Digital Adaptive Governance, Digital Transformation, and Service Quality in Logistics Enterprises

Chao Li, Zhongyuan University of Technology, China
Wei-Xi Feng, Zhongyuan University of Technology, China
Shuihua Han, Xiamen University, China*
Shivam Gupta, NEOMA Business School, France
Sachin Kamble, EDHEC Business School, France

ABSTRACT

Infrastructure digital transformation may create value for logistics enterprises; but its whole process is still full of uncertainties. Prior research focused on smart control in view of the infrastructure and ignored the driving role of digital governance in the process of digital transformation. Here, the authors investigate the relationship between digital adaptive governance and digital transformation, and actively explore the effect of digitalization on service quality improvement in logistics enterprises. The authors take servitization as the moderator to examine the interaction between digital transformation and service quality. Through 227 valid responds of senior executives and workers at the production line from 46 logistics enterprises in China, the authors use partial least squares and hierarchical regression analysis to test the hypotheses empirically. Results suggest that digital adaptive governance, infrastructure digital transformation and servitization have positive influence on service quality. Digital adaptive governance has positive influence on infrastructure digital transformation.

KEYWORDS:
Digital Adaptive Governance, Digital Transformation, Servitization, Service Quality, Hierarchical Regression Analysis

1. INTRODUCTION

As an important basic and strategic pillar industry, the efficiency and service level of logistics industry have a significant impact on the enhancement of industrial production and marketing (Kent & Flint, 1997; Sven & Eric, 2020; Tracey, 1998). The deep integration of logistics industry and manufacturing industry is a strategic and inevitable trend under the background of digital economy on global markets (Weyer et al., 2015). Logistics enterprises need to achieve transformation and upgrading to enhance the level of performance and better service quality in the atmosphere of logistics 4.0, such as by way of realizing the whole digital process, advancing the railways, highways, waterways and other
shipping documents electronically and sharing mutual recognition, providing “one-stop” logistics services of entire monitoring and traceability, encouraging all kinds of enterprises to accelerate the differentiated development of logistics information platforms, strengthening the mutual recognition of logistics-related management information of all departments, and building an open sharing mechanism of comprehensive transportation logistics data resources (Hoa, Krommenacker & Charpentier, 2016; Rai, Patnayakuni & Seth, 2006). Until 2020, logistics cost in China is still a big challenge for the overall economy. It is nearly twice as high as in developed countries. Annual production and living materials in China worth of nearly 300 trillion RMB operate under the environment of low flow and high logistics costs, seriously restricting the market competitiveness of manufacturing industry and is one of the obvious disadvantage for the substantial economy to achieve high-quality development.

Due to the extensive use of digital technology, a lot of logistics infrastructure becomes increasingly complex, including not only the form of physical assets, but also computing and network resources (Gunes et al., 2014; Lu, 2017; Sultana et al., 2021). This situation encourages distributed and collective innovation of new technologies and services (Adrodegari, Pashou & Saccani, 2017; Colm, Ordanini & Bornemann, 2020; Lamba & Surya, 2017; Maestre-Gongora & Bernal, 2019), becomes the driving force of transition to digitalization and servitization for logistics enterprises and relates to the integration of humans and the environment for sustainability. Existing research on infrastructure digital transformation to improve firm service performance and operation performance mainly focus on the application of digital technology indicators and have achieved some significant conclusions (Binti Aminuddin et al., 2016; Kohtamäki, 2015; Sklyar et al., 2019). As security risks proliferate during the process of digital infrastructure transformation, the boundary of the security risk continues to expand, this led to the related researches about infrastructure based on the base and foundation has been hard to ignore the integrity of security risk and its governance problem (Choudhuri et al., 2021; Jean et al., 2020). However, few studies have linked adaptive digital governance to infrastructure digital transformation together. The possible driving force of digital governance can be brought into the action path of infrastructure digital transformation, to have a deeper understanding of the complex relationship between digitalization, servitization and service quality and avoid the negative cycle brought by the servitization paradox and digitalization paradox to the greatest extent (Gebauer et al., 2010; Rachinger et al., 2019).

Paolucci et al (2021) proved the positive effect of digital technologies and governance mechanisms on the efficiency of the automotive supply chain, explored and explained the relationship between digital technology and governance mechanism. While the definition of governance mechanism and the connotation of digital technology have been strictly limited in this research, which makes it difficult to directly apply the conclusions to a wider range. At the same time, variables related to servitization are not involved. In fact, our understanding of the complex relationship among digitalization, servitization and service quality is so finite that it is difficult to provide effective answers to many problems encountered by logistics enterprises in the process of digitalization. The interaction between digitization and servitization is dynamic, alternating and sustainable (Opresnik & Taisch, 2015). But limited research on servitization has been associated with digitalization. Some research try to confirm the role of software in servitization (Coreynen, MatthysSENS & Van Bockhaven, 2017), and emphasize the correlation between digitalization and servitization (Kohtamäki et al., 2019), but lack the necessary emphasis on digitalization and little evidence of the interaction between digitalization and servitization. In order to realize the successful digital transformation and reduce digitalization risks to the greatest extent (Gebauer, 2005; Gupta & Bose, 2022; Kohtamäki, Rabetino & Einola, 2018), we need to further analyze the relationship between digitalization and servitization, and explore their impact on service quality, so as to formulate and implement the correct strategies of digitalization and servitization, and effectively improve the service quality and achieve sustainable development of logistics enterprises (Raisch, Birkinshaw & Probst, 2009; Schad, Lewis & Raisch, 2016).

Given the foregoing, based on the theories of digitization and servitization proposed by Baines et al (2009) and Parida et al (2014), this research seeks to explore the complex relationship among digital...
adaptive governance, infrastructure digital transformation and service quality in logistics enterprises in China, whose investments strategy in digitalization and servitization are made without a standard to refer to. This research looks forward to making contributions in the following two aspects: first, to help logistics enterprises make accurate digital strategy choices and realize the digitalization transformation goal of short-term and long-term by focusing on business rather than relying on technology or infrastructure. Second, to help logistics enterprises improve their awareness of digital adaptive governance and promote overall digital governance and service quality through the digital transformation of infrastructure. The key to interpret the mechanism of digitalization and servitization may be embedded in digital infrastructure (Fürstenau, Baiyere & Kliewer, 2019), senior executives attitude towards digitalization and servitization, the basis for making digital strategy, and service quality that enable the logistics enterprises to firmly believe in servitization and capture the benefits of digitalization (Davies et al., 2021; Gebauer et al., 2010; Kohtamäki et al., 2019; Melville, 2015; Rachinger et al., 2019). We examine this question from the perspective of interaction of digitalization and servitization that prior research ignore.

We mainly address two research questions as follows:

**RQ1:** How does digital adaptive governance affect the infrastructure digital transformation and service quality in logistics enterprise?

**RQ2:** In logistics enterprise, what is the interaction path between servitization and digitalization which combines digital adaptive governance and infrastructure digital transformation?

The findings of this research can deepen the theory of digitalization and servitization and enhance the understanding of digitization and servitization in the field of practice such as logistics enterprises, manufacturing enterprises, etc. In addition, our work extends the prior literature on digitalization and servitization (Abou-Foul, Ruiz-Alba & Soares, 2021; Sklyar et al., 2019) by examining the moderating role of servitization on the linear relationship between digitalization combined digital adaptive governance and infrastructure digital transformation and service quality. Finally, our findings confirm the profound connotation of digitization and reveal the mechanism between digital adaptive governance and digital transformation of infrastructure.

The structure of this research is arranged as follows. Section 2 showcases the literature review and the hypotheses used to develop the conceptual model. In section 3, we highlight the research methodology followed in our study. Section 4 brings out the results of our study and in section 5, we put forward the discussion with emphasis on theoretical contributions and managerial implications. Lastly, in section 6, we mention the limitations and the future scope of research.

**2. THEORY AND HYPOTHESES**

**2.1. Digitalization**

Digitization dominates the current environments of business and social. It is considered to have a profound impact on enterprises, upstream and downstream operators, consumers, networks and ecosystems (Jacobides, Cennamo & Gawer, 2019). It brings greater transparency and flexibility to enterprise processes, resources and capabilities. And it is an important driver of product innovation and higher specialization (Paolucci, Pessot & Ricci, 2021). SF Express, Deppon and other well-known logistics enterprises in China have been transforming to digital business model, data-based value chain, more flexible organizational form and more agile operation. The transformation to digitalization, Internet of things and industrial internet has put forward higher requirements on the digitalization and servitization capabilities of logistics enterprises. More research tends to believe that enterprises need to rely on advanced service portfolio to help them extract value from digitization and achieve positive performance results. This means that the key to unlock digital value may be embedding advanced
services, operational services and results-based services so that enterprises can reap the additional benefits of digitalization (Kohtamäki et al., 2019; Visnjic, Neely & Jovanovic, 2018).

Digitalization has brought new ideas and opportunities to logistics enterprises serving manufacturing industry. In the past, the manufacturing industry reflected the value of international division of labor and international trade through a long supply chain (such as the integration of finished products with parts from multiple regions of the world), and constantly sought to improve economies of scale through the upsizing of ships. But the impacts of COVID-19 and global logistics emergency such as the Suez Canal incident have prompted the industry to rethink the rationality of long supply chains and super-sized capacity, and to explore ways to improve the security of transport services through digital technology and digital strategy (Morton, Wilson & Cooke, 2020). In addition, COVID-19 outbreak causes international shipping prices rose sharply and results in full of shipping space. Although digitalization has a positive impact on financial performance has not been confirmed, many export enterprises in China begin to seek new ways of transportation such as China-Europe Railway Express to reduce data cost, bring new business opportunities and improve process efficiency.

2.2. Digital Adaptive Governance

Digital adaptive governance is one of the most important challenges in the field of digital governance. At present, digital adaptive governance is summarized as the adoption of a set of governance techniques to adapt new data and balance risk and benefit to the organization in order to adjust regulatory rules and practices (Janssen & van der Voort, 2016). It implies a balancing act and depends on senior executives understanding and supporting level of firm digital trend (Ketokivi & Mahoney, 2020; Melville, 2015). The main function of digital adaptive governance is to monitor digital services and describe threats brought by digitalization so as to control digitalization risks through corresponding governance technologies, reduce losses caused by digitalization failures and effectively avoid digitalization paradox (Sjödin, Parida & Kohtamäki, 2019). Digital adaptive governance may be driven by legislative decisions with monitoring risks and reviewing existing regulatory frameworks (Mergel, 2016; Sandoval-Almazan & Ramon Gil-Garcia, 2014). In addition, digital adaptive governance still includes risk assessments and management of periodic revision (Nelson, Howden & Smith, 2008). Third, digital adaptive governance may also be driven by voluntary arrangements among key affected stakeholders (De Bruijn & Ten Heuvelhof, 2008). It can be modified as needed to meet codes of conduct, or as needed to meet new challenges posed by digitalization.

Digitalization risk is increasing day by day. If it is not prevented, supervised and controlled, not only will massive investments fail to achieve expected returns, but also bring huge hidden risks to enterprises (Janssen, Voort, & Veenstra, 2014). Now all kinds of attackers transfer their targets to the field of digitalization, for example, invasion of privacy, stealing money or destroy data and so on. Enterprises must adjust their defensive strategy, through the establishment of adaptive governance with elasticity to better absorb, recovery and adapt to the consequences of network security threats to enhance their competitive ability of network risk (Culot et al., 2020). Due to the inevitable lag in the understanding and judgment of emerging risks by enterprises or markets, governance strategies need to be adjusted timely with the continuous emergence and the deepen understanding of risks (Cao & Luminai, 2015). Therefore, the digital adaptive governance of enterprises must be flexible and adaptable, so as to help enterprises better cope with the emerging threats (Gottge et al., 2020).

To be specific, digital adaptive governance includes three dimensions: first, knowledge accumulation to improve the scientific research on digital risks. Including scientific facts, value knowledge and the fusion of the two. In this dimension, expert advice should be fully not only paid attention to practical cases or key events derived from practice, also actively explore the possible negative consequences of unknown risks (Cao & Luminai, 2015). Second, we need to strengthen coordinated governance and establish a pattern of multi-faceted co-governance to address the governance challenges posed by emerging and systemic risks. In this dimension, considering
complexity of digital adaptive governance, it is necessary to strengthen the responsibility of platform, connecting government, enterprises, social media and other professional research institutions to jointly establish a risk judgment mechanism (Tao et al., 2018). Third, we need to strengthen preventive measures to mitigate the extreme consequences of emerging risks. Logistics enterprises are necessary to continuously improve the accountability mechanism, establish and improve the complaint reporting and mediation mechanism with dedicated leaders to monitor and carry out on time, at the same time, set up online and offline supervision complementary mechanism, embed enterprise credit in the supervision process to promote the supervision validity (Gereffi et al., 2005; Helper et al., 2014; Morton, Wilson & Cooke, 2020).

2.3. Infrastructure Digital Transformation

Infrastructure digital transformation is an important part of new infrastructure layout. The infrastructure digital transformation of logistics enterprises is usually based on sensor terminals, 5G networks, big data technology, industrial Internet, etc., using new generation of information technologies such as internet of things and artificial intelligence to carry out digital, networked and intelligent transformation and upgrading of traditional logistics infrastructure (Goudos et al., 2017; Wessel et al., 2021). Accelerating the infrastructure digital transformation of logistics enterprises will provide strong support for the transformation of old and new driving forces, promote the transformation of logistics technology and equipment, and provide new services for the manufacturing industry (Wang, Ong, & Nee, 2018). It will also help logistics enterprises and manufacturing industries grow steadily and support the economy without increasing costs to the maximum extent.

Infrastructure digital transformation of logistics enterprises appropriately in advance conforms to the objective requirements of developing digital economy. The current infrastructure digital transformation includes not only hardware equipment, such as transport vehicles and warehouses, but also software such as data, signals, service strategies, business models and innovation models (Gupta & Bose, 2022; Klos, Spieth & Klusmann, 2021; Li, 2020; Timm & Lorig, 2015). The success of infrastructure digital transformation depends on the synergistic effect of soft infrastructure and hard infrastructure such as operation system and data management (Wessel et al., 2021). Of course, such goal also depends on the attitude of digital-savvy executives and firm digital strategy (Melville, 2015; Morton, Wilson & Cooke, 2020). Compared with hard infrastructure, soft infrastructure often lag behind. In addition, due to the driving force for innovation of the block chain security, internet security and other emerging market network security is limited, there is currently no reliable digital infrastructure security defense system to ensure data security. If the digital infrastructure is difficult to overcome its own security risks, the larger the scope of its transformation, the more the number of transformation, the greater the safety risks (Mahapatra, Narasimhan, & Barbieri, 2010). In order to maximize data security and network security, adaptive digital governance should be embedded in the infrastructure digital transformation, and the success rate of digital transformation should be enhanced by supervising and guiding the transformation process (Aben et al., 2021).

Therefore, we propose the following hypothesis,

**H1**: Digital adaptive governance of logistics enterprises has a positive influence on infrastructure digital transformation.

2.4. Servitization

Servitization is originated from the manufacturing industry and was proposed by Vandermerwe and Rada (1988). Its connotation is summarized as the transition from products to services and integrated solutions (Lightfoot, Baines & Smart, 2013), that means, enterprises change from providing purely independent products and additional services to providing maintenance contracts and operation services, until providing results-based or performance-based services (Huikkola & Kohtamaki, 2018;
Kowalkowski et al., 2015; Visnjic, Neely & Jovanovic, 2017). This transformation process is called servitization, service injection, service transformation or service transformation (Raddats et al., 2019). The concept of servitization is considered to capture digital technologies related to the internet of things and remote monitoring. Many studies have begun to use the concept of digital servitization to emphasize the role of service technologies (Ravichandran, 2018).

Academia has paid attention to servitization for decades, however, even in the current digitalization trend, due to lack of empirical data, the study for servitization is still mainly focused on qualitative research, such as exploratory research, and presents a state of fragmentation. Although in practice the development of servitization is fast, as is driven by applications and problems, it has been viewed as a nascent theoretical field with dynamic boundaries (Kowalkowski, Gebauer & Oliva, 2017).

So far, little research on servitization has been associated with digitalization. Although some studies have confirmed the role of software in servitization (Coreynen, MatthysSENS & Van Bockhavn, 2017), and have begun to emphasize the correlation between digitalization and servitization (Abou-Foul, Ruiz-Alba & Soares, 2021; Fu et al., 2022; Kohtamäki et al., 2019), these studies lack the necessary emphasis on the interaction effect between digitalization and servitization. In fact, digitalization and servitization are built on infrastructure and implemented through technology (Fürstenau, Baiyere & Kliewer, 2019; Svaln, Matthiassen & Lindgren, 2017), both servitization and digitalization of enterprises require huge investment based on infrastructure (purchase, transformation and construction), however, such investment is not always successful. Servitization paradox and digitalization paradox (Gebauer, 2005) provide partial explanations to the phenomenon that some enterprises are successful while others are not for the same infrastructure investment, but it is still necessary to establish a more general theory from an ecosystem perspective to guide enterprises infrastructure decisions (Sklyar et al., 2019). For example, the interaction mechanism between digitalization and servitization should be further explored to clarify the embeddedness action. In the internal mechanism of the digitalization, the digital adaptive governance affects infrastructure digital transformation positively, high level servitization tend to require higher digital governance. Because high level servitization means infrastructure technology popularization and application of the hardware and software, human-computer interaction and the embedded digital integrated level are high. These represent the more difficult digital transformation. Logistics enterprises need adaptive digital governance to match servitization level to ensure the digital security and continuous innovation under the complicated and uncertain environment.

Therefore, we propose the following hypothesis,

**H2**: The servitization of logistics enterprises plays a positive moderating role in the impact of digital adaptation governance on the infrastructure digital transformation.

### 2.5. Logistics Service Quality

Logistics industry does not produce products, and increases values of products or services through transportation, storage, distribution and other activities. In essence, logistics is also a service product. With the rapid development of global economy, Logistics has also entered the 4.0 era, logistics service has gradually changed from an activity focusing on product operation to an activity taking account of both product operation and customer service (Sven & Eric, 2020; Weyer et al., 2015). Scholars have also realized that it is necessary to break through the traditional concept of logistics service and improve the connotation of logistics service from the perspective of customers. Logistics service quality is not only the basis and core of logistics enterprise marketing, but also the key to win the competition. Improving the service quality of logistics enterprises is an important content to improve the market competitiveness.

According to the SERVQUAL model proposed by Parasuraman et al (1985), logistics service quality evaluation dimensions include tangible, reliability, responsiveness, assurance and empathy.
Mentzer et al (1989) pointed out that Physical Distribute Service Quality (PDSQ) based on the actual logistics work mainly included three dimensions, namely timeliness, availability, and completeness. Mentzer et al (1999) combined service quality of physical distribution logistics with factors affecting service quality to create LSQ scale, specifically including nine dimensions, communication quality of personnel, order release quality, information quality, ordering process, goods accuracy, goods integrity, goods quality, error handling quality, and timeliness, etc. These dimensions and specific indicators depend on the support of digitalization, that means with the promotion of digitalization, logistics service overall speed, service quality, differentiation, personalized service level, rural service, international service and so on all have been greatly improved.

Some leading logistics enterprises in China are already upgrading through digital solutions, such as developing services and solutions that generate demand, rather than just responding to demand. Digitalization can help enterprises increase transparency and reliability, and the integrated logistics business information system can also be established to provide all kinds of enterprises with unified and standardized operation and clear interface of interconnection network to improve the service quality of logistics enterprises (Lummus, Dennis & Robert, 2001). These digital application and promotion processes need to improve the systematic transformation of infrastructure, and need adaptive digital governance to guide and supervise the whole process (Timm & Lorig, 2015). With the deepening of digitalization in logistics enterprises, logistics resources serving the manufacturing industry can be optimized allocation in a wider range, and the service quality of logistics enterprises can be significantly improved.

Therefore, we propose the following hypotheses,

\[ H3: \text{Digital adaptive governance of logistics enterprises has a positive impact on service quality.} \]

\[ H4: \text{Infrastructure digital transformation of logistics enterprises has a positive impact on service quality.} \]

For the logistics enterprises serving the manufacturing industry, the delivery dimension occupies a dominant position. The attributes of on-time delivery, error-free delivery, and delivery time are very important. The main evaluation dimensions of logistics service quality applicable to Chinese logistics enterprises include information quality, error handling quality, personnel communication quality, order completion quality, goods integrity, timeliness, and flexibility (Mentzer et al., 1989). The essence of logistics enterprises is to provide services. Providing basic services and value-added services for customers are the key growth points of logistics enterprises (Kache & Seuring, 2017). In the domestic general logistics enterprises, they are mainly divided into two categories: warehousing and comprehensive services and transportation services (Geng & He, 2016). Servitization level is affected by adaptive digital governance and has a direct impact on the service quality performance of logistics enterprises.

Therefore, we propose the following hypotheses,

\[ H5: \text{Servitization has a positive impact on service quality.} \]

\[ H6: \text{Servitization has a positive moderating effect on the relationship between adaptive digital governance and service quality.} \]

According to the theory above, we describe the research model in Figure 1, which shows the main variables, correlation between variables and hypotheses of this research. We can find the direct effect of four variables was controlled like direct effects from digital adaptive governance, digital transformation and servitization to service quality and two interaction effects including interaction effect of servitization and digital adaptive governance on infrastructure digital transformation and the
effects of four control variables (firm age, firm property, firm servitization level and firm digitalization level) on service quality.

3. RESEARCH METHODS

3.1. Measurement Development

First, we developed the variables and items in the questionnaire that combined digital adaptive governance, infrastructure digital transformation, servitization and service quality about logistics enterprises from existing literatures. To ensure validity and reliability, before large-scale distribution of the final version, we surveyed four logistics enterprises to adjust ambiguous items. At the same time, we interviewed thirteen senior executives and 50 rank-and-file employees in various roles like warehouse administrator, distribution officer and data center administrator from four logistics enterprises to pretest the questionnaire and according to the feedbacks, we evaluated the adequacy of structure and got more accurate expression to revise the questionnaire. Finally, we confirmed the questionnaire were in accordance with requirements of validity and reliability (Straub, 1989).

We operationalized variables with multi-item reflective measures in this study (on a seven-point Likert scale: one represented strongly disagree and seven represented strongly agree). Reflective indicators were caused by the latent construct, interchangeable and covary that shared a common theme (Jarvis et al., 2003). Survey instrument is listed in Appendix A.

3.2. Survey Design

Our questionnaire is based on literatures and semi-structured interviews for logistics practitioners. Hinkin (1998) recognized grounded theory applies to develop survey questionnaire measures, we
took this approach. The questionnaire in this study includes basic situation (respondents’ information and four control variables) and questionnaire subject.

3.3. Data Collection

We send 300 questionnaires to senior executives and ordinary employees of 46 logistics enterprises in Zhengzhou city and Xinzheng city according to the logistics directory provided by Xinzheng Development and Reform Commission. The selection of research samples is mainly based on the Chinese government attaches great attention to the logistics industry and Zhengzhou and Xinzheng contribute excellent performance in logistics. We differentiate the respondents according to gender, age, education background and work experience. And we select the enterprises according to the firm property, firm age, firm size and the level of servitization and digitalization. In the process of visiting enterprises, we conducted on-site interviews, questionnaire distribution and questionnaire recovery. From September to October in 2021, we visited 46 logistics enterprises and received 227 valid responses in total (Table 1).

Table 1. Descriptive statistics

| Item                  | Characteristic         | Sample size | %       |
|-----------------------|------------------------|-------------|---------|
| Your title            | Senior executives      | 65          | 28.6    |
|                       | Ordinary employee      | 162         | 71.4    |
| Your gender           | Male                   | 166         | 73.1    |
|                       | Female                 | 61          | 26.9    |
| Your age              | 20–30 years            | 32          | 14.1    |
|                       | 31–40 years            | 54          | 23.8    |
|                       | 41–50 years            | 59          | 26.0    |
|                       | 51–60 years            | 65          | 28.6    |
|                       | More than 60 years     | 17          | 7.5     |
| Your education background | High school      | 45          | 19.8    |
|                       | Bachelor’s degree      | 119         | 52.4    |
|                       | Master’s degree        | 32          | 14.1    |
|                       | Doctor’s degree        | 12          | 5.3     |
|                       | Others                 | 19          | 8.4     |
| Your work experience  | Less than 1 year       | 13          | 5.7     |
|                       | 1 to 3 years           | 23          | 10.1    |
|                       | 3 to 10 years          | 76          | 33.5    |
|                       | 10 to 20 years         | 64          | 28.2    |
|                       | More than 20 years     | 51          | 22.5    |

Table 1 continued on next page
3.4. Data Analysis Technique

We chose Partial Least Squares (PLS) (Gefen, Straub & Boudreau, 2000) and Hierarchical Regression Analysis as data analysis instrument according to three key reasons: first, our study focusing on firm level is to explore the relationship among digitization, servitization and service quality, in particular, to try to parse the complex interaction between digitization and servitization for predicting new theory and extending existing theory; second, our study can examine tectonic formative construct and reflective construct in the same model; third, compared with the overall model fit, we paid more attention to the interaction between variables.

4. RESULTS

4.1. Measurement Validation

We mainly used SPSS Statistics 26 and SmartPLS (v.3.3.3) to make variables analysis including exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). First, we examine research variables of digital adaptive governance, infrastructure digital transformation, servitization and service quality. Test results show that four variables above are all effective. Then we perform factor analysis and get a good validity and reliability (Zhuang and Lederer, 2003). Related results of the effective samples show factor loadings of four variables above 0.5, factor characteristic root above 1, total explained variance is 76.577 percent (>50 percent), KMO is 0.804 (>0.5) and Cronbach’s α is 0.825 (>0.7) (Table 2).
Table 2. Factor analysis results (n=227)

| Variable                          | Standard factor loading | KMO   | Total explained variance(%) | Cronbach’s α |
|-----------------------------------|-------------------------|-------|-----------------------------|--------------|
| Digital adaptive governance       |                         | 0.724 | 75.11                       | 0.834        |
| DAG1                              | 0.900                   |       |                             |              |
| DAG2                              | 0.913                   |       |                             |              |
| DAG3                              | 0.909                   |       |                             |              |
| Infrastructure digital transformation |                        | 0.740 | 79.41                       | 0.870        |
| IDT1                              | 0.891                   |       |                             |              |
| IDT2                              | 0.885                   |       |                             |              |
| IDT3                              | 0.879                   |       |                             |              |
| Servitization                     |                         | 0.706 | 71.33                       | 0.799        |
| S1                                | 0.919                   |       |                             |              |
| S2                                | 0.935                   |       |                             |              |
| S3                                | 0.918                   |       |                             |              |
| Service quality                   |                         | 0.738 | 78.71                       | 0.865        |
| SQ1                               | 0.887                   |       |                             |              |
| SQ2                               | 0.891                   |       |                             |              |
| SQ3                               | 0.889                   |       |                             |              |

For the CFA, we use composite reliability (CR) and average variance extracted (AVE) to examine reliabilities of latent constructs. When CR above 0.7 and AVE above 0.5, a questionnaire is always considered reliable (Bagozzi & Yi, 1988). Our measurement instruments reveal all the factor loadings above 0.8, AVE above 0.7 and CR above 0.8 (Table 3), we can judge that the measurement model of this research owns a good reliability and validity.

Table 3. Loadings, CR and AVE of measurement instruments (n=227)

| variable | item | loadings | IDT | S  | SQ |
|----------|------|----------|-----|----|----|
| DAG      | DAG1 | 0.844    | 0.079 | -0.024 | 0.219 |
| CR=0.900 AVE=0.751 | DAG2 | 0.835    | -0.130 | 0.014 | 0.199 |
|         | DAG3 | 0.853    | 0.072 | 0.111 | 0.132 |
| IDT      | IDT1 | 0.082    | 0.825 | 0.254 | 0.161 |
| CR=0.919 AVE=0.792 | IDT2 | 0.076    | 0.880 | 0.167 | 0.044 |
|         | IDT3 | -0.011   | 0.878 | 0.144 | 0.143 |
| S        | S1   | 0.141    | 0.063 | 0.845 | 0.063 |
| CR=0.881 AVE=0.712 | S2   | 0.162    | 0.097 | 0.805 | 0.097 |
|         | S3   | 0.219    | 0.063 | 0.814 | 0.063 |
| SQ       | SQ1  | 0.223    | 0.150 | 0.070 | 0.839 |

Table 3 continued on next page
We access discriminant validity by examining loadings, cross-loading matrix and heterotrait-monotrait ratio (Hair et al., 2017). All measurements should load stronger on their respective construct than on other constructs. Second, according to the logic of the Fornell and Larcker method (Fornell & Larcker, 1981), in the correlation matrix, we calculate AVE square root of each construct and each value should be higher than inter-construct correlations. Four constructs in research model satisfy criteria above (Table 4). At last, we take HTMT approach and find all values are well below 0.85 (Table 5).

### Table 4. Discriminant validity of measurement model (n=227)

| Construct | Mean | SD  | DAG | IDT | S    | SQ   |
|-----------|------|-----|-----|-----|------|------|
| DAG       | 6.003| 1.205| 0.867|     |      |      |
| IDT       | 3.977| 1.197| 0.139*| 0.890|      |      |
| S         | 4.390| 1.604| 0.108| 0.425**| 0.844|      |
| SQ        | 5.203| 1.148| 0.423**| 0.277**| 0.209**| 0.887|

Notes: *p<0.05; **p<0.01; ***p<0.001

### Table 5. Heterotrait-monotrait ratio (HTMT) of variables (n=227)

|          | DAG | IDT | S    | SQ  |
|----------|-----|-----|------|-----|
| **DAG**  |     |     |      |     |
| **IDT**  | 0.159|     |      |     |
| **S**    | 0.150| 0.501|      |     |
| **SQ**   | 0.482| 0.323| 0.251|     |

Notes: DAG, Digital adaptive governance; IDT, Infrastructure digital transformation; S, Servitization; SQ, Service quality

### 4.2. Common Method Bias (CMB)

To minimize common method bias (CMB), we selected senior executives (CEO, CIO), department heads and worker at the production line who can understand our research question clearly in the process of data collection. To avoid CMB further, we examined the questionnaire subject by adopting
Harman’s one factor test. The results without rotating principal component factor analysis showed the biggest factor can explain 29.26% variance (<40%). We recognized our effective data collected had no serious CMB in this research (Podsakoff et al. 2003).

4.3. Hypotheses Tests

We use hierarchical regression analysis to test hypotheses in this research. First, we test hypotheses of the whole model through path coefficient and t value of PLS-SEM. Afterwards; we use hierarchical regression analysis to test effects of control variables and moderating effects. Before test, we average score of items to represent each construct in advance and then centralize four control variables to avoid potential multicollinearity. We can find results of hierarchical regression analyses in Table 6 and Table 7. The summary results of H1(β=0.162, p<0.05), H2(β=0.430, p<0.001), H3(β=0.428, p<0.001), H4(β=0.291, p<0.001), H5(β=0.228, p<0.001) and H6 hypotheses test through path coefficient of PLS-SEM presented in Table 8. The results of hypotheses test show that H1, H2, H3, H4 and H5 are supported, H6 is rejected, which means servitization has no significant moderating effect for the positive path of digital adaptive governance on service quality.

Table 6. Results of hierarchical regression analyses

| Variable                      | Infrastructure digital transformation |          |          |
|-------------------------------|--------------------------------------|----------|----------|
|                               | Model 1                             | Model 2  |          |
| Firm age                      | -0.179**                            | -0.163*  |          |
| Firm property                 | 0.05                                | 0.013    |          |
| Firm servitization level      | 0.49                                | 0.032    |          |
| Firm digitalization level     | -0.133*                             | -0.147*  |          |
| DAG                           |                                     | -1.200   |          |
| DAG*S                         |                                     | 0.430*** |          |
| R²                            | 0.058                               | 0.206    |          |
| F                             | 3.427**                             | 9.513*** |          |
| R²                            | 0.041                               | -1.184   |          |

Notes: *p<0.05; **p<0.01; ***p<0.001

Table 7. Results of hierarchical regression analyses

| Variable                      | Service quality |          |          |
|-------------------------------|-----------------|----------|----------|
|                               | Model 1        | Model 2  |          |
| Firm age                      | 0.003          | 0.013    |          |
| Firm property                 | -0.027         | 0.004    |          |
| Firm servitization level      | -0.031         | -0.053   |          |
| Firm digitalization level     | -0.066         | -0.022   |          |
| DAG                           | 0.221          |          |          |
| IDT                           | 0.194*         |          |          |
| S                             | -0.189         |          |          |

Table 7 continued on next page
Table 7 showed during process of the interaction effect of servitization and digitization, firm age ($\beta=-0.163$, $p<0.05$) and firm digitalization level ($\beta=-0.147$, $p<0.05$, $R^2=0.242$) have significant influences. Table 7 showed during process of digital adaptive governance influenced service quality, four controls all have no significant influences.

Table 8. Summary of hypotheses results

| Hypotheses | Path coefficient | t     | p         | Results   |
|------------|------------------|-------|-----------|-----------|
| H1         | 0.162            | 2.473 | 0.014*    | Supported |
| H2         | 0.430            | 5.826 | 0.000***  | Supported |
| H3         | 0.428            | 6.941 | 0.000***  | Supported |
| H4         | 0.291            | 4.394 | 0.000***  | Supported |
| H5         | 0.228            | 3.422 | 0.001**   | Supported |
| H6         | 0.347            | 1.138 | 0.256     | Not supported |

Table 6 showed during process of the interaction effect of servitization and digitization, firm age ($\beta=-0.163$, $p<0.05$) and firm digitalization level ($\beta=-0.147$, $p<0.05$, $R^2=0.242$) have significant influences. Table 7 showed during process of digital adaptive governance influenced service quality, four controls all have no significant influences.

In Table 6 we can find the interaction coefficient between digital adaptive governance and servitization is significant ($\beta=0.430$, $p<0.001$), indicating that servitization plays a significant positive moderating role in the process of digitalization. Figure 2 shows the moderating effect of high and low servitization level on digital adaptive governance in the process of infrastructure digital transformation. A high level of servitization has a more significant effect on the process of digitization.
According to the path coefficients calculated by PLS and hypotheses test results, related coefficients and the revised model in this research are shown in Figure 3.

Figure 2. Moderating effect of high and low servitization

![Figure 2](image)

Figure 3. Related coefficients

![Figure 3](image)
5. DISCUSSION

5.1. Theoretical Contributions

Digital adaptive governance and infrastructure digital transformation are both important components of digitalization and both of them have internal mechanism of action. The empirical research proves that digitalization is a complex process for logistics enterprises in China, covering a wide range of contents, not only simply including informatization and cloud, but also involving the systematic reconstruction and upgrading behind the key links of enterprises (Mahmud, 2017). Based on Chinese logistics enterprises, this research explores the internal action path of digitalization and its relationship with service quality from the perspective of digitalization adaptive governance and infrastructure digital transformation. For RQ1, empirical research results shows that digital adaptive governance has a positive impact on infrastructure digital transformation, and both of them have positive impacts on service quality. The main objectives of digital adaptive governance are to improve operational efficiency, realize data-driven intelligent decision-making, reduce operating costs, acquire new users, promote innovation capability, increase enterprise income, and enhance customer satisfaction and loyalty (Barreto, Amaral & Pereira, 2017; Tadejko, 2015). We need to clearly understand the gap between digital adaptive governance and digital management. Digital adaptive governance not only covers the functions of digital management, but also takes digital security as the premise to improve the quality of digital transformation. Digital adaptive governance and infrastructure digital transformation can help logistics enterprises improve information fragmentation and business performance, and help supervise the whole logistics process in real time. At the same time, it provides comprehensive service solutions for logistics enterprises to improve the overall service quality and efficiency of the logistics industry. Therefore, the research conclusions contribute to the relevant theories of digitalization affecting service quality.

In addition, many studies show that digitization and servitization are two interwoven and simultaneous development processes (Kohtamäki et al., 2020). Digitization immersion in servitization is complicated, discontinuous and atypical, rather than simple, continuous and regular embedding. For RQ2, our research confirms that there is a linear relationship and significant interaction effect between digitalization and servitization in logistics enterprises. Due to the differentiation of research perspectives between digitalization and servitization, our research has contributed to the exploration of the interaction between digitization and servitization for further, which expands the previous research conclusion that digitization has a driving effect on servitization and has an impact on firm financial performance (Abou-Foul, Ruiz-Alba & Soares, 2021; Fu et al., 2022). To achieve the expected goals of digitalization and servitization, a deep understanding and full realization of the synergy between the interaction effects of the two and continuous valuable investment are required. Since the interaction between digitization and servitization is a prerequisite to help ecosystems provide accurate and intelligent solutions, an emphasis on servitization or digitization alone will lead to over focus on technology, strategic missteps and limited growth and innovation (Blome, Schoenherr & Kaesser, 2013; Cabral, 2017).

We find that the interaction effect of servitization and digital adaptive governance has a positive impact on infrastructure digital transformation, but has no significant impact on service quality. This conclusion is crucial to help optimize and balance the unknown areas of digitalization and servitization. The research further proves that the relationship between servitization and digitalization have no clear definition and boundary (Kalra et al., 2021). Taking servitization and digitalization as defensive strategy or breakthrough strategy depends on senior executives judgement. The digitalization paradox and servitization paradox are the problems that every enterprise has to face. Although digitalization and servitization have become the development trend of logistics enterprises, the trend does not necessarily mean opportunities for change, but also may hide huge risks (Kalra, Lewis & Roehrich, 2021). The promotion and improvement of the two should not be divorced from firm strategy and organization goal, fully analyzing the connotation and the role is the primary task (Gulati et al., 2012).
Based on the results of the empirical study, we find that for logistics enterprises, firm age and firm digitalization level have influence on the interaction stage of servitization and digitalization, while firm property and firm servitization level have no significant influence on the whole research model. This can be interpreted as enterprises with older firm age always own a deeper understanding of servitization and a more perfect and optimized servitization system, in additional, with a higher digitalization level. All these factors will promote the transformation and improvement of servitization and digitalization. This also confirms the relevant theory that servitization relies on digitalization (Wang, Lai & Shou, 2018).

5.2. Managerial Implications

Logistics enterprises in China should pay more attention to the role of digital adaptive governance in the process of infrastructure digital transformation. Among them, digital technology is the key support to improve digital adaptive governance. On the one hand, digital technologies such as LoT, AI and advanced data analytics are projected to have far-reaching effects on business of logistics enterprises as follows. First, gradually to establish a unified standard and LoT platform for logistics enterprises, which can truly achieve information sharing and application to meet the demand of governance. Second, gradually to integrate logistics industry into the social Internet of things by way of cross industry interoperability, which means smart logistics will gradually become a part of smart life and realize the synergy of governance. Third, to help China achieves green development as one of the objectives of governance. China government promises to achieve carbon peak in 2030 and carbon neutrality in 2060, in this context, to achieve green intelligence, we need to vigorously promote the greening of intelligent logistics equipment, logistics automation system, logistics brain and logistics information network. On the other hand, digital technology is an important guarantee for the coordinated operation of digital adaptive governance. Since the outbreak of COVID-19, demand of logistics enterprises for digital services has been increasing, and the functions and carrying capacity of relevant systems have also been subjected to more severe tests. Therefore, it is necessary to comprehensively improve digital technology, give full play to the important role of digital technology in breaking through data barriers, improving data circulation efficiency, ensuring the stable operation of the system and expanding new applications, and promote the synergy and efficiency of digital adaptive governance.

Infrastructure digital transformation of logistics enterprises often means huge investment. When formulating investment strategies, digital adaptive governance should be introduced to ensure enterprises take accurate actions and gather all the ideas of employees into a coordinated driving force to drive the implementation of digital transformation vision. At the same time, the strategy of logistics enterprises plan to improve service quality through digitalization, and servitization is the source and driving force of digitalization change. At last, when formulating and implementing the strategy of digitalization and servitization, considering the firm age and firm digitalization level can provide significance guidance to make effective investment and formulate reasonable plans.

Nevertheless, the application and promotion of digital transformation in logistics enterprises and other fields are still full of challenges and uncertainties. First of all, enterprises lack the basis for digitalization strategic selection, which leads to it is difficult to formulate effective strategies that meet their own positioning and competitive needs. In addition, the digitalization capability-building of enterprises is arduous, and many ideas about digitalization remain in the conceptual stage, which is still not to go deep into the reality of enterprises and improve the management practice or production practice. Finally, the effectiveness of digital investment is slow and the cycle is long, and some enterprises use traditional performance indicators to measure the transformation effect. Due to no targeted evaluation system matching the deployment plan according to the actual situation of the enterprises, they always feel that the digital deployment “fails” in the short term which causes the sustainability of digital investment is weak.
6. LIMITATIONS AND FUTURE SCOPE OF RESEARCH

This research has several limitations. First, we use a relatively small sample (227) of logistics enterprises in zhengzhou and xinzheng, which may limit generalizability. In future research, a larger and broader sample size can be used to reduplicate the conclusions of this research, such as selecting large cities with more than 10 million people as research sample. Furthermore, we focus on the perspectives of digital adaptive governance and infrastructure digital transformation to define digitalization, due to the rich connotation of digitalization, more important perspectives like digital technology and knowledge can be used to carry out on digitalization in the future to improve our research. Third, the nonlinear relationship between servitization and digitalization can be carried out to complement and expand our findings. For example, using digitalization to provide comprehensive service solutions for enterprises or industries, or introducing more advanced digital technology in the service process to achieve the goal of cost reduction and efficiency increase, and so on. Finally, in-depth qualitative method can be adopted such as cross-sectional data and text data mining to develop a more detailed understanding of the related theory and enterprise practices, in addition, the combination of qualitative and quantitative methods can also be used to carry out research in related fields, so as to enrich the theoretical system and solve specific problems in practice.

CONFLICT-OF-INTEREST STATEMENT

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Chao Li is a Lecturer at School of Economics and Management, Zhongyuan University of Technology, China. She received her PhD in Management from Xiamen University in China. Her research interests include innovation management and organizational behavior, primarily in the areas of the impact of the information technology on organizational service improvement innovation and performance.

Wei-Xi Feng is a Lecturer at School of Economics and Management, Zhongyuan University of Technology, China. He received his PhD in Management from Xiamen University in China. His research interests include platform governance, organizational service innovation and behavior research in Information Systems.

Shuihua Han is a Professor of Information Systems at the School of Management, Xiamen University, China. He received his PhD from Huazhong University of Science and Technology in China. His research interests are in big data analysis and supply chain Management. His research has published in Europe Journal of Operational Research, Decision Support Systems and other reputed journals.

Shivam Gupta is a Professor at NEOMA Business School, France with a demonstrated history of working in the higher education industry. Skilled in Statistics, Cloud Computing, Big Data Analytics, Artificial Intelligence and Sustainability. Strong education professional with a Doctor of Philosophy (PhD) focused in Cloud Computing and Operations Management from Indian Institute of Technology (IIT) Kanpur. Followed by PhD, postdoctoral research was pursued at Freie Universität Berlin and SUSTech, China. He has completed HDR from University of Montpellier, France. He has published several research papers in reputed journals and has been the recipient of the International Young Scientist Award by the National Natural Science Foundation of China (NSFC) in 2017 and winner of the 2017 Emerald South Asia LIS award.

Sachin Kamble is Professor of Strategy (Operations and Supply Chain Management) at EDHEC Business School, France. He holds a PhD in Management, MBA in Operations and a bachelor’s degree in Mechanical Engineering. Before joining EDHEC worked with National Institute of Industrial Engineering (NITIE) Mumbai, India. His teaching and research interests include operations management, supply chain management, big data analytics, Industry 4.0 and digital transformation. He has more than 50 authored/co-authored publications in refereed international journals. He has done more than 25 consultancy assignments for leading manufacturing and service organizations representing different sectors.
### APPENDIX A

**Table 9. Measurement Scales**

| Items | Supporting Theory |
|-------|-------------------|
| **1. Digital adaptive governance** | Howard et al (2019); Morton et al (2020); Schepker et al (2014). |
| DAG1: Monitoring digital services and describing threats posed by digitization to control digital risks through adaptive governance techniques. |  |
| DAG2: The top management team actively promotes the establishment and promotion of collaborative governance mechanism. |  |
| DAG3: The dedicated leader is responsible for monitoring whether the risk assessment is carried out on time and can dynamically improve the risk assessment management based on the assessment results. |  |
| **2. Infrastructure digital transformation** | Melville (2015); Morton et al (2020); Scurati et al (2018). |
| IDT1: Digital savvy senior executives support the infrastructure digital transformation to achieve smart maintenance and sustainable development. |  |
| IDT2: Better addressing information asymmetry including uncertainty and equivocality. |  |
| IDT3: Transformation for data gathered, analyzed and interpreted. |  |
| **3. Servitization** | Kohtamäki et al (2013); Partanen et al (2017) |
| S1: Managing the customer’s maintenance function |  |
| S2: Service for operating customer’s process |  |
| S3: Providing performance guarantees |  |
| **4. Service quality** | Kesharwani et al (2021); Mentzer et al (1999) |
| SQ1: The overall speed of service has been significantly improved. |  |
| SQ2: The fluency of the service process is significantly improved. |  |
| SQ3: The accuracy of goods is significantly improved. |  |

Please choose the most appropriate according to your experience and understanding.

**Personal Situation and Firm Information**

**Your title in the firm:**
1. CEO; 2. Department head; 3. Worker at the production line

**Your gender:**
1. Male; 2. Female

**Your age:**
1. 20~30years; 2. 31~40years; 3. 41~50years; 4. 51~60 years; 5. More than 60 years

**Years of working:**
1. Below 1 year; 2. 1-3 years; 3. 3-10 years; 4. 10-20 years; 5. More than 20 years

**Your personnel qualification:**
1. High school; 2. Bachelor’s degree; 3. Master’s degree; 4. Doctor’s degree; 5. others

*Table 9 continued on next page*
Table 9 continued

Please answer the following questions according to your experience and understanding, fill 1 to 7 in the back of each subject, 1 represents completely disagree and 7 represents totally agree.

| Items                      | Supporting Theory |
|----------------------------|-------------------|
| **Firm property:**         |                   |
| 1 State-owned; 2 Private; 3 Sino-foreign joint venture; 4 Foreign-owned; 5 others |
| **Firm age:**              |                   |
| 1 1-3 years; 2 3-5 years; 3 5-10 years; 4 10-20 years; 5 More than 20 years |
| **Firm size:**             |                   |
| 1 Below 20; 2 20-300; 3 300-1000; 4 1000-2000; 5 More than 2000 |
| **Firm servitization level:** |                   |
| 1 Initial; 2 Developing; 3 Managed; 4 Standard; 5 World-class |
| **Firm digitalization level:** |                   |
| 1 Initial; 2 Developing; 3 Managed; 4 Standard; 5 World-class |