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How does the pace of digital transformation affect team viability and performance? — The role of adaptive response

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——The Role of Adaptive Response

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Dissertation for School of Accountancy Doctor of Business Administration SMU-ZJU DBA (Accounting and Finance)

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March, 2024

Certificate of Originality

I hereby declare that this DBA dissertation is my original work and it has been written by me in its entirety. I have duly acknowledged all the sources of information which have been used in this dissertation. This DBA dissertation has also not been submitted for any degree in any university previously.

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22th, March, 2024

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——The Role of Adaptive Response

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Abstract

The national strategy of "Digital China" implemented in 2021 has catalyzed efforts to bolster the digital ecosystem across industries. With pervasive claims of digital transformation and upgrading by nearly all enterprises, digital technology permeates various sectors. This study explores, from the perspective of working teams—the smallest unit within enterprise production organizations—how the pace of digital transformation influences team viability and performance. It investigates the transmission mechanism of this effect and identifies influencing factors.

Drawing from extant research on the impact of digital technology on organizations, trends in organizational change, and psychological research on team behavior, this study establishes a theoretical framework based on the Adaptive Response Model and Technology Acceptance Model. Hypotheses derived from this framework are empirically tested.

Tracking 700 teams undergoing digital technology transformation through multiple interviews and long-term observations, this study collected 2,039 valid questionnaires from 373 teams across three waves of surveys spanning seven months. The findings reveal that rapid digital transformation, when preceded by adequate technology preparation, enhances adaptive response, thereby improving team effectiveness, including both performance and vitality.

This study's framework distinguishes itself from prior research by (1) identifying the “pace of digital transformation”, a dynamic measure, as positively impacting team effectiveness, (2) underscoring the mediating role of “adaptive response” in enhancing team effectiveness, (3) emphasizing the moderating effect of technology preparation on the entire mechanism, and (4) focusing on lower-level teams as the smallest organizational production unit, considering the dual-level behaviors of individuals and teams.

The insights from this study deepen our understanding of worker mentality, behavior, and performance during enterprise digital transformation, offering guidance for strengthening production foundations, nurturing high-quality industrial workers, and facilitating successful digital transformation initiatives.

***Keywords*:** digital technology, pace of digital transformation, adaptive response, team performance, team viability

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While overseeing the company's operations and a myriad of public welfare activities, I have successfully managed to complete this paper. I express my sincere gratitude to our valued customers, dedicated teams, supportive supervisors, esteemed alumni, and loving family for their steadfast encouragement. With over two decades devoted to management consulting, I have keenly observed the profound impact of digital technology on enterprises. Many managers, myself included, grapple with the challenge of harnessing digital tools to enhance efficiency while maintaining operational stability and ensuring intrinsic safety within the enterprise.

The transformative power of digitalization extends beyond large enterprises with substantial financial resources and high technical thresholds. During my interactions with alumni enterprises, I was astounded to witness parallel changes unfolding across traditional industries such as fashion clothing and real estate. I am immensely grateful to our customers and Ms. Qian Xiaoyun for providing invaluable data from hundreds of teams and allocating resources to assist in testing, distributing, collecting, and validating questionnaires. It required seven months of dedicated effort and the involvement of over 10,000 individuals to establish the data foundation for this study.

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Introduction

With the rapid development and application of digital technologies such as cloud computing, Internet of Things (IoT), and artificial intelligence (AI), enterprise digital transformation has become the most talked-about subject in the industry. However, in recent years, the majority of research in this field has concentrated on macro aspects, such as the influence of digital technology on total employment and employment structure. Few studies have delved into how grassroots employees perceive and adapt to the permeation of digital technology and the responses they are likely to generate. Based on the trajectory of organizational change research, the paradigm in studying grassroots teams is evolving from a unidirectional and static Input-Process-Output (IPO) model to a bidirectional and dynamic Input-Mediator-Output-Input (IMOI) model paradigm. There is a growing focus on the cognition, feelings, and subjective agency of grassroots employees, along with the repercussions stemming from the intricate and ever-changing team environment. Therefore, through the lens of management psychology, this study constructs a theoretical framework integrating the Adaptive Response Model (ARM) and the Technology Acceptance Model (TAM). It elucidates the mechanism through which the speed of digital transformation influences team performance and vitality, with adaptive response serving as an intermediate variable. The study also explores the boundary conditions within this framework. This study tracked 700 teams undergoing digital transformation to empirically test the theoretical model.

This dissertation consists of five chapters. In chapter I firstly outline the evolution and adoption trends of digital technology. Within the power industry, where I have extensive experience, it assesses the scale of team members likely impacted by digital technology upon its integration into enterprises. Additionally, it reflects on insights gleaned from interviews with grassroots production management personnel in enterprises during their daily work. According to the background, the research questions are put out and the scope and objectives of the study are explored and delineates.

Chapter II starts from the problem and navigates through a review of pertinent literature to consolidate existing research in the field. Initially, I reviewed relevant studies on the impact of digital transformation on organizations in recent years and found that most of them focused on macro analysis of total employment and structure. In recent years, China has shown a greater focus on research into digital technology compared to other countries. As the wave of informatization spread across industries in the latter half of the previous century, prominent academia had already undertaken substantial studies on the impact of information technology (IT) on organizations. Consequently, I examined and deliberated on the literature through the lenses of organizational change theory and team adaptability theory, introducing key notions like "adaptive response" and "team effectiveness."

Chapter III delves into the relationship mechanism between digital transformation speed and team vitality and performance, establishing the theoretical framework of this study by drawing on the research findings of ARM and TAM. Beginning with the dynamic shifts of change, this paper examines the effects of "change speed" through a dynamic lens, forming the central mechanism from individual cognition and behavior to team attitude and performance. It also investigates how "preparedness for digital transformation" influences this mechanism. Building upon existing literature and logical deductions, this study presents specific research hypotheses and corresponding comprehensive theoretical models. Then I detail the quantitative methods employed to address the research questions in this study. The data, collected from the power industry and the women's fashion manufacturing sector, followed 700 digital-technology-influenced teams through three questionnaires conducted at intervals of two months. All scales used in this study are well-established. This chapter elaborates on the fundamental principles of data collection methods, the chosen samples, and the procedures for measuring variables.

Chapter IV reports the empirical analysis and results of this study. Following a delineation of the general steps in hierarchical regression analysis, this chapter proceeds with descriptive statistics, encompassing means, standard deviations, and correlations for all variables employed in the analysis. Lastly, this chapter presents the hypothesis test results of the main effect model, mediating effect model, and moderating effect model.

Chapter Ⅴ concludes with a review and discussion of the results, implications, and conclusions. I re-examined the original purpose of this study, conducted an in-depth discussion based on the data obtained in the previous chapter, and put forward theoretical and practical implications. Furthermore, I addressed the limitations of this study and provided recommendations for potential avenues for future research.

Chapter I: Research Question

1.1 Permeation of Digital Technology into Enterprises and Teams

The historical context of this study involves the ongoing industry discussions on digitization, intellectualization, and smart technologies in recent years. The core of this reform lies in the fusion of digital technology with specific business, revolutionizing information transmission methods and speed, working processes, organizational structures, and business models.

Digital technology is a science and technology closely associated with electronic computers, referring to the technology that uses certain devices to convert various information such as graphics, texts, sound, and images into binary digits “0” and “1” that electronic computers can recognize, and then calculates, processes, stores, transmits, disseminates, and restores the information[1]. Digital technology encompasses IoT, 5G and mobile internet, edge computing, blockchain, cloud computing, big data, and AI. These elements facilitate crucial functions like material feature extraction, communication, processing, storage, restoration, and elimination in the physical realm. They have effectively advanced the efficient interconnection and intelligent optimization of diverse entities in the real world within the broad scope of digital technology through different manifestations, creating an evolving digital ecosystem.

In recent years, digital technology has transcended the confines of the laboratory and significantly expanded its presence across diverse industry sectors. It has found widespread applications in energy, manufacturing, finance, healthcare,

[1] Baidu Baike. https://baike.baidu.com/item/%E6%95%B0%E5%AD%97%E6%8A%80%E6%9C%AF/6539139? fr=aladdin

security, driving, search, education, and more. This integration has led to gradually establishing a comprehensive digital economy industry chain. Since “Digital China” was established as a national strategy in 2021, China has continuously made clear arrangements to accelerate the construction of digital economy, society, and government, with the goal of building a favorable digital ecology. Currently, almost all industries and enterprises assert their commitment to digital transformation and upgrading. Digital technology is not just about reforming and enhancing existing management systems; it also extends its reach into production teams, intensifying the integration with industry expertise and databases in particular industrial sectors. This leads to the creation of an industrial software platform that incorporates a variety of sensors, controllers, and communication devices. For example, within the manufacturing sector, intelligent robots and digital industrial control systems that rely on sensor technology, multi-modal human-computer interaction technology, and image recognition technology are driving advancements in the intelligent production capabilities of the industry. Digital assembly lines and robots are extensively employed across the four key manufacturing stages, including the new energy vehicle (NEV) stamping production line, body center, paint center, and assembly center. Leveraging IoT technology enables capabilities such as status monitoring and abnormity warning for vehicle post-sales operations. This, in turn, delivers precise and quantitative benchmarks for post-sales services. IoT and various other technologies are extensively applied in fundamental operations like transportation, warehousing, distribution, packaging, loading, and unloading, facilitating efficient management of the cargo transportation process, enhancing service quality, and decreasing labor costs.

A team is the smallest organizational unit within production departments such as factories, categorizing workers based on work type or production variety. It consists of individuals performing the same, similar, or diverse tasks who collaborate during the production process. Through the division of labor, these workers contribute collectively to production activities[2]. Team management serves as the foundation of production management. The management standards for production planning, quality, costs, work efficiency, safety, science and technology, and others can be reflected and executed within the team production process. The production team primarily consists of different "technicians" who are stationed in the factory, on construction sites, or en route to various locations to engage in basic productive labor. In contrast to project teams assembled for specific project objectives, the production teams typically exhibit more stability and possess a closer alignment with each other's skill requirements, often characterized as "blue-collar" workers. The integration of digital technology with specific business operations not only furnishes safer and more efficient production tools for team members but also instigates alterations in processes and responsibilities, along with various psychological impacts.

1.2 Application of Digital Technology in Production Teams in the Power Industry

The power industry was taken as an example. Enterprises within the industry have been actively promoting the research and application of digital technology since 2016. The State Grid Corporation of China (State Grid) released the *White Paper on Intelligent Operation and Maintenance* in December 2016, while China Southern Power Grid Co., Ltd. issued the *Application Route Plan of Intelligent*

[2] Baidu Baike. https://baike.baidu.com/item/%E7%8F%AD%E7%BB%84? fromModule=lemma_search-box

Technology in the Production Field (renamed from “intelligent technology” to “digital technology” after 2021) in March 2018. This plan consists of three key stages: modeling, information integration, and extensive application, with the aim to digitize equipment, standardize data, and implement a data-driven approach to establish a digital operational environment characterized by comprehensive perception, thorough connection, complete scenarios, and full intelligence. The ultimate goal is to enhance quality, improve efficiency, and ensure inherent safety in production.

Enterprises in the power industry have embraced “digital technology,” as shown by the remote meter reading system having replaced manual meter readers, UAV patrols and line fault image recognition systems supplanting line inspection teams, and operation support platforms set to replace on-site operational staff in the future. The diversity and ongoing advancements in digital technology within the production sector highlight the long-term commitment involved in this field.

Throughout history, technological advancements have consistently prompted shifts in careers. For instance, in the late 19th century, automobiles replaced horse-drawn carriages, leading many coachmen to seek alternative employment. Similarly, in the 20th century, the popularization of IT saw ATMs replacing human cashiers for deposit and withdrawal services. With the development of digital technology, information systems have progressed to more sophisticated and intelligent levels, expanding into more unconventional domains. This includes the use of chatbots for customer service for information consultation, as well as text robots for the initial screening of bidding documents. However, the more intricate the task necessitating experience accumulation and intelligent judgment is, the longer it takes for machines to learn and build a database of samples. This results in a heightened reliance on engineers/technicians for ongoing optimization and adjustment of system model algorithms. Therefore, during the digital transformation across various sectors and the continuous digital transformation in enterprises, it is imperative to acknowledge that the journey involves a long-term process of human-computer interaction, human-computer integration, gradual substitution, and mutual reliance. The well-established remote meter reading system in the energy sector is used as a case study. The centralized meter reading system has been in operation for over 20 years. Evolving from mechanical to electronic meters, and transitioning from manual access to distribution boxes to direct readings by the prefectural/municipal bureau’s centralized meter reading system, the scope of meter reading responsibilities has progressively encompassed reading, verification, billing, and operation and maintenance of centralized meter reading systems. The impact is not limited to enhancing the efficiency of “meter reading,” more significantly, it has advanced from a bi-monthly reading to a reading frequency as frequent as every five seconds (adjustable intervals), setting the groundwork for implementing time-of-use and step tariff strategies. Over 20 years, the digital electricity meter paired with a centralized reading system has progressively taken over the role of traditional meter readers. However, “metering” continues to be a constant presence, evolving into a task for customers within the realm of digital energy.

According to a study by L. Wang et al. (2022), approximately 19.05% of China’s workforce currently faces a high risk of job displacement due to AI. Industries like mining, manufacturing, and construction are at greater risk of displacement, while sectors such as scientific research, technical services, and education are at a lower risk of substitution[3]. Out of China's national employed population totaling 746.52 million individuals[4], approximately 140 million people are anticipated to be impacted by digital technologies like AI. Take China Southern Power Grid as an example, which has 300,000 employees. With the implementation and promotion of existing digital technology in the production field, 118,000 employees will have their job responsibilities changed and transformed. The five provinces/regions where China Southern Power Grid provides services make up 19.3% of the national population. Consequently, it is reasonable to assume that the job responsibilities of 493,000 team members in the national power industry may undergo changes and transformations with the advent of digital technology.

1.3 Findings from Interviews with Production Manager and Teams in the Power Industry

In the process of integrating digital technology with power production tasks, there is a long period of synergy between humans and intelligence. For example, at the end of 2021, China's first substation constructed by construction robots was officially put into operation. The project is a key physical project to promote the digital transformation of power grid infrastructure projects. To maximize the operational efficiency of construction robots, the civil engineering team collaborated silently with the robots. Concurrently, they needed to reduce the working hours and workspace of the primary installation team, secondary

[3]Wang L., et al. AI Technology, Task Attributes, and Career Substitutability Risk: Empirical Evidence from the Micro Level. *Management World,* No. 7, 2022
[4]The Ministry of Human Resources and Social Security of the People's Republic of China. *The 2021 Statistical Communiqué on the Development of Human Resources and Social Security*. June 2022

installation team, relay protection team, and high-voltage test team. The successful delivery of this groundbreaking project was made possible by over 50 employees from four specialized teams, who took turns working round-the-clock for 41 consecutive days, sometimes catching moments of sleep against the wall and sliding down in exhaustion. The team members are not talkative. When planning for future substation constructions with construction robots, they simply smiled and responded with a silent nod, or answered, “Do as the leader says.” Unfazed by and indifferent to thoughts of being “replaced” in the future, they instead reveled in pride over their achievement of completing the substation’s electrical works in record 40-plus days.

In mid-2022, I conducted interviews with grassroots production management staff at a power company, discussing the influence of digital technology on teamwork. I actively engaged in various work activities alongside the grassroots teams in civil engineering, substation operations, substation relay protection, transmission operations and inspections, and distribution network operations and maintenance. By combining interviews and firsthand observations, I aimed to grasp their perspectives and attitudes toward digital technology. The interview framework is focused on pre-conceived information considerations and includes three main sections. The notes from the four interviews are detailed in Appendix 2.

Interview outline is as follows:

1. Nature of technology

(1) How do interviewers describe their perception of this technology? What is the essence of this technology?

(2) What do they think digital technology is? Which fields and depths related to their work may change?

(3) The relationship between technology and people?

2. Strategy of digital transformation

(1) When is the best time to introduce it? Maturity of technology/urgency of organization’s needs/requirements of superior or environment...

(2) What kind of transformation path? Gradual deepening of small-scale pilots/Thorough development of small-scale initiatives/Implementing selective rollout based on observations from other regions/Expeditious scaling up...

(3) What nodes/positions are critical?

(4)What problems are likely/have been encountered and how have they arisen? How to deal with them?

(5) What do other people around think of this technology?

3. Achievements of digital transformation

(1) Who is using it? How is it used? What changes happened, such as organizational structure or business process or management relationship or technical rules, etc.

(2) What is the impact on employees in different positions? What are the benefits of each?

(3) What is the impact on team/unit/society? Positive/negative

(4) What is the possible change trend of effectiveness?

(5) How can it be maintained or improved?

Findings of interviews and on-site observations

1. While all managers concur on the path toward digitalization, significant disparities exist regarding the pace of implementation. Those with high hopes for digital technology advocate its swift implementation. Despite present challenges, they believe it will substantially boost labor productivity and alleviate their future

work intensity. There are practical advantages in early implementation. Initially, upon project approval, substantial funds can address not just digital transformation but also existing issues like aging equipment and infrastructure. Secondly, coordinating numerous suppliers simultaneously introduces them to new technologies, enhancing their skills, fostering a sense of accomplishment in work, and highlighting role importance. Moreover, digital transformation can lead to patent generation and publication of papers, bolstering promotions. Lastly, if your unit serves as a digital transformation exemplar, it stands to bring both acclaim and fortune to the entire team by meeting senior management's expectations. Another faction asserts that in the power industry, ensuring safety and stability must take precedence for enterprises. Given the relatively new nature of the technology, along with the lack of significant results in certain pilot projects, enthusiastic investments can lead to wastage and impact unit performance metrics. Their strategy involves a wait-and-see approach for evaluation before gradually advancing. Certain individuals believe the lack of clear effect stems from unsystematic technology implementation. They advocate for hastening technology dissemination and launching concentrated efforts in specific regions to realize scalable benefits. Additionally, the delay in adjusting organizational modes and workflows exacerbates the situation. Although the technology meets the criteria for remote inspection, operation, and safety control, traditional practices still necessitate on-site staff presence. Thus, concurrent efforts are needed to implement the technology and adjust organizational patterns accordingly.

2. Digital transformation initially results in an increased workload for team members. As most digital technologies must be implemented at the grassroots level, team members are mandated to collaborate in equipment transformation,

installation, commissioning, and maintenance of diverse sensors and controllers. On the one hand, they must fulfill existing responsibilities; on the other hand, they are tasked with supporting the integration of digital technologies and undergoing training on AI algorithms post-implementation. This results in a workload that is 1-3 times higher than that before digital transformation.

3. Most team members do not show initiative or resist the adoption of digital technology. Team members are not averse to the notion that digital technology might “replace” them. Their lack of initiative stems from the fact that integrating new technologies increases their workload without yielding immediate performance benefits. Consequently, if they have yet to integrate digital technology in their workspace, they remain uninterested and choose to evade rather than actively engage and learn about it. However, as the team gears up to engage in digital transformation, they exhibit exceptional obedience and adaptability, even showcasing great enthusiasm and a positive attitude. They do not fear being replaced. On the one hand, central state-owned and other state-owned enterprises are unlikely to dismiss employees voluntarily. On the other hand, they take pride in their skills. Mechanics, especially seasoned ones, are in high demand in the job market. Lastly, team members collaborate closely, forming strong bonds and feeling a sense of psychological security, thus not perceiving the future as daunting. Team members in private enterprises are often connected by fellow townsmen and clan relatives, a particularly prominent connection.

4. There is a shared belief that digital technology and people coexist harmoniously. To fully leverage the effectiveness of digital technology, it is essential to integrate digital transformation with the change of the production organizational mode. In the sequence of events, digital transformation precedes the

adjustment of the production organizational mode. It is imperative to reconfigure the workspace and processes, considering factors such as technology's safety, availability, and capability. Additionally, the team's size, skill set, and learning capacity must align with these changes, necessitating thorough preparations beforehand.

1.4 Question Formulation

Based on extensive experience collaborating with team members and interviews with managers, it is widely accepted that digital transformation and application are inevitable. One significant debate revolves around the pace of this change: Whether it should be accelerated ('enduring sudden pain is better than long pain') or gradual ('maintaining safe and stable production'). Speed, a crucial aspect of the change process, prompts an important question: How does the pace of digital transformation influence team vitality and performance? What is the underlying mechanism? What factors will affect the mechanism?

As a large manufacturing country, China is promoting digital transformation. Theoretically, the replacement of technology will lead to the overflow of a large number of skilled workers. In reality, we are facing a significant shortage of skilled workers, particularly those possessing hands-on expertise. It is an important responsibility for business managers to successfully lead the enterprise's transformation and upgrade by studying how digital transformation influences the operational efficiency of teams and how managers, based on human cognition and team adaptability theories, can enable people and technology (machines) to coexist within the enterprise's value network, not only symbiotically but also collaborating with each other. At the same time, an increasing number of enterprises are reluctant to disband entire departments or teams due to technological advancements, viewing it as a way to assume social responsibility and maintain workforce stability. They are keen on understanding team members' potential reactions and are exploring methods to adapt the organizational model based on employee responses. Therefore, this study holds universal and practical significance.

Enterprises' digital transformation and upgrading represent a comprehensive and profound productivity overhaul. Teams, as grassroots entities, are responsible for implementing diverse technologies, and utilizing new materials, processes, and equipment to achieve process optimization and enhance effectiveness. Prior research largely concentrated on the macro level, examining shifts in industrial structures and workforce transitions. Additionally, enterprises were analyzed as research subjects to investigate the effects on enterprise performance, organizational structure, power dynamics, and more. There is a lack of in-depth research on teams, facing challenges such as tightly-knit team management at the grassroots level, heavy reliance on personal experience for management and emotional upkeep by team leaders/foremen, limited interaction with academic circles, and significant hurdles in collecting information.

Understanding the response of grassroots teams also helps fortify the foundation of enterprises and cultivate high-quality industrial workers. At present, the application of digital technology has emerged as a focal point across various industries. In many instances, technology doesn't supplant the presence of teams but rather equips team members with more robust production tools. Human-machine symbiosis and integration are poised to persist over the long term and become ubiquitous. However, in reality, digital transformation will also impact the original working mode. As individuals with subjective initiative, grassroots employees will inevitably react to such an impact. Managers should not only monitor alterations in the task processes but also possess the ability to comprehend the responses of grassroots personnel and help them swiftly adapt to these changes. DBA papers should intertwine contemporary social phenomena with management theories, encompassing insights into the profundity and complexity of human nature, while upholding stringent logic and mathematical elegance.

1.5 Research Scope

This study focuses on production-oriented teams mainly from the power industry, along with some teams from clothing manufacturing enterprises. These subjects were chosen for three reasons. First, having worked in the power industry for over 20 years, I have established convenient professional contacts across all levels. The regulatory operations of the power company primarily focus on work safety and involve a substantial team. Second, as the "national team" tasked with steadfastly executing national strategies and implementing digital transformation, power companies have allocated RMB tens of billions annually over the past five years towards digital enhancements. In the upcoming five years, they plan to invest over RMB 100 billion to expedite the digital transformation process further, aiming to effectively meet digital production needs. Within the power industry, certain areas have fully achieved "digitization," such as the centralized meter reading system, which has entirely replaced manual meter readers. Additionally, ongoing "digitization" efforts can be observed in activities like drone inspections, poised to significantly diminish the number and tasks of line inspectors. Furthermore, there are sectors prepared for "digitization," including the substation operation platform and one-key sequence control technology, capable of substituting routine patrol inspections and enabling remote operations. In the future, these technologies are anticipated to replace a majority of substation operators. In the power industry, there are diverse digital technologies with broad applications and substantial impact on teams, facilitating observation and data collection. Third, despite clothing manufacturing being a traditional industry, many large-scale enterprises are embarking on digital transformation, such as visualization and collaborative RandD and design, automated production scheduling, digitization of factory production, intelligent store monitoring, hot product prediction, supply chain collaboration, and MES integration. Some alumni enterprises have showcased outstanding accomplishments in this domain. Therefore, this research also encompasses clothing manufacturing teams from women's fashion wear enterprises, which have implemented flexible production/supply chain management systems and are further refining design, patterning, and clothing manufacturing processes.

1.6 Research Objectives

This study aims to investigate how the pace of digital transformation influences team behavior outcomes (performance) and members' emotions (team vitality). It aims to uncover the underlying reasons behind this phenomenon, identify the transmission mechanism, analyze factors influencing this mechanism, and provide guidance for enterprises to successfully implement digital transformation while integrating digital technology within their organizations and with team members.

Chapter Ⅱ: Literature Review

In recent years, out of more than 140 domestic and international papers published in core economics and management journals which have delved into keywords like “digitization,” “digital technology,” “AI” and “digital transformation,” over 70% primarily investigate how technology impacts total employment and employment structure at a macro level. In contrast, other research emphasizes the influence of technology on organizational performance, organizational climate, and employee behaviors and attitudes. Given the substantial research on organizational transformation stemming from the entry of IT into enterprises in the last century, this study focuses on grassroots teams. This chapter also revisits the key viewpoints and evolving trends in organizational change theory. This study centers on the psychological feelings and behavioral responses of team employees toward digital transformation. Therefore, it also reviews existing research on team and individual cognition, reactions, behaviors, and performance.

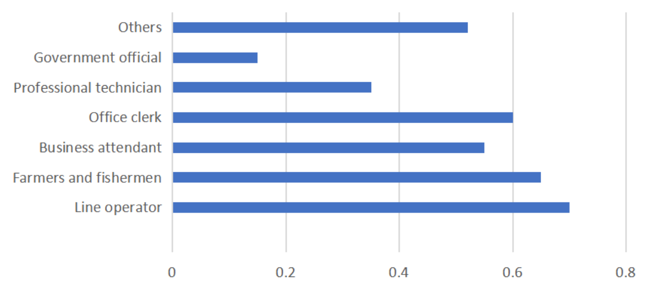
2.1 Research on the Impact of Digital Transformation on Organizations in Recent Years

2.1.1 Macro-level Impact

The majority of studies suggest that digital technologies, such as AI, have a significant and enduring impact on total employment and employment structure. Digital technology primarily influences labor demand through the “employment substitution effect” and the “inhibitory substitution effect.” The overall impact on total employment hinges on the intensity and scale of these two effects. The intensity of these two effects exhibits clear heterogeneity across space, time, industrial structures, and social cultures. AI impacts laborers diversely in distinct regions, economic development stages, industrial frameworks, and social and cultural contexts. As a result, the magnitude and direction of the total effect remain uncertain.

Digital technologies can directly replace labor in three ways. First, the use of digital technologies such as automation, information and communications technology (ICT), and AI can directly replace some parts of the workforce. Second, the digital economy has revolutionized the circulation of goods, leading to the elimination of jobs in the intermediary stages of traditional commodity circulation. Third, the digital economy has hastened information transmission, diminishing information asymmetry in the market and directly influencing traditional intermediary industries. Traditional labor-intensive intermediary services, historically reliant on human resources, are gradually being replaced by emerging technologies such as the internet and big data. This transformation significantly reduces the demand for labor in traditional intermediary industries. A study by Deng Z. and Huang Y. (2019) revealed that digital technology has a notable substitution effect on employment within three key areas: simple and repetitive mental labor jobs, moderately complex and repetitive mental labor jobs, and roles that involve a combination of physical and mental responsibilities. A large number of studies have concentrated on examining the potential risk of labor displacement across various industries, occupations, skill levels, and other sectors, such as

Figure 1. The potential displacement risk of different occupations workers by AI technology



Gong and Peng (2020) (Figure 1).

The ongoing advancement of the digital economy can yield positive spillover effects, continually generating new employment opportunities, thereby producing an inhibitory substitution effect. The inhibitory substitution effect can be further divided into the labor compensation effect and the labor creation effect. The labor compensation effect entails the continuous expansion of industrial scale via digital technology enhancements in enterprise production efficiency. This counters the decrease in job output per unit through a scale effect. It primarily comprises the following three mechanisms: Firstly, digital technology drives productivity enhancements, leading to a rise in demand for labor difficult to replace via digital means, thus aligning with replaceable aspects within production efficiency enhancements. Secondly, as production efficiency improves and enterprise costs steadily decrease, enterprises possess the resources to engage in reproduction. The increase in production lines or business units will inevitably boost the demand for labor. Thirdly, the enhancement of production efficiency lowers production costs and product prices. The increase in consumers' income leads to a rise in demand for products and services, expanding the market size and eventually stimulating the growth of job opportunities. The labor creation effect signifies that the digital economy will significantly influence traditional production methods, giving rise to new industries, new business formats, and new job opportunities.

2.1.2 Impact on organization

Numerous studies, through various observation angles and mechanisms, suggest that digital transformation in enterprises, on the whole, enhances the quality and efficiency of organizations. The implementation of digital management is instrumental for enterprises in enhancing their sustainable competitive advantages (Benner and Waldfogel 2020; Bruce et al. 2017; Li K.et al. 2015; Ross et al. 1996), boosting financial performance (Jeffers et al. 2008; Ning and Lin 2014; Zhang et al. 2016), and elevating organizational efficiency (Cui et al. 2013; Johnson et al. 2017; Zheng et al. 2016; Zhou and Wan 2016). Enterprises drive management reform by digitizing crucial operations, processes, and components, hastening the pace of business model innovation, and amplifying their agility and responsiveness to market fluctuations (Mikalef and Pateli 2017; Yuan 2017). He and Liu H. (2019) utilized a shares data from 2012 to 2017 to explore the impact of digital transformation on the performance enhancement of entity enterprises. It is found that the digital transformation of enterprises has improved the quality and efficiency of operations in the real economy. This has led to the identification of a channel mechanism focused on “cost reduction,” “efficiency enhancement,” and “innovation reinforcement” (Liu J. 2019). This transformation can break down industry barriers and promote cross-border competition among enterprises (X. Zhang et al. 2019). Huang Q. et al. (2019) examined the influence of internet development on manufacturing productivity. Their research, which analyzed the impact across the dimensions of cities, industries, and enterprises, revealed that internet development notably enhances the overall productivity of cities and the manufacturing sector. Importantly, they found that the effect on manufacturing productivity surpasses its impact on urban productivity as a whole. According to Miklós-Thal and Tucker (2019), leveraging algorithms, machine learning, and AI prediction can enhance the accuracy of consumer demand predictions. This improved precision can ultimately drive down product prices and elevate consumer surplus. Fu et al. (2021) discovered that digitizing the processes of incumbent enterprises can notably enhance innovation performance. They observed that a greater level of data sharing strengthens the positive relations between process digitization and innovation performance. Additionally, corporate affiliation was found to diminish this relationship between the aforementioned two, while state-owned investment was shown to amplify the positive association between process digitization and innovation performance in incumbent enterprises. Zhao (2021) believed that digital development has the potential to indirectly stimulate the service-oriented transformation of enterprises by enhancing innovation capabilities and optimizing the human capital structure. An analysis of the service-oriented transformation quality of digital enterprises reveals that digital advancements can enhance the net profit margin on sales, per capita output, and earnings per share of enterprises, and achieve performance improvements and value addition through service-oriented transformation, thus fostering high-quality development of enterprises. Wu F. et al. (2021) suggested that the digital transformation of enterprises can mitigate information asymmetry, elevate market investors' expectations, optimize the enterprise innovation input-output equation, and ultimately enhance the quality and efficiency of enterprise operations. These advancements are conducive to improving the liquidity of corporate stocks. While enterprises innovate or change their products, management, and business models, digital technology strengthens innovation and restrains conflicts (Lyytinen et al. 2020; Xie K. et al. 2020).

The correlation between digital technology investments and effectiveness is not linear and it can even lead to negative outcomes like decision-making paralysis within organizations. Liu S. et al. (2021) discovered that in digital transformation, the elasticity of capital output in enterprise management surpasses that of labor output. They also observed that the influence of these inputs on digital benefits evolves with time. Moreover, the investment efficiency of digital transformation projects exhibits distinct heterogeneity, generating corresponding progressively increasing or decreasing effects as the scale of the enterprise expands. Further research indicates a nonlinear correlation between enterprise digital investment and efficiency, with a pattern of first declining, then accelerating towards a decline until reaching an inflection point, followed by an increase, resulting in an inverted "U-shaped" relationship post the inflection point. In the process of digital transformation, enterprises frequently encounter elevated levels of uncertainty and ambiguity resulting from inadequate understanding and prediction of new technologies, products, and market responses (Matt et al. 2015). This ambiguity can potentially lead to a standstill in the organization's decision-making apparatus (Lüscher and Lewis 2008). The digital divide increases the collaboration challenges (Chen et al. 2018; Dodson et al. 2015; Grewal et al. 2019; Han et al. 2014; Rao et al. 2008; Wu X. et al. 2017), diminishes efficiency (Jacobides et al. 2018), and reduces the agglomeration of innovation resources and factors (Zeng et al. 2018). Organizational accountability in the digital age is expected to be heightened as entities are afraid of reputational damage from negative reports (Kim et al. 2015). Karunakaran (2019), in a 24-month ethnographic field survey combined with historical and quantitative analysis, revealed that digital organizational accountability heightens risk aversion among frontline professionals, erodes their role identity, strains the relationship between organizations and the public, and ultimately constrains resources available to the public. The research results show that these interconnected dynamic processes might culminate in a vicious cycle, potentially resulting in the deterioration of the organizational sense of responsibility.

2.1.3 Impact on employees

Studies have shown that digital transformation will affect the cognition, emotion, and behavior of employees in a diverse way. Technology has altered the employment landscape, rendering employees more mobile and flexible. Individuals can now operate within various organizations as full-time, part-time, and casual workers, or work in teams from any location at any time (Sivathanu and Pillai, 2018). Ellmer et al. (2019) performed crowd sourcing participatory observation and literature analysis on six digital platforms in Germany. They developed a theory on how digital platforms manage crowd-workers. Their findings suggest that while crowd-sourcing has emerged as a prevalent work model, it exerts limited influence on critical platform operations, highlighting the constraints on platform engagement in the digital era. In addition, data technology helps improve the coordination efficiency among individuals and between individuals and digital technologies. Human resources managers utilize algorithms and other methods to execute human resource process management, enabling task assignment and performance management without face-to-face interaction (Duggan et al. 2020). This significantly enhances the efficiency of human resource management. Another example is how organizations leverage big data and associated algorithms to acquire insights into employees' backgrounds, work statuses, relationship networks, and other relevant information for talent analysis and personnel decision-making. AI-powered performance management systems utilize real-time data to offer immediate feedback to both employees and companies (Abdeldayem and Aldulaim 2020). Data-centric human resource management (HRM) processes help eliminate biases in performance assessment (Hacioglu 2019).

In general, fewer studies highlight the positive impacts of digital technology on employees compared to those emphasizing its negative effects. For instance, Maslach and Leiter (2008) argued that organizations using digital monitoring technology may diminish employees' job autonomy, potentially leading to job burnout. Implementing monitoring systems can reduce employees' autonomy and intrinsic work motivation (Arnaud and Chandon 2013). Jeske and Santuzzi (2015) indicated that digital monitoring negatively affects employees' job satisfaction, affective commitment, self-efficacy, and sense of control. The replacement of traditional roles by digital transformation exacerbated the potential loss of employee autonomy, lowered wages, reduced decision-making rationality, and increased organizational risks and social instability (Arntz et al. 2016). The allocation of job functions between humans and robots, trust issues, and other factors make HRM more complex (Li Y. et al. 2020).

Xie X. et al. (2021) systematically reviewed pertinent studies on the utilization of digital technology in HRM, employing structured theory and actor-network theory. They contended that current research overlooks the structural shifts instigated by technology and the interplay between employee reactions, while most approach the topic unilaterally from technology to employees. There is a deficiency in exploring how the two sides can be merged from a holistic standpoint. There is also an inadequate focus on the theoretical and empirical underpinnings of the potential competitive dynamic between AI and human intelligence.

According to current research, China has shown considerably more focus on digital technology research compared to other countries in recent years. This is evident in the robust growth of the digital economy in China, with emerging business matching or even surpassing the breadth and depth of application seen in many Western countries. Additionally, during the second half of the last century, extensive studies were carried out on how IT (such as e-mail, the internet, information management systems, and automation systems) influenced various industries as the wave of informatization swept across different sectors. This paper will deepen research on the micro-level effects of digital technology on employees and grassroots organizations. It will examine how employees perceive organizational change arising from technological advancements, their reactions, and their resulting behavioral outcomes through a psychological lens.

Many studies have explored the influence of “automation” on organizational teams. Schumacher (2016) determined when examining the manufacturing process that digitization and automation, although distinct, are intertwined concepts that should be collectively analyzed. According to Bloom (2018), “digitization” pertains to utilizing digital technology and data to alter or transform business processes to enhance income flux, cut costs, or improve services, while “automation” involves executing tasks or processes without human intervention. The terms exhibit noteworthy intersections. Therefore, whenever machinery/equipment (including computers) is harnessed not just to supplant human physical labor but also to assist or replace mental tasks in literature, and when coordination, management, control, and optimization of the man-machine interface and the overall system are needed to enhance task completion, even if the term used in the literature is “automation,” such studies will be deemed to hold a similar meaning to “digitization” and, accordingly, cited as a point of reference.

2.2 Organizational Change Theory and Related Research

2.2.1 Main theoretical basis, model, and evolution of organizational change theory

Organizational change refers to the implementation of new strategies, structures, technologies, and cultures within an organization to enhance performance, adapt to new market conditions, or address external challenges. Change is pervasive and inevitable in all organizations. In a broad sense, organizational change encompasses incremental alterations that occur during routine operations and are not part of the planned system, as well as purposeful and planned changes. It involves not only radical strategic shifts or organizational innovations but also gradual and evolutionary transformations within the organization (Meng et al. 2008).

The origins of organizational change theory can be dated back to Kurt Lewin's research during the 1940s. Lewin, a significant figure in social psychology and organizational change, introduced several pivotal theories and concepts. His well-known "unfreeze-change-refreeze" model (Lewin 1951) is commonly utilized to grasp the organizational change processes. This model underscores three fundamental stages of organizational change. The first stage is "unfreeze," which involves disrupting the current state and ensures that employees recognize the necessity for change. This is followed by the "change" phase, during which a new approach, structure, or policy is implemented. Finally, organizations need to "refreeze"—consolidate the new status and ensure that the change becomes permanent and irreversible. In addition, Lewin proposed the basic social field theory, emphasizing the influence of social environment on individual behaviors. He believed that individual behaviors are shaped by various factors within the social field, such as social stress, family, friends, and organizations. Lewin highlighted the importance of employee participation in decision-making and change processes, suggesting that involving employees can boost their acceptance of change, leading to a more successful change. Lewin's theories have had a profound influence on organizational psychology and change management. The unfreeze-change-refreeze model continues to be widely utilized in both research and application in organizational change. His research offers a crucial framework and mindset for comprehending the process of organizational change and promoting organizational innovation.

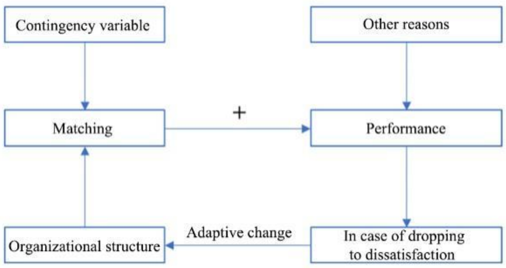


Figure 2 SARFIT Model

In the 1960s and 1970s, organizational change theorists started embracing a system perspective, highlighting the interconnected nature of all components within an organization and the importance of viewing them as a unified whole. This viewpoint underscores the significance of comprehending the intricate interactions among various components of an organization and how they influence the process of change. During this period, the far-reaching **contingency theory** gradually surfaced. Contingency theory holds that there is no one-size-fits-all approach to organizational change, emphasizing that the effectiveness of a change strategy depends on a specific context or situation. According to contingency theory, organizations should tailor their change strategies based on factors like the size, structure, culture, and external environment of the organization. Among them, Lex Donaldson, the most influential one, introduced the SARFIT (Structural Adjustment to Regain Fit, as shown in Figure 2) model following empirical studies conducted across five nations (Donaldson 1987). Donaldson and other researchers continually changed their perspectives to develop and enrich this theory.

The **resource dependence theory** emerged in the 1980s, primarily focusing on examining the influence of resource dependencies on organizational change. The theory posits that organizations must manage their relationships and dependencies with external stakeholders to acquire the resources required for implementing change. It underscores the significance of collaboration, consultation, and strategic alliances in driving successful change programs.

In the 1990s and early 2000s, strategic change management gained prominence as organizations acknowledged the necessity of aligning change initiatives with strategic objectives. Models like John Kotter's eight-step change model (Kotter 1995) and McKinsey's 7S framework offer structured approaches to change management, underscoring the significance of leadership, communication, and employee engagement. The eight-step change model also demonstrates Lewin's three-stage approach but with a more detailed progression. It includes creating a rationale for change and instilling a sense of urgency; building dedicated leadership and change facilitation teams; developing a vision and strategic initiatives; effectively communicating the vision to inspire action; identifying and eliminating potential barriers; achieving early wins to demonstrate progress; cementing gains and accelerating development; and institutionalizing change as new norms to sustain them. The 7S framework model highlights, from a system theory perspective, the importance for managers to address all components during organizational development and change management, encompassing strategy, structure, system, staff, style, skill, and shared value. These models provide a step-by-step process and tools for planning, executing, and managing change.

In recent years, **complexity theory** has emerged as a more detailed approach to understanding organizational change. It recognizes that organizations are dynamic, nonlinear systems with multiple interacting elements. Complexity theory suggests that change is an abrupt, unpredictable process influenced by various factors, including feedback loops, self-organization, and adaptation. It encourages organizations to embrace ambiguity, experimentation, and learning to effectively harness change.

The evolution of organizational change theory mirrors a shifting comprehension of organizational complexity and the acknowledgment that a universal approach to managing change does not exist. As researchers delve into new perspectives and approaches in light of the challenges and opportunities in organizational change, the field continues to evolve.

2.2.2 Development trends of organizational change research

First, research on organizational change has shifted towards a broader and more diversified perspective in recent years. This includes exploring the impact of organizational change on various stakeholders, such as employees, managers, shareholders, and customers. It will explore stakeholder roles, reactions, and responses to change initiatives, providing insights into the importance of stakeholder engagement and communication during the change process. In particular, the involvement of leaders and employees, such as transformation-oriented leaders who inspire employees during the change process, is regarded as a crucial factor. In addition, effective communication and stakeholder engagement are considered central to a successful change program. Several studies highlight the need for a clear and transparent communication strategy that provides timely updates, addresses concerns, and engages stakeholders actively in decision-making processes. Many organizations are adopting social media platforms, interactive forums, and virtual collaboration tools to enhance communication during change initiatives. Second, it is combined with psychological theories related to cognition and emotion. In this field, factors such as resistance to change and cultural barriers are discussed to reveal the psychological dynamics of change for resolving resistance and promoting smoother transition mechanisms and boundaries. The results show that employees' emotions, perception of fairness, and fear of the unknown significantly affect their responses to change. New approaches, such as emotional intelligence training and change-readiness programs, have demonstrated a positive effect in alleviating resistance and fostering acceptance of change. Third, digital technology acts as a tool or setting for change. Research emphasizes leveraging technology to enhance the change management process, utilizing AI and big data analytics to predict change outcomes and identify potential challenges. Additionally, change management is underpinned by agile methods commonly employed in software development. The iterative and collaborative nature of agile practices enables organizations to implement changes incrementally, adapt to evolving environments, and continuously learn from feedback. The research on digital transformation as a background or variable has been discussed in Section 2.1. Fourth, it emphasizes diversity and inclusiveness. It believes that diverse perspectives and inclusive decision-making can enhance creativity and problem-solving abilities, foster innovation, and alter implementation outcomes.

Most of the above reviews are related to research on planned changes initiated by enterprises. The extent of planning and the level of intensity are two crucial dimensions of organizational change. According to Porras and Robertson (1992), organizational change can be categorized into four types based on these two dimensions: developmental, evolutionary, transformational, and revolutionary (see Table 1). They further outlined intervention strategies for each type of organizational change and synthesized nearly 50 published evaluation findings of organizational development intervention measures.

Table 1 Types of Enterprise Organizational Change

		Extent of planning	
		Planned	Unplanned
Level of intensity	Progressive	Developmental	Evolutionary
	Aggressive	Transformational	Revolutionary

Since planned changes are typically instigated by enterprises, prior studies have predominantly encompassed multiple organizational levels, including enterprises, teams, and individuals from top to bottom. Following over a decade of research (2000–2013), Steve et al. proposed that two fundamental processes characterize the dynamic nature of organizational change across various levels within an organizational system: the top-down background effect and the bottom-up “emergence.” Top-down contextual effects pertain to lower-level phenomena that are constrained, sculpted, and impacted by higher-level phenomena. Bottom-up emergence denotes the dynamic interaction process among lower-level entities such as individuals, teams, and units. Over time, this phenomenon manifests at a higher collective level. “Emergence” remains present even in planned changes instigated from the top.

Kozlowski and Klein (2000) define multilevel emergence in organizational *behavior as a bottom-up process whereby individual characteristics and dynamic social interaction yield a higher level property of the group. A phenomenon is emergent when it originates in the cognition, affect, behaviors, or other characteristics of individuals, is amplified by their interactions, and manifests as a higher-level, collective phenomenon.*

As individual emotions become team actions, the “emergence” phenomenon is propelled by the dynamics of interpersonal communication and interactions, leading to the evolution of initial states into novel ones over time. In recent years, many studies have honed in on this domain, exploring how research method design, precise measurements, and the daily behaviors of organization members influence the development of organizational cognition (Orlikowski 2002). They have also delved into alterations in boundary relations among three professional groups with the introduction of new technologies (Barrett et al. 2012), as well as how team interaction patterns and individual inclinations impact teamwork and subsequently influence team performance (Grand 2016).

Within the same change context (e.g., digital transformation), a particular enterprise/group may have identical functional areas, yet the impact of the change differs significantly across various regions. While regional conditions vary, the crucial distinctions stem from diverse employees and inter-employee connections, leading to differences in cognition, abilities, and reactions. These discrepancies ultimately shape distinct organizational behaviors and outcomes.

2.3 Team Theory and Related Research

2.3.1 Development of team research paradigm

Alchain and Demsetz (1972) put forward the concept of “team production” in the *Production, Information Costs, and Economic Organization*. Later, many scholars defined "team" (Hackman 1987; Katzenbach and Smith 1993; Stephen 1994; Sundstrom et al. 1990). In summary, teams are formal groups with complementary skills, common purposes, and shared responsibilities. From crowds to groups to teams, member commitment and collaborative efforts are deepening, fostering more unified goals. In an enterprise, all work teams are groups, but only formal groups have the potential to evolve into work teams.

The most classic paradigm for analyzing team organizational behavior is the IPO model (Input-Process-Output), which has been used for more than 50 years and remains relevant today. The model considers over 30 input factors, including leadership, planning, information, and team objectives. It also examines various process states including employee/team cognition, reaction, knowledge acquisition, interactive memory, team conflict, team decision-making, collaboration and interaction, and action regulation. Additionally, it assesses output factors including team effectiveness, performance, satisfaction, and behavioral results.

Over the past two decades, with the increasingly complex and dynamic research on organizational behavior (described in Section 2.2.2), the one-way and static IPO model research paradigm has been greatly challenged. This paradigm ignores the effect of employee feedback and bottom-up emergence influence in teamwork. Moreover, it is not equipped to address research on the cyclical and dynamic development process of teams. For example, high-level LMX (leader-member exchange) can enhance team performance and deepen employees' affective commitment. In turn, a high level of affective commitment also substantially contributes to performance improvements in subsequent phases. Therefore, Marks et al. (2001) proposed a cyclical stage model, that is, the results of the previous stage in an IPO model are theoretically the antecedent variables for the subsequent next stage. Ilgen et al. (2005) introduced the IMOI model (Input-Mediator-Output-Input), which divides the team evolution into the IM team adaptability stage, the MO team operation stage, and the OI stage that concludes the current stage and triggers the subsequent one in chronological order. They also explored different morphological factors for each sub-stage and comprehensively discussed circular loop causality in team behavior. The IMOI model has been recognized and applied by many researchers in terms of necessity and operability, such as Burke et al. (2006), Langfred (2007), Tasa et al. (2007), and Mo et al. (2009). Under the IMOT paradigm, more attention is paid to phenomena presented in time sequence during the research process and data collection. This approach also enhances the ability to mitigate endogenous problems.

2.3.2 Behavioral research from the perspective of psychology

To truly comprehend human behavior, we must first gain an understanding of human cognitive processes. In the same organizational context, employees have different understandings of the current situation as a result of their distinct cognitive abilities and thus exhibit different reactions. Social cognition is a branch of social psychology. It refers to "*examining how people process, store, and apply information about others and social situations, as well as how people deal with information of members of the same species or from different species. This examination encompasses four critical stages: encoding, storage, retrieval, and processing. This approach focuses on the perception, judgment, and memory processes of social stimuli; the impact of socio-emotional factors on information processing and that of cognitive processes on behavior and interpersonal* *relationships"* (Bandura 1986 and Park et al. 2015). There are abundant studies and theories on cognition. Studies of human behavior focus on two main topics: One is about the acquisition process of behavioral skills or knowledge, which is represented by various learning theoretical systems; the other relates to the output or expression process of behavioral response, which is represented by various motivational theoretical systems.

Social learning theory (Bandura 1977, 1986) explores the influence of individual cognition, behavior, and environment on human behavior. It pays attention to the role of observational learning and self-regulation in inducing human behavior, as well as the interaction between human behavior and the environment. Complex human behaviors are largely acquired through learning. Behavior acquisition is not only restricted by genetic and physiological factors but also influenced by the acquisition experience and environment. The interplay between biological factors and learning experience in determining behavior is subtle and complex, making it difficult to separate the two factors. According to this theory, almost anything can be learned through two distinct processes: One involves learning patterns based on direct experience, and the other concerns learning patterns relying on indirect or vicarious experience. Social learning theory emphasizes the alternative experience gained through observational learning. The process of psychological matching includes the observational learning process, imitation behavior, and recognition behavior. In addition, leaders with greater power and higher status are more attractive, prompting followers to pay closer attention to the behaviors they exhibit as role models (Bandura 1986).

The motivation for action often stems from the anticipation of something or the desire to avoid something unpleasant. It is the intrinsic reason that drives people to engage in various activities (Tolman 1932). Locke (1968) argued that objectives are the decisive driving force of motivation. Vroom (1964) believed that people were always motivated to meet certain needs and seek to achieve particular objectives. When this objective has not been achieved, it is expressed as an expectation, and the objective in turn serves as a motivating force for personal motivation. The strength of this force depends on the product of valence and expectation. However, there are many different ways to achieve the purpose of an activity. Why does a person choose this one over the other? It depends on how people perceive the causality of things because they adopt means to achieve their objectives based on their understanding of the causality.

Fishbein and Ajzen (1975), scholars from the United States, put forward the theory of reasoned action (TRA), positing that humans are rational beings. According to TRA, before taking an action, individuals synthesize all kinds of information, deliberate on the implications and consequences of their actions according to their subjective norms and attitudes, and form behavioral intentions. Their individual behaviors can be reasonably inferred to a certain degree based on these intentions (Figure 3).

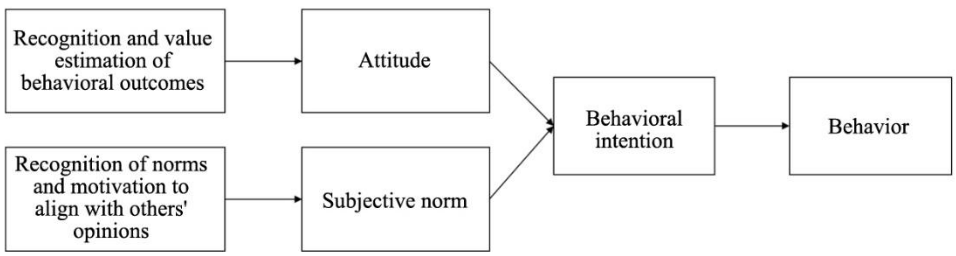


Figure 3 TRA Model

Behavioral intention is a measure of people’s intention to engage in a specific behavior. Attitude is people’s positive or negative emotions about engaging in a certain target behavior, and it is determined by the main belief in the outcome of the behavior and the estimation of the importance of this outcome. Subjective norms (subjective criteria) measure individuals' perceptions of how much influential figures desire their adoption of a new system. This assessment is influenced by trust in others' opinions on what should be done, coupled with the individual's motivation to align with group expectations. These factors combine to create behavioral intentions (propensities) that ultimately lead to behavior change.

2.3.3 Adaptive response model and technology acceptance model

In the process of organizational transformation, the organizational environment tends to be increasingly volatile, resulting in a series of events, such as new needs for skills due to shifting work tasks, along with changes in collaborative personnel, the relationship between superiors and subordinates, the working environment, and evaluation standards. When these changes clash with employees' personal work cognition/habits, it is natural for employees to experience a range of emotions. They will judge the specific content and possible trends of these events and then adjust their attitudes and behaviors to adapt to this dynamic organizational environment, that is, to generate an adaptive response. The adaptive response model (ARM) (Griffeth 1999) describes how employees adapt to organizational transformation. Burke et al. (2006) believed that a team's adaptive response was a functional response of the team to environmental changes, which is manifested as innovation or adjustment based on existing structures, abilities, or behaviors guided by cognitive objectives. This encompasses adaptive behaviors and beliefs that people use to cope with job developmental tasks and change work and occupational conditions (Hirschi et al. 2015). The existing studies mainly build the ARM model from three aspects: the initial events that trigger employees' reactions, the analysis of different types of employees' responses to these events, and the behavioral results and impacts of employees' adaptive responses. There are four common types of adaptive responses: solving problems, seeking feedback and information, learning and experimentation, and modifying roles and processes. These include cognitive, behavioral, and interpersonal relationship adjustments by team members in response to evolving circumstances.

Employees/teams are capable of producing adaptive responses to changes, but teams exhibit varying levels of adjustment and adaptation abilities within a dynamic and complex environment. These abilities are referred to as team adaptability (Griffin 2007). Griffin (2007) pointed out that traditional performance research was based on a relatively fixed environment and clearly defined work tasks, emphasizing that employees' proficiency significantly influences their job performance. However, in a dynamic organizational environment, job roles become broader, with increased penetration and dependence among job tasks. The adaptability and initiative of teams have a more explicit and positive impact on performance. Griffin (2007) conducted a detailed discriminatory measurement of the proficiency, adaptive behaviors, and initiative behaviors of team members as part of an in-depth study of job role performance in a context full of uncertainty and interdependence. This led to the creation of nine sub-dimensional models for job role performance. The measurement of adaptive response is based on two levels: individuals' task-adaptive behavior and team members' adaptive behavior.

The adaptive response of teams is the basis for many team functions, such as dealing with performance obstacles, producing innovative solutions to problems, and adopting new working practices (Deng J. 2011). Rudolph (2017) found in a study on occupational adaptability that occupational adaptability is positively correlated with adaptive response. Furthermore, adaptive response was found to moderate the positive relationship between adaptation and its outcomes.

Several studies have explored factors that influence teams' adaptive responses. For example, highly shared information and open communication drive teams to exhibit larger and more flexible adaptive responses in a changing environment (Marks et al. 2001). Additionally, transformation-oriented leadership has a more positive impact on teams' adaptive behavior, and diverse teams are more likely to exhibit adaptive responses (Edmondson and Nembhard 2009; Santos and Passos 2013). Organizational support is a crucial factor influencing teams' adaptive responses (Sebastian et al. 2010).

In the 1980s and 1990s, advancements in computer software and hardware technologies led to widespread integration of information systems with enterprises, sparking a wave of informatization in the industry. In this process, it is one of the most challenging problems in organizational behavior research to understand why employees accept or reject information systems (Swanson 1988). With social psychology as the underlying theoretical basis, researchers proposed a series of intention models (Christie 1981; Swanson 1982) to study users' behavioral decisions. Among them, Fishbein and Ajzen (1975, 1980) put forward the theory of reasoned action, an extensively studied intention model. This theory has demonstrated great success in forecasting and explaining behaviors in many areas. This theory boasts a wide range of adaptations and is "designed to explain virtually any form of human behavior" (Ajzen and Fishbein 1980). Davis (1986, 1989) studied the usage behavior of computer systems as a special case based on the theory of reasoned action and proposed the technology acceptance model (TAM).

The TAM model explains the usage behavior of computer systems by team members within enterprises/teams in the process of perceiving and accepting computer systems and automation technologies. It establishes causal relationships among several key constructs based on the theory of reasoned action: perceived usefulness, perceived ease of use, users' attitudes and intentions, and actual computer usage behavior. *TAM assumes that perceived usefulness and perceived ease of use significantly influence users' decisions to accept and employ the technologies, leading to an adaptive response.* That is, TAM encompasses three interpretations. Firstly, based on people's intentions, we can predict their use of information systems and automation technologies. Secondly, the perceived usefulness of these systems and technologies is a major decisive factor in their adoption and usage. Thirdly, perceived ease of use is an important decisive factor that influences whether people accept and utilize information systems and automation technologies TAM combines the research experience and results of information systems that have been developed for more than a decade. It is considered particularly well suited to interpret the process of the acceptance and use of computer and automation technologies.

In the context of computer and automation technology advancements, TAM focuses on how humans effectively interact with information systems. It recognizes the profound influence of automation technologies on work roles, processes, and decisions, emphasizing the subjective initiative and importance of human adaptation to these changes. By following this model, individuals and organizations can ensure the full use of automation technologies to enhance productivity, efficiency, and overall performance while taking into account the human factors involved.

2.3.4 Team effectiveness

Team effectiveness refers to the description of a team's output. Hackman (1987) believed that team effectiveness refers to the tangible outcomes of a team reaching predetermined goals. This includes: the performance standard met by the team's outputs, the enhancement of collective skills in team development, and the satisfaction of team members with their overall experience in the team.; Sundstrom et al. (1990) defined team effectiveness as the actual results attained by a team in meeting set objectives, encompassing three aspects: the output of group production, the group's influence on its members, and the enhancement of the team's work capabilities. Z. Qi, and D. Wang (2003) divided team effectiveness into three dimensions: business performance described by the quantity and quality of products, employees' attitudes, and employees' behavior results. Burke (2006) believed that team adaptability is an important part of team effectiveness. Sundstrom, De Meuse, and Futrell (1990) believed that team effectiveness included both team performance and team vitality, emphasizing the importance of team vitality:

It shows effectiveness as consisting of performance and viability. This two-part definition agrees with some earlier approaches, but is more inclusive than those based only on output. …We favor a broad definition that accounts for members' satisfaction and the group's future prospects as a work unit by incorporating team viability.

The research literature is replete with studies discussing the main factors that affect team effectiveness, mainly including team composition such as diversity, heterogeneity, and fault zone (Liu, B. et al. 2010 and Xie, X. Y. et al. 2011), team climates such as team cohesion, conflict, and learning (Mo et al. 2009; Xiang et al.

2010 and Zhang X. et al. 1997), leadership style (Danni et al. 2013 and Li C. P. 2014), and environmental changes such as organizational transformation (Mathieu et al. 2019 and Zhang X. L. 1997).

Based on previous views, this study plans to explore team effectiveness from two dimensions: team performance, which refers to the behavioral outcomes stemming from a team's efforts to accomplish work tasks, and team vitality, which encompasses the attitude and feeling of team members as they engage in collaborative work. Both are juxtaposed as outcome variables. Team vitality also promotes team performance in the next stage, thus forming an input-mediator-output-input cycle. Within this framework, feeling, cognition, emotion, and behavior intertwine to form a continuous synchronous cycle.

Team viability, as a team social activity, indicates that team members are satisfied with their identity and show a willingness to stay in the team (Balkundi et al. 2006 and Foo et al. 2006). It reflects the satisfaction of team members with team experience and their willingness for further collaboration. It is also a reflection of team emotions. As a work resource variable describing organizational climate, it stands as a core element for achieving effective team processes and securing sustainable competitive advantages (Barrick et al. 2007 and Bell et al. 2011).

2.4 Previous Research Methods, Progress, and Problems to Be Solved

The research on teams has experienced exponential growth over the past two decades (Mathieu et al. 2017, 2019), demonstrating the importance of this topic in the organization and human resources research fields.

Team interventions regarding team composition, equitable processes, climate creation, and leadership style are well established and have demonstrated their effectiveness and value in enhancing team effectiveness and organizational performance in many industries.

The paradigm of team research is evolving from a unidirectional and static IPO model to a bidirectional and dynamic IMOI model paradigm. There is a growing focus on the cognition, feeling, and subjective initiative of grassroots employees, along with the repercussions stemming from the intricate and ever-changing team environment. Therefore, the research integrating organizational behavior with social psychology theory has become an emerging research method in this field. Team output encompasses not only the performance of objective achievement but also the emotional feedback of team members.

The rise and wide application of digital technology in enterprises is an important means to enhance productivity and drive innovation. The most significant contrast of digital technology from previous technological revolutions is its ability to not just replace basic physical labor but also to substitute and impact human labor at advanced levels—such as memory, cognition, thinking, and decision-making—through machine learning of mental labor methods employed by humans.. The resulting organizational transformation will be profound and lasting. Currently, research on the integration of digital technologies into enterprises remains macro and superficial, with studies on human-machine coexistence, understanding, acceptance, and integrated work far from being deeply explored.

The previous research on changes focused on the role of reformers. However, the understanding of the direction of change and the focus of action varies not only among individuals at various organizational tiers—such as high-level change decision-makers, middle-level implementers, and bottom-level receivers (Kanter et al. 1992)—but also within roles with distinct affiliations to the technology within the same tier,, such as technicians, maintenance personnel, and users. Moreover, the perception and acceptance of technology will change over time. In addition, the interaction processes among team members are largely implicit. The more challenging and variable the task conditions are, the greater the need for implicit knowledge structures and interaction processes is. External observations should track explicit team adaptive responses. Adaptive responses are essential for teams to thrive in a dynamic and complex environment. By employing adaptive responses such as solving problems, seeking feedback, and learning, teams can effectively manage uncertainty and seize opportunities to achieve success. Future research in this field should continue to explore the complexity of team adaptation and identify strategies for enhancing team adaptability.

Chapter Ⅲ: Research Design

3.1 Research Hypotheses

The team exemplifies the definition of a group: (a) With two or more persons; (b) Requiring social interaction (face-to-face or increasingly virtual interaction); (c) Sharing one or more common objectives; (d) Members are brought together to perform organizationally relevant tasks; (e) Demonstrating interdependence in terms of work processes, objectives, and outcomes; (f) Members assume distinct roles and responsibilities; (g) Embedded within a contained organizational system, with boundaries and connections with broader systemic hierarchies and task environments. A project team is another common form of group in an organization, typically comprising various professionals aimed at completing a specific task. Compared with the project team, the team exhibits a more stable personnel structure and long-term and stable objectives. Members possess a higher degree of professionalism and skills that are closely interrelated. Therefore, this study will combine ARM and TAM to study the impact of digital transformation on team effectiveness based on the team research paradigm.

3.1.1 Measurement from a dynamic perspective

The implementation of digital transformation—including the time, methods, and scope and depth of applications—varies significantly across different enterprises, leading to a diverse range of outcomes. An important focus of discussion in the interviews was transformation speed:

“Opinions varied greatly. I lean towards seeking change, while some colleagues prefer stability, and others seek few changes and adjustments. Each person holds a unique perspective."—Ming XX (specialist in substation operation in the Production Technology Department of an electric power company)

"In my view, it would be more prudent to proceed by taking small steps and maintaining a gradual adjustment pace. Otherwise, progress may be impeded if issues arise midway."—Zhou XX (deputy head of a patrol and maintenance station)

"As a demonstration area for organizational model optimization, achieving scale efficiency is critical. Our current technology supports a reduction in our workforce. …With our established foundation and the growing maturity of external technologies, we're ready to explore technological applications ahead of schedule."—Yu XX (maintenance specialist in the Production Technology Department of an electric power company)

The decentralized approach to improvement presents challenges in achieving scale benefits. The whole production process is restricted by shortcomings, resulting in stagnant system efficiency. Moreover, the presence of two sets of processes at many nodes exacerbates the burden on team members. The long-term parallel operation of the two sets of processes also makes team members more prone to fatigue and errors, increasing production risks.

"The current pilot model operates on a dual-track (system). New tasks are required to be completed in addition to the original workload, which significantly increases the workload and causes resistance and passive work in the team."—Zhang X (deputy head of a substation of an electric power company)

"Therefore, they experience increased work pressure and give a lot of negative feedback."—Zhou XX (deputy head of a patrol and maintenance station of an electric power company)

On the contrary, focusing efforts in specific regions can effectively embody the effect of “creating rapid victories and demonstrating progress” as advocated in Kotter’s eight-step change model, which is conducive to boosting morale. Given the realistic background, digital technology is currently being integrated into various industries, discovering application scenarios, and synergizing with specific business. Therefore, this study defines the independent variable as the “pace of digital transformation” rather than “digital transformation level.”

As digital transformation accelerates, we will see a marked increase in the pace of digital transformation. This change is promoted from the top to the bottom, involving the requirements of leaders, supporting software and hardware, and resource coordination. In this case, teams face greater changes in work content, processes, and cooperation. Marks et al. (2001) believed that a team is a unit implementing multiple tasks. Such a team simultaneously and continuously performs multiple processes to coordinate objective-oriented task work. They proposed a conceptual model of time-based team processes, which divides team activities into the transition stage, the action stage, and the interpersonal process in chronological order. Furthermore, they clarified the wide applicability of this model and detailed how the team process operates cyclically within the scenario framework of team performance. Teams possess the ability to monitor objectives and systems during the action process, presenting more intense fallback responses and coordination activities in more dynamic and volatile internal and external team environments. This implies that team members exhibit greater and more flexible adaptive responses. A fast digital transformation means smooth integration of technology applications, indicating that team members exhibit good acceptance and adaptability to technology and demonstrate a stronger adaptive response. Hence, this study proposes Hypothesis 1.

Hypothesis 1: The pace of digital transformation is positively correlated with adaptive response to digital transformation.

For teams with strong adaptive responses, employees show more behaviors of seeking feedback and information and are more likely to engage in imitation, experimentation, and adjustments. As a result, the frequency of mutual communication and coordination intensifies, and the scope of content becomes more dynamic. Team members have established relatively stable cooperative relationships, and grassroots employees typically prioritize actions over words, often showing loyalty to each other. When facing external pressures and changes, employees communicate more frequently based on the two-factor theory of emotion involving physiological and cognitive factors. This leads to closer relationships, forming closer-knit groups. In this team climate, members can perceive the importance of efforts, sharing, and cooperation in the workplace and emphasize learning and technical mastery (Cerne et al. 2014). Nerstad (2013) called this mastery climate, which was thought to enhance the supportive cognition and behavior of team members. In this mastery climate, team members accept help from others while providing help for others. In this process, members are moved and inspired by each other, greatly strengthening the emotional connection between them. Balkundi et al. (2006) pointed out in the meta-analysis that teams with stronger emotional connections showed higher team vitality. In summary, this study proposes Hypothesis 2.

Hypothesis 2: Adaptive response to digital transformation is positively correlated with team vitality.

A higher adaptive response is helpful to establish a robust communication network within a team and achieve the purpose of improving team spirit. The coordination theory posits that when people engage in positive communication and interaction, it leads to an increase in energy due to its promotion of an individual's sense of belonging, ability, and autonomy (Quinn and Dutton 2005). An important function of adaptive response is to promote effective communication among team members, emphasizing interactive communication. In teams with a high level of adaptive response, employees have close relationships and offer rapid feedback, allowing them to obtain more detailed and comprehensive information. The adaptive response also fosters comprehensive thinking, teamwork, and organizational cohesion. Facing common work challenges will greatly promote the formation of cultural values such as trust, respect, and support within a team, foster an open and egalitarian team atmosphere, motivate employees to engage actively in behaviors expected by the team, and ultimately influence their innovative behavior (Langfred and Moye 2004) and stimulate their creative performance (Graen and Scandura 1987; Liden and Graen 1980). Therefore, this paper proposes Hypothesis 3.

Hypothesis 3: Adaptive response to digital transformation is positively correlated with team performance.

Since the pace of digital transformation affects the adaptive response to digital transformation, which in turn influences team vitality and work performance, the adaptive response to digital transformation serves as a moderating variable between the pace of digital transformation and team vitality, and between the pace of digital transformation and work performance. Therefore, this paper proposes Hypothesis 4 and Hypothesis 5.

Hypothesis 4: Adaptive response to digital transformation moderates the relationship between the pace of digital transformation and team vitality.

Hypothesis 5: Adaptive response to digital transformation moderates the relationship between the pace of digital transformation and team performance.

3.1.2 Preparedness ensures success and unpreparedness spells failure

At first glance, the above hypotheses significantly deviate from our intuitive feelings. In the interview, many production personnel expressed that digital transformation increased the burden of teams, without improving team viability and performance.

What are the causes of employees' resistance and negative effects? The primary factor determining whether employees accept or resist change is the extent to which employees perceive the change as beneficial or detrimental to them. These factors constitute the "rational part" of resistance to change (Dent and Goldberg 1999; Jermier and Nord 1994). Anxiety is a key factor influencing the "emotional part" of change. Any routine change can provoke anxiety (McGrath 1976). All employees facing changes are likely to experience some level of anxiety. If certain events or new information increase their anxiety, then the anxiety can adversely affect the change. However, moderate anxiety is not a hindrance to change but rather a positive factor. Anxiety can negatively impact employees' health (Cooper and Marshall 1976; McGrath 1976; Schuler 1980), but it can also alert employees to new rules, stimulate information search, and improve employees' performance. This conscious behavior is necessary for employees to learn new work processes and guarantee the success of the planned change (Langer 1978). Moderate anxiety is beneficial for employees in making positive responses, increasing communication frequency, adjusting their roles, and enhancing teamwork, while anxiety caused by insufficient information and facing changes can adversely affect their attitude toward change (Vernon et al. 1994). The heavy burden and negativity complained by team members of the electric power company's team can be attributed to the sluggish and replayed pace of transformation. According to the ancients, "In a battle, morale is crucial. It surges with the first beat of the drum, wanes with the second, and diminishes with the third."[5] The premise for raising morale at the drum beat lies in full preparedness for battles.

In the interview, "adjustment and matching of organizational structure" was also considered to be an important factor determining the success or failure of digital transformation. Organizational inertia in structure, decision-making process, and institutional dependence may lead to a slower response of enterprises. There is a certain lag between management organization systems and abilities and the advancement of the technical architecture for digital transformation. The benefits brought about by digital transformation are offset by derived management costs (Qi Y. and Cai 2020), leading to high hidden costs associated with enterprises' digital transformation (Xu and Lyu 2020) and relatively limited performance outcomes.

The negative factors mentioned above are not insurmountable. According to TAM (Davis 1986, 1989), the perceived usefulness of technology and perceived ease of use significantly influence users' decisions regarding the acceptance and utilization of the technology (i.e. digitization), leading to their adaptive responses. The preparedness for digital transformation can facilitate the above two factors, playing a pivotal role in fostering team members' adaptive responses to digital transformation and subsequent team effectiveness.

Firstly, in the process of digital transformation within an enterprise, if formal organizations can assist grassroots managers and employees in gaining a deep

[5] Zuo Zhuan ·10th year of Duke Zhuang

understanding of the challenges and uncertainties brought by digital technology and provide direction and guidance for relevant innovative activities, thus effectively reducing ambiguity in the innovation process, it is beneficial for enhancing the level and performance of innovation within the enterprise (Pesch and Endres 2019). Secondly, employees have the subjective initiative to complete their work and the enthusiasm to engage in digital transformation. Georgia (1986) found in the research on the entry of robots into factories that workers, especially highly skilled workers, responded positively to robots and believed that the implementation of robots provided them with an opportunity to expand their skills. Michael and Carol (1991, 1993) tracked and evaluated the benefits of expanding work scope and increasing job auxiliary responsibilities through a variety of interdisciplinary methods, finding that teams experienced higher employee satisfaction, less burden, greater opportunities, and improved customer services. However, they also noted that these benefits came with higher training requirements, a higher level of foundational skills, and increased compensation expenses. Employees who can obtain sufficient information in a timely and appropriate manner, as well as those who have a high demand for a sense of achievement, are willing to participate in organizational transformation. Furthermore, adjustments to organizational structure and procedural systems can be pre-designed to align with digital transformation progress and influenced workflow. Technologies such as EEPC modeling and simulation fully support process optimization or even reengineering. Despite the presence of some delays, most employees can accept it under the condition of full communication and good expectations. When team members fully understand the benefits and potential improvements that digital transformation can bring to their roles, they are more likely to perceive it as beneficial. The perceived ease of use is naturally high when individuals are trained to use the digital platform system and are provided with the necessary supporting resources. In reality, team members in the power industry shoulder the burden of the short-term dual-track system from the promotion of digital technology. However, they also enjoy benefits such as greatly reduced field operations, improved inherent safety, and decreased personal risks.

Thus, the preparedness for digital transformation may be a key boundary condition for team members to adapt successfully to technological changes. When team members fully understand the benefits and potential improvements that digital transformation can bring to their roles, they are more likely to perceive it as beneficial. The perceived ease of use is naturally high when individuals are trained to use the digital platform system and are provided with the necessary supporting resources.

Hypothesis 6: Preparedness for digital transformation moderates the relationship between the pace of digital transformation and adaptive response to digital transformation. When the level of preparedness is higher, they are more positively correlated.

3.2 Model

All hypothetical models derived from literature and logical reasoning are shown in Figure 4. The main mechanism is that under the adjustment of the preparedness for digital transformation, the pace of digital transformation is positively correlated with the adaptive response to digital transformation. That is, with the rapid progress of digital transformation, employees generate more robust adaptive responses, fostering stronger team vitality and enhancing team performance.

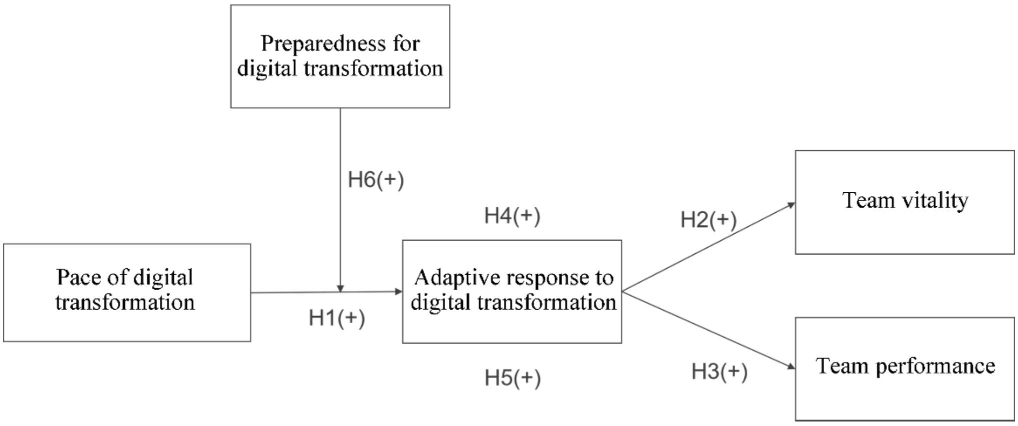


Figure 4 Research Model

This study follows the paradigm of empirical research for hypothesis argument. Inspired by natural science, positivism consistently emphasizes a two-way dependence between objective phenomena and abstract theories (Comte 1988). We should place greater emphasis on the reliability of knowledge and experience acquiring process rather than knowledge itself (Boyles 2006), thereby ensuring our conclusions are built upon a reliable foundation. To this end, I planned to collect data via questionnaires and draw conclusions through statistical analysis.

3.3 Samples

The samples of this study are mainly from 690 teams in the power industry in Southwest and South China and 10 teams in a fashionable women's clothing factory in East China. All the teams are conducting digital transformation or have achieved preliminary results in this regard.

To address the issue that a single survey is insufficient to demonstrate causation (Rosenthal and Rosnow 1991) and to mitigate endogenous interference, data were collected over three time periods with an interval of 2-3 months between each survey. This approach provided sufficient time lag, allowing for a clear distinction between the measurement of predictive factors and mediating factors and outcome variables.

Control variables include gender, age, working years, and team type.

3.4 Procedures

Before the survey, I first communicated with the persons in charge of the surveyed enterprises to explain the research content, survey scope, and procedures in a bid to gain their support. The management personnel cooperated in distributing and collecting questionnaires. Before the collection of data commenced, employees received an email/message ensuring their personal information and responses to the questionnaire would not be disclosed to their organization or any individuals unrelated to the current study. These employees voluntarily participated in the study and were allowed to complete questionnaires during working hours.

The first survey commenced from October to November 2022. Approximately 7,000 employees from 700 teams were given an electronic questionnaire to collect their demographic information including age, gender, year of education, and years of working, as well as their digital transformation level and preparedness for digital transformation. After the first round of collection, three criteria were followed to check the integrity of our results: Firstly, any questionnaire with over 30% of the questions left unanswered was considered incomplete and deleted. Secondly, for teams comprising fewer than four members without a supervisor, or those from which fewer than three questionnaires were collected, their questionnaires were all excluded. Thirdly, some questions that remained unanswered were recorded as missing values. Finally, in this initial survey, I successfully obtained 600 groups of valid samples, comprising a cumulative total of 5,141 completed questionnaires.

The second survey was conducted from February to March 2023. I distributed electronic questionnaires to about 6,000 members from the 600 teams that were proven effective in the initial survey, asking employees to fill in their digital transformation level and adaptive responses. The collected questionnaires were checked one by one and compared with the questionnaires collected in the initial survey via WeChat account, telephone number, IP address, and nickname to remove unqualified questionnaires. In addition to the three criteria set in the initial survey, one additional criterion was added: Given there was no change in team leadership compared with the first survey, there should be over three qualified and matched questionnaires for both surveys. For example, if the initial survey identified questionnaires 1-7 as qualified for a team of 10 members, and the second survey recognized questionnaires 6-10 as qualified, then only questionnaires 6 and 7 were matched as qualified in both surveys. Consequently, all of the team's questionnaires were excluded from consideration. If the second survey deemed questionnaires 4-9 as qualified, then only questionnaires 4-7, totaling four questionnaires, were retained for this team. According to these criteria, although 5,516 questionnaires were collected, only 2,080 questionnaires from 375 teams were qualified.

The third survey was conducted from June to July 2023, respectively targeting team leaders and members from 375 teams qualified in the first two rounds. Team leaders were required to evaluate the digital transformation level of their teams, their team performance, and the job performance of each employee. Team members were asked to evaluate the digital transformation level of their teams and team viability. The collected questionnaires were rechecked and matched according to the previous criteria. Ultimately, I collected a total of 2,039 valid questionnaires from 374 teams.

The number of qualified samples and survey response rates for the three surveys are shown in Table 2.

Table 2 Number of Qualified Samples in Three Surveys

	Team number	Sample size	Number of matched samples	Average team size
Initial	700	7,000	7,000	10
First survey	600	5,141	5,141	8.56
Second survey	375	5,516	2,080	5.55
Third survey	374	3,772	2,039	5.45

3.5 Measurement

All data were collected using structured questionnaires. All scales used in this study are well-established. All surveys were translated from English to Chinese using the translation-reverse translation procedure recommended by Brislin (1980). The questionnaires used in these surveys were originally composed in English and then translated into Chinese and subsequently re-translated into English. Then, I made a comparison between the original and translated questionnaires. Inconsistencies identified between the two versions have been resolved and corrected. The content of the scales in English is presented in this section, and copies of the questionnaires in Chinese are provided in Appendix 3. Remaining faithful to the original questionnaires, I made minor modifications to the wording of the questions, mainly translating “automation” in various scales into “digitization.” In previous studies, “automation” was defined as “automatic control of production processes using electronic or mechanical equipment instead of human labor,” which aligns with the digital technology in this study. After that, a small-scale trial scoring was conducted, incurring no ambiguity.

3.5.1 Pace of digital transformation

"Pace" refers to the change of level value per unit time. In this study, the "digital transformation level" was measured every three months, with three months as a unit time. The "pace of digital transformation" was calculated by subtracting the results of the second survey from those obtained in the third survey.

Frohm et al. (2008) studied the definition and classification of automation levels across multiple scientific and industrial fields. They proposed a comprehensive framework for "automation level," along with an assessment methodology that hinges on an understanding of task allocation within semi-automated systems. These researchers conducted a literature review of automation levels across disciplines and industry sectors. They concluded that automation levels were not a single-step conclusion from manual to completely automated tasks but involved two distinct "continua" representing physical and cognitive tasks. Consequently, they proposed the development of two scales aimed at assessing the automation levels within these two dimensions. Sampson (2021) proposed an automation model in professional services and empirically tested this model using O*Net data, deducing the automation requirements in two dimensions: interpersonal skills and creative skills. Both studies have demonstrated extensive adaptability and a large number of citations. Their proposed "automation level" is part of carrying out the work based on task-level analysis technology (such as IT, machine learning, and robotic processes), which is consistent with the work (performing specific tasks) of the team members in this study. There is no difference in the specific technical description between the "automation" described and the "digitization" of this study. Therefore, the "digital transformation level" scales of this study integrates the recommendations of Frohm et al. (2008) and

Sampson (2021), and measures from three aspects: core business, independent work, and collaboration with others. The original text of the scale is as follows.

A job is automated to the degree that technology (e.g., artificial intelligence, machine learning, robotic process) performs some portion of the job. (1 = not automated at all; 7 = completely automated)

1. How AUTOMATED is it for your team to perform core tasks?
2. How AUTOMATED is your current job that involves independent work?
3. How AUTOMATED is your current job that involves coordinating or collaborating with other team members?

3.5.2 Preparedness for digital transformation

Organizational change, process optimization, and technological innovation have become routine practices for enterprises, necessitating employees to meet the requirements of their roles while staying healthy and motivated. To reduce the adverse effects of work-related stress and changing environments on employees' health and improvement of work abilities, many employee care programs, occupational health initiatives, and work intervention strategies have been developed and implemented in the workplace. Vinokur, Price, and Schul (1995) randomly categorized 1,801 individuals with high or low risks for unemployment into an intervention group and a control group to conduct an efficacy experiment of the JOBS II occupational interventions. Results of the previous JOBS I study indicated that offering social support, job-seeking skills, and interventions to mitigate depression yielded positive outcomes on reemployment and mental health among employees at high risk of unemployment. Moreover, a long-term follow-up spanning 21 years demonstrated the interventions' enduring effectiveness. The study by Vinokur et al. enhanced the intensity, comprehensiveness, and efficacy of interventions, improved respondents' sense of control, reduced the intervention duration and was implemented in various economic contexts. The results re-confirmed previous positive effects while revealing that respondents at high risk of unemployment benefited the most in terms of reduced depressive symptoms. Vuori et al. (2011) from the Finnish Institute of Occupational Health developed intervention measures that were included in companies' training programs. These measures aimed to equip employees with better skills to manage their careers, thus enhancing occupational management and mental health among team members. The follow-up study conducted with groups confirmed that the objective of a sustainable and healthy occupation could also be realized in more unpredictable work environments. Vuori et al. (2011) noted that preparing for careers in unpredictable work environments "*can be regarded as a motivational process through which individuals adapt to their work environments, develop plans, set objectives, endeavor to enhance their future, and evaluate their probability and ability to accomplish those objectives.*" The specific measurement includes two dimensions: self-efficacy and resilience to frustration.

In practice, extensive training is necessary for employees before and during digital transformation. This not only encompasses briefing team members on the digital transformation's timeline and extent but also involves their collaboration in setting up and debugging sensors and systems. Employees need to be trained on applying new technologies (mobile devices, monitoring systems, and remote control panels), followed by multiple rounds of discussions about new organizational structures and shifts in responsibilities. This is paramount to transitioning to new working methods and establishing a new human-machine integration model. The training content aligns with specific measure connotations in existing work intervention research. The measurement methods for preparatory work in the research are equally applicable to this study. Accordingly, the “preparedness for digital transformation” was assessed during the first questionnaire round. The scale merges findings from research conducted by Vinokur et al. (1995) as well as Vuori et al. (2011), consisting of four questions. The original text is as follows.

1. For the coming digital transformation change, I have backup plans in case of possible setbacks.
2. I would be able to continue my work in case of possible difficulties and setbacks related to the coming digital transformation change.
3. I am fully prepared for the coming digital transformation change.
4. I am ready for the coming digital transformation change.

3.5.3 Adaptive response to digital transformation

As discussed in Section 3.3, training that focuses on the usefulness and ease of use of technology can foster adaptive responses among employees and their willingness to embrace technological changes. Concurrently, such preparedness can enhance employees’ sense of participation and control, and augment their bravery and confidence when they confront challenges. Griffin et al. (2007) developed a new model of work role performance that includes three tiers (individual, team, and organization) and identifies three distinct behaviors (proficiency, adaptive response, and proactivity). They highlighted that interdependence in the workplace determines the extent to which employees become integrated into broader social systems, and uncertainty in the organizational context influences the degree to which employees’ complete tasks via adaptive and proactive behaviors. When uncertainty levels are high, it becomes impractical to predict every contingency, and the requirements of tasks become more challenging to be fully formalized and standardized, thus demanding greater flexibility from employees to adapt to changing conditions and requirements. The work role performance model and its scales have garnered substantial citations. In this study, the team members exhibited relative stability and a pronounced interdependency in their roles, and their adaptive responses were in line with the constructs defined in the model. Consequently, “adaptive response to digital transformation” was assessed in the second questionnaire round using an eight-question scale derived from Griffin et al. (2007) as follows.

Individual task adaptivity:

1. I adapt well to changes in core tasks due to digital transformation.

2. I cope with digital transformation changes to the way I have to do my core tasks.

3. I learn new digital transformation skills to help me adapt to changes in my core tasks.

4. I find it easy to adapt to changes in core tasks due to digital transformation.

Team member adaptivity:

1. I respond flexibly to digital transformation changes in the team.

2. I cope with digital transformation changes in the way the team operates.

3. I learn skills or acquired information that help me adjust to digital transformation changes in the team.

4. I find it easy to adapt to changes in the team due to digital transformation.

3.5.4 Team vitality

In examining the paradox of team member boundary crossing, Marrone et al. (2007) developed a model elucidating the impact such crossing has on team vitality and team performance. They formulated a table comprising three items to measure team vitality and found that role overload at the team level adversely affects team vitality. This study used the “team vitality” scale put forth by Marrone et al. (2007), with data collected from team member reports in the third questionnaire round.

1. Team members have found being a member of this team to be a very satisfying experience.

2. Team members feel like they are learning a great deal by working on this team.

3. Team members would welcome the opportunity to work as a group again in the future.

3.5.5 Team performance

When studying the emotional mechanism underlying the relationship between dysfunctional team behavior and team performance, Cole et al. (2008) constructed a “team performance” evaluation scale. This scale drew upon the metrics developed by Conger et al. (2000) and covered five dimensions: “have high work performance,” “accomplish most of their tasks quickly and efficiently,” “set a high standard for work accomplishment,” “achieve a high standard for task accomplishment,” and “always achieve or surpass their targets.” The scale has been extensively cited by researchers since its inception. This study adopted the “team performance” measurement scale proposed by Cole et al. (2008), utilizing data sourced from team leaders’ reports in the third questionnaire round. The original text is provided below.

Supervisors were asked the extent to which their teams

1. Have high work performance.
2. Accomplish most of their tasks quickly and efficiently.
3. Set a high standard for work accomplishment.
4. Achieve a high standard for task accomplishment.
5. Almost always beat their targets.

Chapter Ⅳ: Empirical Analysis and Results

4.1 Demographic Information of Samples

The modeling and calculation of data from 2,039 employees across 374 teams, precisely matched across three questionnaire rounds, were conducted using Mplus 5.2 software (Muthen and Muthen 2007). Additionally, the Monte Carlo methods (Preacher et al. 2010) were employed to estimate confidence intervals.

Demographic information of the respondents was collected in the first questionnaire round. The average age of respondents is 39.25 years (SD = 9.76), with an average of 14.49 years of education (SD = 4.54). Their average tenure in relevant fields is 16.29 years (SD = 9.68), while the average organization tenure is 9.69 years (SD = 8.74), and the average team tenure is 8.60 years (SD = 8.63). Respondents' average tenure with the supervisor is 6.35 years (SD = 7.13), aligning with the context provided in Chapter I: Team members have clearly defined and fixed tasks, a relatively stable structure, and need relatively efficient skill training. In such grassroots organizations, communication between members and between superiors and subordinates often involves a significant amount of "tacit knowledge" or implicit knowledge, rather than language.

4.2 Reliability and Validity Analysis

4.2.1 Variable reliability

First, Cronbach's α coefficient was used to assess the reliability of each variable. The coefficient values are generally interpreted to represent the following degrees of internal consistency reliability[6]: $\alpha \geq .9$, "excellent" reliability; $.9 > \alpha \geq .8$, "good" reliability; $.8 > \alpha \geq .7$, "acceptable" reliability; $.7 > \alpha \geq .6$, "problematic" reliability; $.6 > \alpha \geq .5$, "poor" reliability; $.5 > \alpha$, "unacceptable" reliability.

Preparedness for digital transformation was measured using a four-item scale adapted from Vinokur et al. (1995), as well as Vuori et al.(2011), yielding a Cronbach's α of .98. Adaptive response to digital transformation was assessed with an eight-item scale developed by Griffin et al. (2007), resulting in a Cronbach's α of .96. Team vitality was evaluated using a three-item scale from Marrone et al. (2007), which demonstrated a Cronbach's α of .97. Team performance was measured using a five-item scale from Cole et al. (2008), with a Cronbach's α of .97.

4.2.2 Intrateam correlation

Given that the theoretical model operated at the team level and empirical data were obtained by collecting employees' responses and aggregating them to the team level, the intra-class correlation coefficient (ICC) was calculated. This metric was used to measure and evaluate the inter-observer reliability and test-retest reliability, ensuring reasonable data aggregation. The results showed that in terms of preparedness for digital transformation, ICC (1) = .07, ICC (2) = .26, average rwg (j) = .81, and median rwg (j) = .91. For the adaptive response to digital transformation, ICC (1) = .12, ICC (2) = .37, average rwg (j) = .88, and median rwg (j) = .95. From the perspective of team vitality, ICC (1) = .09, ICC (2) = .29, average rwg (j) = .88, and median rwg (j) = .92. When it comes to team performance, ICC (1) = .08, ICC (2) = .26, average rwg (j) = .90, and median rwg (j) = .95. These results validated

[6] George, D., & Mallery, P. (2003). SPSS for Windows step by step: A simple guide and reference. 11.0 update (4th ed.). Boston: Allyn & Bacon.

the effectiveness of aggregating individual-level responses as team-level ones.

4.2.3 Construct validity

To check whether different constructs are captured by multi-item measurements, and to account for the nested nature of the data structure, this study utilized Multi-level Confirmatory Factor Analysis (MCFA) to analyze construct validity. The MCFA results indicated that the theoretical four-factor model fits the data well: χ^2 (196) = 280.63, $p < .001$, comparative fit index (CFI) = .99, Tucker-Lewis index (TLI) = .99, root mean square error of approximation (RMSEA) = .02, and standardized root mean square residual (SRMR) within and between levels = .01.

Moreover, the model was presumed to fit the data significantly better than an alternative model with any two latent factor combinations ($\Delta\chi^2$s [6] $\geq$ 678.66, *ps* < .001). These results support the measurement approach's robust validity and suggest that distinct constructs were captured by the measurements used in the study.

The means, standard deviations, and correlations for all variables employed in the study are displayed in Table 3.

Table 3 *Means, Standard Deviations, and Correlations among Study Variables*

	Variable	*M*	L1 *SD*	L2 *SD*	1	2	3	4	5	6	7	8	9	10	11
1	Average organization tenure	16.29	9.68	7.43	—	.57**	.43**	.42**	-.29**	.01	.00	-.14**	-.05	-.02	-.02
2	Average position tenure	9.69	8.74	6.45	.56**	—	.66**	.64**	-.12*	.05	-.02	.04	.08	.10	.12*
3	Average team tenure	8.60	8.63	6.23	.43**	.63**	—	.75**	-.07	.03	.07	.01	.12*	.15**	.14**
4	Average tenure with the supervisor	6.35	7.13	5.30	.36**	.57**	.67**	—	-.06	-.01	.06	.14**	.18**	.16**	.17**
5	Average education years	14.49	4.54	3.25	-.22**	-.08**	-.04	-.01	—	-.04	-.10	.04	.00	-.06	-.04
6	Team size	1.46	—	.68	.03	.10**	.07*	.05	-.04	—	.05	-.02	-.14**	-.15**	-.11*
7	Change in digital transformation level (T3-T2)	-.29	1.75	1.27	.08*	.01	.04	.03	-.09*	—	—	-.04	.09	.09	.08
8	Preparedness of digital transformation (T1)	5.82	1.28	.89	-.05	.03	.03	.09**	.01	—	-.03	**(.98)**	.46**	.41**	.45**
9	Adaptive response to digital transformation (T3)	4.24	.78	.52	.02	.06	.10**	.12**	.01	—	.24**	.44**	**(.97)**	.78**	.80**
10	Team viability (T3)	4.28	.73	.52	.03	.08*	.11**	.13**	-.01	—	.21**	.46**	.71**	**(.97)**	.89**
11	Team performance (T3)	4.26	.73	.51	.00	.08*	.12**	.14**	.00	—	.18**	.46**	.73**	.88**	**(.97)**

Notes. L1 = Individual level (N = 2,039), L2 = Team level (N = 374). A natural logarithm function was used to scale team size because its distribution departed from normality. Individual-level correlations are presented below the diagonal, and team-level correlations are presented above the diagonal. Cronbach's alpha coefficients are presented in parentheses along the diagonal.

$^{*}p < .05$, $^{**}p < .01$.

4.3 Hypotheses Tests

The unstandardized modeling results are presented in Table 4. The results indicated that the pace of digital transformation is positively associated with adaptive response to digital transformation ($\gamma = .05$, $p < .05$), confirming Hypothesis 1. Adaptive response to digital transformation is positively associated with team vitality ($\gamma = .72$, $p < .01$), thus Hypothesis 2 is supported. Likewise, adaptive response to digital transformation is positively associated with team performance ($\gamma = .74$, $p < .01$), supporting Hypothesis 3.

Results of the mediating effect model are shown in Table 5. Based on the mediating effect of adaptive response to digital transformation, there is an indirect relationship between the pace of digital transformation and team vitality (indirect effect = .034, 95% CI = [.002, .066]), supporting Hypothesis 4. Besides, there is an indirect relationship between the pace of digital transformation and team performance (indirect effect = .035, 95% CI = [.003, .067]), confirming Hypothesis 5.

Furthermore, as indicated in Table 4 and Figure 5, the relationship between the pace of digital transformation and adaptive response to digital transformation is amplified by preparedness for digital transformation ($\gamma = .04$, $p < .05$). The result implies that the relationship between the pace of digital transformation and adaptive response to digital transformation is stronger among teams that exhibit higher levels of preparedness for digital transformation.

Second, as shown in Table 5, the results indicate that preparedness for digital transformation also amplifies the indirect effects of the pace of digital transformation on team vitality and team performance through the mediating effect of adaptive response to digital transformation. Specifically, the results from the conditional indirect effects analysis revealed that when the level of preparedness for digital transformation is high, the indirect relationship between the pace of digital transformation and team vitality through adaptive response to digital transformation is positive and significant (*conditional indirect effect* = .060, 95% CI = [.013, .107]). At lower levels of preparedness, the indirect relationship is not significant (conditional indirect effect = .008, 95% CI = [-.025, .041]). The difference in the conditional indirect effects based on the level of preparedness is statistically significant (difference = .051, 95% CI = [.003, .102]). Similar results were observed for the indirect effect of the pace of digital transformation on team performance through the mediating effect of adaptive response to digital transformation. When preparedness for digital transformation is high, a stronger indirect relationship is identified (conditional indirect effect = .061, 95% CI = [.013, .111]). At lower levels of preparedness for digital transformation, the indirect relationship is not significant (conditional indirect effect = .008, 95% CI = [-.026, .042]). The difference in the conditional indirect effects based on the level of preparedness is statistically significant (difference = .053, 95% CI = [.004, .106]). Thus, Hypothesis 6 is supported.

The model and calculation results are shown in Figure 6.

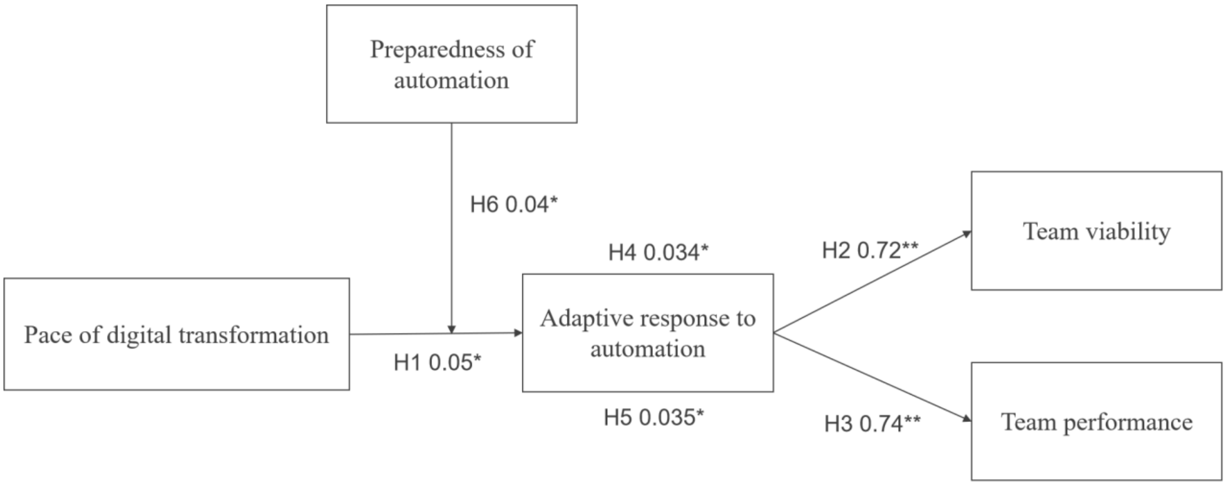


Figure 6 Hypothetical Results of the Research Model

Table 4 Unstandardized Modeling Results

	Adaptive response to digital transformation			*Team viability*			*Team performance*		
	Est.	*SE*	*p*	Est.	*SE*	*p*	Est.	*SE*	*p*
Average organization tenure	-.00	.00	.33	-.00	.00	.58	-.00	.00	.73
Average position tenure	.00	.01	.81	.00	.00	.56	.01	.00	.26
Average team tenure	.01	.01	.16	.01	.00	.09	.00	.01	.42
Average tenure with the supervisor	.00	.01	.49	-.01	.01	.24	-.01	.01	.35
Average education years	-.00	.01	.84	-.01	.01	.09	-.01	.01	.26
Team size	-.12**	.03	.001	-.04	.03	.14	.00	.02	.86
Change in digital transformation level (CAL)	.05*	.02	.03	.01	.02	.44	.00	.01	.85
Preparedness of digital transformation (PA)	.25**	.03	<.001	.05*	.02	.04	.07**	.02	.004
CAL × PA	.04*	.02	.04	.00	.01	1.00	-.02	.02	.22
Adaptive response to digital transformation				.72**	.05	<.001	.74**	.05	<.001
Intercept	4.28**	.02	<.001	1.22**	.23	<.001	1.12**	.22	<.001
Residual variance	.20**	.02	<.001	.10**	.01	<.001	.09**	.01	<.001

Notes. $N = 374$ at the team level. *SE* = standard error.
$^{*}p < .05$, $^{**}p < .01$.

Table 5 *Summary of Indirect and Moderated Mediation Effects*

Hypothesized effects	Estimate	95% CI
Change in digital transformation level → Adaptive response to digital transformation → Team viability		
Indirect effect	.034*	[.002, .066]
Conditional indirect effects		
Higher preparedness of digital transformation (*M* + 1 *SD*)	.060*	[.013, .107]
Lower preparedness of digital transformation (*M* - 1 *SD*)	.008	[-.025, .041]
Difference between the two conditional indirect effects	.051*	[.003, .102]
Change in digital transformation level → Adaptive response to digital transformation → Team performance		
Indirect effect	.035*	[.003, .067]
Conditional indirect effects		
Higher preparedness of digital transformation (*M* + 1 *SD*)	.061*	[.013, .111]
Lower preparedness of digital transformation (*M* - 1 *SD*)	.008	[-.026, .042]
Difference between the two conditional indirect effects	.053*	[.004, .106]

Notes. CI = confidence interval.
* The 95% confidence interval excluded zero.

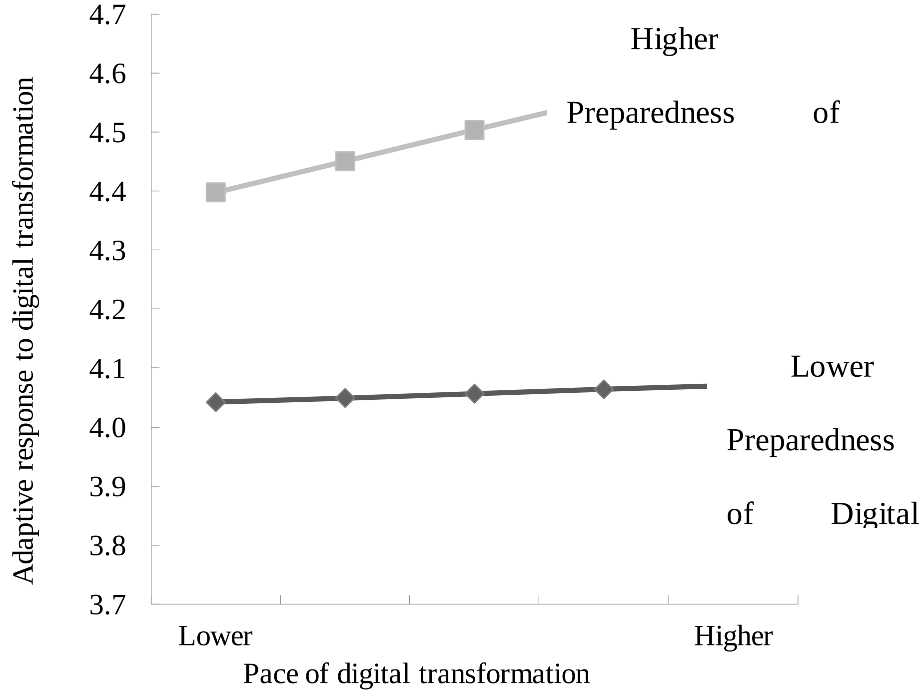


Figure 5 Moderating Effect of Preparedness for Digital Transformation on the Relationship between Pace of Digital Transformation and Adaptive Response to Digital Transformation

4.4 Supplementary Analysis

As shown in Table 4, among all control variables included in the model, only team size significantly correlated with endogenous variables. Therefore, to test the robustness of the results, after excluding all control variables that were not significantly associated with endogenous variables, the model was rerun with only the controlled team size in the model. The computational results are shown in Table 6. These recalculated findings remain robust: The pace of digital transformation is significantly related to adaptive responses to digital transformation ($\gamma = .05$, $p < .05$), and this relationship is amplified by preparedness for digital transformation ($\gamma = .04$, $p < .05$). Furthermore, adaptive response to digital transformation is found to be positively correlated with both team vitality ($\gamma = .73$, $p < .01$) and team performance ($\gamma = .75$, $p < .01$).

Table 6 Unstandardized Modeling Results with Significant Control Variable Lucluded Only

	Adaptive response to digital transformation			*Team viability*			*Team performance*		
	Est.	*SE*	*p*	Est.	*SE*	*p*	Est.	*SE*	*p*
Team size	-.11**	.04	.001	-.03	.03	.22	.001	.02	.96
Change in digital transformation level (CAL)	.05*	.02	.02	.01	.02	.34	.004	.01	.80
Preparedness of digital transformation (PA)	.26**	.03	<.001	.04	.02	.07	.06**	.02	.007
CAL × PA	.04*	.02	.04	.001	.01	.97	-.02	.02	.25
Adaptive response to digital transformation				.73**	.05	<.001	.75**	.05	<.001
Intercept	4.28**	.02	<.001	1.18**	.23	<.001	1.09**	.21	<.001
Residual variance	.21**	.02	<.001	.11**	.01	<.001	.09**	.01	<.001

Notes. $N = 374$ at the team level. *SE* = standard error.
$^{*}p < .05$, $^{**}p < .01$.

Chapter Ⅴ: Discussion and Conclusion

5.1 Question Review and Results Discussion

Throughout this two-year study from conception and investigation to completion, various topics on AI and digital technology, such as Boston Dynamics, ChatGPT, and Sora, have repeatedly come into the spotlight. These technologies have ignited ongoing discussions on their effects on daily life, the economy, and industries. In recent years, the Chinese government has been actively promoting the research and application of digital technologies. This initiative began in 2015 with the introduction of *Made in China 2025* and was facilitated in 2023 when the State Council unveiled the *Plan for the Overall Layout of Building a Digital China*. The government's endeavors include fostering digital infrastructure through national strategies, enhancing the integration and sharing of data resources, and encouraging the digital transformation of enterprises and society.

China is a manufacturing giant. Nevertheless, since scholars identified the "shortage of skilled workers" in China's coastal areas in 2004, there has been fervent debate about the potential vanishing of the demographic dividend. This concern persists today, with shortages evident not only in the number of skilled workers but also in their skill levels, compounded by issues such as an aging workforce and labor instability. It is estimated that by 2025, China may face a deficit of almost 30 million skilled workers in the manufacturing sector[7]. Promoting digital technology and fostering enterprises' digital transformation are viable solutions to the shortage of

[7] Data source: *Guidelines for Manufacturing Talent Development Planning* issued by the Ministry of Education of the People's Republic of China, the Ministry of Human Resources and Social Security of the People's Republic of China, and the Ministry of Industry and Information Technology of the People's Republic of China, 2017

skilled workers. From the perspective of production teams, the application of digital technology can boost labor productivity, compensate for some job vacancies, enable existing personnel to undertake more production tasks, and improve management standards. The coexistence and integration of humans and machines are likely to be foreseeable trends for the future. As reported by the National Committee of the Chinese People's Political Consultative Conference, among enterprises that have implemented digital transformation, over 80% report a shortage of personnel across various levels, including general managers, production managers, and ordinary operators[8]. Take power companies as an example. There is an urgent need to address the disparity between expanding asset scales and limited human resources through technical means. This is essential to enhancing the efficiency and profitability of power grids, reducing production risks, alleviating staff workloads, and empowering companies' shift in management model from traditional labor-intensive operations to a lean management approach. In recent years, the annual investment in digital technology has exceeded RMB 10 billion. Indeed, substantial investments have yielded good results. For instance, over the past four years, the total equipment assets of a power company have grown by an annual average of 9%. Meanwhile, the number of producers per RMB 100 million of assets has been reduced from 11.36 to 8.04, an average annual decrease of 11%, which signifies a considerable boost in work efficiency. In the same period, the precision of production has markedly improved. For example, manual inspections of power transmission equipment, which were carried out monthly, can be conducted daily with the help of UAVs. Substation inspections have transitioned from a once-daily routine to minute-based automated

[8] Data source: Summary of the Investigation on the Impact of AI Development on Labor Employment by the CPPCC National Committee, 2020, CPPCC website (www.rmzxb.com.cn)

monitoring and reading. Additionally, the operation of knife switches has been improved from six hours of on-site labor to half an hour of programmed operation.

Production team members work at the foundational level in enterprises. However, these individuals are seldom included or consulted during the strategic research and planning phases of digital transformation. Team members are passive recipients of digital transformation, despite being its primary users and the human component in “human-machine integration.” Consequently, from the perspective of production teams, this study examines how digital transformation speed influences team vitality and team performance, as well as the factors impacting this relationship. It also seeks to comprehend team members’ responses to the transformation, thus facilitating better design and management of enterprises’ digital transformation. The objective is to ensure that the transformation is conducted in an organized and efficient manner.

The findings of this study show that the digital transformation speed plays a crucial role in encouraging adaptive responses from team members. Moreover, it impacts team viability and team performance, with “adaptive responses” as an intermediate variable. Studying the speed of digital technology implementation rather than focusing on “whether digital technology is adopted” or “digital transformation level” is based on observations and insights after practice. With the advancement and pervasive application of digital technology in enterprises, it is hard to find enterprises that do not use digital technology at all. Production-oriented enterprises are navigating progress from mechanization, industrial automation, and electrification to intellectualization. Given that the rise of digitization is closely related to the advent of informatization at the end of the last century, distinguishing between the two can be challenging. While the digital transformation level can assess the breadth and depth of a technology’s application, it merely provides a static and temporary depiction. From this perspective, it is difficult to feel the influence of “transformation,” which is dynamic and impactful, on the psychology of those involved or to understand the ensuing changes and behaviors catalyzed by the transformation. Through the interviews, it is evident that grassroots production staff is deeply concerned about the transformation speed, as incremental transformation leads to a greater workload (employees have to comply with dual work standards) and challenges in achieving the anticipated benefits of digital technology due to a lack of systematic coordination.

The mechanism of prompting adaptive responses at a high digital transformation speed to enhance team viability and team performance aligns with ancient Chinese proverbs suggesting “success requires everyone’s utmost efforts” and “cutting an enemy’s one finger is more effective than injuring ten.” However, during the functioning of this mechanism, the moderating variable of “preparedness for digital transformation” also plays a crucial role. Such preparedness includes not only the order and organization at the technical level but also the psychological expectations of employees. Being well-prepared ensures that the communication between leaders and employees is more effective, information asymmetry is reduced, and everyone fully understands the benefits, challenges, and countermeasures related to the transformation. Influenced by the incredible effects of digital technology in the news and public opinions, managers often have excessively high expectations for the changes brought by digital technology, while lacking adequate preparation when faced with challenges. Enabling employees to understand the whole transformation procedures, possible changes, potential difficulties, and corresponding measures and properly apprehend the benefits of digital technology will greatly reduce the confusion, anxiety, and fear brought about by change. The model’s empirical results also suggest that preparedness for digital transformation moderates not only the positive correlation between the digital transformation speed and adaptive responses but also the mechanism of indirect influence of the pace of digital transformation on team vitality and team performance.

5.2 Theoretical and Practical Significance

5.2.1 Theoretical contributions

This study uncovers the mechanism through which the digital transformation speed impacts the attitudes and behaviors of team members. Most digital transformations in enterprises are initiated by senior management and implemented in a top-down approach. Most studies investigate the digital transformation process either from a macro perspective or through the lens of enterprises. At the individual level, they focus on the impact of various factors such as personality, job motivation, career commitment, and personal values. Supported by extensive follow-up questionnaire data from grassroots team members, this paper researches the influence of digital transformation on grassroots teams and enriches the research dimensions of such studies.

The dynamic index “digital transformation speed” is employed as an independent variable to broaden the scope of enterprise digital transformation-related antecedents in research. This perspective has not been explored, yet this dynamic index aptly captures the evolution of digital transformation and provides insights for similar studies in the context of organizational change.

The identification of preparedness for digital transformation as a key moderating variable delineates the limits of the “fast and effective” approach. Sufficient preparedness enhances employees’ perception of digital technology’s usefulness and ease of use, encourages positive responses, achieves remarkable efficiency, and validates the principle of "planning before action, knowing when to pull the plug to achieve something."

5.2.2 Practical guidance

Adequate preparedness is an essential prerequisite for an enterprise's digital transformation. The goal of such preparedness is to ensure that all teams involved in digital transformation have a clear understanding of the transformation's objectives, processes, timeline, division of responsibilities, resource preparation, protective measures, personnel and workflow engagement, potential challenges, and corresponding countermeasures. This comprehensive strategy aims to minimize the anxiety and a sense of helplessness that may arise from unforeseen circumstances during digital transformation. Enterprise production is a systematic endeavor. Digital transformation requires a transition from separate efforts to systematic coordination for effective transformation. When digital technologies are applied in specific fields without the formation of a new and comprehensive system, the transformation will be hindered by disadvantages, as shown in the "bucket effect," causing low efficiencies and resource waste. For instance, women's fashion wear enterprises leverage IoT technology backstage to analyze consumer behaviors from trying on apparel to making a purchase. After quickly and accurately determining popular products, these enterprises need the entire supply chain—including fabric, accessories, garment manufacturing, and logistics—to respond rapidly. This requires collaboration among dozens of or even more than a hundred enterprises. If any link in this quick-response supply chain system fails to integrate and operate collaboratively, the sales revenue will not increase significantly. Systems theory thus should be utilized to guide the preparedness for digital transformation. From the perspective of usefulness, plans are made for digital technology's application scenarios, anticipated effects, impacts on existing architectures and processes, and countermeasures. In terms of ease of use, considerations are given to training for use, risk mitigation strategies, follow-up support, and the operation and maintenance of new equipment brought by digital transformation. Moreover, preparation work does not only occur before digital transformation; anticipating and making advanced arrangements for the next phase during digital transformation are equally vital aspects of preparation.

The transformation process is vigorous and decisive, aiming for success while requiring close monitoring of employees' responses to maintain morale. Though digital transformation should proceed swiftly with adequate preparedness, employees' responses during transformation require special attention. Emotional guidance and prompt feedback from team leaders can foster closer collaboration among employees and encourage proactive role supplementation. It is crucial to make adaptive adjustments where necessary. As a huge organizational change, the swift digital transformation significantly disrupts existing workflows and leads to high arousal states among employees. There are two different mental arousal states: negative psychological arousal, which includes anxiety, anger, and fear, as well as positive psychological arousal, which encompasses happiness, anticipation, and excitement (Gould and Krane, 1992). Adequate preparedness can help mitigate negative psychological arousal and boost employee morale. However, feelings of anticipation and excitement may be quickly tempered by issues such as technical glitches, lack of immediate achievements, and the need to learn and adapt to new work tasks. Positive guidance and feedback are crucial in helping employees quickly adapt to intensive changes and make constructive responses.

Companies should be well-prepared for digital transformation in the following aspects: (1) Digital transformation plan: define the transformation's scope, depth, estimated duration, timeline, involved organizations, positions, and personnel, expected outcomes, potential risks, risk mitigation measures, required organizational structures, human resources, funding, and technical support; (2) Employee training manual: detail plans for the training for internal trainers, training schedules, locations, participants, support equipment and systems, training's technical content, psychological support, and evaluation mechanisms; (3) Technical manual: outline the principles, functions, usable range, and operational methods for newly introduced digital technologies, data input, transmission, storage, and retrieving format, software and hardware specifications, models, and security and confidentiality protocols; (4) Process and organizational change plan: specify the triggers for change, process improvement plans and technical standards, new work standards and safety guidelines, role and responsibility definition, staff realignment, employee adjustment plans, and updated job descriptions; (5) System revision plan: identify triggering conditions for system revisions, system names, content, and clauses to be revised, responsible personnel for revisions, and review requirements. During the digital transformation process, attention should be paid to employees' mindset and performance. It is important to help them grasp the overall process and maintain a sense of control, support them to address challenges, facilitate communication between employees and technical engineers, and offer frequent training over a short period. High focus should be put on employees facing changes in job responsibilities and assistance should be given to them to adapt to new requirements, ensuring smooth communication with employees.

5.3 Limitations

This study covers teams from various fields, including vehicle manufacturing, ironing, substation operations, maintenance, relay protection, power transmission inspections, and power marketing. Nonetheless, the type of teams was not differentiated in the questionnaires. Consequently, it is challenging to analyze the efficiency of each team type in later stages, and the sample size is insufficient to ensure the reliability and validity of any further classified analysis. Furthermore, digital technology manifests differently across various fields, involving distinct technical aspects and content and potentially influencing employees in diverse ways. The study does not categorize these technology characteristics and analyze them separately.

The study's respondents are from large and medium-sized enterprises that have been in operation for over 15 years and exhibit stable performance. First, large companies in favorable operating conditions possess more resources for digital transformation. Second, their teams have high stability, which facilitates follow-up investigations. Nonetheless, the effectiveness of this model in small-scale or start-up enterprises, which show lower stability, requires further verification. During the questionnaire phase, this study did not conduct a comparative experiment on digital transformation speed across groups, which means it did not eliminate endogeneity problems. For instance, a high digital transformation speed could be attributed to the high quality and adaptability of employees who had better performance. If feasible, future studies can improve this by measuring achievements while controlling the digital transformation speed.

Throughout the process from employees generating adaptive responses to ultimately manifesting in outcomes related to team vitality and performance, it can be anticipated that individual factors, socialization factors within the team, and organizational contextual factors will play influential roles. This means that employees with varying personalities may respond differently to digital transformation. Social factors, including team cohesion and leadership style, along with organizational contextual factors, such as organizational culture, resource availability, and performance evaluations, will also influence or mediate these outcomes. Besides, the impacts of these factors are interactive and bidirectional. This paper has not incorporated these factors due to research scope constraints.

In the process of digital transformation in enterprises, the cycle of change, psychological impact, psychological responses, and actions are constantly interwoven and repeated. Theoretically, team vitality is positively correlated with subsequent team performance. The study's findings suggest that a virtuous cycle can emerge through well-prepared and adequately supported digital transformation. However, it is not uncommon for the original virtuous cycle to be interrupted, leading to worsening conditions. The incentive mechanism of adaptive responses on team effectiveness will also be influenced by moderating variables. While this study took dynamic factors into account, it investigated and evaluated dependent variables only once, failing to develop a dynamic and multi-cycle model. Moreover, boundary research was not conducted on the incentive mechanisms through which adaptive responses enhance team effectiveness.

5.4 Future research directions

Future research can build upon this study and expand in four directions.

First, it can highlight the impact of individual factors, especially leadership styles, on this model. Individual differences among employees, such as personality, expertise field, educational background, values, and even gender, will naturally influence their perceptions of and responses to digital transformation. However, in practice, enterprises build teams with a primary focus on expertise, while the style of a leader shapes the behaviors of team members and influences the team climate.

Second, it can focus on the influence of environmental factors such as industry stability, organizational culture, team cohesion, and the training incentive system. Digital transformation aims to enhance labor productivity and achieve higher business goals. It is a process that ultimately touches on every facet of an organization, including business processes, work standards, position setting, organizational structures, authority, and culture. Factors such as team climate, organizational environment, industry sector, and even the country where an enterprise operates can affect the achievements of digital transformation.

Third, it can examine the transfer and dissemination of tacit knowledge. The team members are usually good at doing rather than speaking, and they have formed a lot of tacit knowledge in their work. The technical expertise of team members is not readily acquired through theoretical instruction or mere observation. In teams, a mentor-apprentice relationship often emerges naturally (and many enterprises foster this through systematic approaches). Much knowledge is imparted through actions, facial expressions, and other non-verbal communication methods. Digital transformation in production disrupts established experiential knowledge. Examining how team members share their newly acquired digital technology insights using their methods and how to truly achieve human-machine integration can assist in knowledge management and technical staff training.

Fourth, it can dynamically monitor team viability and team performance through various stages. Based on the cyclical progression from mindset to action and from individual behaviors to team behaviors, identifying the incentive mechanism's influencing factors and limitations can help us more efficiently steer the initiation and maintenance of a virtuous cycle in practice.

Indeed, integrating several factors to construct a multi-tiered dynamic model that spans the individual, team, and enterprise levels will pose intriguing challenges as well.

5.5 Conclusions

Managers with formal education are often perceived as impractical idealists by their team members. I aim to facilitate a better understanding of team members. As a manufacturing giant, China pursues technology-driven sustainable growth and intelligent manufacturing, which requires more skilled workers equipped with scientific and technological expertise. Many of our lofty ambitions are accomplished by these comparatively quiet skilled workers. This paper provides reference for managing grassroots teams in the context of enterprise digital transformation. The research results offer fresh insights and solutions regarding the management of digital transformation: the incentive mechanism that correlates the digital transformation speed with team vitality and team performance, as well as factors that influence the mechanism's validity. The results show the importance of the digital transformation speed in enhancing team vitality and team performance. This study reveals how the most grassroots production teams enhance their team effectiveness through enterprise digital transformation. Moreover, it offers reference for enterprises to manage and oversee digital transformation in future practices.

Reference

Abdeldayem, M. M., and S. H. Aldulaimi. 2020, Trends and Opportunities of Artificial Intelligence in Human Resource Management: Aspirations for Public Sector in Bahrain [J]. International Journal of Scientific and Technology Research, 9(1): 3867-3871

Ajzen, I., and M. Fishbein. 1975, A Bayesian Analysis of Attribution Processes [J]. Psychological bulletin, 82(2):261-277

Ajzen, I, and M. Fishbein. 1980, Understanding Attitudes and Predicting Social Behavior [M]. Prentice-Hall, Englewood Cliffs, NJ

Albert, B. 1977, Self-efficacy: Toward a Unifying Theory of Behavioral Change [J]. Psychological Review, 84(2): 191–215

Albert, B. 1986, Social Foundations of Thought and Action: A Social Cognitive Theory [M]. Englewood Cliffs, NJ: Prentice-Hall

Albert, B. 1997, Self-efficacy: The Exercise of Control [M]. New York: Freeman and Company

Alchian, A. A., and H. Demsetz. 1972, Production, Information Costs, and Economic Organization [J]. The American Economic Review, 62(5): 777-795

Amiram, D. V., R. H. Price, Y. Schul. 1995, Impact of the Jobs Intervention on Unemployed Workers Varying in Risk for Depression [J]. American Journal of Community Psychology, 23(1) : 39-74

Arnaud, S., and J. L. Chandon. 2013, Will Monitoring Systems Kill Intrinsic Motivation? An Empirical Study [J]. Revue de Gestion des Ressources Humaines, 90(4): 35-53

Arntz, M., Gregory T., and U. Zierahn. 2017, Revisiting the Risk of Digital Transformation [J]. Economics Letters, 159: 157-160

Balkundi, P., and Harrison D. 2006, Ties, Leaders, and Time in Teams: Strong Inference about Network Structure's Effects on Team Viability and Performance [J]. Academy of Management Journal, 49(1):49-68

Barrett, M., E. Oborn, J. W. Orlikowski, and J. Yates. 2012, Reconfiguring Boundary Relations: Robotic Innovations in Pharmacy Work [J]. Organization Science, 23(5): 1213-1522

Barrick, M. B., B. H. Bradley, A. L. Kristof-Brown, and A. E. Colbert. 2007, The Moderating Role of Top Management Team Interdependence: Implications for Real Teams and Working Groups [J]. Academy of Management Journal, 50, 544-557

Bell, S. T., and B. J. Marentette. 2011, Team Viability for Long-Term and Ongoing Organizational Teams [J]. Organizational Psychology Review, 1(4): 275-292

Bloom, E. D., M. McKenna, and K. Prettner. 2018, Demography, Unemployment, Automation, and Digitalization: Implications for the Creation of (Decent) Jobs, 2010-2030 [R]. Working Paper, http://www.nber.org/papers/w24835, National Bureau of Economic Research

Boyles, D. R. 2006, Dewey's Epistemology: An Argument for Warranted Assertions, Knowing, and Meaningful Classroom Practices [J]. Educational Theory, 56: 57-68

Brislin, R.W. 1980, Translation and Content Analysis of Oral and Written Material [M]. In: Triandis, H.C. and Berry, J.W., Eds., Handbook of Cross-Cultural Psychology Methodology, Allyn and Bacon, Boston

Bruce, N. I., B. P. S. Murthi, and R. C. Rao. 2017, A Dynamic Model for Digital Advertising: The Effects of Creative Format, Message Content, and Targeting on Engagement [J]. Journal of Marketing Research, 54(2): 202-218

Burke, C.S., K. C. Stagl, E. Salas, L. Pierce, and D. Kendall. 2006, Understanding Team Adaptation: a Conceptual Analysis and Model [J]. Journal of Applied Psychology, 91: 1189-1207

Campion, A. M., and L. C. McClelland. 1991, Interdisciplinary Examination of the Costs and Benefits of Enlarged Jobs: A Job Design Quasi-Experiment [J]. Journal of Applied Psychology, 76(2): 186-198

Campion, A. M., and M. L. Carol. 1993, Follow-Up and Extension of the Interdisciplinary Costs and Benefits of Enlarged Jobs [J]. Journal of Applied Psychology, 78(3): 339-351

Cerne, M., C. Nerstad, and A. Dysvik. 2014, What Goes Around Comes Around: Knowledge Hiding, Perceived Motivational Climate, and Creativity [J]. Social Science Electronic Publishing, 57(1): 172-192

Christie, B. 1981, Face to File Communication: A Psychological Approach to Information Systems [M]. New-York, USA: Wiley

Cole, S. M., F. Walter, and H. Bruch. 2008, Affective Mechanisms Linking Dysfunctional Behavior to Performance in Work Teams: A Moderated Mediation Study [J]. Journal of Applied Psychology, 93(5): 945-958

Comte, A., and F. Ferre. 1988, Introduction to Positive Philosophy [M]. Indianapolis: Hackett Publishing Company, Inc.

Conger, J. A., R. N. Kanungo, and S. T. Menon. 2000, Charismatic Leadership and Follower Effects [J]. Journal of Organizational Behavior, 21, 747-767

Cooper, C. L., and J. Marshall. 1976, Occupational Sources of Stress: A Review of the Literature Relating to Coronary Heart Disease and Mental Ill Health [J]. Journal of Occupational Psychology, 49(1): 11-28

Cort, W. R., N. L. Kristi, and H. Zacher. 2017，Career Adaptability: A Meta-analysis of Relationships with Measures of Adaptivity, Adapting Responses, and Adaptation Results [J]. Journal of Vocational Behavior, 98: 17-34

Dodson, M.，D. Gann, I. Wladawsky-Berger, N. Sultan, and G. George. 2015, Managing Digital Money [J]. Academy of Management Journal, 58(2): 325-333

Donaldson, L. 1987, Strategy and Structural Adjustment to Regain Fit and Performance: In Defence of Contingency Theory [J]. Journal of Management Studies, 24(1): 1-24

Duggan, J., U. Sherman, R. Carbery, and A. Mcdonnell. 2020, Algorithmic Management and App‐Work in the Gig Economy: A Research Agenda for Employment Relations and HRM [J]. Human Resource Management Journal, 30(1): 114-132

Edmondson, C. A., and I. M. Nembhard. 2009, Product Development and Learning in Project Teams: The Challenges Are the Benefits [J]. Journal of Product Innovation Management, 26(2): 123-138

Ellmer, M., T. K. Gegenhuber, and E. S. Schuessler. 2019, Exploring Crowdworker Participation on Digital Work Platforms [C]. Academy of Management Proceedings. Briarcliff Manor, NY 10510: Academy of Management, 2019(1): 14552

Eric, B. D., and S. G. Goldberg. 1999, Challenging “Resistance to Change” [J]. The Journal of Applied Behavioral Science, 35(1): 25-41

Fishbein, M., and I. Ajzen. 1975, Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research [M]. MA: Addison-Wesley

Foo, M. D., H. P. Sin, and L. P. Yiong. 2006, Effects of Team Inputs and Intrateam Processes on Perceptions of Team Viability and Member Satisfaction in Nascent Ventures [J]. Strategic Management Journal, 27(4): 389-399

Fred, D. D. 1986, A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results [D]. Doctoral dissertation, Sloan School of Management, Massachusetts Institute of Technology

Fred, D. D., R. P. Bagozzi, and P. R. Warshaw. 1989，User Acceptance of Computer Technology: A Comparison of Two Theoretical Models [J]. Management Science，35(8): 982-1003

Frohm, J., V. Lindström, M. Winroth, and J. Stahre. 2008, Levels of Digital Transformation in Manufacturing [J]. Ergonomia, 30(3), DOI:http://dx.doi.org/

Georgia, T. C., S. W. J. Kozlowski. 1986, Employee Perceptions on the Implementation of Robotic Manufacturing Technology [J]. Journal of Applied Psychology, 71(1): 70-76

Gould, D, and V. Krane. 1992, The Arousal-athletic Performance Relationship: Current Status and Future Directions [M]. Horn T. Advances in Sport Psychology. Champaign: Human Kinetics, 119-141

Graen, G. B. S., and A. Terri. 1987, Toward a Psychology of Dyadic Organizing [J]. Research in Organizational Behavior, 9, 175-208

Grand, J. A., M. T. Braun, G. Kuljanin, S. W. J. Kozlowski, and G. T. Chao. 2016, The Dynamics of Team Cognition: A Process-oriented Theory of Knowledge Emergence in Teams [J]. Journal of Applied Psychology, 101(10): 1353–1385

Grewal, L., A. T. Stephen, and N. V. Coleman. 2019, When posting about products on social media backfires: the negative effects of consumer identity signaling on product interest [J]. Journal of Marketing Research, 56(2): 197-210

Griffin, A. M., A. Neal, and S. K. Parker. 2007, A New Model of Work Role Performance: Positive Behavior in Uncertain and Interdependent Contexts [J]. Academy of Management Journal, 50(2): 327-347

Griffeth, R. W., and S. Gaertner 1999, Taxonomic Model of Withdrawal Behaviors: the Adaptive Response Model [J]. Human Resource Management Review, 4: 577-599

Hackman, J. R. 1987, The Design of Work Teams [C]. Handbook of Organizational Behavior, 315-342

Hacioglu, U. 2020, Digital Business Strategies in Blockchain Ecosystems [J]. Springer International Publishing, DOI, 10: 978-3

Hirschi, A., A. Herrmann, and A. C. Keller. 2015, Career Adaptivity, Adaptability, and Adapting: A Conceptual and Empirical Investigation [J]. Journal of Vocational Behavior, 87: 1-10

Langer, E. J., B. Arthur, and C. Benzion. 1987, The Mindlessness of Ostensibly Thoughtful Action: The Role of "Placebic" Information in Interpersonal Interaction [J]. Journal of Personality and Social Psychology, 36(6): 635-642

Langfred, W. C., and N. A. Moye. 2004, Effects of Task Autonomy on Performance: An Extended Model Considering Motivational, Informational, and Structural Mechanisms [J]. Journal of Applied Psychology, 89(6): 934-945

Langfred, W. C. 2007, The Downside of Self-Management: A Longitudinal Study of the Effects of Conflict on Trust, Autonomy, and Task Interdependence in Self-Managing Teams [J]. The Academy of Management Journal, 885-900

Liden, R. C., and G. Graen. 1980, Generalizability of the Vertical Dyad Linkage Model of Leadership [J]. Academy of Management Journal, 23(3): 451-465

Jacobides, M. G.，C. Cennamo, and A. Gawer. 2018, Towards a Theory of Ecosyst MES [J]. Strategic Management Journal, 39(8):2255-2276

Jayakar, K., and E. A. Park. 2013, Broadband Availability and Employment: An Analysis of County-Level Data from the National Broadband Map [J]. Journal of

Information Policy, 3: 181-207

Jeffers, P. I., W. A. Muhanna, and B. R. Nault. 2008, Information technology and process performance: an empirical investigation of the interaction between IT and non‐IT resources[J]. Decision sciences, 39(4): 703-735

Jermier, J. M., D. Knights, and W. R. Nord. 1994, Resistance and Power in Organizations [M]. Taylor and Frances/Routledge

Jeske, D., and A. M. Santuzzi. 2015, Monitoring What and How: Psychological Implications of Electronic Performance Monitoring [J]. New Technology, Work and Employment, 30(1): 62-78

Johnson, G. A., R. A. Lewis, and D. H. Reiley. 2017, When Less is More: Data and Power in Advertising Experiments [J]. Marketing Science, 36(1): 43-53

Karunakaran, A. 2019, Front-line Professionals in the Wake of Digital Scrutiny: The Paradox of Public Accountability [C]. Academy of Management Proceedings. Briarcliff Manor, NY 10510: Academy of Management, 2019(1): 13114

Katzenbach, J. R., and D. K. Smith. 1993, The Discipline of Teams [J]. Harvard Business Review, 71:111-120

Kim, W. G., H. Lim, and R. A. Brymer. 2015, The Effectiveness of Managing Social Media on Hotel Performance [J]. International Journal of Hospitality Management, 44: 165-171

Kotter, J. P. 1995, Leading Change: Why Transformation Efforts Fail [J]. Harvard Business Review, 3: 59-67

Kozlowski, W. J. S., and J. K. Klein. 2000, Multilevel Theory, Research, and Methods in Organizations: Foundations, Extensions, and New Directions [A]. https://www.researchgate.net/publication/232522112

Kozlowski, W. J. S., T. G. Chao, A. J. Grand, T. M. Braun, and G. Kuljanin. 2013, Advancing Multilevel Research Design: Capturing the Dynamics of Emergence [J]. Organizational Research Methods, 16(4) 581-615

Kretschmer, T., and P. Khashabi. 2020, Digital Transformation and Organization Design: An Integrated Approach [J]. California Management Review, 62(4): 86-104

Lewin, K. 1951, Field Theory in Social Science: Selected Theoretical Papers (Edited by Dorwin Cartwright) [M]. New York: Harper and Row.

Locke, E. A. 1968, Toward a Theory of Task Motivation and Incentives, [J]. Organizational Behavior and Human Performance, 3 (2): 157

Lüscher, L. S., and M. W. Lewis. 2008, Organizational Change and Managerial Sensemaking: Working Through Paradox [J]. Academy of Management Journal, 51(2): 221-240

Lyytinen, K., S. Nambisan, and Y. Yoo. 2020, A Transdisciplinary Research Agenda for Digital Innovation: Key Themes and Directions for Future Research [J]. Handbook of Digital Innovation, 279-286

Marks, A. M., E. J. Mathieu, I. S. Zaccaro. 2001, A Temporally Based Framework and Taxonomy of Team Processes [J]. Academy of Management Review, 26(3): 356-376

Marrone, J., A., P. E. Tesluk, and J. B. Carson. 2007, A Multilevel Investigation of Antecedents and Consequences of Team Member Boundary-Spanning Behavior [J]. Academy of Management Journal, 50(6): 1423-1439

Maslach, C., and M. Leiter. 2008, Early Predictors of Job Burnout and Engagement [J]. The Journal of Applied Psychology, 93(3): 498-512

Mathieu, J. E., J. R. Hollenbeck, K. D. Van, and D. R. Ilgen. 2017, A Century of Work Teams in the Journal of Applied Psychology [J]. Journal of Applied Psychology, 102(3): 452-467

Mathieu, J. E., P. T. Gallagher, M. A. Domingo, and E. A. Klock. 2019, Embracing Complexity: Reviewing the Past Decade of Team Effectiveness Research [J]. Annual Review of Organizational Psychology and Organizational Behavior, 6:17–46

McGrath, J. E. 1976, Stress and Behavior in Organizations [M]. Handbook of Industrial and Organizational Psychology. Dennett, M. D. (ED) Chicago: Rand McNally College Publishing,

Mikalef, P., and A. Pateli. 2017, Information Technology-enabled Dynamic Capabilities and Their Indirect Effect on Competitive Performance: Findings from PLS-SEM and fsQCA [J]. Journal of Business Research, 70: 1-16

Miklós-Thal, J., and C. Tucker. 2019, Collusion by Algorithm: Does Better Demand Prediction Facilitate Coordination Between Sellers? [J]. Management Science, 65(4): 1552-1561

Matt, C., T. Hess, and A. Benlian. 2015, Digital Transformation Strategies [J]. Business and Information Systems Engineering, 57(5): 339-343

Nerstad, C. G. L., G. C. Roberts, and A. M. Richardsen. 2013, Achieving Success at Work: Development and Validation of the Motivational Climate at Work Questionnaire (MCWQ) [J]. Journal of Applied Social Psychology, 43(11): 2231-2250

Orlikowski, W. J., and J. Yates. 2002, It’s about Time: Temporal Structuring in Organizations [J]. Organization Science, 13(6): 684-700

Park, M., J. Song, S. J. Oh, M. Shin, J. H. Lee, and S. H. Oh. 2015, The Relation between Nonverbal IQ and Postoperative CI Outcomes in Cochlear Implant Users: Preliminary Result [J]. BioMed Research International, 1-7

Pesch, R., and H. Endres, 2019, The Marginal Utility Effect of Formalization for Digital Product Innovation [C]. Academy of Management Proceedings, Briarcliff Manor, NY 10510: Academy of Management, 2019(1): 14834

Porras, J. I., and P. J. Robertson. 1992, Organizational Development: Theory, Practice, and Research [M]. Handbook of Industrial and Organizational Psychology (2nd ed). Consulting Psychologists Press, 719-822

Preacher, K. J., M. J. Zyphur, and Z. Zhang. 2010, A General Multilevel SEM Framework for Assessing Multilevel Mediation [J]. Psychological Methods, 15(3): 209-233

Quinn, R. W., and J. E. Dutton. 2005, Coordination as Energy-in-Conversation [J]. The Academy of Management Review, 30(1): 36-57

Rosabeth, M. K., A. S. Barry, and D. J. Todd. 1992，Organizational Change: How Companies Experience It and Leaders Guide It [M]. A Division of Simon and Schuster, Inc.,

Rosenthal, R., and R. L. Rosnow. 1991, Essentials of Behavioral Research: Methods and Data Analysis [M]. New York: McGraw-Hill

Ross, J. W., C. M. Beath, and D. L. Goodhue. 1996, Develop Long-term Competitiveness Through IT Assets [J]. Sloan Management Review, 38(1): 31-42

Santos, C. M., and A. M. Passos. 2013, Team Mental Models, Relationship Conflict and Effectiveness over Time [J]. Team Performance Management, 19(7/8): 363 - 385

Schumacher, A., W. Sihn, and E. Selim. 2016, Automation, Digitization and Digitalization and Their Implications for Manufacturing Processes [C]. Innovation and Sustainability, International Scientific Conference Bucharest, Romania

Schuler, R. S. 1980, Definition and Conceptualization of Stress in Organizations [J]. Organizational Behavior and Human Performance, 25(2): 184-215

Scott, E. S. 2021, A Strategic Framework for Task digital transformation in Professional Services [J]. Journal of Service Research, 24(1): 122-140

Sebastian, V., A. Maschwitz, and O. Zawacki-Richter. 2010, From Knowledge Transfer to Competence Development – a Case of Learning by Designing [C]. EdMedia Innovate Learning, Toronto, Canada, Association for the Advancement of Computing in Education

Sivathanu, B., and R. Pillai. 2018, Smart HR 4.0-How Industry 4.0 is Disrupting HR [J]. Human Resource Management International Digest, 26(4): 7-11

Stephen, P. R. 1994, Essentials of Organizational Behavior [M]. Prentice Hall

Stephen, P. R. 2004，管理学 [M]. 人民大学出版社出版，377-381

Sundstrom, E. D. M., P. Kenneth, and D. Futrell. 1990, Work Teams: Applications and Effectiveness [J]. American Psychologist, 45(2): 120-133

Swanson, E. B. 1982, Measuring User Attitudes in MIS Research: A Review [J]. OMEGA, 10: 157-165

Swanson, E. B. 1988, Information System Implementation: Bridging the Gap between Design and Utilization [M]. Irwin, Home-wood, IL

Tasa, K. T., S. Simon, and H. Gerard. 2007, The Development of Collective Efficacy in Teams: A Multilevel and Longitudinal Perspective [J]. Journal of Applied Psychology, 92(1): 17-27

Tolman, C. E. 1932, Purposive Behavior in Animals and Men [M]. 浙江教育出版社，李维译，1999

Vernon, D. M., J. R. Johnson, and J. Grau 1994, Antecedents to Willingness to

Participate in a Planned Organizational Change [J]. Journal of Applied Communication Research, 22: 59-80

Vuori, J., S. Toppinen-Tanner, and P. Mutanen. 2011, Effects of Resource- Building Group Intervention on Career Management and Mental Health in Work Organizations: Randomized Controlled Field Trial [J]. Journal of Applied Psychology, Online First Publication, DOI: 10.1037/a0025584

Wang, D., D. A. Waldman, and Z. Zhang. 2014, A Meta-Analysis of Shared Leadership and Team Effectiveness [J]. Journal of Applied Psychology, 99(2): 181-198

Chen, G. Q., G. Wu, D. Y. Gu, B. J. Lu, and Q. Wei. 陈国青，吴刚，顾远东，陆本江，卫强 2018, 管理决策情境下大数据驱动的研究和应用挑战——范式转变与研究方向 [J]. 管理科学学报, 21(07):1-10

Cui, Y., H. Jiao, and Y. Zhang. 崔瑜，焦豪，张样 2013，基于 IT 能力的学习导向战略对绩效的作用机理研究 [J]. 科研管理，34(07): 93-100

Deng, J. Z., and C. M. Wang. 邓今朝，王重鸣 2012，团队目标取向对适应性的影响: 突变情景下的阶段特征 [J]. 软科学，26(5): 86-91

Deng, Z. and Y. N. Huang. 邓洲，黄娅娜 2019, 人工智能发展的就业影响研究 [J]. 学习与探索，7：99-106+175

Fu, Y., Q. Xu, and S. Lin. 傅颖，徐琪，林嵩 2021, 在位企业流程数字化对创新绩效的影响——组织惰性的调节作用 [J]. 研究与发展管理，33(01): 78-89

Gong, Y., and X. Z. Peng. 龚遥，彭希哲 2020, 人工智能技术应用的职业替代效应 [J]. 人口与经济，3： 86-105

Han, X. F., N. Hui, and W. F. Song. 韩先锋，惠宁，宋文飞 2014, 信息化能提高中

国工业部门技术创新效率吗 [J].中国工业经济，12：70-82

He, Fang, and H. X. Liu. 何帆，刘红霞 2019, 数字经济视角下实体企业数字化变革的业绩提升效应评估 [J]. 改革，4：137-148

Huang, Q. H., Y. Z. Xu, and S. L. Zhang. 黄群慧，余泳泽，张松林 2019，互联网发展与制造业生产率提升：内在机制与中国经验 [J]. 中国工业经济，8：5-23

Li, C. P. 李超平 2014，变革型领导与团队效能: 团队内合作的跨层中介作用 [J]. 组织行为与人力资源管理，26(4): 73-81

Li, K. W., W. B. Shao, and Y. J. Wang. 李坤望，邵文波，王永进 2015，信息化密度、信息基础设施与企业出口绩效——基于企业异质性的理论与实证分析 [J]. 管理世界，4：52-65

Li, Y. P., L. Li, and X. Hu. 李燕萍，李乐，胡翔 2021，数字化人力资源管理：整合框架与研究展望 [J].科技进步与对策，38(23): 151-160

Liu, B., and X. Lin 刘冰，蔺璇 2010，团队异质性对团队效能的影响研究 [J]. 经济管理，32(11): 74-81

Liu, J. 刘杰，2019，企业走向新的数字化之路 [J]. 清华管理评论，(09)：75-83.

Liu, S. C., J. C. Yan, S. X. Zhang, and H. C. Lin. 刘淑春，闫津臣，张思雪，林汉川 2021，企业管理数字化变革能提升投入产出效率吗 [J]. 管理世界，37(05)：170-190+13

Meng, X. B., C. M. Wang, and J. F. Yang. 孟晓斌，王重鸣，杨建锋 2008，企业组织变革中的动态能力多层适应性探析 [J]. 外国经济与管理, 30(2)：1-8

Ning, G. J., and Z. L. Lin. 宁光杰，林子亮 2014，信息技术应用、企业组织变革与劳动力技能需求变化 [J]. 经济研究, 49(08)：79-92

Mo, S. J. and X. Y. Xie. 莫申江，谢小云 2009，团队学习、交互记忆系统与团队

绩效：基于 IMOI 范式的纵向追踪研究 [J]. 心理学报，41(7)：639-648

Qi, Y. D., and C. W. Cai. 戚聿东，蔡呈伟 2020，数字化对制造业企业绩效的多重影响及其机理研究 [J]. 学习与探索，7：108-119

Qi, Z. J., and D. X. Wang. 戚振江，王端旭 2003，研发团队效能管理 [J]. 科研管理，24(2)：127-132

Rao, P. G., L. K. Zhao, and H. Yue. 饶品贵，赵龙凯，岳衡 2008，吉利数字与股票价格 [J]. 管理世界，11： 44-49+77

Wang, L. H., S. M. Hu., and Z. Q. Dong. 王林辉，胡晟明，董直庆 2022，人工智能技术、任务属性与职业可替代风险：来自微观层面的经验证据 [J]. 管理世界，7：60-70

Wu, F., H. Z. Hu, and H. Y. Lin. 吴非，胡慧芷，林慧妍，任晓怡 2021，企业数字化转型与资本市场表现——来自股票流动性的经验证据 [J]. 管理世界，37(07)：130-144+10

Wu, X., M. Zhu, and B. Chen. 吴溪，朱梅，陈斌开 2017，“互联网+”的企业战略选择与转型业绩——基于交易成本的视角 [J]. 中国会计评论，15(02)：133-154

Xiang, C. C., and L. R. Long. 向常春，龙立荣 2010, 团队内冲突对团队效能的影响及作用机制 [J]. 心理科学进展, 18(5)：781-789

Xie, K., Y. Wu, J. H. Xiao, and X. H. Liao. 谢康，吴瑶，肖静华，廖雪华 2016, 组织变革中的战略风险控制——基于企业互联网转型的多案例研究 [J]. 管理世界，2：133-148+188

Xie, K. Z. H. Xia, and J. H. Xiao. 谢康，夏正豪，肖静华 2020，大数据成为现实

生产要素的企业实现机制：产品创新视角［J］．中国工业经济，5：42-60

Xie, X. Y.,and Q. Zhang. 谢小云，张倩 2011，国外团队断裂带研究现状评介与未来展望［J］.外国经济与管理，33(1)：34-42

Xie, X. Y., Y. H. Zuo, and Q. J. Hu. 谢小云，左玉涵，胡琼晶 2021，数字化时代的人力资源管理：基于人与技术交互的视角［J］.管理世界，37(01)：200-216+13

Xu, M. Z., and T. Lv. 徐梦周，吕铁 2020，赋能数字经济发展的数字政府建设:内在逻辑与创新路径［J］.学习与探索，3：78-85+175

Yuan, Y. 袁勇 2017，BPR 为数字化转型而生 [J]. 企业管理，10：102-104

Zeng, F. E., X. Zheng, X. Zheng, and X. Li. 曾伏娥，郑欣，李雪 2018，IT 能力与企业可持续发展绩效的关系研究 [J].科研管理，39(04)：92-101

Zheng, G.J., D. J. Lin, and W. Q. Tan. 郑国坚，林东杰，谭伟强 2016，系族控制、集团内部结构与上市公司绩效［J］.会计研究，2：36-43+95

Zhang, W. G. 章文光，Ji Lu，Laurette Dubé 2016，融合创新及其对中国创新驱动发展的意义 [J]. 管理世界，6：1-9

Zhang, X. L., and C. M. Wang. 张小林，王重鸣 1997，群体绩效和团队效能研究的新进展 [J]. 应用心理学， 3(2)：58-64

Zhang, Y. and Q. Wu. 张骁，吴琴，余欣 2019，互联网时代企业跨界颠覆式创新的逻辑 [J]. 中国工业经济，3：156-174

Zhao, C. Y. 赵宸宇 2021，数字化发展与服务化转型——来自制造业上市公司的经验证据 [J].南开管理评论，24(02)：149-163

Zhou, S. H., and G. H. Wang. 周驷华，万国华 2016，信息技术能力对供应链绩效

的影响：基于信息整合的视角 [J]. 系统管理学报，25(01)：90-102

Appendices

1. Interview Notes

Interview Note 1

Time: 9:54 a.m., July 14, 2022

Interviewee: Chen XX (a specialist in the System Department) of an electric power company

Q: Could you please share your thoughts on existing digital technologies first?

Chen: Network security comes to my mind. Various network-related issues may arise throughout the digital development process, like operating supporting platforms and unmanned infrastructure development. Network security is primarily concerned with managing and controlling the entire process, starting from project approval to final acceptance and operation.

Q: Is the process of digitization today about bridging those different sections to solve the issue of synchronizing data?

Chen: Connecting those sections does not appear to be a big challenge, as it is supported by safety regulation documents. The power industry will adhere to the security zone and network requirements, which are clearly specified. The primary challenge may lie in addressing risks associated with adopting new technologies. Due to the lack of applied cases, there is a concern about the possible unknown risks. For instance, when drones use WiFi, there may be transmission risks associated with WiFi. According to our discussions with some experts, WiFi is not considered reliable, but it can be temporarily utilized during project construction. Developing new systems involving technologies like 5G, WiFi, and Beidou Navigation Satellite System encompasses network security considerations. This is a process of ongoing exploration.

Q: What are your opinions on network security organizing personnel's positions, responsibilities, and counts during exploration or pilot application phases?

Chen: In any case, the supporting role is crucial given its mandatory nature. My partner and I are responsible for the network security of the power monitoring system.

Q: Regarding digitization, the growing volume of data may necessitate an increase in network security managers. So how many network security managers are needed? Will the network security management workload expand?

Chen: No special personnel arrangement is needed. Our job function principle stipulates that the individual managing a task is also responsible for its security. Hence, those managing the system or involved in its construction and completion are accountable for its security.

Q: So this responsibility is assumed by individuals managing the system?

Chen: Yes. There is one point to note: system builders, including coordinators, are accountable for providing technical assistance.

Q: We might have given less thought to network security in aspects like making plans. I'm curious to know if the network security workload is only present during system development or extends throughout the entire process.

Chen: It involves the entire process, including the planning, equipment, grid connection, and operation and maintenance.

Q: Given that operation and maintenance work does not need specialized personnel, is strict compliance with its relevant requirements sufficient?

Chen: The operation and maintenance staff only need to complete the key tasks assigned by the security supervisor without requiring additional time and effort on it.

Q: As you just mentioned, connecting sections does not appear to be a big challenge.

Chen: Indeed. It is not a challenge, because we always have solutions in back support for any type of connection.

Q: Now, the crucial factor lies in the security of the new technology. Does the company conduct a general technical test or regional technical tests?

Chen: Currently, the company lacks clear specifications. The existing document "Technical Specifications for Network Security" is quite outdated and has not been updated for a long time. Many aspects of the Specifications do not align with our current operations. Hence, this is an exploratory process, and the company executives are also deliberating on this matter.

Q: How do you ensure data security when the company's current regulations and norms are outdated? Do you think that national and industrial standards in the market can adequately meet the requirements in certain working scenarios?

Chen: This is the focus of our upcoming tasks. National standards, including specific assessment criteria, are obligatory. If there are corresponding regulations in national and industry standards, they must be strictly enforced. This holds significant importance for us.

Q: Do you think the current obligatory regulations are falling behind or keeping up with ongoing advancements?

Chen: National and industry standards may not fully meet our internal requirements.

Q: The company is also working on standardization. Have you ever envisioned the evolution of network security?

Chen: The system's network security is managed and overseen by the system administrator.

Q: Is maintaining network security equipment the same as maintaining intelligent substation equipment?

Chen: No, they're not the same. Currently, we lack numerous network security devices, but they're expected to increase in the future. We've secured several projects to enhance the future network security of substations.

Q: You're defining the duties of the individual overseeing intelligent inspections and other roles. How is the operational efficiency of the intelligent operation team?

Chen: We're exploring in this regard.

Q: Do they monitor data in routine work?

Chen: Yes. Following the provincial branch's directives, pilot work can commence without waiting for the company's explicit instructions. The procedure system will be concurrently enhanced in subsequent stages.

Q: Could you introduce the selection standards for the intelligent operations team members?

Chen: Currently, each institute independently determines the selection criteria, emphasizing awareness of station conditions. This involves the company's digital development. Our current deliberation in this domain is not flawless, and further refinement will be carried out according to the specifications of the company's three-year digital promotion plan.

Q: OK. Thank you for your time.

Interview Note 2

Time: 10:15 a.m., July 15, 2022

Interviewees: Yu XX (maintenance specialist in the Production Technology Department) and Luo XX (operation specialist in the Power Transformation Department) of an electric power company

Q: Do you perceive essential distinctions between the digital production technologies available on the market and those utilized by your company? With the nation endorsing digital advancement, are there fundamental differences in the depth or intelligence levels of technologies used by your company in digital production, such as digital power transformation and transmission?

Yu: Generally speaking, this is about intelligentization that releases human resources. In my opinion, the fundamental technology objectives in the market remain consistent, but technology disparities exist for various scenarios and tasks.

Q: What do you perceive as the fundamental objectives of digitization? For instance, is it about just replacing manual tasks with machines or reshaping the logic of the world or the logic of world business?

Yu: I think it involves three aspects. Firstly, it aims to release workforce resources by automating manual tasks and reducing the need for personnel. Secondly, it enhances personal safety by automating activities linked to production safety, thus reducing risks among employees and addressing safety concerns. Lastly, it focuses on refining operational precision and lowering the chances of human error by facilitating machine operations.

Q: How do you perceive the relationship between digital production and human operation? For example, are they mutually replaceable or complementary? Or do you concur that digital technology complements human labor rather than exists independently?

Yu: I think digital technology and human operation are complementary.

Q: Based on your understanding of global digital technology trends, do you think it is appropriate for the company to engage in digital production considering the level of development in external technologies?

Yu: As technology is advancing rapidly nowadays, some novel technologies can be piloted. With our established foundation and the growing maturity of external technologies, we're ready to explore technological applications ahead of schedule. In my view, the timing is ideal for the implementation of digital production.

Q: Based on your experience in introducing technology at companies, it typically commences on a small scale. Which technologies and applications do you think are viable but not quite mature yet? What technologies are ineffective? Could you provide insights into this area?

Yu: As an illustration, our current efforts involve promoting AI integration to entirely supplant human operations. Nevertheless, AI falls short of achieving absolute 100% accuracy in tasks such as action recognition, which presents a significant drawback.

Q: As far as I know, cameras, robots, and UAVs are the three main technologies used in power transformation inspection. Are you involved in these technologies?

Luo: Yes. As for the UAV technology, we have been testing it indoors. Last year, we made a preliminary exploration of patrol and maintenance work. The utilization of UAVs showed limited impact last year. However, thanks to the good performance of key network security, there have been revolutionary breakthroughs in UAV technology this year. Building upon the groundwork in Songtao, we plan to delve into this new technology. UAVs can help us monitor all power facilities within the patrol radius.

Q: Apart from challenges in image recognition facing the current practical technology application, are there other bottlenecks in technology applications? Furthermore, which technologies have shown more maturity and a strong base for broader adoption?

Yu: In fact, we have many applied scenarios of new technologies that were promoted in the early stage. For the UAV and transformer monitoring we discussed earlier, our technology projects also have corresponding support, including options for partial discharge, monitoring, identification, and terminal surveillance. Promptly evaluating new things, such as the transformer health model, remains challenging, and the credibility of evaluations still needs complete confirmation. Within our technology application process, our approach stands out for its maturity, bridging the previous lack of effective construction means in switch cabinets. This approach helps identify hidden troubles and temperature issues in switch cabinets. It has achieved good results among stations in our city, such as identifying temperature-rising issues and avoiding the scope expansion of equipment failures and power outages. While fixed terminals like cameras offer reliability, they come with technical limitations due to their immobility once installed at a fixed angle. Later adjustment will lead to abnormal conditions. Hence, we are continuously exploring new technologies this year. The groundbreaking progress in UAV technology offers a fresh perspective, overshadowing fixed terminals due to the unparalleled advantages UAVs provide. In terms of mechanical performance, UAVs effectively meet our inspection requirements for outdoor substation equipment and requirements for power transmission and transformation devices.

Q: Special patrol inspections are often required in severe weather conditions. Will that affect UAVs' routes? Can the new technology automatically identify images during the dynamic inspection process of UAVs? Or does it still need human assistance to re-identify and confirm the information obtained?

Yu: It automatically acquires the image. Identifying images is a difficult task. I believe there is no need for excessive concern regarding the identification success rate. The core concept of our entire digital transformation is to minimize field operations by leveraging robots. In the company's 14th Five-Year Plan and 2022 Initiatives, remote inspection is highlighted instead of intelligent patrol. Regarding the previous application route of intelligent technology in the production field, we talked more about some forward-looking directions and ideas. After pilot exploration from 2018 to 2021, I think our company's leadership has gradually favored practicality. Despite the fast advancement of technology, the core objective should be to decrease the onsite workforce.

Q: From our earlier dialogue, it appears that the application of intelligent technology notably affects the on-site workforce and leads to significant modifications in job roles and responsibilities. The completed pilot endeavors indicate that there is minimal backstage work experience in intelligent or automated recognition systems.

Yu: Yes, it cannot be improved in a short time. We're also delving into this area but remain in the exploratory stages, having not yet achieved the level of application in management. Following several years of pilot projects within our company, my perspective has largely shifted toward emphasizing straightforward objectives and tangible outcomes. As a demonstration area for organizational model optimization, achieving scale efficiency is critical. Our current technology supports a reduction in our workforce. Regarding new technological breakthroughs, we must persist in enhancing the intelligent effect of remote operations. My colleagues are engaged in intelligent operations, including automated patrol and remote manual inspections. These operations certainly require their in-depth involvement. We'll maintain close communication to foster exploration in various aspects. In terms of requirements of broader schemes, my personal view is to commence exploratory efforts once the technical route is delineated. However, our primary focus should be on reducing the on-site workload in the company's substation domain by employing intelligent solutions. Regarding the residual workload, we may contemplate reassigning some staff to undertake intelligent tasks during the establishment of the demonstration area, while a limited number of maintenance and inspection employees continue on-site activities.

Q: If the aim is to downsize the workforce, then the impact of such reductions should be considered. What is your opinion? For instance, it typically takes an individual half a day to conduct an on-site inspection, yet with remote inspection technology, this process could be completed in a couple of minutes. This suggests a significant reduction in employees' workload. You have indicated that those downsized staff members can be redirected to intelligent tasks. Could you elaborate on how their roles are being integrated with intelligent tasks?

Yu: Yesterday, the company's Production Technology Department released the job responsibilities for the Shenzhen Command Center. I find some of these responsibilities to be somewhat insignificant. Specifically, it involves electric power big data analysis, where I envision engineers overseeing intelligent decision-making to create new business opportunities. Such a position was unprecedented in the traditional power industry. My main focus for discussion is how we can delve into this realm.

Q: There is a notable gap between the original on-site work positions and the current role centered around intelligent operations instead of previous mechanical work. Presently, intelligent technology-based identification is not yet fully developed. The company needs to consider that the new positions, new algorithms, and new strategies demand exceptional human abilities. The original on-site staff cannot be shifted to handle intelligent operations directly.

Yu: That’s my point. I’m not saying to directly place operation employees in roles they may not be qualified for, but rather to make appropriate employee arrangements after considering the overall human resources, such as the number of employees. Intelligent work often involves design and decision-making aspects. Previous operation employees might be reassigned to other specialized roles or integrated with maintenance teams. Currently, maintenance tasks require human intervention and cannot be automated. This integration can enhance our maintenance strength. For instance, if the substation department is adequately staffed, surplus employees of high quality could be reassigned to design and decision-making tasks. Let me provide a specific example. If there are 100 operation employees, but only 10 are required for design work, the remaining 90 may be transferred to other departments or roles outside the substation domain.

Luo: I agree with your viewpoint on the overall human resources strategy, as releasing human resources aligns well with the concept of digital transformation. This release impacts not only the operation area but also city-level branches and the entire group. It signifies the change in human resources effect.

Q: We’ll collect and analyze interview data to specify aspects like the number of employees to release, their positions, and the number of positions that will need transformation according to the digitization process in each of the next five years. Additionally, we'll evaluate whether the pace of transformation requires acceleration. So, we may need you to provide additional details about the positions for future reference.

Luo: No problem. Regarding the requirements for new business and positions you just mentioned, one area involves operation skills or proficiency. This is essential as our company has introduced a three-year quality improvement action plan emphasizing enhancing employee proficiency. The second aspect pertains to supporting infrastructure, facilities, and tools, requiring technical upgrade funds or other collaborative efforts. This necessitates scientific and technological innovation grants for tool development or collective efforts for some demonstration projects.

Q: Could you talk about job adjustments and functions after years of digital technology application?

Luo: The current situation is somewhat awkward. The human resources system has not been updated yet, which means that some employees who have been reassigned are still listed under their original positions, even though they're deeply involved in intelligent work. We're in the process of preparing documents for job roles. The company guidelines mention that pilot projects can be initiated first. However, we have no defined system in place for position or structural adjustments.

Yu: In situations where the plan or technology remains undecided, or the company system has yet to undergo modifications, significant personnel changes are unlikely. While ongoing intelligent projects may necessitate adjustments to our workforce, the existing substation operation and maintenance staff cannot be immediately unemployed or reassigned to other tasks.

Q: So the workload of operation and maintenance staff has been reduced to some extent, or a dual-track approach is adopted?

Luo: The workload has been reduced. Every week, we evaluate the task efficiency of the intelligent operations team. Specifically, driving mileage is significantly reduced. Certain tasks like operations, automated patrols, and work tickets can be conducted remotely without requiring on-site personnel. Tasks that previously took two hours can now be completed within just ten minutes. As per our schedule, we intend to produce an efficiency analysis report by the year's end, focusing on analyzing and summarizing the accumulated efficiency gains. As the project progresses, sites that currently lack adequate conditions will gradually meet the requirements. The completion timeline is not set for two or three years; rather, it is required for next year by the leadership, which presents a slightly challenging goal.

Q: In that case, the saved workforce can work remotely through the patrol center system or handle the gathered information. Are the remote tasks carried out by a saved workforce whose responsibilities have been adjusted, or by someone else?

Luo: They are finished by people assigned from Substation 1 and Substation 2. We started this practice in July, so we're improving supporting procedures, application requirements, and authority changes. The work will proceed accordingly. As intelligent work progresses, the routine patrol and maintenance workload will decrease. This will free up additional time and resources to ensure improvements in areas such as quality.

Yu: I don't think we've reached a mature phase. In the ongoing efforts to advance intelligent operations, I don't foresee immediate savings in human resources, as we may need to allocate more manpower in this phase. Once our organizational models evolve to a mature state, then—as you mentioned—we can anticipate releasing manpower in the upcoming five years or sometime. However, we're in the exploratory phase, demanding additional manpower. I believe that obtaining the desired result—realizing resource savings—is based on mature technology and organizational models. Presently, our research phase necessitates manpower input.

Q: OK. Is there anything else you would like to share? (If not) Thank you for your time.

Interview Note 3

Time: 10:30 a.m., July 18, 2022

Interviewees: Zhou XX (deputy head of a patrol and maintenance station), Ming XX (specialist in substation operation in the Production Technology Department), and Zhang XX (deputy head of a substation) of an electric power company

Q: Could you provide an overview of the application of digital technology in your substation?

Zhou: Currently, we've implemented intelligent or digital power transformation practices, with the primary goal of streamlining staff operations and enhancing efficiency. Judging from exploration and implementation efforts over the past several years, I believe we can achieve this goal in optimized inspection and operational processes. Our intelligent operations team has been established initially and has shown progress.

Q: Could you elaborate on the progress you've made so far?

Zhou: One advancement lies in intelligent inspection procedures. Our current approach predominantly involves utilizing cameras for inspections. Initially, the application of robots did not yield the desired outcomes likely due to technical limitations that failed to meet our site requirements and various stability issues. However, using cameras has delivered some results, like eliminating the need for on-site work. Despite the benefits of cameras, there are some drawbacks such as limited viewing angles that obstruct visibility of certain devices or cause overlap on the screen. The company plans to introduce UAVs for intelligent inspections. While the Taiping Station has already deployed numerous cameras that could serve as auxiliary tools, other stations are expected to rely primarily on UAVs, supported by cameras. In this way, all devices can achieve 100% coverage within relevant equipment areas.

Q: Are there any rules or regulations in place that endorse the utilization of cameras or UAVs instead of on-site personnel?

Zhou: Yes.

Ming: The company has developed corresponding manuals, and some stations have specific configurations in place. Video-based remote inspections have been conducted using various tools, including operating the support platform. In 2019 or 2020, the company issued a notice requiring all units to undertake video-based remote inspections. Those units that have not yet transitioned to a highly intelligent process can choose camera inspections instead of physical on-site inspections. Regarding our intelligent operations, within two weeks, we've reduced inspection mileage by nearly 3,000 kilometers and saved around RMB 2,000 in fuel costs. These figures represent the initial effectiveness of our intelligent operations. Presently, notable results have been achieved, including reduced vehicle usage, decreased distances traveled, and a lower frequency of personnel physically visiting sites.

Q: Are there established procedures or standard protocols for remote inspections, such as capturing screenshots, maintaining records, or requiring inspectors to sign for confirmation of their activities?

Zhou: Not yet. At present, our company does not have guidelines defining specific job roles, their responsibilities, and team responsibilities. Our team has been exploring to develop operational guidelines for automated inspections, including manual remote inspections and intelligent inspections, along with associated responsibilities. While we've done preliminary work, these guidelines are not finalized yet. Our current workflow involves uploading relevant images into the system after inspections; however, there is room for enhancing the standardization of this process. In response to identified issues, our interim solution involves implementing specific treatments without altering the current management platform's information flow. However, we prefer integrating specialized processes for intelligent operations within the information system, such as those for automated inspections and manual inspections. The three members of the intelligent operations team have been tentatively determined. We discussed the nuances of manual remote video inspections, automated inspection report reviews, and the necessary remote work ticket licenses. Therefore, the workload of the intelligent operations team requires a specialized evaluation approach. Moving forward, we plan to conduct weekly analyses of the effectiveness of the cumulative workload.

Q: What's your opinion on the new organizational model?

Ming: Recently, we had a discussion where opinions varied greatly. I lean towards seeking change, while some colleagues prefer stability, and others seek few changes and adjustments. Each person holds a unique perspective.

Zhou: In my view, it would be more prudent to proceed by taking small steps and maintaining a gradual adjustment pace. Otherwise, progress may be impeded if issues arise midway.

Q: Can you give some examples?

Zhou: Currently, some of our equipment meets the requirements for automated operation, while a significant portion still requires manual operation. Mr. Luo's proposal is to disband the inspection and maintenance center and shift the center's tasks, including maintenance, operations, and certain inspections, to the intelligent operations team. The team will implement centralized management and deployment of personnel on-site. However, I feel that this transition might be a bit too abrupt. I believe it may be necessary to retain some staff in the center to continue carrying out the maintenance and operational tasks as before, including permitting work tickets. At the same time, some employees of the center can be transferred to the intelligent operations team, with a well-defined division of labor being ensured.

Q: Should the job responsibilities between the inspection and maintenance center and intelligent operations team be clarified by station or other methods in your opinion?

Zhou: By station. Responsibilities are based on whether a station meets the requirements of intelligent operations. If a station does not meet intelligent operation requirements, responsibilities can be allocated based on specific equipment within the station. In cases where the requirements for intelligent operations cannot be fulfilled, tasks will continue to be handled by the inspection and maintenance center.

Q: How many substations in your company do you deem manageable for the intelligent operations team?

Zhou: Through assessments of video inspections, work ticket permits, and intelligent operations, few substations fulfill the necessary criteria. We're making incremental progress. We've constantly tested intelligent operations on the equipment to ensure compliance with the specified requirements.

Q: Are there established test specifications?

Zhou: Yes, there is a test plan. We're progressively conducting tests at stations in alignment with this plan. Our five inspection and maintenance centers within Substation 1 are striving to enhance compliance with the set criteria.

Q: From your perspective, aside from monitoring the identical content using various methods currently, are there other directions for advancing intelligent substations in the future?

Zhou: Our strategy involves phasing out physical meters and using digital ones, enabling direct uploading of readings to the operational support platform to facilitate inspection report generation. While readings are currently manually viewable through cameras, intelligent recognition remains challenging. Therefore, I think transitioning to digital meters and oil level indicators may represent the future development direction.

Q: Do you have any insights on the development trend of knife switch recognition?

Zhou: I'm not aware of any advanced knife switch recognition technology. Presently, the relatively developed technology can determine the position and move quality of the knife switch.

Q: So the reliability of remote sensing, telemetry, and attitude sensing does not align with present requirements?

Zhou: No. So far, the test outcomes do not meet our requirements, with noticeable deviations. Sensors like attitude sensors are placed in the transmission segment. We aim to inspect the upper part of the knife and verify if the conductive rod stays vertically aligned at 180 degrees. If not, how can we recognize it? Addressing these presents technical challenges.

Q: Based on the ongoing work progress, how have station staff and production personnel embraced intelligent technology? Could you provide a brief overview? Do they perceive intelligent technology as beneficial? Alternatively, do they experience a heightened workload or find it challenging to grasp these intelligent things?

Zhou: A significant cohort of people exhibiting a notably negative attitude toward intelligent and digital substation technologies. For instance, when tasked with organizing inspection points in the inspection reports, they approach it begrudgingly, resulting in subpar quality. Conversely, a minority group demonstrates greater openness to this technological shift. Due to years of involvement in this field, Mr. Luo and I hold high hopes for these technologies, recognizing their promising future.

Q: What could be the potential reason for their negative attitude? Is it perhaps a fear of job loss or reluctance to learn new things?

Zhou: One potential reason is their resistance to embracing new methods and technologies. Another factor is the substantial workload associated with completing inspection reports, which involves analyzing and checking hundreds of photos or items at one interval. Therefore, they experience increased work pressure and give a lot of negative feedback. People generally display favorable attitudes toward intelligent operations, primarily due to the tangible outcomes they witness. For instance, equipment no longer requires manual operation as it is now managed through scheduling, with operational quality feedback subsequently reviewed. The predominant challenge currently lies in the inspection process, with future efforts aimed at streamlining inspection reports to alleviate the burden on report auditors. I envision integrating AI strategies into the operational support platform. This could involve intelligent analysis of potential issues based on factors like electrical capacity, switch positions, and signals to enable swifter fault detection.

Q: Up to this point, which position do you believe will be most impacted by the advancement of intelligent development?

Zhou: I think it would be the position of substation operation. The position is prone to elimination, but new positions or fresh professional domains may emerge.

Q: The phase-out of the existing position and the creation of intelligent operations teams, along with changes in organizational structure or personnel, do not entail a straightforward transition process. What intelligent tasks could the affected staff members handle? How do you plan to reassign them?

Zhou: If the position of substation operation diminishes or fades in the future, a greater number of individuals will likely be reassigned to various specialized roles based on their specific skills, such as substation maintenance and high-voltage testing. Those individuals who demonstrate a quicker adaptability could potentially transition into the intelligent operations team.

Q: May I ask whether the inspection and maintenance center primarily operates from the main station, while the intelligent operations teams focus their work at city-level branches?

Zhou: That’s right.

Ming: Which option do you believe is more advantageous: setting up a specialized intelligent operations team for each substation or two substations or a centralized team to oversee all substations?

Zhou: I think two options can be presented to leaders at the initial stage. It depends on the department to which the team is assigned. If the team operates under substations, each substation should be assigned one as it falls under operation and maintenance.

Q: Should the management of the intelligent operations teams be standardized at the city-level branch level or tailored based on individual substations?

Ming: A document released by the company’s production command center incorporates intelligent operations. Regarding the pilot work’s implementation, I believe it is essential to adhere to the leaders’ directives, starting with the company’s overarching principles and subsequently refining the implementation. The fundamental concept of the document pertains to flat management, potentially reshaping substation management into an operational and inspection center or something.

Q: The advancement of digitalization will result in a reduction of middle management roles since they typically handle tasks like information transmission and integration that can be gradually handled by digital means. This shift represents a management trend. Yet, when it comes to practical implementation, is it challenging to leverage technology for integrated or intensive business management?

Ming: I believe that as digitalization advances, enhanced intelligent decision-making capabilities can facilitate flat management, reducing the necessity for numerous middle-level leaders or managers to coordinate and support tasks.

Based on what I've observed, the difference doesn't seem significant between having department leaders coordinate and directly assigning tasks to the team by the command center after a defect notice is issued. When handled at the substation level, challenges related to interactivity may arise, potentially leading to variations in the time and resources allocated to address the same issues. From a general perspective, identical problems can be handled collectively, and resource deployment can be streamlined, eliminating numerous unnecessary processes.

Q: Can you provide an example of streamlining the process? Which processes do you think are unnecessarily complicated and do not require multiple layers of review?

Ming: For instance, consider the defect I just mentioned. Currently, the defect grading process involves reporting to the operation specialist, and then forwarding it to the appropriate department, among other steps. If one individual can independently report the defect's nature and cause, analyze, and grade it, he or she may possess multiple skills. If so, the need for operation specialists diminishes, and defects could directly reach the production technology department for supervision and spot checks. In the original scenario, each level had to be involved, which might lead to a larger number of personnel being involved in the project. Simplified processes may have higher personnel requirements and can be fulfilled with the support of intelligent functions. Let me take defect analysis and grading as an example. Traditionally, we deemed this analysis and grading crucial, assigning specialized substation operators to perform it. Currently, we follow regulations where specific performance corresponds to predefined levels. In reality, there is no need for human judgment or decision-making in terms of flexibility in this regard. Our frequent low-level errors may result from unfamiliarity with regulations. In the future, once the defect description is input, intelligent technology will help swift grading and eliminate the need for manual labor. By leveraging intelligent technology to identify defects based on image cues, automatically input equipment data, document historical records, and conduct in-depth analyses, operators may become redundant in these tasks, and substantial process simplification will realized.

Q: Currently, in which aspects automated operation is not available? Or largely automated?

Ming: Automated operation has not been available in many aspects, such as collecting the nameplate and recording information of equipment for testing or maintenance. Adopting the traditional approach of inputting nameplate information from pictures taken by cameras or mobile phones in the system often results in information errors. With intelligent equipment access and return, can it be integrated with the power grid management platform? Within our substation operation platform, one key responsibility involves inspecting and maintaining safety tools. Well, can inspection and maintenance records be automatically inputted? Will manual maintenance no longer be necessary? Is it feasible to receive automatic reminders for tests of tools or instruments?

Q: As far as I'm concerned, it's been several years since the inception of a unified network platform encompassing the entire life cycle. The planning section has initiated a unified QR code connecting all information.

Ming: That is about the asset life cycle management. At that time, the design process required a QR code which was then displayed on the platform. However, the backend application was subpar, lacking coding information in the equipment records setup. The equipment record entry relied on manual input by the construction unit. My idea involved direct scanning of the QR code and using OCR to identify the relevant information.

I was familiar with this area because of my previous participation in the company's power grid management platform project throughout its life cycle, which involved equipment assets based on the unified QR code utilization. The QR code should be prepared before equipment departs from the factory. Upon equipment's arrival at the site or warehouse, the QR code can be scanned to establish the equipment records directly. Subsequently, equipment installation on-site can be handled by scanning the QR code. This desired functionality represents a starting phase where only a limited application scope exists. I believe a standardized, network-wide approach is inadequate at the trial stage, and the full potential will not be realized until a unified standard is established across the network. Additionally, the method of QR code display warrants consideration. If affixed directly to equipment as before, the code could naturally fall off due to maintenance tasks.

Q: Let's return to the discussion on the organizational model. Given digital technology's role in the power grid, especially in relation to human interactions, do you perceive it as a substitution or support? Automated operation and human operation are separate systems. How do you interpret this relationship?

Ming: I believe digital technology should largely serve as auxiliary support for humans. However, our overarching objective is to substitute human roles with digital technology. Based on the present technological landscape, I see digital technology primarily assisting or mimicking human actions.

Q: With the advancement of digital technology, robots have currently delivered two outcomes. One ensures safety, while the other reduces the need for human personnel. Which of these outcomes do you believe holds greater significance?

Ming: I find both aspects to be important. Regarding our company’s situation, the high understaffing rate is a concern, making staff reduction beneficial. Safety is a top priority across our company. So, I believe that both these aspects hold considerable importance.

Q: In which areas do you believe there have been deficiencies in the overall process of intelligent technology application? Are there any notable contradictions, or is there a pressing need for adjustments?

Ming: Currently, we haven’t established the team hierarchy or finalized the ownership structure of the organizational model. Additionally, our focus on hardware configuration is limited to the intelligent terminals of devices. Should we also consider outfitting individuals with offices, computers, and other resources? Furthermore, there is uncertainty regarding whether our technical procedures can align with rapid technological advancements. In the course of implementing intelligent technology, it is essential to acknowledge that the existing procedures may lack coverage in certain areas or may only address a minimal number of scenarios.

Q: Which regulation or procedure do you deem the most pressing at this time?

Ming: I believe the procedures pertaining to critical scenarios where machines substitute human intervention are of utmost urgency.

Our current operation and maintenance procedure for equipment is the valid 2018 version. Presently, the company has introduced the 2022 initiative, emphasizing the necessity for digital transformation and the advancement of intelligent technologies.

Regarding the detailed rules for the implementation of substation management, as we introduce new equipment, inclusive of intelligent terminals, we encounter the challenge of managing these devices effectively. Moreover, the question arises regarding potential modifications in operator responsibilities following the integration of these devices. Furthermore, procedures related to intelligent operations differ from the original ones.

Q: Does a method or standard exist to validate that your current efforts have surpassed previous endeavors?

Ming: I believe this can be gauged through various metrics, but it is likely to be a prolonged process, and immediate improvements may not be evident in just a few months or a year. For instance, considering more than 100 stations, the number of manual inspections and the number of defects identified during these inspections will be shown. Conversely, if the number of defects detected in remote or intelligent inspections surpasses previous figures, could this signify a more efficient defect identification process? Moreover, accuracy can be a measurement indicator. Historically, manual inspections might have had low-level errors, possibly resulting in a lower identified and reported defect rate. Wouldn’t these issues be reduced with intelligent inspections in place? Could this discrepancy indicate that intelligent or remote inspections are superior to manual inspections? Over the long term, we can consider the enhancement in equipment health as an indicator after engaging in a few years of intelligent inspections and identifying and handling defects.

Q: Is there any impact on grassroots teams after applying intelligent technology?

Zhang: The most significant impact is labor reduction, decreased vehicle usage, and enhanced efficiency. Through intelligent operation and maintenance practices, a noticeable reduction in labor can be achieved. This signals a positive development wherein employees can transition to higher-quality roles. Given the current skill set of the workforce, they may not be best suited for higher-quality tasks.

Q: What are the primary issues or inconsistencies encountered during the organizational model reform process?

Zhang: Although we invested time, we failed to witness considerable enhancements in quality. The current pilot model operates on a dual-track (system). New tasks are required to be completed in addition to the original workload, which significantly increases the workload and causes resistance and passive work in the team, meaning team members only act when superiors conduct inspections. This process is both labor-intensive and time-consuming. I believe that practically implementing a special team mode could be more viable for workers. Establishing an intelligent operations team would empower team members to voluntarily concentrate on and fulfill remote inspection duties, resulting in tangible outcomes.

Q: OK. (If not) Thank you for your time.

Interview Note 4

Time: 12:15, July 19, 2022

Interviewee: Lin XX (director of the Production Technology Department) at an electric power company

Q: I'm interested in the influence of digital production on grassroots organizations, like the current stage of implementation, the perspectives of team members on these technologies, and the potential evolution of the production organization in the future.

Lin: Let's begin with power transformation. Currently, the major issues revolve around power transmission, transformation, and distribution. The most significant investment typically pertains to power transformation, with intelligent stations posing a prominent challenge. It is crucial to strategize how to effectively merge practicality with optimizing organizational models after investment.

Intensified management requires professionalism, triggering concerns related to distance, transportation, and operation and maintenance services. Presently, low-voltage operation and maintenance are largely absent. The crux lies in the organizational model, emphasizing the promotion efforts rather than the sole adjustment of pricing.

The company is considering centralizing transmission activities within the provincial company and delegating distribution tasks to prefecture/city-level branches. We need to investigate the distribution network for UAV inspections to ascertain whether concentration within regional organizations or allocation across diverse entities would be more viable. Additionally, the centralized analysis of UAVs is necessary. Given the existing travel challenges due to scattered stations, we need to appropriately allocate related resources. An examination is warranted to determine the necessity of dispersing personnel or concentrating them in the transmission area. Furthermore, a comprehensive examination is required to gauge the realizability under existing environmental conditions and resources. If decentralization is inevitable, a corresponding management strategy should be devised. This remains ambiguous and warrants clarification in power transmission.

Q: The centralized approach was initially developed for densely populated cities in Guangdong.

Lin: Currently, a significant challenge we face with many of our procedures and methodologies is an excessive reliance on practices from Guangdong. However, attaining the superior conditions of Guangdong in terms of equipment, websites, and transportation remains unfeasible for us. In reality, our unique circumstances present us with heightened difficulties. Our procedures and methodologies should be tailored to suit local conditions. Recently, the company introduced a cross-control scheme for managing operational risks. I doubt that the scheme would yield the intended outcomes for our company. To optimize the organizational model, an in-depth examination of the environmental factors and voices at the grassroots level is imperative. This process necessitates investigation and study.

2. Questionnaire

2.1 Wave 1 Questionnaire (English)

Questionnaire （一）

Dear all,

Thank you very much for participating in this research. There are three waves of surveys and it’s the first one. The second and the third survey will be conducted in three months and six months respectively. The following questions ask some information about you or your team. There is no right or wrong point in your answer, please feel free to finish the questionnaire according to the facts. All the data are used for internal research only and we will keep everyone confidential, so no one, including your superiors or subordinates, will know your answer. Thank you again and wish your good health and successful career.

Name：______________________

Date：_____Y______M_______D

A job is automated to the degree that technology (e.g., artificial intelligence, machine learning, robotic process) performs some portion of the job.	Not at all	Little	Less	Medium	Basic	More	Completely automated
1. How AUTOMATED is it for your team to perform core tasks?	1	2	3	4	5	6	7
2. How AUTOMATED is your current job that involves independent work?	1	2	3	4	5	6	7
3. How AUTOMATED is your current job that involves coordinating or collaborating with other team members?	1	2	3	4	5	6	7

Please evaluate your agreement degree to the following description according to your situation and circle your options.	Somewhat Agree	Relatively Agree	Strongly Agree

	Strongly Disagree	Relatively Disagree	Somewhat Disagree	Uncertain			
4. For the coming automation change, I have backup plans in case of possible setbacks.	1	2	3	4	5	6	7
5. I would be able to continue my work in case of possible difficulties and setbacks related to the coming automation change.	1	2	3	4	5	6	7
6. I am fully prepared for the coming automation change.	1	2	3	4	5	6	7
7. I am ready for the coming automation change.	1	2	3	4	5	6	7
8. Automated systems have 100% perfect performance.	1	2	3	4	5	6	7
9. Automated systems rarely make mistakes.	1	2	3	4	5	6	7
10. Automated systems can always be counted on to make accurate decisions.	1	2	3	4	5	6	7
11. People have NO reason to question the decision automated systems make.	1	2	3	4	5	6	7

Your Basic Information

12. ________Age

13. ________Gender：1.Male; 2.Female

14. _________Work experience (Year)

15. _________Organizational tenure (Year)

16. _________Position tenure (Year)

17. _________Team tenure (Year)

18. _________Supervisor tenure (Year)

19. _________Year of education

20. _________ Region:

1. Local 2. Within the province 3. Outside the province

Thanks For Your Participation!

2.2 Wave 2 Questionnaire (English)

Questionnaire（二）

Dear all,

Thank you very much for participating in this research. There are three waves of surveys and it's the second one. The first survey was conducted three months ago and the third survey will be conducted in three months later. The following questions ask some information about you or your team. There is no right or wrong point in your answer, please feel free to finish the questionnaire according to the facts. All the data are used for internal research only and we will keep everyone confidential, so no one, including your superiors or subordinates, will know your answer. Thank you again and wish your good health and successful career.

Your department：_______________Team：_______________ （Please fill in）

A job is automated to the degree that technology (e.g., artificial intelligence, machine learning, robotic process) performs some portion of the job.	Not at all	Little	Less	Medium	Basic	More	Completely automated
1. How AUTOMATED is it for your team to perform core tasks?	1	2	3	4	5	6	7
2. How AUTOMATED is your current job that involves independent work?	1	2	3	4	5	6	7
3. How AUTOMATED is your current job that involves coordinating or collaborating with other team members?	1	2	3	4	5	6	7

Please evaluate your agreement degree to the following description according to your situation and circle your options.	Somewhat Disagree	Uncertain	Somewhat Agree	Relatively Agree	Strongly Agree

	Relatively Disagree						
	Strongly Disagree						
4. I adapt well to changes in core tasks due to automation.	1	2	3	4	5	6	7
5. I cope with automation changes to the way I have to do my core tasks.	1	2	3	4	5	6	7
6. I learn new automation skills to help me adapt to changes in my core tasks.	1	2	3	4	5	6	7
7. I find it easy to adapt to changes in core tasks due to automation.	1	2	3	4	5	6	7
8. I respond flexibly to automation changes in the team.	1	2	3	4	5	6	7
9. I cope with automation changes in the way the team operates.	1	2	3	4	5	6	7
10. I learn skills or acquired information that help me adjust to automation changes in the team.	1	2	3	4	5	6	7
11. I find it easy to adapt to changes in the team due to automation.	1	2	3	4	5	6	7

Thanks For Your Participation!

2.3 Wave 3 Questionnaire - Supervisor (English)

Questionnaire - Supervisor（三）

Dear all,

Thank you very much for participating in this research. There are three waves of surveys and it's the third one. The first and the second survey was conducted six months and three months ago respectively. The following questions ask some information about you or your team. There is no right or wrong point in your answer, please feel free to finish the questionnaire according to the facts. All the data are used for internal research only and we will keep everyone confidential, so no one, including your superiors or subordinates, will know your answer. Thank you again and wish your good health and successful career.

Your department：_______________Team：_______________ （Please fill in）

A job is automated to the degree that technology (e.g., artificial intelligence, machine learning, robotic process) performs some portion of the job.	Not at all	Little	Less	Medium	Basic	More	Completely automated
1. How AUTOMATED is it for your team to perform core tasks?	1	2	3	4	5	6	7
2. How AUTOMATED is your current job that involves independent work?	1	2	3	4	5	6	7
3. How AUTOMATED is your current job that involves coordinating or collaborating with other team members?	1	2	3	4	5	6	7

Please evaluate your agreement degree to the following description according to your situation and circle your options.	Uncertain	Agree	Strongly Agree

	Disagree Strongly Disagree				
4. My team have high work performance.	1	2	3	4	5
5. My team accomplishes most of their tasks quickly and efficiently.	1	2	3	4	5
6. My team sets a high standard for work accomplishment.	1	2	3	4	5
7. My team achieves a high standard for task accomplishment.	1	2	3	4	5
8. My team almost always beats their targets.	1	2	3	4	5

Please evaluate your agreement degree to the following description according to your situation and circle your options. [Please evaluate each team member in turn] Employee's name：_________________	Strongly Agree Agree Uncertain Disagree Strongly Disagree				
9. The team member initiated better ways of doing core tasks.	1	2	3	4	5
10. The team member came up with ideas to improve the way in which core tasks are done.	1	2	3	4	5
11. The team member made changes to the way core tasks are done.	1	2	3	4	5
12. The team member adapted well to changes in core tasks.	1	2	3	4	5
13. The team member coped with changes to the way which had to do core tasks.	1	2	3	4	5
14. The team member learned new skills to help him/her adapt to changes in core tasks.	1	2	3	4	5
15. The team member carried out the core parts of job well.	1	2	3	4	5
16. The team member completed core tasks well using the standard procedures.	1	2	3	4	5
17. The team member ensured tasks were completed properly.	1	2	3	4	5

Thanks For Your Participation!

2.4 Wave 3 Questionnaire - Team Member (English)

Questionnaire - Team Member（三）

Dear all,

Thank you very much for participating in this research. There are three waves of surveys and it’s the third one. The first and the second survey was conducted six months and three months ago respectively. The following questions ask some information about you or your team. There is no right or wrong point in your answer, please feel free to finish the questionnaire according to the facts. All the data are used for internal research only and we will keep everyone confidential, so no your superiors will know your answer. Thank you again and wish your good health and successful career.

Your department：_______________Team：_______________（Please fill in）

A job is automated to the degree that technology (e.g., artificial intelligence, machine learning, robotic process) performs some portion of the job.	Not at all	Little	Less	Medium	Basic	More	Completely automated
1. How AUTOMATED is it for your team to perform core tasks?	1	2	3	4	5	6	7
2. How AUTOMATED is your current job that involves independent work?	1	2	3	4	5	6	7
3. How AUTOMATED is your current job that involves coordinating or collaborating with other team members?	1	2	3	4	5	6	7

Please evaluate your agreement degree to the following description according to your situation and circle your options.	Uncertain	Agree	Strongly Agree

	Disagree Strongly Disagree				
4. I have found being a member of this team to be a very satisfying experience.	1	2	3	4	5
5. I feel like I'm learning a great deal by working on this team.	1	2	3	4	5
6. I would welcome the opportunity to work as a group again in the future.	1	2	3	4	5

Thanks For Your Participation!

2.5 Wave 1 Questionnaire (Chinese)

团队成员问卷（一）

您好,非常感谢您参与本研究。本研究共有三轮问卷，您目前填写的是第一轮问卷，第二、三轮问卷将分别于三个月和六个月后发放。以下问题询问的是***您或您所在团队***的相关信息。您的回答没有对错之分，请根据实际情况进行回答。您所填写的内容将被完全保密并只用于本研究，因此除了您自己和研究人员之外，没有任何人（包括您的上下级）会知晓您的答案，请您放心作答。再次感谢您用宝贵的时间填写本问卷，祝您身体健康、事业成功！

姓名：______________________

日期：______年_____月_____日

请综合评估您的工作的***数字化程度***，即您的工作在多大程度上实现了由技术(如人工智能、机器学习、机器人)执行工作。	完全不数字化	极少数字化	较少数字化	中等数字化	较多数字化	基本数字化	完全数字化
1. 您的团队执行核心任务的数字化程度如何?	1	2	3	4	5	6	7
2. 您目前的工作中在个人独立作业方面的数字化程度如何?	1	2	3	4	5	6	7
3. 您目前的工作中在与其他团队成员协调或合作方面的数字化程度如何?	1	2	3	4	5	6	7

请评价您对下列条目的同意程度。	有些不同意	不确定	有些同意	比较同意	非常同意

比较不同意 非常不同意							
4. 对于可能到来的数字化变革，我们团队有备用计划以应对可能面临的挫折。	1	2	3	4	5	6	7
5. 即使在未来的数字化变革中遇到困难和挫折，我们团队也能继续完成团队的工作。	1	2	3	4	5	6	7
6. 我们团队已经为可能到来的数字化变革做好了充分的准备。	1	2	3	4	5	6	7
7. 针对未来的数字化变革，我们团队已经准备完毕。	1	2	3	4	5	6	7
8. 对于未来的数字化变革，我认为它应该会有完美的表现。	1	2	3	4	5	6	7
9. 对于未来的数字化变革，我认为它不大会出问题。	1	2	3	4	5	6	7
10. 未来的数字化变革将会帮我做出最准确的决策。	1	2	3	4	5	6	7
11. 人们对未来的数字化变革不该有任何质疑。	1	2	3	4	5	6	7

您的基本信息

21. ________岁 您的年龄

22. ________您的性别：1. 男。2. 女。

23. _________年 您从事相关工作的年数

24. _________年 您在现公司工作的年数

25. _________年 您在现公司从事目前工作岗位的年数

26. _________年 您在现团队工作的年数

27. _________年 您和现团队领导共事的时间

28. _________年 您的受教育年限

29. _________ 您来自的地区： 1. 本地 2. 本省（非本地） 3. 外省

感谢您的参与！

2.6 Wave 2 Questionnaire (Chinese)

团队成员问卷（二）

您好，非常感谢您参与本研究。本研究共有三轮问卷，您目前填写的是第二轮问卷。第一轮问卷已于三个月前发放。第三轮问卷将于三个月后发放。以下问题询问的是***您或您所在团队***的相关信息。您的回答没有对错之分，请根据实际情况进行回答。您所填写的内容将被完全保密并只用于本研究，因此除了您自己和研究人员之外，没有任何人（包括您的上下级）会知晓您的答案，请您放心作答。再次感谢您用宝贵的时间填写本问卷，祝您身体健康，事业成功！

您所在的部门：_______________班组：________________（请填写）_

请综合评估您的工作的***数字化程度***，即您的工作在多大程度上实现了由技术(如人工智能、机器学习、机器人)执行工作。	完全不数字化	极少数字化	较少数字化	中等数字化	较多数字化	基本数字化	完全数字化
1. 您的团队执行核心任务的数字化程度如何?	1	2	3	4	5	6	7
2. 您目前的工作中在个人独立作业方面的数字化程度如何?	1	2	3	4	5	6	7
3. 您目前的工作中在与其他团队成员协调或合作方面的数字化程度如何?	1	2	3	4	5	6	7

请评估您在多大程度上同意以下陈述。	非常不同意	不同意	不确定	同意	非常同意
4. 我能很好地适应数字化带来的核心任务的变化。	1	2	3	4	5
5. 我能很好地应对数字化对我完成核心任务方式的改变。	1	2	3	4	5

6.	我学习新的数字化技能，以帮助我适应核心任务的变化。	1	2	3	4	5
7.	我很容易适应数字化造成的核心任务的变化。	1	2	3	4	5
8.	我灵活地应对团队中的数字化变化。	1	2	3	4	5
9.	我灵活地应对团队运作方式的数字化变化。	1	2	3	4	5
10.	我学习技能或获取信息，帮助我适应团队中的数字化变化。	1	2	3	4	5
11.	我很容易适应数字化造成团队中的变化。	1	2	3	4	5

感谢您的参与！

2.7 Wave 3 Questionnaire - Supervisor (Chinese)

班组长问卷（三）

您好，非常感谢您参与本研究！本研究共有三轮问卷，您目前填写的是第三轮问卷。第一、二轮问卷已于六个月、三个月前发放。以下问题询问的是***您的团队***的相关信息。您的回答没有对错之分，请根据实际情况进行回答。您所填写的内容将被完全保密并只用于本研究，因此除了您自己和研究人员之外，没有任何人（包括您的上下级）会知晓您的答案，请您放心作答。再次感谢您用宝贵的时间填写本问卷，祝您身体健康，事业成功！

您所在的部门：_______________班组：________________（请填写）_

请综合评估***您所领导的团队的数字化程度***，即您的团队在多大程度上实现了由技术(如人工智能、机器学习、机器人)执行工作。	完全不数字化	极少数字化	较少数字化	中等数字化	较多数字化	基本数字化	完全数字化
1. 您的团队执行核心任务的数字化程度如何?	1	2	3	4	5	6	7
2. 您团队的成员们在个人独立作业方面的数字化程度如何?	1	2	3	4	5	6	7
3. 您团队的成员们在相互协作共同完成作业的方面数字化程度如何?	1	2	3	4	5	6	7

请评价您对下列条目的同意程度。	非常不同意	不同意	不确定	同意	非常同意
4. 这个团队有高水平的绩效。	1	2	3	4	5
5. 这个团队迅速有效地完成大部分任务。	1	2	3	4	5

6. 这个团队制定高标准的工作目标。	1	2	3	4	5
7. 这个团队高水平地完成任务。	1	2	3	4	5
8. 这个团队总是达到或超过制订的目标。	1	2	3	4	5

请评价您对下列条目的同意程度。 【请依次评价每个团队成员】 成员姓名：________________	非常不同意	不同意	不确定	同意	非常同意
9. 这个员工经常改进工作方法来更好地完成核心任务。	1	2	3	4	5
10. 这个员工经常想办法来提高完成核心任务的方式方法。	1	2	3	4	5
11. 这个员工经常改善其完成主要任务的方式。	1	2	3	4	5
12. 这个员工能很好地适应主要任务的变化。	1	2	3	4	5
13. 这个员工能够很好地应对核心任务要求的不断变化。	1	2	3	4	5
14. 这个员工能够不断学习新技能来帮助自己适应主要任务的变化。	1	2	3	4	5
15. 这个员工能很好地完成自己工作的主要部分。	1	2	3	4	5
16. 这个员工能用标准程序很好地完成自己的主要任务。	1	2	3	4	5
17. 这个员工能确保妥善地完成自己的任务。	1	2	3	4	5

感谢您的参与！

2.8 Wave 3 Questionnaire - Team Member (Chinese)

团队成员问卷（三）

您好，非常感谢您参与本研究！本研究共有三轮问卷，您目前填写的是第三轮问卷。第一轮和第二轮问卷分别已于六个月和三个月前发放。以下问题询问的是***您或您所在团队***的相关信息。您的回答没有对错之分，请根据实际情况进行回答。您所填写的内容将被完全保密并只用于本研究，因此除了您自己和研究人员之外，没有任何您的上级会知晓您的答案，请您放心作答。再次感谢您用宝贵的时间填写本问卷，祝您身体健康，事业成功！

您所在的部门：______________班组：_______________（请填写）_

请综合评估您的工作的***数字化程度***，即您的工作在多大程度上实现了由技术(如人工智能、机器学习、机器人)执行工作。	完全不数字化	极少数字化	较少数字化	中等数字化	较多数字化	基本数字化	完全数字化
1.　您的团队执行核心任务的数字化程度如何?	1	2	3	4	5	6	7
2.　您目前的工作中在个人独立作业方面的数字化程度如何?	1	2	3	4	5	6	7
3.　您目前的工作中在与其他团队成员协调或合作方面的数字化程度如何?	1	2	3	4	5	6	7

以下条目有关***您和您的团队***的一些陈述。请评价您对下列条目的同意程度。	非常不同意	不同意	不确定	同意	非常同意
4.　我认为能成为这个团队的一员是非常让人满意的经历。					
5.　我觉得通过在这个团队工作我学到了很多东西。					
6.　我希望以后继续作为团队一起工作。					

感谢您的参与！