Study of Crowdsourcing Logistics Mode for Rural Logistics "Last Mile" Delivery

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Abstracts: As the outcome of network technical development in the age of big data, Crowdsourcing logistics mode is considered as the effective solution for terminal distribution. Taking the account of rural logistics terminal distribution development situation, the thesis is to analyze the development advantage of crowdsourcing logistics mode and establishment of crowdsourcing logistics platform then focus on the last mile delivery mode, it also analyzes management strategy by utilization of interpretative structural modeling, thus proposes corresponding control measures and provides reference of rural logistics last mile delivery.

Keywords: crowdsourcing logistics; last mile delivery; terminal distribution

1. Introduction

With the e-commerce and new retail model booming, shopping online become a normal lifestyle, the third tier market which is represented by rural areas promotes the vigorous development of logistics in countryside. However, owing to the particular situation of rural logistics, the conflict inside of "last mile" terminal distribution is becoming more apparent, high cost of conflicts with low efficiency for the distribution, how to solve this conflict is became the major focus of scholars' attentions. "Internet+" technology and development of Sharing Economy expedite the birth of a new logistic mode – Crowdsourcing logistics, which is supported by internet technology, effectively integrates social idle resources to improve the distribution efficiency of last mile delivery in rural areas and reduce the logistic cost on the frame of crowdsourcing platform, it is regarded as the effective way to solve the "last mile" delivery in rural areas [1].

2. Basic Concept

2.1. "Last Mile" Delivery of Rural Logistics

"Last mile" delivery refer to the process that commodity delivered from logistic network to hand of customers, a terminal service that makes "door to door" delivery realized. "Last mile" delivery of rural logistics refers to the distribution service to deliver the commodity from logistic center to rural citizens and consumers [2].

2.2. Crowdsourcing Logistics

As an important manifestation of utilization of the Internet + sharing economy, crowdsourcing logistics is free and open distribution model inside logistics industry which vision of crowdsourcing has been applied. This mode which is rooted in mature big data technology and supported by mobile internet technology outsources the distribution tasks through the network to the unspecified social group, who are able to freely select a time slot and provide paid distribution service as grabbing the order, picking up the goods and delivering the goods [3].

3. Feasibility Study for the Application of Crowdsourcing Logistics Mode into "Last Mile" Delivery of Rural Logistics

3.1. Status and Problem of "Last Mile" Delivery of Rural Logistics

With the consumption level increased, rural 3rd tier market occupies greater weight in e-commercial retail sales. Figure in <2019 China e-commerce annual development report> indicates national rural network retail sales reaches 1.2 trillion yuan in the first 3 quarters on 2019, with growing by 19.7% year on year, and 2.9 % above the national average figure. In the context of huge potential of rural market development, e-commerce giants such as JD, Alibaba, Suning and etc. grab this opportunity to develop potential market of rural areas. Rapid increase of retail sales requests the same pace of distribution volume, however, the situation of rural area as unbalanced scale of villages, uneven population distribution and big gap of citizens flow and income, results in the disordered status of logistic orders, additionally, owing to complicated geography and routine and inconvenient transportation, major logistics companies are unwilling to build distribution network in high operational and distribution cost. At present, most of rural areas have neither distribution network nor dedicated couriers, and it is inconvenient for citizens to take parcels back by themselves, therefore, under restriction of different reason, rural last mile delivery logistic service is unable to fulfill the increasing demands of delivery and demands of this service by rural citizens [4].

3.2. Advantages of Application of Crowdsourcing Logistics to Terminal Distribution in Rural Logistics

3.2.1. Reduce the investment of logistics of enterprises in rural area and the cost of terminal logistics

Crowdsourcing logistics can reduce cost for logistics enterprises, with the management role of crowdsourcing platform, logistics enterprises could link consignor and outsourcee via the platform instead of distribution network established in a high cost or equipping with transportation means and couriers, which could reduce the transportation capacity and investment of labor.

3.2.2. Integrate idle social resource effectively, improve logistic distribution efficiency and release the pressure of rural logistics "last mile" delivery

Most of outsourcees serving for crowdsourcing platform are local idle labors coming from individual countries, who are familiared with local infrastructures like roads. Making them as part-time couriers could, on one side, provide manpower nearby to pick the goods up, improve the distribution efficiency and fulfill the service of point to point delivery to home to solve the difficulty of "last mile" delivery, it could provide employment or part-time chance for local idle labor and increase the income of them in another side [5].

3.2.3. Widen the categories deliverable and fulfill the diversified logistic demands of rural areas.

The scope of crowdsourcing logistics service is not limited to traditional express service and could be extended to the agent service for purchase or sell and new service mode rolling out to satisfy the demands of citizens. Relying on the agent service, rural citizens can also enjoy the service "Remain indoor, Supermarket home". Meanwhile, the agent service could be expanded from pick-up goods or purchasing to delivering flowers service, queuing service, registration service and etc., to satisfy personalized and diversified service demands of users [6].

4. Rural Logistics "Last Mile" Crowdsourcing Distribution Mode

Crowdsourcing logistics is regarded with outstanding advantages to solve the "last mile" distribution difficulty and feasible choice for rural logistics "last mile" distribution. In the process of crowdsourcing distribution, platform is major carrier, whose construction would provide distribution service media for consignor and couriers and realize "last mile" distribution through deal.

On the basis of logistic information system, crowdsourcing platform relies on advanced information technology to realize the one-stop service including information collection, demands and supply matching, real time surveillance, commodity tracking, settlement on line, insurance and control. it also integrates consignor, outsourcee and consignee into a functional network chain with the resource consolidation, to complete the logistics distribution task of rural areas, detailed work flow in shown in "Fig. 1".

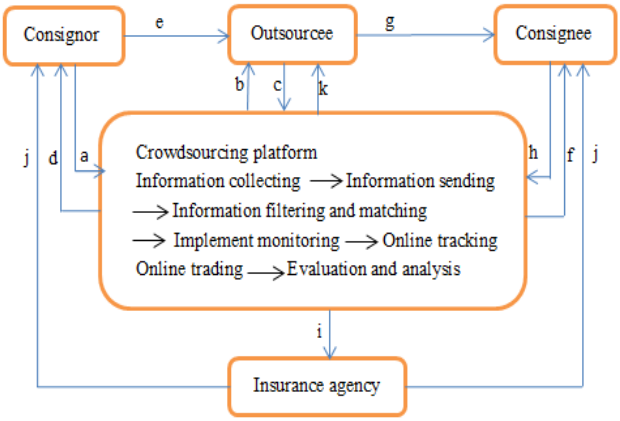

Figure 1. Detailed work flow of logistics distribution task of rural areas

There into, a Consignor releases demand information; b, Crowdsourcing platform sends demand information to suitable outsourcee upon matching function etc.; c, Outsourcee grabs the orders in consideration of distance or similar factors; d, Crowdsourcing platform feedbacks the acceptance information to consignor; e, Outsourcee gets in touch with consignor and negotiates about place and time of pick-up and collects it; f, Crowdsourcing platform feedbacks sending and distribution information to consignees; g, Outsourcee delivers commodity to consignee; h, Consignee feedbacks delivery information to crowdsourcing platform and evaluates the outsources, deal closed; Crowdsourcing platform pays insurance fee to insurance institute; j, pay compensation according to the law; k, Crowdsourcing platform rewards or punishes the outsourcees based on factor as customer feedback and evaluation etc. [7].

Detailed work flow as below

4.1. Release Order

Crowdsourcing platform provides specialized information interaction place for logistic service provider or rural customers who have express transportation demands in order to launch ordinary express crowdsourcing distribution service or agent service of purchasing. This platform possesses part-time couriers from vast of public groups who own free time or transportation resources, say the outsourcees. Upon the commodities arrival at logistic centers of villages, the staff on site only need to fill the commodities information in crowdsourcing app without scheduling vehicle loading plan, and input order quantity, commodity category, dimension, weight, destination, time and needed information according to platform instruction, and release distribution demand order through the platform. The platform is set with different pricing standing according to parameters like commodity category, weight and distance of distribution and etc., as long as the information of consignee is key in, the platform would provide deal price automatically for reference; meanwhile, when rural citizens have demand to send parcel, they can register and log in crowdsourcing app to

send the order out and await for suitable outsourcee to receive the order and collect the parcel.

4.2. Release Order Information, Automatically Match between Routines and Crew and Real-Time Response

Upon collection of order information, the crowdsourcing platform concentrates and optimizes calculation of logistic resource, district transportation routine and outsourcee's personnel information and matches the order with registered and on-lined outsourcees in adedicated areas. Outsourcees could one-button grab the order and promise the delivery against the stipulated time, in the same time, the platform would feedback to consignor with the information of outsourcee who successfully grabbed the order. The platform system is functioned with GPS, by which tracked distribution status of commodities at any time by consignors and consignees, and avoid loss of commodities by real-time tracking and whole process monitoring. In case of damage or loss happening because of force majeure or human factor, the platform will involve insurance company to settle and handle the emergency case properly. Furthermore, the platform is equipped with real-time communication function, similar to communication software as QQ or Wechat etc. and able to communicate in text, voice, audio phone and etc., such function is utilized in the discussion about delivery time, delivery place or related topics before and during the delivery of commodities between consignor and outsourcee. In order to improve the efficiency of communication, this function is set auto reply for frequent question in chat interface in platform to ensure the prompt and effective response.

4.3. Complete Dual Parties Deal of Crowdsourcing and Evaluate

The platform cooperates with the third party payment platform as Alipay, Wechat and network alliance etc. to provide online payment service. Upon receipt of the commodities by outsourcee, platform app feedback information instantly to consignors, upon the delivery of commodities and integrity check finished by consignees, the consignees can confirm the good receipt and provide related evaluation to outsourcee. The consignor would receive good receipt verification code upon consignees confirm the good receipt and complete the final payment of the order by input of the verification code. Upon order confirmation, consignor could take overall consideration about distance, weather, complexity of goods sent or other factor to make comprehensive evaluation on platform for the service quality provided by outsourcee. Based on long-term accumulated evaluation information, the platform will release the credit rank for outsourcee unscheduled and provide referent standard for further cooperation.

5. Crowdsourcing Strategy

5.1. Crowdsourcing Logistics Management Mode Analysis

The construction of crowdsourcing logistics management model: ISM was used for analysis rural crowdsourcing logistics management system. Firstly fix the contributing factor, symbol description as below: S1 Industrial regulation; S2 Market supervision regulation; S3 Professional quality of couriers; S4 Service quality of couriers; S5 Training system of couriers; S6 Couriers management system; S7 Stability level of information platform; S8 Level of platform intelligence. Draw a directed graph of binary relation according to system elements, shown in "Fig. 2" [8].

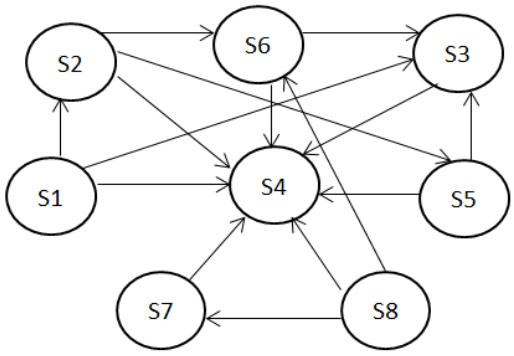

Figure 2. Directed graph of system elements relationships

5.1.1. Adjacency matrix building

Adjacency matrix is a square matrix used to explain the basic binary relationship between system elements, if element aij=1 in adjacency matrix, it indicates a direct binary relationship between element Si and Sj if element aij=0 in adjacency matrix, it indicates no direct binary relationship between element Si and Sj, upon discussion, the adjacency matrix is built, as in (1)

$$\begin{bmatrix} & S1 & S2 & S3 & S4 & S5 & S6 & S7 & S8 \\ S1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ S2 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ S3 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ S4 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ S5 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ S6 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ S7 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ S8 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix} \quad (1)$$

5.1.2. Compute Reachability matrix and proceed domain partition

Reachability matrix indicates the transitive binary relation between the Elements Si and Sj, set I as identity matrix, make A1=A+I, The addition and multiplication of the matrix conform to the Boolean algebra operation rules, that is 0+0=0,0+1=1,1+0=1,1+1=1, 0*0=0, 0*1=0,1*0=0, 1*1=1. Use the formula to compute Reachability Matrix with Adjacency Matrix, as in (2).

$$(A + I) \neq (A + I)^2 \neq L \neq (A + I)^r = (A + I)^{r+1} \quad (2)$$

Then, the reachability matrix is built, as in (3). And obtain reachability matrix from computing, as in (4).

$$M = (A + I)^r \quad (3)$$

$$M = (A + I)^2 \quad (4)$$

Finally, the reachability matrix is shown in (5).

$$M=\begin{bmatrix} & S1 & S2 & S3 & S4 & S5 & S6 & S7 & S8 \\ S1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ S2 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 \\ S3 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 \\ S4 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ S5 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \\ S6 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ S7 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ S8 & 0 & 0 & 1 & 1 & 0 & 1 & 1 & 1 \end{bmatrix} \quad (5)$$

5.1.3. According to reachability matrix to obtain Reachable Set R(Si), Antecedent set A(Si), collective set C(Si) and initial set B(S)

Reachable set refers to the set of every influencing factor that can be reached, That is, the number of columns with point "1" in the row, for example, S1 is reachable to S1, S2, S3, S4, S5, S6, so R(S1)={ S1, S2, S3, S4, S5, S6}, The antecedent set refers to the set of every influencing factor in the reachability matrix that can reach Si, That is, the number of rows with point "1" in the column, for example, S1,S2 can reach S2, so, A(S2)={S1, S2}.The intersection of reachable set and antecedent set is an example table of C (SI) set, as shown in Table 1

Table 1. Reachable Set R(Si), Antecedent set A(Si), collective set C(Si) and initial set B(S) example table.

Si	R (Si)	A (Si)	C (Si)	B (S)
1	1,2,3,4,5,6	1	1	1
2	2,3,4,5,6	1,2	2	
3	3,4	1,2,3,5,6,8	3	
4	4	1,2,3,4,5,6,7,8	4	
5	3,4,5	1,2,5	5	
6	3,4,6	1,2,6,7,8	6	
7	4,6,7,	7,8	7	
8	3,4,6,7,8	8	8	8

Because B(S) = {S1, S8}, when R(S1)∩R(S8)≠ø, then the domain is undividable.

5.1.4. Level division

The basic principle of level division is : when the equation R(Si)∩A(Si)=R(Si) is satisfied, that is C (SI) and R (SI) inclusion factors are the same, then the obtained influencing factor Si is the first level influencing factor of crowdsourcing logistics. After eliminating the influence factors of the first level and repeat calculation of influence factor from second level to fifth level according to same theory and step. Level division process is shown as Table 2.

After the layered treatment of influencing factors and based on the vector action relationship of each influencing factor, the hierarchical structure of crowdsourcing logistics management is obtained. Then bring in the influence factors represented by Si, finally obtain ISM model of crowdsourcing logistics managements. The ISM model of crowdsourcing logistics managements is shown as “Fig. 3”.

Table 2. Level division process table.

collection of elements	Si	R(Si)	A(Si)	C(Si)	C(Si)=R(Si)	Π(P)
P-L0	1	1,2,3,4,5,6	1	1	1	L1={S4}
	2	2,3,4,5,6	1,2	2	2	
	3	3,4	1,2,3,5,6,8	3	3	
	4	4	1,2,3,4,5,6,7,8	4	4√	
	5	3,4,5	1,2,5	5	5	
	6	3,4,6	1,2,6,8	6	6	
	7	4,7	7,8	7	7	
	8	3,4,6,7,8	8	8	8	
P-L0-L1	1	1,2,3,5,6	1	1	1	L2={S3,S7}
	2	2,3,5,6	1,2	2	2	
	3	3	1,2,3,5,6,8	3	3√	
	5	3,5	1,2,5	5	5	
	6	3,6	1,2,6,8	6	6	
	7	7	7,8	7	7√	
	8	3,6,7,8	8	8	8	
P-L0-L1-L1-L2	1	1,2,5,6	1	1	1	L3={S5,S6}
	2	2,5,6	1,2	2	2	
	5	5	1,2,5	5	5√	
	6	6	1,2,6,8	6	6√	
	8	6,8	8	8	8	

P-L0-L1-L1-L2-L3	1	1,2,	1	1	1	L4={S2,S8}
	2	2,	1,2	2	2√	
	8	8	8	8	8√	
P-L0-L1-L1-L2-L3-L4	1	1,	1	1	1	L5={S1}

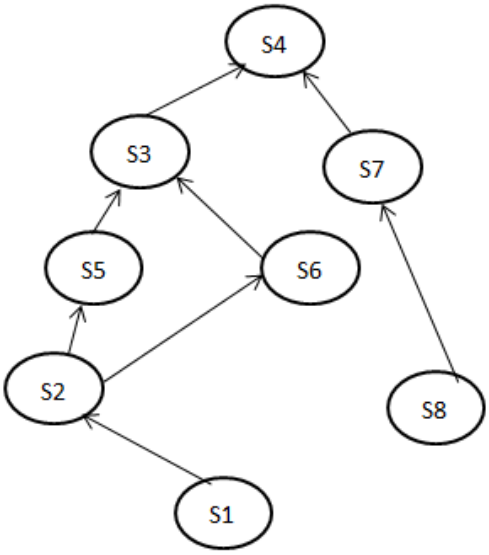

Figure 3. ISM model of crowdsourcing logistics managements

Plug the factors which influence rural terminal delivery crowdsourcing logistics management system into the hierarchical structure model and then obtain ISM (interpretative structural modeling) as indicated in the picture above. This ISM contains five levels, first level only relates to service quality of couriers, second level is professional quality of couriers and stability level of information platform, the third level is training system of couriers and couriers management system, the fourth level is market supervision regulation and level of platform intelligence, the fifth level is industrial regulation. The ISM makes an intuitionistic description of the complicated factors of crowdsourcing logistics management system, as service quality is ultimate influence factor, so in prior to establishing the whole management system, it is mandatory to consider the way to improve the service level of rural logistics tail end distribution and shorten distribution time and reduce distribution cost. The element of second level is the direct factor which influences the first level's , playing the role as outsourcee, the courier and their personnel professional quality impacts the overall distribution time and service attitude. The degree of intelligence of platform represents the speed and accuracy of information transfer which impacts delivery time directly.

The element of third level is the direct factor which influences the second level's. By meaning of orientation training and effective management of part-time contours, it is to improve their professional quality. The elements of fourth level is the direct factor which influences the third level's, market supervision mechanics would perform strict review of enrollment qualification for part-time couriers and standardization of work. The intelligent system of platform would impact efficiency of information platform directly. The elements of fifth level is the most profoundly and critical factor influencing crowdsourcing logistics management system. It secures information transaction timely and effectively by the means of industrial regulation to normalize the market access and monitoring mechanism, by means of training and management system of couriers to improve their professional quality, by means of keeping the level of intelligence of the platform to secure the stability of platform. Based on the existing hierarchical relationship among each element, it analyzes in cascade of level beginning from the fifth one and discover the most critical element which impacts realization of crowdsourcing logistics management, and finally firm how to achieve the higher service level in rural crowdsourcing logistics according this critical element.

5.2. Control Measures of Crowdsourcing Logistics

5.2.1. Improve relevant laws and regulations and strengthen market supervision

Facing the increasing intense competition of logistic industry and big management difficulty for mass involvement of platform, the crowdsourcing mode is far from fully acceptance by publics and facing big doubt about its service quality, therefore, it is necessary to normalize the related law and rules and provide rational measures through the laws to handle case as commodities lost or damaged and to maintain the market environment of crowdsourcing logistics. Concerning the supervision mechanism, it is necessary to perform strict review of legitimacy and authenticity of the individual identity who registered in platform app in order to improve the level of user monitoring and controlling, furthermore, supervision department need to uniform the stipulation for crowdsourcing logistics industry in its access threshold, operation mechanism and liability allocation in aiming to perfect operational mechanism of crowdsourcing, clarify the responsibility of entity and provide support to improve safety of commodities and information [9].

5.2.2. Improve the training system and strengthen the construction of human resources

The majority of outsourcee of crowdsourcing logistics are part-time couriers, who are lack of specialized industrial training and unable to standardize the distribution work, therefore, crowdsourcing platform should establish dedicated training department or delegate to third party logistics training institution and set up sound training business system. For the person who firstly undertakes the outsourcing task should receive on-line training at beginning, and pass the preliminary online, examination afterward he would be officially enrolled in the enterprise and trained. Upon the qualification of preliminary examination, the enterprise sends invitation and asks personnel to proceed job

training in the company, assessment is followed up after training, he can not undertake the outsourcing task until he joins he final assessment and pass it. Above process would secure the service quality of outsourcee [10].

5.2.3. Improve the management system and take rational incentive measures

Improve the credit evaluation system, convert the service quality of outsourcee to credit score and link this credit score with individual credit reporting system related to banks, health insurance and other departments, and further restrain outsourcee' behavior. In additional, take rational incentive measures, on one side, for the distribution staff who are evaluated as high service quality and credit level, the platform should take material rewards to initiate his enthusiasm, on the other side, execute blacklist system to the outsourcee who has no faith, no competence in work and extreme low credit score and consider to revoke the identity of crowdsourcing couriers. Meanwhile, according to various credit level, push the information hierarchically that personnel in different hierarch could receive order in different values [11].

5.2.4. Reinforce information system construction, improve the level of platform intelligence

Aiming to implement the logistic process intellectualization and ensure the liability and promptness of logistics services, crowdsourcing logistics must escalate technology service level during the development process, improve various modules whose function includes information integration, real-time monitoring, commodity tracking, on-line transaction and real-time communication to ensure its sustainable development. There are two aspects to improved information system construction, the first one is to update crowdsourcing platform system in time and optimize constantly internal information management system to escalate operational capability and ensure the effective operation of business, the second aspect is to reinforce further researches of utilization of cloud calculation, internet, big data, artificial intelligence and internet of things, apply these research output into the crowdsourcing platform to effectively improve the information technical merit of logistics service and purse long-term development on the basis of technology.

6. Conclusion

Under the repaid development of current social e-commerce and new retail, the 3rd tier market that the rural areas represent powerfully expands the growth space of network consumption and raises higher demand to logistic distribution service. The situation of rural logistics "last mile" delivery which is on the terminal phase of flow is not bode well, with existing difficulties like low distribution efficiency and high delivery cost. As a new mode of sharing economy in big data age and founded on internet, crowdsourcing logistics can either effectively reduce cost or contribute to guarantee the promptness of delivery through establishing network platform, attracting massive involvement and fully mobilizing and integrating idle social resource. Even though there is a room to improve in the aspects like operational mode, management strategy and laws and rules on initial development stage, crowdsourcing logistics would definitely play an important role in "last mile" delivery of rural logistics under the proactive guidance of local government and continuous improvement of law, regulation, credit system and etc.

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