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The Formation Logic of the Digital Divide and Feasible Ways to Cross It: An Access-Based Analysis

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Abstract: How enterprises overcome the digital divide in a digital economy is a topic related to efficiency and fairness. The formation of the digital divide has showcased a certain level of objectivity and is also influenced by the characteristics of enterprises themselves. Based on the model that expands the information and communication technology (ICT) access, concept, we explored the digital divide's formation logic of the digital divide and feasible ways to cross it. Our findings shed light on its formation logic, which includes elements of the subjective will of enterprises to transform, the fear of transformation, the dependence on development paths, and the cost of using digital technology, all of which have contributed to disparities in enterprises' motivational access. In addition, differences in the construction of digital infrastructure, financial strengths, business models, and heterogeneity in cluster networks have led to differences in enterprises' material access. The absorptive capacity of enterprises has affected their skill access, while the management capability influences the application access of enterprises. We also found that crossing the digital divide requires the joint efforts of governments, markets, and enterprises in the four access dimensions.

Keywords: digital divide, ICT access, digital technology, motivational access, skill access

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Introduction

The boom of next-generation technology has made digitization a fundamental element of modern society and an indispensable factor of production in enterprises' productions and operations, creating a huge impact on the competitiveness of enterprises and expediting the cross-sectoral integration of various industrial links and chains. The digital transformation and digitalization-enabled innovations of enterprises can enhance China's industrial chain's resilience and vertical development, and promote its upgrading and restructuring (Li, 2021).

However, the proportion of Chinese enterprises undergoing digital transformation remains low, and there is a clear digital divide among enterprises of different industries and sizes. The Analysis Report on Digital Transformations within Small and Medium-sized Enterprises (SMEs) (2021) shows that nearly 80 percent of SMEs are still in the primary stage of digital transformation, while more than half of large enterprises have entered the stage of practical adoption and comprehensive application (China Electronics Standardization Institute [CESI], 2022). Meanwhile, industries close to end markets and consumers, such as traditional retail, logistics, electronic parts, and materials, are witnessing faster digital transformations (CICS-CERT & Accenture, 2021). In addition, there are significant differences in the levels of digitalization, even for enterprises in the same industry. For instance, within the manufacturing category, high-tech industries and knowledge-intensive industries such as chemical raw materials and products, automobiles, computer/electronic equipment, and electrical machinery and equipment have a higher level of digitalization (Institute for Global Industry of Tsinghua University, 2021). The digital divide can easily lead to a knowledge monopoly, exacerbate competition among enterprises, and store troubles produced by the "polarization effect" in the development of enterprises. Therefore, it is of great significance to conduct in-depth research on how the digital divide is created and how to cross it.

The year 2000 was a turning point for the political community to recognize the global digital divide, with most major global actors (such as the US, the UK, Japan, the International Monetary Fund, the World Bank, the UN, and Microsoft) voicing their opinions on this issue (Hwang, 2006). In the wake of the 2000s recession, the scientific community began synthesizing various empirical materials from a theoretical perspective. Today, most scholars believe that the existence of the digital divide has widened the gap between social classes and exacerbated inequality in society (Li & Ren, 2022), contributing to imbalances between countries (Tian &

Chen, 2022) and regions (Yang & Li, 2002). Additionally, the digital divide can result in increased market monopolies, undermine the motivation of enterprises to innovate (Zhou & Zou, 2023; Wang et al., 2022), and make collaborations among enterprises less efficient due to the increased costs of collaboration (Liu et al., 2017). However, much of the existing research has focused on exploring factors that influence the development of digital technology in enterprises. For example, researchers have studied the impact of geographical locations (Bapna et al., 2011), industry types (Labrianidis & Kaloressis, 2006), customer characteristics (Galliano & Orozco, 2011), management capabilities (Grimes et al., 2012) and technology adoption capabilities (Arora et al., 2010) on the use of digital technology by enterprises.

Therefore, further investigation is needed to understand how the factors mentioned above affect enterprises' acquisition and adoption of digital technology and how to bridge the digital divide and promote the transformation and upgrading of enterprises. In this context, based on the model that extends the ICT access concept proposed by Van Dijk (2006), we attempted to explore the formation logic of the digital divide among enterprises from four dimensions: motivational access, material access, skill access, and user access. This paper clarifies the mechanism by which various factors have a bearing on the formation of the digital divide and proposes feasible ways to cross it. The marginal contribution of this paper lies in exploring the formation logic of the digital divide from four dimensions: motivational access, material access, skill access, and user access, based on a model that extends the concept of ICT access to advance relevant theories regarding the digital divide.

Formation Logic of the Digital Divide

As the digital economy has developed, different enterprises have had varying degrees of access to modern digital technology and data resources due to multiple factors such as industry, geographic, and economic differences. The digital divide arises when there is heterogeneity in the digital transformation of enterprises. The formation of the digital divide has showcased a certain level of objectivity and is also influenced by the characteristics of enterprises themselves.

Digital Divide Created by Objective Laws

The digital divide has a certain level of objectivity regarding spreading and acquiring knowledge technology. The diffusion of technological products follows the S-shaped diffusion theory, where adoption grows slowly at the beginning,

skyrockets when it hits the critical number and slows when it reaches saturation. The eastern coastal regions of China and knowledge-intensive industries are often the first to access advanced information technology, which is then spread to neighboring regions and other industries. As a result, the diffusion curves between regions and industries differ (as shown in Figure 1). Similarly, since enterprises' acquisition and application of digital technology are synchronous, it is natural to observe a digital divide among enterprises in different regions and industries when compared at the same point.

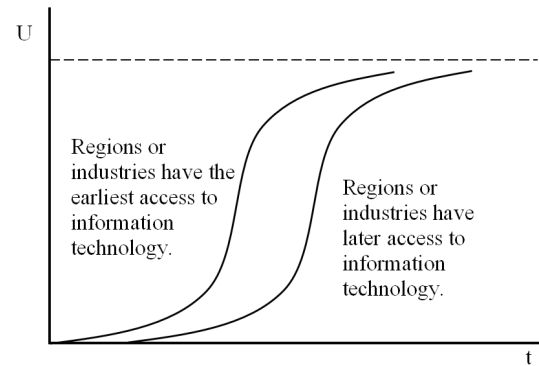


Figure 1 Diffusion Model

The Digital Divide Created by a Motivational Access Gap

A motivational access gap refers to whether enterprises have the motivation to drive their information and digital transformations and leverage digital technology. The factors contributing to this gap are:

The understanding of digital transformation

Research has shown that compared with enterprises that have undergone digital transformation, the proportion of those that have yet to start the process and think transformation is challenging is smaller. These enterprises show more confidence in digital transformation (Shi et al., 2021). This suggests that some enterprises do not implement digital transformation not because of specific difficulties they might expect in the process but because they are unaware of its importance and necessity, resulting in low motivation.

The difficulties in achieving digital transformation

Digitization is not only a pure technological revolution in and of itself. It also has a bearing on enterprises' value propositions, operation and management methods, production processes, and the way employees work. Digital transformation is a long-term, tortuous, and uncertain process (Matt et al., 2015). Enterprises with insufficient capabilities may find themselves in an awkward situation where they start the transformation process but fail to complete it, or they do not transform at all and thus fail to survive. Such a dilemma makes enterprises less willing to attempt digital transformation or prevents them from trying altogether.

The reliance on the development path

Some manufacturing enterprises rely too heavily on traditional development paths, making them unable to adapt to new technologies (Li et al., 2022). Such

reliance hinders enterprises from updating their information skills, resulting in delays in the organic integration of digital technology and enterprises, creating a digital divide. For example, the old industrial base in northeast China, dominated by heavy industry, exhibits clearly depends on past development paths in its industrial development (Liao & Zhang, 2019). According to the data released in the *White Paper on the Development and Employment of China's Digital Economy (2019)* the total economic volume of the digital economy in the Northeast China industrial base and its share as a proportion of the GDP both rank No.4 among the five major regions in China, with the lowest growth rate (China Academy of Information and Communications Technology [CAICT], 2019). Breaking the dependence on development paths and bridging the digital divide has become necessary for revitalizing the old industrial base in Northeast China (Cheng, 2020).

The differences in returns and costs

The application of information technology has a network effect, meaning that the value of information technology for enterprises increases as the number of users increases. It is of no use when there is only one user. Enterprises can only obtain massive amounts of data when the user group is sufficiently large to help analyze management decisions. This also explains why manufacturing enterprises targeting individual consumers in industries such as traditional retail, logistics, electronic parts, and materials are undergoing more rapid transformation than those targeting enterprise users. Enterprises in these industries often have a larger consumer base and more pressing needs for transformation. In addition, information technology is a type of club good that is excludable but non-rivalrous for enterprises. The larger the enterprise's scale and customer base, the lower the cost of utilizing information technology. As a result, small and medium-sized enterprises may find the transformation cost per customer unit too high compared with large enterprises, making them unwilling or unable to use digital technology.

The Digital Divide Created by Material Access Gaps

A material access gap refers to the difference in the abilities of enterprises to access information technology and digital resources and the access quality. The reasons for the gap are:

A gap in digital infrastructure

As the saying goes, "A craftsman who wishes to do his work well must first sharpen his tools." Digital infrastructure is the solid foundation of the digital economy, without which there is no such thing as data or its application as a new factor of production. Digital infrastructure is an important engine for driving the digital transformation of enterprises and optimize the efficiency of factor

allocations (Guo et al., 2021). As the core infrastructure empowering the digital transformation of enterprises, cloud computing is still in its infancy in China, and the gap in the adoption rate between industries and regions is evident. According to the *White Paper on the Development and Application of China's Cloud Computing* the adoption rate of cloud services by enterprises in various industries in China was only about 40 percent in 2018, far lower than the 85 percent in the US and the 70 percent in the EU (Development Research Center of the State Council of People's Republic of China, 2019). The report *Evaluation of the Socio-Economic Value and Regional Development of Cloud Computing* shows that the scale of cloud computing in Hangzhou, Shenzhen, Beijing, and Guangzhou accounts for 55.6 percent of the national total, and there is a significant gap in the development level of cloud computing between the east, west, and central regions (Alibaba Cloud Research Center & National Academy of Economic Strategy, CASS, 2021).

Differences in the financial strength of enterprises

Financial constraints have led to notable disparities between SMEs and large enterprises regarding office networks and information system coverages, digital equipment applications, and internet access rates of equipment (as illustrated in Figure 2) (Yang et al., 2020). The absence of core digital infrastructure and access to digital equipment has prevented some enterprises from obtaining the necessary conditions for digital transformation, forming a digital divide.

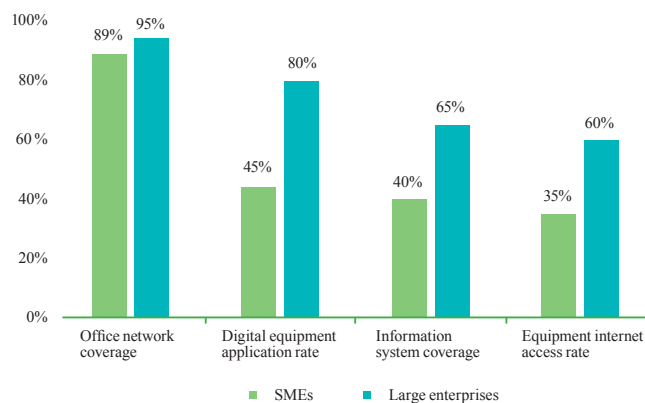


Figure 2 Comparison of Enterprise Equipment Access

Differences in the business scale

Data is the foundation for integrating data technology, platform technology, and operations technology in the industry. Therefore, the material access gap exists not only in the availability of the equipment mentioned above by enterprises but also in the accessibility of information and data resources. Information feedback from the demand side is an asset for enterprises. Products of larger enterprises can be used in more scenarios, making it easier to amass massive digital resources. Meeting the market demand is an essential driver for enterprises to perform a digital transformation (Zhang, 2020). The huge digital scale has better motivated and equipped large enterprises with a greater ability to undertake digital transformation.

Heterogeneity in cluster networks

A cluster network with strong connections between devices can foster trust and cooperation between enterprises and reduce defensiveness among network members. This can facilitate the transmission of information and knowledge skills between cluster enterprises, improving the efficiency and quality of exchanges while lowering the costs of information transmission (Liu et al., 2016). Furthermore, the opportunities for enterprises to identify, acquire, and utilize external knowledge resources vary depending on their location in the network. Enterprises at the center are more likely to connect with other enterprises in the network, thus enjoying greater opportunities to obtain external knowledge and information.

The Digital Divide Created by Skill Access Gaps

A skill access gap refers to a gap in the ability of enterprises to utilize the acquired digital equipment and data processing resources. While access to various digital facilities and equipment is the prerequisite for, and the beginning of, “getting connected with the Internet,” the greater value lies in the use of digital resources and digital technology. A skill access gap is about whether a company can process the digital resources and master the digital technology acquired, and this gap is mainly attributable to differences in absorptive capacity. As per the competitive advantage theory of enterprises, the digital technology and data resources acquired by enterprises are their resources, which translate into their capabilities. The absorptive capacity of enterprises, or rather the actual absorptive capacity of knowledge transformation and utilization, is the link between mastering and using technology and resources. The differences in actual absorptive capacity have created a digital divide. The human resources of enterprises influence the absorptive capacity, while the absorptive capacity of enterprises is underpinned by individuals (Cohen & Levinthal, 1900). Having more digital talent in an enterprise, industry, or even a region means that the due value of the acquired digital technology can be leveraged with better and faster technological applications. Advanced manufacturing enterprises prioritize the application of information technology and attract many talents, making it easier for them to push for the digital transformation of enterprises more easily than traditional manufacturers (Dong et al., 2022).

The Digital Divide Created by Usage Access Gaps

A usage access gap refers to the disparity in digital output and profitability. As logical entities, enterprises acquire and utilize digital technology to achieve better profitability and development, but the gap in data management capabilities

leads to a gap in user access. Data is a key factor of production in a digital economy. However, data can only become an effective driver for development and competitive advantage when converted into a factor of production, which requires strong data management capabilities. Many enterprises are aware of the arrival of the information age, but they have yet to understand how to materialize information-based production. They focus blindly on “building the network” and only emphasize the supporting role of information technology for businesses. They develop digital and electronic business with computers (Chen et al., 2004) without establishing a complete data management system or a sound information transmission system. Without a scientific management process and management system, the data resources obtained by advanced digital technology become an information silo for all departments in the enterprise, leaving information miscellaneous and far from being able to support management decision-making. This results in a digital paradox, where enterprises invest in digitalization but fail to achieve expected revenue growth (Gebauer, 2020). According to the report titled “Joining Forces for Win-Win Success: Turning Crisis into Opportunities through Collaboration,” released by Accenture (2020), many Chinese companies have failed to realize the value of digital investments due to a lack of effective collaboration between key functions within the enterprise. More than 90 percent of Chinese executives of industrial enterprises claimed that the lack of effective collaboration among various departments in driving the digitalization process has increased costs. Data management capabilities directly affect enterprises' digital transformation costs, and differences in capabilities give rise to a digital divide.

Feasible Ways to Cross the Digital Divide

Closing the digital divide is a systematic project that involves several factors, such as population, economic and personal factors, social support, technology, digital training, and infrastructure improvements. It requires the collective efforts of the governments, the markets, the industries, and the enterprises themselves to achieve the goal. Considering the formation logic of the digital divide, we will explore potential approaches to bridging the gap from four perspectives: motivational access, material access, skill access, and user access.

Motivational Access

Improving market mechanisms ensures reasonable profits for enterprises and stimulates their motivation to undertake digital transformations

Profitability and development are the fundamental driving forces of digital

transformations. First, enterprises that use digital technology should be allowed to innovate in core technologies and management to gain reasonable excess profits and be encouraged to join the action of digital transformations. Second, measures should be taken to prevent early adopters from using digital technology to monopolize the market by grasping market demands and launching extensive commercial promotions. Instead, enterprises should be motivated to make technological breakthroughs rather than innovative business models. Finally, efforts should be made to establish and improve the data factor market. In the era of the digital economy, data is considered a fundamental strategic resource and a key factor of production. We should promote the development of the data factor market and adopt better approaches to mining data resources while improving the efficiency of data utilization and reducing data acquisition costs. Only when enterprises are profitable will they be willing to adopt and develop digital technologies.

The establishment of industry platforms stimulates the motivation of enterprises to transform and supports their transformations

Industry platforms have an upstream supplier of products and a downstream target customer base. Product and supply & demand information is disseminated within the platform. Enterprises facing information disadvantages can use industry platforms to share information, collaborate efficiently with enterprises with information advantages, learn from the technical experience of top-performing enterprises, and refer to advanced enterprises in solving the difficulties encountered in the process of transformation. In addition to connecting the supply side with the demand side, industry platforms should share information such as the latest innovative technologies, the most widely used technologies, the classic cases, successful experiences, and benefits brought by these technologies. As logical entities, enterprises will naturally be willing to learn about and apply such technologies and accept digital transformations when they see the benefits of this technology.

Collaborating with external organizations can enhance enterprises' transformation capabilities and help them overcome path dependence

Traditional manufacturing enterprises cannot operate in isolation. They should strengthen cooperation with universities, research institutes, and cluster enterprises and create a good ecosystem for innovation. Also, they should absorb and learn management experience and skills from advanced industries and enterprises and stay updated with the latest digital technology. This will enable them to break free from development path dependence and better leverage digital technology to drive innovation and development.

Material Access

Improving digital infrastructure transcends regional heterogeneity and ensures access to digital equipment for enterprises in various regions

Digital infrastructure is a fundamental hardware requirement for enterprises to access digital technology. Efforts should be made to improve the quality of Internet access and transmission capacity, encourage enterprises to “utilize cloud platforms,” increase the investment in digital infrastructure such as 5G and the industrial Internet in rural and underdeveloped areas, and provide necessary hardware support for enterprises’ information-based digital transformations in these regions.

Establishing digital standards breaks down barriers to the flow of data elements and helps enterprises access digital resources

Unlike on the consumer end, manufacturing enterprises face significant barriers to the flow of data elements, such as commercial privacy and data security. These barriers make it difficult for data elements to integrate and flow to enterprises helping to increase the potential to create higher values for marginal products according to market rules. Breaking down these data barriers will inevitably pose challenges to data security. Therefore, corresponding digital standards are needed to accelerate establishing and improving basic systems and regulations for data security, shared development, and security authentication, among others. This will enable data to flow to enterprises in need and improve its utilization efficiency.

Technology finance (TechFin) companies can help by removing lending constraints for small and medium-sized enterprises, enabling them to access digital devices

Investment is a key factor affecting the progress of enterprises’ transformations toward digital technologies, and disparities in financial strength between enterprises have, to some extent, caused a digital divide. TechFin policies have been implemented to expand enterprises’ financing channels, alleviate lending constraints for small and medium-sized enterprises, and provide financial support for enterprises accessing digital equipment. As a special policy tool to enhance innovation, TechFin policies are more specialized and targeted than general economic policies (Lin, 2019), thus serving as a greater driving force for the digital transformation of enterprises. To enable under-funded enterprises to access digital technologies, a unified credit information-sharing platform should be established to facilitate the flow of financial data, increase data utilization rates, and enhance the inclusiveness of TechFin.

Skill Access

Cultivating digital talents enhances enterprises' absorptive capacity and supports their skill access to digital technologies. At present, there is a significant gap in digital talent. According to the report "The Digital Talent Gap: Are Companies Doing Enough?" released by Capgemini (2017), all surveyed enterprises claimed that the digital talent gap was widening. Almost 54 percent of enterprises believed that the shortage of digital talent is an important factor hindering digital transformations. In comparison 50 percent of enterprises indicated that they had always been concerned about this gap and would try to address the lack of competitiveness due to the talent gap. Cultivating digital talents requires joint efforts from the country, society, and enterprises. First, we need to adhere to the talent development strategy for strengthening the country and improve the demand-oriented mechanisms for talent cultivation and acquisition. Second, efforts should be made to improve the market-oriented labor force reforms, activate the two-way flow of talent, and provide solid human capital for the digital transformation of enterprises in rural and underdeveloped areas. Finally, enterprises should focus on strengthening the digital skill training of their employees and providing necessary talent support for their data-driven transformation.

Usage Access

Improving data management capabilities can break down the internal "information silo" and enhance the digital profitability of enterprises. Enterprises should establish data management systems and strengthen cross-functional collaboration capabilities to achieve this. They need to establish robust data management and transmission systems, break down the internal "information silo," share information among all departments, and promote the internal flow of information data. The organization should sort out, build, and improve the data model, data architecture, data quality, data security, and data life cycle from multiple dimensions, such as organizational structure, management systems, operation specifications, information technology applications, and performance review support. Through effective data governance, enterprises can achieve precision marketing, improve user experience and service quality, convert disorderly data into profits, and boost the digital profitability of enterprises (Shao, 2020). The organizational structure and internet application of enterprises shape each other. This will lead to a flat, networked, virtualized organizational structure with blurred departmental boundaries.

Conclusion

In a digital economy, with digital transformations delivering more economic benefits to enterprises, the development of the digital economy also creates and expands the digital divide. This divide can lead to knowledge monopolies, intensify unequal competition among enterprises, and accumulate troubles caused by the “polarization effect” in enterprise development. The formation of the digital divide has exhibited a certain level of objectivity, and different regions and industries have inevitably gained access to digital technologies at different times. Regional and industry differences result in differences in the speed of knowledge dissemination.

However, based on the model that expands the concept of ICT access, the subjective willingness of enterprises to transform, the fear of transformation, the dependence on development paths, and the cost of using digital technology have contributed to disparities in enterprises’ motivational access. In addition, differences in the construction of digital infrastructure, financial strength, business models, and heterogeneity in cluster networks have led to differences in enterprises’ material access. The absorptive capacity of enterprises has affected their skill access, while the management capabilities influence the application access of enterprises. These four types of access gaps have contributed to the formation of the digital divide.

To narrow the digital divide, measures should be taken to ensure that enterprises can capitalize on “digital dividends” and promote the balanced development of the digital economy. Governments, markets, and enterprises should work together in four access dimensions to improve market mechanisms and ensure transformation benefits while suppressing monopolies. Industry platforms should be established to help enterprises overcome difficulties and reduce costs in the transformation processes, and collaborate with external organizations to break free from dependence on development paths. Efforts should also be made to improve the digital infrastructure, formulate digital standards, and use TechFin to eliminate lending constraints for enterprises and enhance their financial capabilities. Finally, cultivating talents and improving data management capabilities can ensure that enterprises will use data resources well.

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