Optimisation Strategies for the Coordination of Logistics Service Integrator Capabilities under the Influence of Supply Capacity

* Shengwei Li

* Corresponding author: 19986769616@163.com

Evergrande School of Management, Wuhan University of Science and Technology

Abstract—With the development of supply chain and logistics industry, logistics supply chain as a form of providing logistics services is gradually formed and developed, which integrates flexible logistics services with logistics service providers as the core. However, logistics has always been closed information resources, resulting in slow transportation efficiency, high costs, resulting in high freight costs. The development of computer technology has become an indispensable technical tool for human society. In order to alleviate the drawbacks of the development of the logistics industry, relying on computer Internet platform technology, combined with big data, Beidou, cloud computing, AI technology as an integrated mode of operation, to help the development of the logistics industry, online operation, offline implementation, the two sides complement each other, the centralized release of capacity resources, information sharing, combined with the platform technology for Vehicle drivers are monitored throughout the process, making transportation more standardized and safe. At the same time also enhance the efficiency of transport Make logistics development more attractive. In this paper, we analyze and study the master-slave game model of logistics service integrator's capacity procurement and logistics service provider's capacity investment decision under the uncertain environment of capacity supply and demand by combining theoretical research and empirical research, qualitative analysis and quantitative research, using management science and optimization modeling methods, and analyzing and studying the master-slave game model of logistics service integrator's capacity procurement and logistics service provider's capacity investment decision under the uncertain environment of capacity supply and demand. The optimal decisions of logistics service integrators and providers under centralized decision making are analyzed. In order to improve the logistics service level and realize the synergy between logistics service integrators and providers in capacity procurement and investment decisions, a coordination mechanism of capacity procurement cost compensation contract based on revenue sharing is proposed. The research results show that the contract parameters can achieve the optimal revenue and procurement quantity under the centralized decision-making mechanism when certain requirements are met. The logistics service integrator can also selectively adjust the parameters in the coordination contract according to the supply and demand risk situation in the operating environment to improve the efficiency of resource integration.

Keywords- Supply capacity; Logistics services; Business Capability; Fine production methods; Demand and supply.

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1. INTRODUCTION

With the development of economic globalization and the promotion of JIT and refined production methods, the degree of synergy between manufacturing enterprises in the fields of production and distribution has deepened, and the complexity of enterprise logistics operations has increased. Since logistics service integrators can effectively integrate various scattered logistics resources to provide integrated logistics services to customer enterprises and enhance their competitive advantages, the synergy between logistics service integrators and suppliers has become a current research hotspot in the field of supply chain logistics management. Wu (2002) and Spinler (2006) proposed a flexible option-based capacity procurement contract to address the risks posed to both parties by fluctuations in demand and supply prices [1]. Chen Juan et al. (2008) developed two models for capacity investment decisions in service systems based on external flexible capacity cooperation and investigated the impact of a shared benefit capacity cooperation model on the decisions and benefits of both parties. In the above-mentioned studies, the main issue addressed was the coordination and optimization of logistics service integrator capacity under fluctuating demand volumes, without considering the stochastic factors of supply [2]. Wu (2002) and Spinler (2006) considered uncertainty in their studies, but only in terms of fluctuating supply costs. In fact influenced by the service network, the capabilities of logistics service providers also exhibit uncertainty in the quantity supplied (Liu, 2008b). To address this issue, this paper investigates the coordination of logistics service integrator-provider capacity under uncertainty in supply and demand quantities and proposes a revenue-sharing based capacity procurement cost reimbursement contract. The logistics service integrator sets the revenue allocation coefficient and the compensation price for capacity investment at the beginning of the decision period and proposes an initial order quantity for the capacity. The logistics service provider invests in the capacity according to the order quantity and the contract parameters [3]. At the end of the decision period when demand has occurred, the logistics service integrator pays a percentage of the revenue to the service provider, while requiring the logistics service provider to compensate the integrator with a portion of the funds for the amount of capacity not fully utilised.

2. DESCRIPTION OF THE PROBLEM

Consider a logistics service system consisting of a single logistics service provider and a single logistics service integrator, assuming that each unit of logistics service demand requires one unit of logistics service capacity to satisfy. The initial supply capacity of the logistics service provider is Y. This capacity is a common capacity and is used to meet the service needs of all logistics markets, including logistics service integrators.

At the beginning of the decision period, the logistics service provider also needs to invest in logistics capacity to fulfil the logistics distribution tasks issued by the logistics service integrator, with an additional amount of logistics capacity of k. Since capacity expansion takes some time, logistics service integrators need to determine the quantity of capacity to be purchased Q at the beginning of the decision period based on forecasts of service demand D [4].

Assume that D follows a uniform distribution with mean PD and standard deviation D on [a,b] and density and distribution functions f(x), F(x) (x>0) respectively. Logistics service providers sell this capacity to other customers in order to minimise idling of initial logistics capacity during capacity expansion. When the logistics service integrator places an order, the logistics service provider is not able to determine the size of the remaining quantity of initial capacity Y at the end of the decision period (i.e. when the integrator's demand for logistics services actually occurs), but can only know that Y obeys a uniform distribution with mean Ps and standard deviation CTS on a, with density and distribution functions g(Y), G(Y) respectively. Therefore the random variation in the number of logistics capacities owned by the logistics service provider at the end of the decision period is k + Y9 eve leads to uncertainty in the number of capacities supplied by the logistics service provider at the end of the decision period, which affects the final number of capacities delivered by the logistics service provider to the integrator as $\min\{Q, k + y\}$.

For the sake of discussion, the relevant notation definitions and parameter assumptions are given below:

ω: Logistics services integrator capacity purchase unit price;

C_1: Investment costs per unit of logistics capacity for logistics service providers;

C_2: Operating costs per unit of capacity for logistics service providers;

P: Logistics service integrators selling price per unit of capacity in the logistics service market;

S_1: Unit capacity losses borne by logistics service integrators when logistics capacity is under-procured;

S_2: A penalty charge per unit of capacity charged by the integrator to the logistics service provider in the event of insufficient capacity availability.

Assuming that all the above prices and costs are exogenous and satisfy $C1 + C2 < \omega < P + S1$ and $\alpha + \beta < 4\mu$ There is information symmetry between logistics service providers and integrators, both of which are risk neutral [5].

3. NUMERICAL ANALYSIS

In the following, the effectiveness of the revenue-sharing-based contractual synergy for capacity procurement cost reimbursement is first verified by assuming that the demand for logistics services obeys a uniform distribution of [0, 300] at the end of the decision period. $P = 90, \omega = 50, C1 = 30, C2 = 10, S1 = S2 = 20$, and Y follows a uniform distribution on [20, 40].

Based on the previous analysis of the decision under the wholesale price contract, the optimal capacity of the logistics service integrator to order quantities at this time can be calculated Q^w*=170,* Expected return is $\prod_R^W = 1954\mathit{1}$, Optimal amount of capacity investment for logistics service providers K^w*=140,* Expected return is $\prod_S^W = 2918\mathit{2}$ [6]. And the optimal capacity procurement quantity and investment quantity at the time of centralised decision making are Q^c*=220,* K^c*=180,* The overall expected benefits for logistics service integrators and providers are $\prod_I^C = 5244$. The above results show that $\prod_B^W + \prod_S^W < \prod_I^C$, That is, the inability to achieve synergy in the wholesale price contract between the physical service integrator and provider capability decisions reduces the overall benefit of the system. And under a revenue sharing based capacity sourcing cost reimbursement contract, it can be derived from equation (4-16) that the expected revenue of the logistics service provider can be expressed as $\prod_S$ = $11392 - 9443\delta$, Similarly the expected revenue function for a logistics service integrator by equation (4-18) can be written as $\prod_B$ = $9443\delta - 6148$. Therefore, with the adoption of the coordination mechanism, the additional system revenue relative to that under the wholesale price contract is $\Delta\prod = \prod_S + \prod_B - (\prod_S^W + \prod_B^W) = 372$ Also to meet the participation constraints of logistics service integrators and providers under the coordination mechanism $\prod_S \geq \prod_S^W$ and $\prod_B \geq \prod_B^W$ i.e. $11392 - 9443\delta \geq 2918$, $9443\delta - 6148 \geq 1954$ should be established at the same time. Solving these two inequalities yields that when δ In [0.858,0.897] When the value is taken on and $b = (440 - 227\delta)/7$ When the participation constraints of logistics service integrators and providers hold, the logistics service system can effectively achieve synergy in a decentralised decision-making mode. And the logistics service integrator can influence the distribution of the new benefits of the system after the collaboration by adjusting the value of s taken, as shown in Figure 1. When $\delta = 0.859$, the logistics service provider receives all the new benefits of the post-synergy system. As δ increases, the new benefits to the logistics service provider gradually decrease, while the new benefits to the logistics service integrator gradually increase. When $\delta = 0.897$, the new revenue of the logistics service integrator reaches its maximum, at which point the new revenue of the logistics service provider is zero [7].

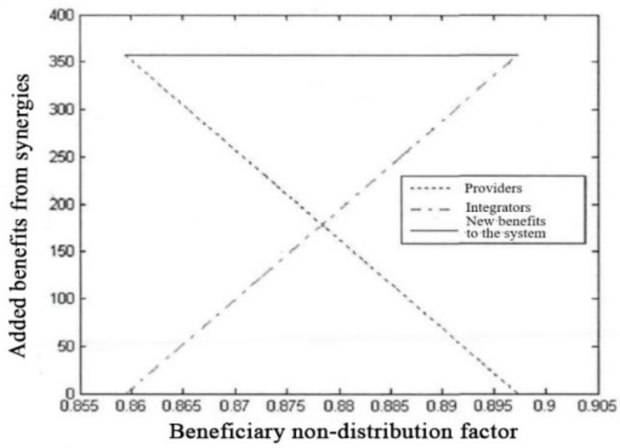

Figure 1 Figure 1 δ Impact on the distribution of new benefits of the post-synergy system

In addition, in order to investigate the impact of the parameters of a revenue-sharing based capacity procurement cost compensation contract on the investment, procurement risk and decision-making behaviour of logistics service providers and integrators, numerical analyses of the quantity of logistics capacity procurement and investment, the expected revenue of logistics service providers and integrators, and the values of δ and b under fluctuating supply and fluctuating demand were conducted in this paper, as shown in Tables 1 and 2, respectively [8]. The demand for logistics services in Table 1 follows a uniform distribution on [0,300] with μ_D=150 and σ_D decreasing gradually; the initial supply of logistics capacity at the end of the decision period in Table 2 follows a uniform distribution on [20,40] with μ_S=30 and σ_S decreasing gradually. where the specific value of δ is taken using $\prod_B / \prod_I = \prod_B^W / (\prod_B^W + \prod_S^W)$

to calculate [9]. This expression implies that the post-cooperative service system receives the same proportion of the new revenue as the distribution of revenue among members under the wholesale price, i.e $\frac{\Pi_B - \Pi_B^W}{\Pi_B^W} = \frac{\Pi_S - \Pi_S^W}{\Pi_S^W}$, The value of δ determined by this equation must therefore satisfy the participation constraints on both sides of the decision.

TABlLE I. RESULTS OF THE ANALYSIS OF THE IMPACT OF CHANGES IN THE STANDARD DEVIATION OF LOGISTICS CAPACITY SUPPLY ON EACH PARAMETER (μ_D=30)

X~U [0,300]	**Centralised decision-making**			**Wholesale prices**				
σ_S	k^C	Q^c	$\prod_I$	k^w	Q^w	$\prod_S^W$	$\prod_B^W$	$\prod_S^W + \prod_B^W$
17.320	180	240	5200	146	174	2657	2023	4680
15.977	180	237.5	5208	145.7	173.5	2690	2011	4701
14.434	180	235	5215	145	173	2722	2002	4724
12.990	180	232.5	5222	144.4	172.6	2757	1993	4750
11.547	180	230	5228	143.6	172	2788	1984	4772
10.104	180	227.5	5233	143	171.6	2822	1975	4797
8.660	180	225	5237	142	171	2853	1968	4821
7.217	180	222.5	5241	141.6	170.6	2888	1956	4844
5.773	180	220	5244	140	170	2918	1954	4872
4.330	180	217.5	5247	140.3	169.7	2955	1936	4891
2.887	180	215	5249	139	169	2984	1930	4914

TABlLE II. RESULTS OF THE ANALYSIS OF THE IMPACT OF CHANGES IN THE STANDARD VARIATION OF LOGISTICS SERVICE DEMAND ON EACH PARAMETER (μ_D=150)

***Y~U*[2040]**	**Centralised decision-making**			**Wholesale prices**				
σ_S	k^C	Q^c	$\prod_I$	k^w	Q^w	$\prod_S^W$	$\prod_B^W$	$\prod_S^W + \prod_B^W$
86.602	180	220	5244	140	170	2918	1954	4872
79.386	175	215	5506	139	169	2817	2295	5112
72.169	170	210	5768	137	167	2809	2636	5445
64.952	165	**205**	6030	135	165	2747	2978	5725
57.735	160	200	6292	134	164	2701	3318	6019
50.518	155	195	6553	133	162	2640	3650	6290
43.301	150	190	6814	131	161	2593	4000	6593
36.084	145	185	7074	130	159	2532	4332	6864
28.868	140	180	7333	128	158	2485	4680	7165
21.651	135	175	7590	127	156	2424	5012	7436
14.434	130	170	7842	126	155	2378	5349	7727

From the results of the numerical analysis in Table 1 as well as in Table 2, the following conclusions can be drawn:

(1). Under the coordination mechanism, both k and Q values increase when σ_D increases; k values are only related to μ_S and a,b values taken, so k does not change with σ_S, but Q changes in a positive variation relationship withσ_S, mainly because logistics service integrators increase their logistics demand to customer companies in order to ensure the logistics demand and prevent capacity shortages in the case of large fluctuations in the supply capacity of logistics service providers procurement quantities.

(2). There is a relationship between the value of the contract parameter δ or b and the variation of σ_S and σ_D. As shown in Figures 4 and 5, with the mean and standard deviation of demand remaining constant and σ_S gradually increasing, δ keeps increasing b gradually decreasing; but with the mean and standard deviation of capacity supply remaining constant and σ_D ncreasing, δ keeps decreasing and b gradually increasing. The opposite is true when supply movements remain stable and demand volatility increases. As show in Figure 2&3&4&5.

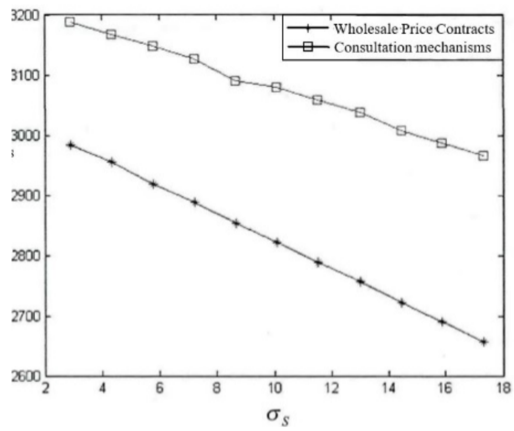

Figure 2 Impact of σ_S on logistics service provider's revenue before and after synergy

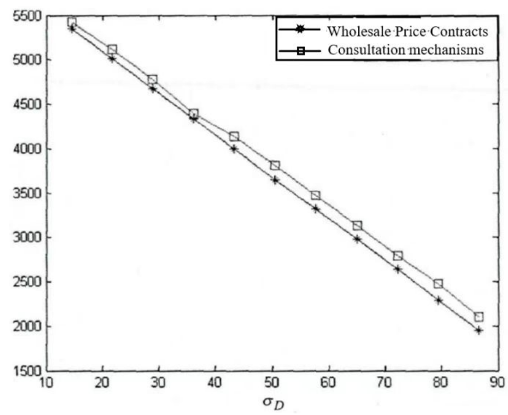

Figure 3 Impact of σ_D on logistics service integrators' revenue before and after collaboration

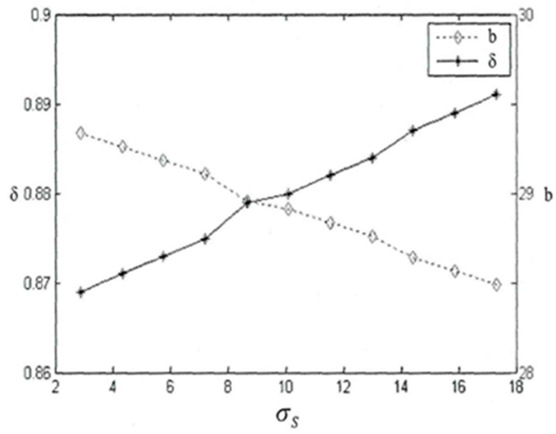

Figure 4 Effect of σ_S on contract parameters

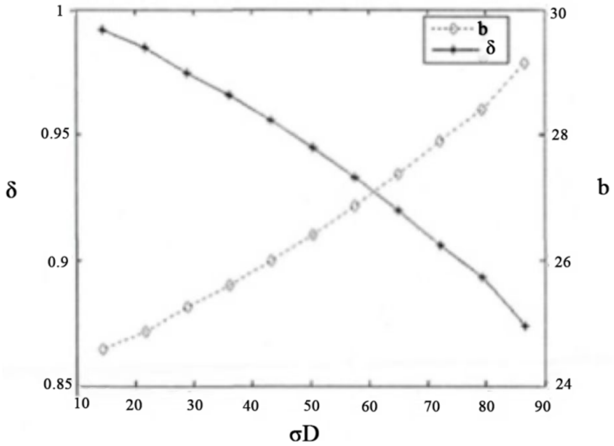

Figure 5 Effect of σ_D on contract parameters

4. CONCLUSIONS

This paper investigates the issue of procurement and investment synergies in an environment of uncertain supply and demand for logistics capacity in the process of service resource integration for a single-cycle logistics service system consisting of a logistics service provider and an integrator. In order to achieve synergy in logistics service integrator-provider decision making, a revenue-sharing based capacity procurement cost reimbursement contract was proposed in the study. The analysis found that the number of logistics service system capabilities purchased and invested, as well as the benefits to both decision makers, improved after the adoption of the contract, and that the value of the benefit allocation factor δ affected the distribution of the new benefits of the system between the logistics service provider and the integrator after the agreement. Numerical analysis also sheds further light on the relationship between revenue sharing and compensating price parameters and fluctuations in supply and demand. The results show that logistics service integrators can adjust the contract parameters for different variations in demand and supply to achieve risk sharing and benefit sharing. When the quantity of capacity supplied fluctuates more, logistics service integrators can incentivise logistics service providers to expand capacity investments by increasing the revenue sharing factor δ and reducing the capacity purchase compensation price b; When fluctuations in the volume of capacity demand are evident, logistics service integrators can reduce their own risk by reducing the revenue allocation factor δ and increasing the capacity procurement compensation purchase price b.

REFERENCES

[1] Miao Huachang, Luo Jiale, Wan Jingjing, Jiang Haiqin. Research on logistics service capability of pharmaceutical retail chain enterprises from the perspective of supply chain[J]. China Storage and Transportation,2021(11):121-123.DOI:10.16301/j.cnki.cn12-1204/f.2021.11.062.

[2] Cai Chao. Contract design of logistics service supply chain considering reliability [D]. Shenyang University of Technology,2019.

[3] Jiang Tiantian. Research on platform-based supply chain capacity coordination contract for logistics services [D]. Wuhan University of Technology,2019. doi:10.27381/d.cnki.gwlgu.2019.001825.

[4] SONG Juanjuan,LIU Wei,GAO Zhijun. The mechanism of the role of logistics service supply chain network on the growth of logistics service integrators-mediated by network capacity[J]. China circulation economy,2016,30(09):49-59.DOI:10.14089/j.cnki.cn11-3664/f.2016.09.007.

[5] Wang Fen. Research on the coordination mechanism of logistics integrated service network contract [D]. Zhejiang University of Industry and Commerce, 2015.

[6] Li Yangzhen. Research on the reliability of logistics service supply chain[D]. Southwest Jiaotong University, 2014.

[7] Yao Jianming. Research on the integration of supply chain resources in fourth-party logistics [M]. People's University of China Press:Management Library, 201311.156.

[8] Xu De-hong, Xi Ping. Planning and design of supply chain capacity integration of logistics services in international dry ports: the case of Xi'an International Port Area[J]. 2012(12):60-63.

[9] Huang Han. Cooperation and coordination of supply chain capabilities in logistics services[J]. Frontier,2012(20):81.