarios to which intelligent manufacturing can be applied, and this is closely linked to the national conditions in China [5]. Unlike those in developed countries, many Chinese enterprises are characterized by outdated technologies and management paradigms, an insufficiently educated workforce, and poor R&D capabilities; however, the advantages are low-cost labor and a massive market. Considering China's national conditions, replacing workers with machines may not work. In fact, a wide range of successful cases such as RED-COLLAR still involve manual workers. Each year, around eight million new graduates from colleges and universities join the labor force, providing many low-paid white-collar workers for intelligent manufacturing.

Investigations in some enterprises show that losses caused by human error are a significant drag on overall profitability. In such scenarios, intelligent technologies can always be adopted; one can reduce human errors by introducing more machines, improving coordination between departments by information integration, and providing senior executives with grassroots information to improve decision making. ICT is the solution that provides all these essential functions successfully.

People tend to hide the loss caused by their own fault; this makes these losses invisible to decision makers. Hence, reorganization and process reengineering are often needed to tackle these problems. This also shows the need for transformation and upgrading.

Enterprises are always looking to improve their work efficiency and marketing responsiveness by shifting business focus to services and R&D and moving toward high-end production lines. However, the major objective of promoting intelligent manufacturing, along with transformation and upgrading, is to address market demand and adapt to the external environment.

It is the government's responsibility to establish the right economic environment for enterprises. In the past, when the protection of consumer rights was inadequate, the result was inferior products; some industries even eliminated higher-quality products through reverse engineering, thereby making it hard for such products to gain economic efficiency. This not only makes it difficult for enterprises to move toward high-end categories, but also hurts the adoption process of new technologies. Stricter laws and regulations need to be in place for quality controls and consumer rights protection, thereby forcing companies to consciously pursue higher-quality products. This might brighten the future of Chinese manufacturing.

6 Conclusions

Intelligent manufacturing technology has huge demand in China. However, we can effectively promote these technologies only by transforming such demand into economic benefits for companies. Hence, the government must establish a healthy market environment that permits high-quality development. Enterprises must also carry out strategic transformation and improve their management techniques to create conditions for the proper application of related technologies. If intelligent manufacturing is viewed only from a technical perspective, various difficulties and confusion are inevitable.

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References

[1] Hu H, Zhao M, Ning Z B, et al.Three-body intelligence revolution [M]. Beijing: China Machine Press, 2016.Chinese.

[2] Kagermann H, Wahlster W, Helbig J. Recommendations for implementing the strategic initiative Industrie 4.0 [R]. Miinchen: National Academy of Science and Engmeering(acatech), 2013.

[3] Evans P C, Annunziata M. Industrial Internet: Pushing the boundaries of minds and machines [J]. Science Reports of Kanazawa University, 2012(1–2): 1–23.

[4] Zhou J, Li P G, Zhou Y H, et al. Toward new-generation intelligent manufacturing [J]. Engineering, 2018,4(1): 11–20.

[5] Development Research Centre of the State Council. Drive the transformation and upgrading of China's manufacturing industry by drawing on the experiences of Germany's Industry 4.0 [M]. Beijing: China Machine Press, 2018. Chinese.