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Crowd-Sourcing a Way to Sustainable Urban Logistics: What Factors Influence Enterprises' Willingness to Implement Crowd Logistics?

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ABSTRACT The sharing economy has brought new opportunities to the logistics industry, which has created an emerging trend known as crowd logistics. Implementing this mode offers a basis for more sustainable urban logistics, but there is limited research on what leads enterprises to adopt crowd logistics. Based on the technology-organization-environment (TOE) theoretical model, this paper developed a model to study the influencing factors of enterprises' willingness to implement crowd logistics. The data were collected through questionnaire surveys, SPSS and AMOS were used for data analysis. The empirical results showed that the relative advantage, absorptive capacity, market environment, and external motivations have significant positive impact on the company's willingness to implement crowd logistics, while complexity and resources have no significant impact. Crowd logistics offers an important route to more sustainable urban logistics. Logistics enterprises should take measured steps when implementing crowd logistics, improve their absorptive capacity, and take necessary precautions towards minimizing the risks of crowd logistics.

INDEX TERMS Crowd logistics, crowdsourcers, influencing factors, TOE model, stakeholder analysis.

I. INTRODUCTION

Crowd logistics has emerged as a result of the rapid growth in internet users, the extensive construction of collaborative network communities, and growing consumer awareness. These factors have facilitated the emergence of the sharing economy, which has a number of new business modes [1]. Typical examples of this new breed of business models include car sharing (e.g., car2go), book sharing (e.g., Craigslist), software repository sharing (e.g., SourceForge and Github), space sharing (e.g., Airbnb), and of course crowd logistics (e.g., Renren Express, JD-dada, Waze).

Crowd logistics refers to the outsourcing of goods distribution by enterprises (or retailers), with the use of the internet as platform, into public groups that are not fixed, have free time, and have transportation resources [2]. Compared with traditional logistics modes, crowd logistics has the advantage of improving distribution efficiency and reducing logistics costs [3]. In the sharing economy environment, there are two types of crowd logistics: the tournament-based (classic) and the collaboration-based (information) systems. The tournament-based crowd logistics, which appears at the end of the value chain, focus on the flow and storage of tangible goods [4]. For example, Checkrobin, which locates itself as a C2C transport service platform, provides information exchange services for enterprises or individuals who wish to receive or send goods and share private freight vehicles. Collaboration-based crowd logistics focuses on the flow and storage of information, which can occur at any stage of the value chain related to information management [4]. For example, mobile crowdsourcing-based traffic and navigation software Waze can be used by users to share traffic and other road data, while others can use the information to modify driving routes and avoid heavy traffic. Although the two types of crowd logistics are different, both reflect the concept of the sharing economy in the logistics industry.

Ubiquitous mobile devices enable users to conduct information interaction at any time and any place [4], bridging

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time-location gaps between users and enterprises or between users and users [5], [6] and providing powerful technical support for the development of crowd logistics. In recent years, a number of crowd logistics companies have emerged in China (e.g., JD-dada, Renren Delivery, and Dian-wo-da). The number of registered users has exceeded 7 million in Renren Delivery, with daily transaction orders reaching 200,000 [7]. The Dian-wo-da platform covers 350 cities across the country and has 3 million crowd workers [8].

However, crowd logistics is still in its early stages of development [9]. Several urgent problems need to be resolved, such as determining the factors that affect the implementation of crowd logistics, and knowing how to stimulate their implementation. If these issues are solved, they will promote the sustainable development of crowd logistics in cities [10], [11] and improve the conditions of last-mile delivery [12]. To provide some understanding on these important issues, this study develops a technology-organization-environment (TOE) model to explore the influencing factors of enterprises' willingness to implement crowd logistics and implements an empirical test on logistic enterprises.

This paper makes several contributions to the literature. First, it adds to the crowd logistics literature by constructing the TOE model and exploring the influencing factors of enterprises' willingness to implement crowd logistics (WICL). Second, this study expands the research boundary of TOE theory by applying the theory to the field of crowd logistics. Finally, this study offers a number of recommendations useful in promoting and developing crowd logistics and provides a new avenue for the development of research on sustainable urban logistics.

The rest of this paper is as follows. The second section presents the study background and theoretical foundation. The third section discusses the hypotheses. The fourth section summarizes the methods used and presents the empirical results. The fifth section provides a discussion on the empirical results and reviews their theoretical and practical implications. And in the sixth section, we conclude and discuss the limitations of the study and recommendations for future work.

II. STUDY BACKGROUND AND THEORETICAL FOUNDATION

A. STUDY BACKGROUND

Speed and cost are crucial in the completion of the last mile delivery [13], [14], and the last mile is the site of great environmental impact, particularly in urban settings. Geared towards increasing speed and cutting costs, crowd logistics has been an important research direction in optimizing the last mile delivery. It can enhance the use of resources by redistributing, sharing, and utilizing spare vehicle space of the mass population [15]. One study used contingency theory to compare the differences in logistical efficiency between crowdsourced logistics and traditional dedicated fleets, and confirmed the speed advantage of using crowdsourcing to solve the last mile problem [16]. In addition, the use of crowd logistics can reduce the multiple deliveries of the same package due to ''not-at-home syndrome'' or ''table tennis effect'', which effectively reduces economic and environmental costs [17]. Therefore, crowd logistics can be a valid solution to the last mile problem. Similarly, Wooseok *et al.*'s research results show that both large and small companies can benefit from collaborative logistics, saving delivery costs, and time through economies of scale [18]. Since we focus our attention on the factors influencing the willingness to implement crowd logistics, our review is focused mainly on the participation and implementation of crowdsourcing entities.

The retailers, crowd workers, and the crowdsourcing platforms are the main stakeholders of crowd logistics [19], and their development constraints directly affect whether crowdsourcing activities can be implemented smoothly [20]. Previous studies (e.g., Shen *et al.*, 2014 [21]; Ye and Kankanhalli, 2017 [22]; Huang *et al.*, 2020 [23]) have focused on the crowd workers' willingness to participate. Motivation theory has often been used to analyze the intrinsic and extrinsic motivation of the retailers to participate in crowd logistics. Monetary reward and reputation comprise the extrinsic motivation of public participation [24], [25], while the intrinsic motivation mainly consists of the change in daily life and enjoyment brought by doing new things [26]. Social exchange theory is often used to analyze the impact of cost and benefit on public participation behavior. The theory posits that the more rewards people receive, the greater their willingness to participate in crowd logistics; the higher the perceived cost on the crowd workers, the lower the participation in crowdsourcing [24]. In addition, task design theory is often applied in the model, analyzing the factors affecting the crowd's willingness to participate. The task analyzability, difficulty, and credit of the retailers will affect the public participation in crowd logistics [27], [28]. Retailers with better credit are more likely to attract a large number of appropriate crowd workers [22].

The crowdsourcing platform relies mainly on technology to connect the excess transport capacity of individuals with the delivery requirements of the crowd workers. Platform vendors are typically built by big companies (e.g., Amazon and DHL), or start-ups (e.g., Deliv and Postmates) [29]. Platform availability and the public are essential features influencing the success of the platform [30]. Platform vendors can adjust the platform plan to guide the efficient use of vehicular space or propose incentives that encourage more package deliveries or cut down on dedicated trips [19]. Conforming to retailers' delivery requirements, some platforms utilize algorithms to correspond with the recipient in order to improve the delivery rate and delivery efficiency [31], [32]. Oftentimes, finding enough crowd workers is problematic during peak delivery periods, so the platform can provide appropriate compensation programs to increase public participation [33]. Small monetary incentives and activities, for example, have been commonly employed to increase public loyalty of crowdsourcing communities [9].

Retailers perform a crucial role in crowd logistics. However, the existing research has primarily been based on the perspective of crowd workers and the crowdsourcing platform. Few studies (e.g., Bin *et al.*, 2019 [34]) have analyzed the implementation of crowd logistics, and have overlooked the analysis from the retailers' perspective. In terms of speed and cost, Carbone *et al.* pointed out that crowd logistics has enormous potential for large enterprises such as Amazon [35], while others believe it is more suitable for small and medium enterprises [32], [36]. This dichotomy of opinion results from the limited research focused on the specific determinants affecting the performance of crowd logistics. Therefore, this paper proposes a synthetic model founded on theoretical research to analyze the factors influencing retailers' willingness to implement crowd logistics.

B. THEORETICAL FOUNDATION

Technology-organization-environment (TOE) theory was proposed by Tornatzky *et al.* based on the theory of innovation absorption [37]. It considers the internal and external variables affecting enterprises and posits that the determinants on an enterprises' absorption of innovation are comprised mainly of technical, organizational, and environmental factors. Technical factors refer to the impact of technology on enterprises. Organizational factors usually include enterprise-scale, material, human, and financial resources. Environmental factors describe the impact of the external environment (e.g., government, competitors, industries) on corporate technology absorption [37]. The relationship between innovation absorption and these three factors is presented in Figure 1. In recent years, the TOE theoretical model has been widely used in the empirical research of innovation absorption of information technology and information system. For example, Picoto *et al.* studied the influencing factors of retailers' absorption of mobile commerce based on the TOE theory [38]. Xu *et al.* found that the TOE factors have varying effects on absorption of ERP system [39]. Hwang *et al.* applied the TOE theoretical model to study the factors affecting the adoption of the green supply chain in the semiconductor industry [40]. Lin and Hu studied the influencing factors of agricultural products in the retailer's e-commerce absorption based on the TOE theory [41]. Their study showed that the TOE theory provides a useful conceptual framework to analyze the determinants of corporate innovation absorption.

Various factors impact the implementation of crowd logistics. The TOE theoretical model provides a comprehensive perspective in studying the factors of crowd logistics, including the characteristics of the technology itself and the internal and external factors of enterprises. The relative advantages of crowd logistics attract companies to implement them; but as the process progresses, complexity may hinder the application's continued usage. In order to realize the full advantage of crowd logistics, companies would need to meet the requirements of the technology, which may include business process reorganization. It is therefore important to consider

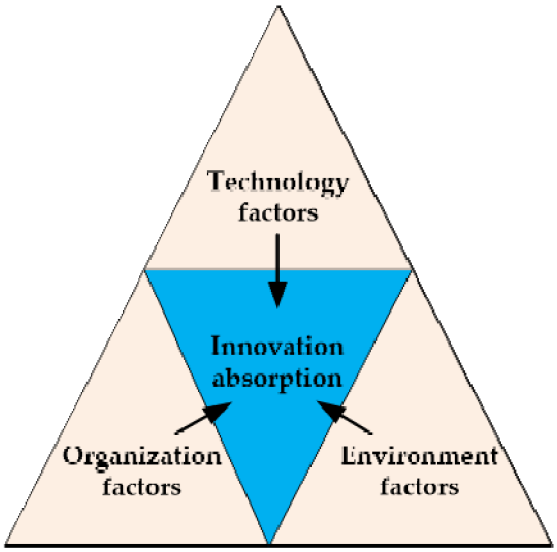

FIGURE 1. TOE theoretical model.

whether enterprises can adapt to the changes brought about by the implementation of crowd logistics. When the company's internal resources are insufficient, it may exert numerous restrictions at the performance of crowd logistics. In addition, analyzing the external environment is equally important. Developing trends in the market, government, industry, and customers may have significant impact on the implementation of crowd logistics. It is therefore our belief that the TOE theory provides a suitable framework for studying the factors affecting the willingness of enterprises to implement crowd logistics.

III. HYPOTHESIS

Based on TOE theory and previous research, we established a model of enterprises' willingness to implement crowd logistics, as shown in Figure 2. The technology factors include the relative advantages and complexity of innovation diffusion theory. The organization factors are comprised of absorptive capacity and resources, which consists of existing human and material resources that support the implementation of crowd logistics. Environmental factors include the market environment and external motivations, which refer to the competition

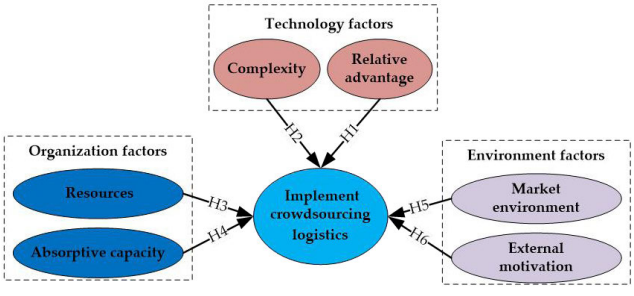

FIGURE 2. The theoretical model proposed in this paper.

and opportunities in the market, as well as the approval of the government, partners, and customers on the implementation of crowd logistics.

Using an extensive review of the current literature and the prevailing theoretical foundation, we selected the appropriate factors, according to the practical characteristics of crowd logistics, that would be used in constructing the theoretical model for this study. A detailed explanation for each factor and their connection to crowd logistics is provided in the rest of the section.

A. TECHNOLOGY FACTORS

Relative Advantage (RA). Relative advantage refers to the higher distribution efficiency and lower logistical cost advantages from crowd logistics. Sharing transportation resources can save a company from additional costs [42]. Mladenow *et al.* pointed out that the direct economic advantage is a primary motivator for enterprises to implement crowd logistics [43]. Since the participation in crowdsourcing is often complemented with satisfaction from life change and experiencing new things, companies can motivate crowd workers to complete the task at a small cost [26]. In addition, since crowd logistics promotes the sharing and use of passenger and freight resources, it also has the advantage of efficiency and sustainability, making the distribution process more convenient and flexible and provides an effective method to alleviate the ''last mile'' distribution problem [44]. Therefore, we propose the following hypothesis:

Hypothesis 1. The potential relative advantage has a positive impact on the company's willingness to implement crowd logistics.

Complexity (C). Complexity refers to the degree of difficulty that companies perceive would be involved in adopting an innovation [45]. Chatzoglou *et al.* pointed out that users tend to accept and use new technology when they believe it is easy to use [46]. If an enterprise implements an innovation that requires a lot of effort and changes in its processes to adapt, the company will tend not to implement it [47]. Crowd logistics is an innovative business mode grounded on the strength of the network community [48] and involves various participants, such as managers, platform providers, crowd workers, and mass groups. Business coordination is complex. Hence, if the process of adapting to crowd logistics is complex, enterprises may abandon its innovative model. Based on these arguments, we propose the following hypothesis:

Hypothesis 2. Complexity has a negative impact on the willingness of enterprises to implement crowd logistics.

B. ORGANIZATION FACTORS

Resources (R). Enterprise resources include tangible (.e.g., infrastructure) and intangible resources (e.g., human resources) that, to a certain extent, impact the implementation of crowd logistics. The whole process of crowdsourcing requires the support and coordination of technical infrastructure. Enterprises need to have specific technical facilities to implement crowdsourcing logistics and outsource tasks to the masses [4]. Yang *et al.* pointed out that human resources, as the carrier of knowledge absorption and transformation, is the most crucial element in the allocation of enterprise innovation resources [49]. Similarly, enterprises would need to have human resources familiar with the work and operations of the crowdsourcing platform, to better facilitate crowd logistics. Hence, we propose the following hypothesis:

Hypothesis 3. Resources have a positive impact on the enterprise's willingness to implement crowd logistics.

Absorptive capacity (AC). Absorptive capacity refers to the ability of an enterprise to evaluate, digest, integrate, and utilize external knowledge [50], which mainly includes enterprise-scale, organizational learning mechanism, and effort level [51]. Zhang *et al.* concluded that the larger the enterprise-scale, the more it can promote the implementation of new technologies [52]. For example, large enterprises such as Amazon, DHL, and JD have established their own crowd logistics platforms. However, the lack of training has been the main obstacle for some companies to successfully implement innovative technologies [53]. Effective organizational learning mechanisms can help increase and consolidate the knowledge in crowd logistics and promote its integration. In addition, the employees' knowledge absorption ability forms the foundation of the company's own knowledge of absorption capacity. The intensity of the employees' efforts affects the extensiveness and depth of their understanding of crowdsourcing, which ultimately impacts the company's knowledge accumulation and absorption of crowd logistics. Thus, we propose the following hypothesis:

Hypothesis 4. Absorptive capacity has a positive impact on the willingness of enterprises to implement crowd logistics.

C. ENVIRONMENTAL FACTORS

Market environment (ME). The environment of enterprise management is comprised of the internal environment and the external environment [54], [55]. In this paper, the market environment mainly refers to the external environment of logistics enterprises. The development of information and communication technology (ICT) has made crowdsourcing an emerging trend, which has become more dominant in recent years [43]. The crowdsourcing model has been applied in various fields, such as the ''crowdfunding'' APP for project financing, the ''crowd voting'' APP for mass voting, and the ''crowd searching'' APP for finding people or objects. The application of crowdsourcing mode in logistics enterprises has become ubiquitous. Traditional logistics enterprises that fail to adapt crowdsourcing into its business model will not only appear as being behind the trend but may also be missing a major opportunity for enterprise transformation and upgrade. Therefore, the external environment puts pressure on enterprises to implement crowd logistics. This is consistent with Porter's idea that ''the main purpose of enterprises' external environment analysis is to discover opportunities and threats in the external environment'' [56]. Based on these arguments, we propose the following hypothesis:

Hypothesis 5. The market environment has a positive impact on the willingness of enterprises to implement crowd logistics.

External motivation (EM). External motivation refers to the compliments that enterprises receive from the government, industry, and customers for implementing crowd logistics. Zhang and Li concluded that crowdsourcing science would yield more high-quality results if the government encouraged it more [57]. Benchmarking theory argues that well-managed enterprises can receive commendations while acquiring valuable experiences from partner enterprises [58]. In addition, crowd logistics is in line with the growing trend of the sharing economy. When customers find that goods are delivered by crowd workers, they are likely to be pleasantly surprised [59]. Thus, we propose the following hypothesis:

Hypothesis 6. External incentives have a positive impact on the willingness of enterprises to implement crowd logistics.

IV. RESEARCH METHODOLOGY AND DATA ANALYSIS

Based on the hypothesis and the research methodologies used and proposed by previous research (e.g., Shen *et al.*, 2014 [21]; Ye and Kankanhalli, 2017 [22]; Bin *et al.*, 2020 [60]; Huang *et al.*, 2020 [23]), we designed the research framework for this paper. As shown in Figure 3, the research framework includes six steps: (1) design of questionnaire, (2) questionnaire test, (3) data collection, (4) control variables setting, (5) data analysis and results, and (6) recognition of factors influencing enterprises to implement crowd logistics.

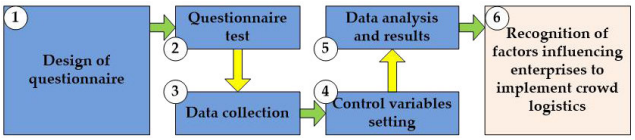

FIGURE 3. Research framework.

A. DESIGN OF QUESTIONNAIRE

The data used in this study were collected using questionnaires, which were used in determining six latent variables. Each variable included three test items and was quantified using a Five-point Likert scale [61]. The test items and sources of the scale are presented in Table 1. The item used in developing the questionnaire based on an extensive review of existing studies.

B. QUESTIONNAIRE TEST

To determine whether the questions would be understandable for the respondents, we conducted a questionnaire testing before the formal survey. We randomly contacted three logistics enterprises in Zhuzhou, Changsha, and Xiangtan and asked two middle or senior managers in each enterprise to volunteer in answering the questionnaire. The questionnaire was sent as a link via WeChat (a social application) to the respondents' mobile phones. On the eighth day after the pretest questionnaires were sent out, that is, October 25, 2018, we received all the questionnaires (9 in total) from the respondents. Based on the answers to the test questionnaire, the respondents found the questionnaire to be clear and comprehensible.

TABLE 1. Item of constructs in the proposed model.

Latent variables	Test item	References
H1: RA	H1.1: The implementation of crowd logistics will reduce logistics costs. H1.2: The implementation of crowd logistics will reduce fixed costs. H1.3: Implementing crowd logistics will improve logistics efficiency.	Mladenow et al., 2014 [42]; Klumpp, 2017 [3]; Arvidsson et al., 2016 [43]
H2: C	H2.1: Implementing crowd logistics is a complex process. H2.2: Enterprise needs to spend a lot of time and energy to change business process and implement crowd logistics. H2.3: The implementation of crowd logistics needs to increase staff workload and business scope.	Oliveira et al., 2014 [46] Verlinde et al.,2017[47]
H3: R	H3.1: The enterprise has the technological infrastructure to support crowd logistics. H3.2: The enterprise has the human resources to support the operation of crowd logistics business. H3.3: The enterprise has the human resources to support the use of crowd logistics platforms.	Mladenow et al., 2015 [4]; Yang et al., 2010 [48]
H4: AC	H4.1: The development scale of enterprise can support the implementation of crowd logistics. H4.2: Enterprise actively carries out crowd logistics knowledge training for employees. H4.3: Employees actively seek information about technical changes that may affect crowd logistics.	Li and Zhang, 2015 [50]; Zhang et al., 2018 [51]
H5: ME	H5.1: Enterprise can gain competitive advantages by implementing crowd logistics. H5.2: Enterprise can obtain new development opportunities by implementing crowd logistics. H5.3: There are already comprehensive laws and regulations on crowd logistics in the external environment.	Mladenow et al., 2014 [41]; Porter, 1986 [55]
H6: EM	H6.1: The implementation of crowd logistics can obtain the support of the government and improve corporate image. H6.2: The implementation of crowd logistics can be supported by partners and enhance their enthusiasm. H6.3: The implementation of crowd logistics can get customer support and improve customer satisfaction.	Piazolo, 2017 [57]; Zhang et al., 2018 [51]
WICL	HA1: Enterprise is ready to continuously implement crowd logistics. HA2: The enterprise will further expand the business segment of crowd logistics. HA3: Crowd logistics will be the next breakthrough in the transformation and upgrading of enterprises.	Bansal et al., 2005 [61]; Tang et al., 2016 [62]

C. DATA COLLECTION

The logistics enterprises in Changsha, Zhuzhou, and Xiangtan were selected as study sites for the survey. Situated in southern China, these three cities are the construction areas for the ''two-oriented society'' [64], which is a resource-conserving and environment-friendly society, and are given special status with regards to economy, politics, and culture [65]. In recent years, crowd logistics has gained momentum in these cities [66]. Therefore, these cities are suitable choices to conduct the study.

We conducted the questionnaire survey From November 2018 to January 2019. The respondents were mainly middle and senior managers of logistics enterprises. The survey was conducted online and only closed questions. Initially, we got the contact information of some logistics enterprises through the company's official website, and made phone inquiries for their willingness to participate in the survey. We also sent out survey invitations to logistics enterprises that had previously cooperated with our research team. The questionnaire was sent to the respondents via a WeChat or email link. After each questionnaire was received, a short complementary phone interview (about five minutes) was conducted to confirm that the respondent was middle or senior management and to determine how long it took to accomplish the questionnaire. And we found that the respondents took about 10 minutes to finish per questionnaire. Since no financial incentive was offered, the respondents were entered into a lottery with small monetary incentives to encourage participation. Since crowd logistics had just started in the region, the available sample size was limited. A total of 150 questionnaires were issued in this survey, 135 of which were valid, with an effective recovery rate of 90%.

Data regarding the respondents' information from valid questionnaires are presented in Table 2. The implementation rate with regards to crowd logistics was mostly below 50%, and the implementation time frame was mostly less than one year. Colleges and communities were the main areas implementing crowd logistics, and the majority of crowd workers were freelancers and students. These statistics indicate that the development of crowd logistics is still in its infancy, which was consistent with prior information obtained by our project team during the investigation.

D. CONTROL VARIABLE SETTING

Similar to previous research (e.g., Ye and Kankanhalli, 2017 [22]; Huang *et al.*, 2020 [23]; Bin *et al.*, 2020 [60]), in order to eliminate the influence of latent factors, we used control variables in the research model. These variables include the operation time of the enterprise, the city where the enterprise is located, the implementation scale of crowd logistics, the implementation duration, the implementation area of crowd logistics, and the occupation of crowd workers. In particular, the operation time of the enterprise, implementation scale, and implementation duration of crowd logistics can better reflect whether the respondents' enterprises have experience in implementing crowd logistics. These control variables comprise the basic respondent's information (see Table 2), which were also inquired in the questionnaire.

TABLE 2. Descriptive statistics of the sample.

Category	Item	Ratio	Category	Item	Ratio
Operating Time	>10 years	2%	Implementation Time	< half a year	56%
	6-10 years	21%		0.5 to 1 year	34%
	3-5 years	32%		>one year	10%
	< 3 years	45%	Implement Crowd logistics Area	University	49%
City	Changsha	47%		Community	32%
	Zhuzhou	30%		Commercial District	14%
	Xiangtan	23%		Other	5%
The Implementation Scale of Crowd logistics	Less 25%	59%	Occupation of Crowd workers	Freelancers	24%
	26%-50%	39%		Employees	43%
	51%-75%	2%		Students	26%
	76%-100%	0%		other	7%

E. DATA ANALYSIS AND RESULTS

1) RELIABILITY AND VALIDITY ANALYSIS

SPSS24.0 and AMOS24.0 software were used to analyze the reliability and validity of latent variables, and the results are shown in Table 3. Reliability refers to the consistency and stability of measurement results [67]. The observed value of any measurement includes the actual value and the error value, such that the lower the error value, the higher the reliability of results. The observed value does not change in form or time and therefore has considerable stability [67].

As shown in Table 3, the Cronbach's alpha coefficients for all latent variables were greater than 0.8, suggesting the acceptability of the scale's internal reliability [68]. The minimum value of combined reliability CR was 0.867>0.8, indicating that the variables passed the internal consistency test [68]. The lowest AVE value was 0.688>0.5, indicating that the variable has good convergence [68]. The square root of AVE value was larger than the correlation coefficient between variables, indicating that there is a good discriminant validity between variables [68].

During data collection, the respondents answered the questions about independent variables and dependent variables simultaneously, which meant that the effect of common method bias (CMB) has to be considered when analyzing the analysis [69]–[71]. In order to eliminate the influence of CMB, the following measures were undertaken: (1) The questions were constructed as simple and easy to understand as possible; (2) The respondents were promised that their information and responses would be kept confidential and not be used for commercial purposes; and, (3) Harman's single factor test was used for exploratory factor analysis of all variables [69], [70]. The results show that factor analysis produces neither a single factor nor one general factor that could explain the majority of the variance (>40%) [69], [70], which suggests that the CMB is not a problem for this study.

TABLE 3. Reliability and validity test of latent variables[1].

Valid	H	H1	H2	H3	H4	H5	H6
H	0.855						
H1	0.207	0.876					
H2	-0.303	-0.232	0.843				
H3	0.321	0.272	-0.141	0.871			
H4	0.311	0.290	-0.306	0.168	0.870		
H5	0.342	0.335	-0.305	0.113	0.227	0.829	
H6	0.164	0.298	-0.225	0.274	0.272	0.194	0.854
α	0.826	0.865	0.807	0.844	0.838	0.801	0.828
AVE	0.732	0.767	0.711	0.758	0.757	0.688	0.727
CR	0.891	0.908	0.880	0.904	0.903	0.867	0.889

[1]Annotation: The diagonal values represent the square root of AVE; values off the diagonal represent correlation coefficients.

2) HYPOTHESIS TESTING

AMOS24.0 software was used to test the adaptability of the model, using covariance-based structural equation modelling (the CB-SEM used in our paper is the default method in AMos24.0), and the results are presented in Table 4.

TABLE 4. Adaptability analysis.

Index	$\chi 2$/df	RMR	GFI	NFI	CFI	IFI	RMSEA
Index value	1.924	0.032	0.957	0.984	0.981	0.975	0.036

Table 4 shows that the values for the latent variables were all less than three, the values of RMR and RMSEA were all less than 0.1, and the values of GFI, NFI, CFI, and IFI were all higher than 0.9 [72]. This is indicative that the model has a good fitting effect and good adaptability.

Table 5 and Figure 4 show the hypothesis testing results. From Table 5, the p-values for hypotheses H1, H4, H5, and H6 were all less than 0.05, and the t-value was higher than 1.96 [72]. These values passed the significance test, indicating that relative advantage, absorption capacity, market environment, and external incentive have significant positive impact on the willingness of enterprises to implement crowd logistics. However, the p-values of hypotheses H2 and H3 were higher than 0.05, and the t-value was less than 1.96 [72]. The two values failed the significance test, indicating that complexity and resources have no significant impact on enterprises' willingness to implement crowd logistics. The R^2 (R-squared) value is 0.62, which indicates that the model has a good explanatory capacity [72].

3) FINDINGS

This paper finds that relative advantage, absorptive capacity, market environment, and external motivation have significant

TABLE 5. Hypothesis test results.

Path	Path coefficient	T-value	P-value[2]	Hypothesis supported?
H1-H	0.482	2.007	0.045*	Y
H2-H	-0.121	1.393	0.164	N
H3-H	0.254	0.418	0.676	N
H4-H	0.249	4.698	0.000***	Y
H5-H	0.206	5.272	0.000***	Y
H6-H	0.178	3.180	0.002*	Y

[2]Annotation: *** indicate P<0.001, * indicate P <0.05.

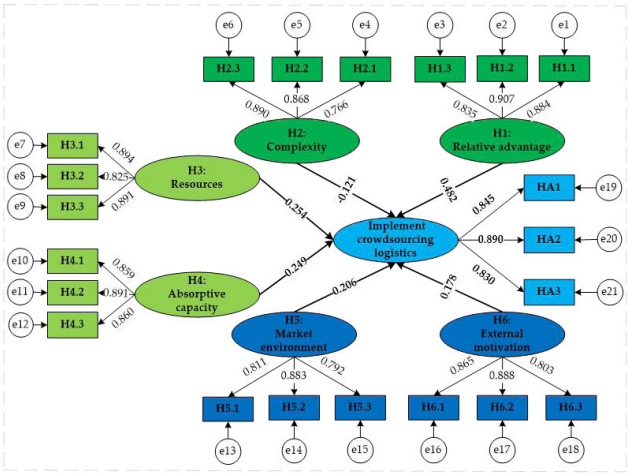

FIGURE 4. Model operation result.

effects on the willingness of enterprises to implement crowd logistics, while complexity and resources are the opposite.

–Significant influence factors

Relative advantage was shown to have significant positive impact on the willingness of enterprises to implement crowd logistics. Under traditional logistics mode, different consumers have various requirements with regards to quantity, time, and efficiency in the delivery of goods. Logistics enterprises need to have vehicles and manpower at standby in maximum distribution capacity, which eventually leads to redundancy problems. Since crowd workers use their own vehicles to deliver the goods, the number of vehicles required by logistics enterprises for parcel delivery can be reduced significantly [73], which results in significant reduction of costs. Also, logistics enterprises can effectively cut costs from employing and training employees by making use of crowds for delivery. Through the crowd logistics platform, enterprises can effectively match the crowd workers needed to complete the task, reduce the queuing time of parcel delivery, and improve the efficiency of logistics. Indeed, crowd logistics avoids the trouble of not being able to find the nearest deliverer during peak times.

Absorptive capacity has a significant positive impact on the willingness of enterprises to implement crowd logistics.

Larger enterprises have stronger information reserve and information search abilities [51]. Enterprises can quickly and accurately collect the required knowledge and information resources with crowd logistics. In promoting the platform, companies can enhance crowd workers' ability to master crowd logistics through personnel training, while crowd workers can enhance their personal understanding of crowd logistics, thereby improving their efficiency and response speed.

The market environment has a significant positive impact on the willingness of enterprises to implement crowd logistics. Most of the existing logistics companies do not offer door-to-door delivery services, such that the customers must get their packages from designated places [36]. When the competition starts implementing crowd logistics, companies are compelled to match or surpass their rivals' services, which may include adopting to the new logistics scheme themselves. In regions with underdeveloped distribution networks or low customer density, the combination of crowd logistics and third-party logistics becomes an important direction in logistics development [17], bringing new opportunities for logistics enterprises to expand their market scope. In addition, rules and regulations can provide added market confidence, particularly when sufficient legal mechanisms are in place to provide protection to enterprises implementing crowd logistics [35].

External motivation has a significant positive impact on the willingness of enterprises to implement crowd logistics. Customers with stricter low-carbon environmental requirements bring external pressure to logistics enterprises [74] to deliver goods more efficiently and reduce their carbon footprints (crowd workers delivery packages by riding electric bike or bicycle) [4], in order to establish an environment-friendly corporate image. Also, the implementation of crowd logistics can attract other enterprises to imitate and adapt [54]. Crowd logistics provides opportunities for job flexibility, increased income, and greater satisfaction for crowd workers while enhancing the company's social recognition [75]. Moreover, the implementation of crowd logistics can help meet the expectations for timely door-to-door delivery of products, provide a unique logistics experience.

–Non-significant influence factors

Complexity did not show significant impact on the implementation of crowd logistics. Under traditional logistics mode, logistics enterprises plan their deliveries based on vehicular capacity and distribution demands. This requires careful planning and design of distribution routes according to the time and place required by orders and available proprietary vehicles [76]. However, by implementing the crowdsourcing mode, logistics enterprises transfer the distribution route planning to the crowd workers, which reduces the dependence of logistics enterprises on complex route planning [77] and simplifies the workflow. And compared with the traditional logistics mode, a crowd worker processes fewer packages than traditional transporters, which effectively reduces the need for further interaction between customers and carriers [31]. In addition, in the process of continuous development of crowd logistics, crowd logistics APP becomes easier and easier to operate due to peer competition and increasing demand. The benefits of crowdsourcing outweigh the complexity. Companies are willing to take on complexity issues in order to reap the benefits of crowdsourcing.

Resources did not present significant influence on the willingness of enterprises to implement crowd logistics. The ubiquity in internet usage has made positioning and tracking identification and information communication technologies a major part of logistics enterprises [9]. Information infrastructure has become an essential tool in the development process [78]–[80]. For example, in the ''Chang-Zhu-Tan'' two-oriented social construction area, the use of internet has become a standard infrastructure in its development and urbanization. Enterprises and individuals can quickly obtain the information network technology required by crowdsourcing. Order releases, carrier communication, delivery tracking, and payment are made relatively simple. When a company requires crowdsourcing services, it can easily publish the task requirements online, which requires less ability for employees. Therefore, there is no great resource threshold for enterprises to implement crowd logistics in terms of technology, manpower, and information.

V. DISCUSSION

Based on the TOE theory, this paper constructs a model to study the factors affecting the implementation of crowd logistics. It provides a new perspective for the study of crowd logistics and has the following theoretical and practical implications.

A. THEORETICAL IMPLICATIONS

First, this paper enriches the literature on crowd logistics. Numerous scholars (e.g., Ye and Kankanhalli, 2017 [22]; Huang *et al.*, 2020 [23]; Bin *et al.*, 2020 [60]) have previously explored the factors affecting continued participation of the crowd worker, while often neglecting logistics enterprises. For this study, the factors affecting the implementation of crowd logistics are explored based on the perspective of logistics enterprises, which significantly expands the understanding of crowd logistics and can provide a useful reference for future studies.

Second, this paper extends the application of the TOE theory. In recent years, the TOE theoretical model has been applied to the empirical research of information technology and information system innovation absorption (e.g., Picoto *et al.*, 2014 [38]; Xu *et al.*, 2015 [39]; Lin and Hu, 2017 [41]). In this study, we implemented the theory in the field of crowd logistics, which promotes the interdisciplinary application of TOE theory.

Third, this study provides theoretical guidance in the decision-making for logistics enterprises. Crowd logistics is still in the development stage, and it remains unclear what enterprises should consider when implementing this scheme.

In this study, we have identified some factors affecting the implementation of crowd logistics, which can provide theoretical guidance for the managers of logistics enterprises and reduce decision-making errors and risks.

B. PRACTICAL IMPLICATIONS

First, our empirical results show that relative advantage has a significant positive impact on the willingness of enterprises to implement crowd logistics. Thus, enterprises should carefully analyze and examine the daily distribution volume and characteristics of the delivery location. When the delivery volume is too large, when the delivery locations are too dispersed, or when the enterprise has inadequate logistical means, crowd logistics can be adopted to compensate for the limitations of traditional logistics schemes. It can also effectively reduce logistics costs while ensuring timely delivery of parcels. In other words, hiring idle crowd workers nearby conducive to solve the issues of insufficient distribution staff, scattered parcels and untimely delivery; and crowd workers provide delivery tools can reduce the capital investment of enterprises.

Second, logistics enterprises should build a conducive learning environment to improve their innovation absorption capacity. Intra-organizational or cross-organizational learning is the basis for innovation implementation. Enterprises guided by clear organizational learning theory can better acquire, digest, and apply new knowledge and technology, to acquire a competitive advantage in the market. Enterprises should actively build a learning organization environment, conduct regular knowledge training on crowd logistics for crowd workers, promote the diffusion and sharing of knowledge resources related to crowd logistics within enterprises, and enhance the knowledge reserve in crowdsourcing. Enterprises should also append greater emphasis on the absorption of external crowdsourcing knowledge and other resources by strengthening communication with the external environment and encouraging more participation in the crowdsourcing community.

VI. CONCLUSION, LIMITATIONS AND FURTHER RESEARCH

The growth of crowd logistics in recent years has provided a logistics alternative in providing faster, more personalized, and cost-efficient delivery services for the general public. To understand how to encourage enterprises towards this logistics scheme, we have developed and tested a model based on TOE theory and context-related literature to explain the influence of technology, organization, and environmental factors on enterprises' willingness to implement crowd logistics. Our findings indicate that relative advantage, absorptive capacity, market environment, and external motivation positively influence active participation toward crowd logistics, while complexity and resources showed no significant effect. Moreover, we have found that the ideal of crowdsourcing is more and more recognized by logistics enterprises. Since the flexibility of participants, economical and friendly operation mode, and the efficiency of distribution. These findings can contribute to the growing body of research on crowd logistics and allowed us to offer a number of recommendations useful in promoting and developing crowd logistics. This study also provides a new avenue for the development of research on sustainable urban logistics. Particularly in China, where the sharing economy is developing, crowd logistics is likely to be a new mode of urban logistics development. Understanding the factors influencing the implementation of crowd logistics by enterprises and the impact of crowd logistics on the sustainable development of urban logistics would crucial for its continued growth. Crowd logistics could also be an environmental alternative in delivering packages by riding electric bike or bicycle. The implementation of this logistics mode by enterprises is an important driving force for the sustainable development of urban logistics.

Although this paper offers a valuable contribution to our understanding of crowd logistics, there are some limitations in the study, which can be addressed in future research. In terms of the study model design, the TOE was used as the theoretical model from the perspective of the enterprises in analyzing the affecting the willingness to implement crowd logistics. However, in the operation process, the credit risk of the crowd workers and the reliability of the information platform may contribute towards the implementation of crowd logistics. Meanwhile, the factors involved in TOE theory (such as the relative advantages, complexity, absorptive capacity, resources, market environment, and external motivations we mentioned) are open. Even if we combine TOE theory with the implementation of crowd logistics in enterprises and then identify these influencing factors, some vital factors may not have been considered due to the insufficient research capacity. Future studies should consider the influence of these factors and other variables to improve research results.

In terms of sample distribution, we focused on analyzing enterprises in Changsha, Zhuzhou, and Xiangtan in southern China, and did not conduct a comparative study on Chinese enterprises in underdeveloped areas in the west and developed areas in the east. The technological development and market competition environment in different regions may cause the results to vary in those areas. We suggest that future studies consider how differences in economic development and regional environment affect the willingness of companies to adopt crowd logistics.

In terms of sampling type, our study made use of random sampling in selecting which companies to survey, which meant that logistics enterprises were not subdivided into groups. In order to further analyze the universality of the model, future studies can consider the specific types of logistics enterprises (e.g., production logistics and fresh logistics).

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