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An Supply Chain Network Optimization for Yacht Service Using C2C Cycle

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Abstract

This paper proposes a method to optimize a supply chain network for yacht service that maximizes values for service users / customers, and profits for service providers. The yacht industry includes many sectors such as yacht design, yacht engineering, yacht manufacture, marina service, yacht maintenance, finance/insurance, training and education for professional and non-professional sailors, chartering, leisure service, and technical clothing. In order to boost up yacht / marine leisure culture, we must consider yacht infrastructure, yacht research, and yacht service from a systematical point of view. This paper uses the C2C cycle to optimize a yacht service supply chain network inclusive of design, research, manufacture, and leisure service.

Keywords: *yacht service, supply chain network, C2C cycle*

1. Introduction

People of advanced countries and developing countries are enjoying various culture activities and leisure sports. Especially, Korean culture is new turning point from simple enjoyable culture to experience culture since Korea's GNI exceeded $20,000 [1]. A yacht has been recognized as familiar leisure sports in the upper class as well as the middle class for years in America, Europe, Australia, and etc. In Korea, the yacht has been widely dispersed in the high class since 2000s. Now, it is being settled as new leisure culture [2].

An effective leisure service must consider facility design, inventory management, operation strategy, marketing, and *etc*. [3]. The facility design includes facilities planning, managing human resources, managing queues, service quality, service productivity, and etc. The inventory management includes economics, supply and demand, planning process, strategic planning, risk management, legal and ethical issues, and *etc*. The marketing includes merchandising, and *etc*.

The leisure service which includes a yacht service should develop a creative business model and make profit using the method of network management because it covers various enterprises, human resources, facilities, services, and *etc*. The network management is the method of revenue management of when products which are composed of resources are sold [4].

The yacht industry should include many sectors such as yacht design, yacht engineering, yacht manufacture, marina service, yacht maintenance, finance/insurance, training and education for professional and non-professional sailors, chartering, leisure service, lodging business, and technical clothing [1]. Because the yacht industry is closely related to various types of business and industries, we should simultaneously develop not the yacht's self but the related industries and services to activate the yacht leisure culture.

Kadadevaramath *et al.*, [5] explained that a supply chain which has cost efficiency should

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be managed to succeed in the industry such as a yacht service because various markets, logistics, and manufacturing circumstance are unclear. Also the paper elucidated an optimization method such as Particle Swarm Optimization (PSO) is needed to optimize a supply chain network.

Lee *et al.* [6] explained that “the bullwhip effect or whiplash effect refers to the phenomenon where orders to the supplier tend to have larger variance than sales to the buyer (i.e., demand distortion), and the distortion propagates upstream in an amplified form (*i.e.*, variance amplification)” and Forrester [7] explained the effect for the first time. This shows itself in the increasing of inventory and cost because the communication among tiers of a supply chain does not go on smoothly or cooperate with one another. The causes of bullwhip effect were classed as demand signal processing, rationing game, order batching, price variations, and promotions [6].

Dehghanian & Mansour [8] explained that customers and the government bludgeon companies into doing the redesign of a logistics network to reduce negative environmental effects and social effects. The customer can obtain stable services if a company has a sustainable recovery network that harmoniously maintains economic, social, and environmental conditions. A company, therefore, should effectively manage a yacht service supply chain and should make an optimized system.

An effective method to design a bi-directional network such as a yacht service supply chain designs independently a reverse and a forward network [9]. In this paper, therefore, it is necessary to consider the design of a reverse and a forward network while optimizing a yacht service supply chain because all companies influence each other and then a corporate issue spreads to all companies.

In this paper, the study should have a correct understanding that the yacht service doesn’t activated by the vitalization of a yacht itself. So, the optimization method of a yacht service supply chain in its entirety is suggested to compose the related companies which are closely connected to yacht service. It is to setup a service supply chain network which is composed of a supplier, a service provider, a customer, and a service partner in order to transfer resources which are connected with a yacht service to servitized products [10], deliver to a customer, and to gain a profit by all comers of the yacht service supply chain. The proposed optimization method of a yacht service supply chain is approached in aspect of assets and the suggested method is distinct from the previous method [5].

This paper explains the motivation and the objective of this research in Section 1 and the characteristics of the suggested model in Section 2. In Section 3, this paper explains an optimal model for the yacht service supply chain. The model is simulated, and the result is analyzed in Section 4. In Section 5, this paper concludes the study and describes the further work.

2. Yacht Supply Chain

Simchi-Levi *et al.* [11] defined Supply Chain Management (SCM) as “a set of approaches utilized to efficiently integrate suppliers, manufactures, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements”.

As it was explained in Section 1, the yacht industry is composed of many sectors such as yacht design, yacht engineering, yacht manufacture, marina service, yacht maintenance, finance / insurance, training and education for professional and non-professional sailors, chartering, leisure service, lodging business, and technical clothing. Figure 1 describes a yacht service supply chain which is composed of many tiers [1, 12].

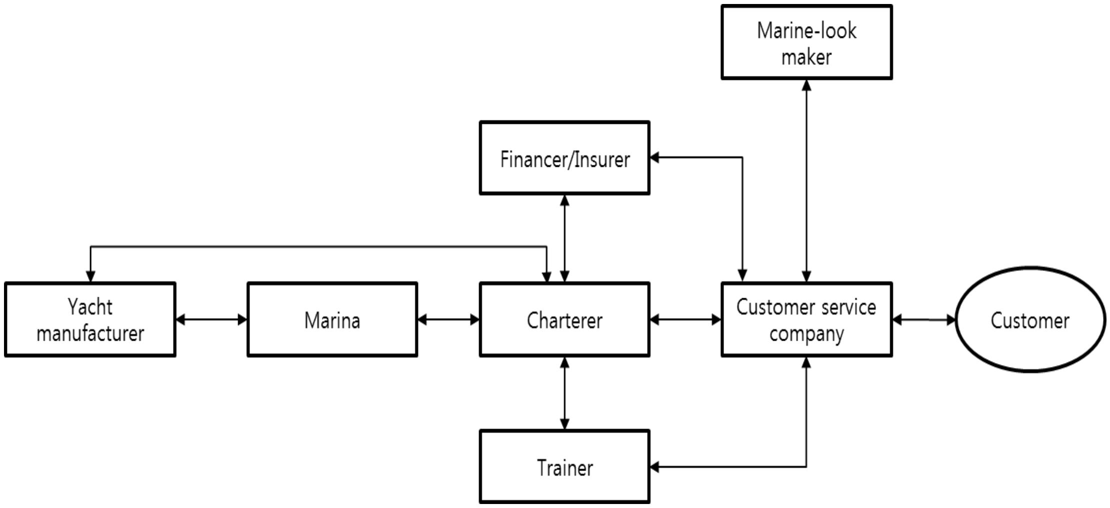

Figure 1. Yacht Service Supply Chain Model

Because a yacht has 50% depreciation three years later, a yacht owner tries to make a profit to counter the cost from a customer who wants to enjoy using a yacht. The daily expenses which are charged by a customer are much more than the expenses which are charged by a customer in other leisure sports. To reduce a customer's expenses, a yacht service provider should develop various strategies, for example, package products which are connected with a hotel, a pension, and etc., and then the provider should disperse expenses which are cost by a customer.

If the yacht population increases, a customer can enjoy not only the yachting but also the various leisure sports which are related with each other. That is, a yacht customer can enjoy a live-aboard trip that enjoys scuba diving on board a ship. A customer, also, can go on a cruise from Korea to foreign countries on a yacht. The yacht services, therefore, can be variously expanded [2]. The yachting mania and the rich who uses a golf resort or a hotel mainly enjoyed it. But, nowadays, the yacht services are spreading to everywhere while accommodations like a pension become popular and the average customer enjoys the experiential yacht services like sightseeing on a ship, fishing, and etc.

The infrastructure of leisure sports using a yacht is enlarging by the construction of 27 marina ports which is pushed ahead by the government and local governments [13]. New yacht industrial society, therefore, caused by not only small yacht companies but also large-scale yacht companies that possess powerboats is coming to Korea [2].

As mentioned earlier, a yacht is out of a simple riding recreation and is connected by various related industries and types of business. It, therefore, is necessary to make a method to efficiently manage the yacht-related industry and types of business to develop the yacht industry instead of only focusing on yacht service.

3. Optimization of Yacht Service Supply Chain

In this study, an optimization method based in assets is used using an evolutionary algorithm, PSO [1], and C2C cycle [14] to optimize a yacht service supply chain. Because many types of business are involved in yacht service and companies have a great notion that the efficiency of financial perspective comes first, this paper optimizes a yacht service supply chain based on the financial performance. Also, this paper uses PSO method to optimize a yacht service supply chain in a global viewpoint.

3.1. C2C Cycle

Supply Chain Operations Reference Model (SCOR) of Supply Chain Council (SCC) established performance metrics based on reliability, responsiveness, agility, cost, and asset management efficiency [15]. Because the optimization of a yacht service supply chain based on financial statements is relevant to the asset management efficiency of SCOR performances, the financial factor is an appropriated measure to optimize the yacht service model and it will give an energetic consequence.

Mayer [16] explained the components of the extended value stream and C2C cycle in Fig. 2. The extended value stream is composed of suppliers, business, and customers. It, also, shows the components of C2C cycle.

Figure 2. The Extended Value Stream and the C2C Cycle

Park [1] expressed the formula of a yacht service supply chain optimization as Eq. (1) and used PSO method [17] to optimize all supply chains. But this paper optimizes Eq. (1) from the financial perspective of a yacht service supply chain using the cash-to-cash (C2C) cycle analysis and PSO method.

Maximize yacht mfg. profit + marina operating profit + lease operation profit + training profit + finance profit + marine-look selling profit + customer service profit (1)

C2C cycle is used as the same meaning with cash conversion cycle (CCC) [14]. C2C cycle analysis is a method which connects the concept of time to the financial viewpoint and then evaluates it because the concept of time with internet development is increasingly important [18]. C2C cycle manages days from the payment for materials and services which are needed in product manufacturing to the withdrawal of payment resulted from the sales of products [19]. The shorter the period, it means that the cash flow of a company is good. C2C cycle is expressed as Eq. (2).

C2C Cycle = Days of Inventory + Days of Receivables – Days of Payables (2)
Days of Inventory (DOI) = (Average Inventory / Cost of Goods Sold) ·365

Days of Receivables (DOR) = (Accounts Receivable / Revenue) ·365
Days of Payables (DOP) = (Accounts Payable / Cost of Goods Sold) ·365

DOI is the first of the three inputs into the C2C formula. DOI is by itself a popular supply chain formula which demonstrates the mount of inventory within an enterprise when compared to its historical sales. Mayer [17] explained DOI as “The goal is to have the number as small as possible while maintaining stability within the supply chain. Most supply chain leaders believe that this number has steadily declined over the last decade. Instead, as we will see in the following data, industries have made little progress. Finally, DOI displays existing positive cash flow within the company and is represented by a positive number in the C2C ratio.

DOR is the second input into the C2C formula and DOP is the third and final component of C2C cycle. Wikipedia [20] explained DOR and DOP as “It is a calculation used by a company to estimate their average collection period. It is a financial ratio that illustrates how well a company's accounts receivables are being managed. The DOR figure is an index of the relationship between outstanding receivables and credit account sales achieved over a given period. DOR is considered an important tool in measuring liquidity. DOR tends to increase as a company becomes less risk averse. Higher DOR can also be an indication of inadequate analysis of applicants for open account credit terms. An increase in DOR can result in cash flow problems, and may result in a decision to increase the creditor company's bad debt reserve.

DOP is an efficiency ratio that measures the average number of days a company takes to pay its suppliers. DOP provides one measure of how long a business holds onto its cash. DOP can also be used to compare one company's payment policies to another. Having fewer days of payables on the books than your competitors means they are getting better credit terms from their vendors than you are from yours. If a company is selling something to a customer, they can use that customer's DOP to judge when the customer will pay (and thus what payment terms to offer or expect). Having a greater DOP may indicate the company's ability to delay payment and conserve cash. This could arise from better terms with vendors. DOP is also a critical part of the "Cash Cycle", which measures DOP, DOR, and DOI. When combined these three measurements tell us how long (in days) between a cash payment to a vendor into a cash receipt from a customer. This is useful because it indicates how much cash a business must have to sustain itself.”

C2C is most effective with retail-type companies, which have inventories that are sold to customers. Consulting businesses, software companies and insurance companies are all examples of companies for whom this metric is meaningless.

3.2. Particle Swarm Optimization

The optimal service supply chain process suggested in this study is depicted in Figure 3. In Figure 3, the input information in the supply chain includes financial information, service supply chain information, and *etc*. Using the input information, the values of the objective functions with the decision variables are determined. From the service supply chain model, this paper gets the values of performance measures under a given condition rather than an optimal value.

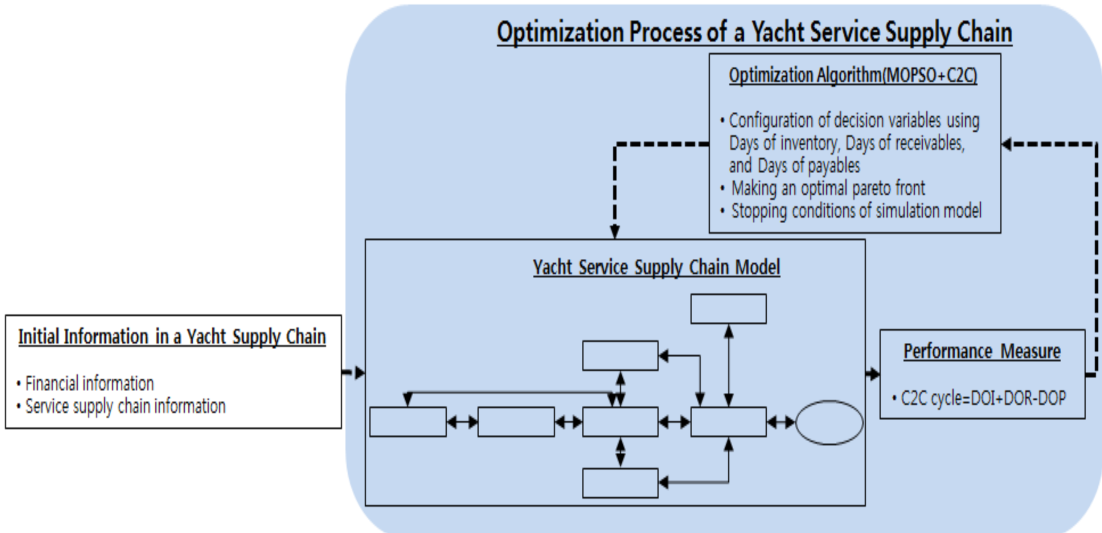

Figure 3. The Optimal Service Supply Chain Process

The yacht service supply chain model of Figure 3 calculates the objective values of decision variables using the initial information of a yacht service supply chain. The model can't give the optimal solution because the model gives only the values of performance measures through given conditions. Therefore, the optimization model obtains the objective values using PSO algorithm and makes optimal pareto candidate sets which satisfy given objective functions. The terminating condition of the model is determined through the optimizing process. Initial set values are developed into best values using the generation of a pareto front through the optimizing process.

This paper follows an algorithm to determine the personal and global bests of PSO, which was supposed by Alvarez-Benite *et al.*, [21]. The main algorithm is outlined in Figure 4.

A:=0
$\{X_n, V_n, G_n, P_n\}_{n=1}^{N}$:= initialize()
for t:= 1: G
  for n:= 1: N
    for k:= 1: K
      $v_{nk}^{(t+1)} = wv_{nk}^{(t)} + c_1 r_1 (P_{nk} - x_{nk}^{(t)}) + c_2 r_2 (G_{nk} - x_{nk}^{(t)})$
      $X_n^{(t+1)} = X_n^{(t)} + \chi V_n^{(t)} + \varepsilon^{(t)}$
    end
    X_n:= enforceConstraints(X_n)
    Y_n:= f(X_n)
    if $X_n \npreceq u \forall u \in A$
      A:= {u∈A| u$\nprec X_n$}
      A:= A∪X_n
    end
  end
  if $X_n \preceq P_n \vee (X_n \nprec P_n \wedge P_n \nprec X_n)$
    P_n:= X_n
  end
  G_n:= selectGuide(X_n, A)
end

Figure 4. Multi-Objective Particle Swarm Optimization Algorithm

In Figure 4, at the start of the MOPSO, the archive is a tentative Pareto set A and empty. And, the components and velocities of N particles are initialized randomly or zero. The personal bests, pBest, for each particle are initialized to be the starting location, $P_n = X_n$. The global bests, gBest, for each particle are initialized to be its initial component, $G_n = X_n$.

This paper uses the PSO algorithm that was explained in Park & Kyung [22] as follows. "The optimal model can get the objective value using the PSO, and the objective values generate a set of Pareto front candidates. This paper uses the concept of non-dominated solution explained as Pareto front because it is impossible to get the optimal solutions which satisfy all the objectives simultaneously. A solution is called a non-dominated solution if it is not dominated by other solutions among all candidate solutions. The Pareto front is composed of a set of all non-dominated solutions. The simulation ends when termination conditions (e.g., the total simulation period) are met.

PSO, introduced by Eberhart & Kennedy [23], is based on the social behavior pattern of a biological group such as a flock of birds or a school of fish, whereas Genetic algorithm (GA) imitates a natural evolutionary process. In the PSO method, a decision variable is regarded as a particle, and the population of decision variables is considered as a swarm [23] [24] [25].

In the PSO method, the decision variable $X_n^{(t+1)}$ of the population in a swarm of N particles has the velocity determining the location of the next generation. $X_n^{(t+1)}$ is the vector value of the n[th] particle of the t+1[th] generation. The location for each particle is estimated as follows [26].

$$X_n^{(t+1)} = X_n^{(t)} + V_n^{(t)} \tag{3}$$
$$X_n^{(t+1)} = X_n^{(t)} + \chi V_n^{(t)} + \epsilon^{(t)} \tag{4}$$

The expression (3) is generally used for estimating each particle of the t+1[th] generation using the location and velocity of the t[th] generation. $V_n^{(t)}$ is the velocity of the n[th] particle of the t[th] generation. The expression (3) can be replaced with the expression (4) to adjust the location and the velocity of a particle. The expression (4) includes a constriction factor, χ ($\chi \in [0, 1]$), and the velocity of a particle moving to the next generation becomes slow as the value of χ is near zero. The term of $\epsilon^{(t)}$ in the expression (4) is a turbulence factor of the t[th] generation, a small stochastic perturbation for searching the decision place to avoid falling into a local optimum and to search for a global optimum. The expression (4) can be modified as the expression (5) including $R^{(t)}$, a special turbulence factor [27, 28].

$$X_n^{(t+1)} = R^{(t)} + X_n^{(t)} \tag{5}$$

In the expression (5), $R^{(t)}$ is used for updating the location of each particle. The turbulence factor is similar in its concept to the mutation operator used in Evolutionary Algorithm, and the next location is calculated by adding a random value to the current location [28]. The velocity of each particle is estimated as following:

$$v_{nk}^{(t+1)} = wv_{nk}^{(t)} + c_1r_1\left(P_{nk} - x_{nk}^{(t)}\right) + c_2r_2\left(G_{nk} - x_{nk}^{(t)}\right) \tag{6}$$

The velocity of each particle, $v_{nk}^{(t+1)}$, is updated considering both the particle optimum, P_{nk}, and the global optimum, G_{nk}. $v_{nk}^{(t+1)}$ is the velocity of the k[th] component of the n[th] particle of the t+1[th] generation. P_{nk} is the particle optimum which is found by each particle up to the present time, and G_{nk} is the global optimum which is found by population to share information and search the place. r_1 and r_2 are random variables uniformly distributed on the interval [0, 1], and c_1 and c_2 are acceleration constants adjusting the effect of the particle optimum and the effect of the group optimum.

If the velocity of a particle is too high, it might be necessary to lower its velocity in order to prevent it from being placed out of the valid place. On the other hand, if its velocity is too low, the feasible region is less likely sufficiently searched. w is inertia weight and limits this velocity. A global optimum is more likely found with a large value for w, whereas a local optimum is more likely found with a small value for w.

The population of decision variables to perform the PSO method in this study is summarized in Table 1.

Table 1. The Population of Decision Variables for the Supply Chain Model using PSO

Element K

Population N

Company	AI	*COGS*	Receivable	Revenue	Payable	DOI	DOR	DOP	C2C
1	65.5	190.5	41.5	234.1	50.9	43.2	123.1	97.5	68.8
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.

The variables in Table 1 are used to calculate the objectives during the optimization process of the PSO method. Those values are randomly chosen or set to 0 when the simulation begins. The initial values are updated as a better solution is found through the optimization process and the generation of pareto front. Thus, the optimization process is performed with the information summarized in Figure 3 and Table 1 to maximize a profit while considering the initial information in a yacht service supply chain and a performance measure."

4. Experimental Results

The optimization of companies which are included in a yacht service supply chain depicted in Figure 1 can be progressed by the C2C cycle analysis of Eq. (2) to solve the objective function, Eq. (1). The necessary information for optimization from financial statements of companies which are affiliated to a yacht service supply chain is supposed as Table 2.

Table 2. Information of PSO from Financial Statements of Companies

Variable of C2C cycle	Yacht manufacturer	Marina	Charterer	Trainer	Marine-look maker	Customer service company
Average Inventory	65.5	23.7	157.2	85.3	17.6	101.6
Cost of Goods Sold	190.5	230.6	457.2	470.4	171.3	560
Accounts Receivable	41.5	60	99.6	51.0	60.4	60.7
Revenue	234.1	450.1	561.84	555.2	334.4	805
Accounts Payable	50.9	100	122.16	121.0	35	144.1
						Unit: Million $

In Table 2, this paper considers information about Yacht manufacturer, Marina, Charterer, Trainer, Marine-look maker, and Customer service company. For example, average inventory, cost of goods sold, accounts receivable, revenue, and accounts payable of Yacht manufacturer are 65.5, 190.5, 41.5, 234.1, and 50.9 respectively. The optimizing process calculates average inventory, cost of goods sold, accounts receivable, revenue, and accounts payable and selects optimal candidates.

The C2C cycle explained as Eq. (2) for a yacht service supply chain is calculated in Table 3 using Table 2.

Table 3. C2C Cycle of a Yacht Service Supply Chain Model

Tier / Metric	Yacht manufacturer	Marina	Charterer	Trainer	Marine-look maker	Customer service company
DOI	43.2	37.5	125.5	66.2	37.5	66.2
DOR	123.1	48.7	64.7	33.5	65.9	27.5
DOP	97.5	158.3	97.5	93.9	74.6	93.9
C2C cycle	68.8	-72.1	92.7	5.8	28.9	-0.2
						Unit: Day

In Table 3, the C2C cycles of Yacht manufacturer, Marina, Charterer, Trainer, Marine-look maker, and Customer service company are calculated as 68.8 days, -72.1 days, 92.7 days, 5.8 days, 28.9 days, and -0.2 days. The values of C2C cycle of Yacht manufacturer, Charterer, and Marine-look maker are very larger than 0. It means that the companies have a large amount of average inventory and much accounts receivable while less accounts payable. On the contrary, the value of C2C cycle of Marina is very smaller than 0. It means that the company has a small amount of average inventory and less accounts receivable while much accounts payable. The C2C cycles of Trainer and Customer service company are balanced among average inventory, accounts receivable, and accounts payable.

That is, the C2C cycles of Trainer and Customer service company are balanced and the C2C cycle of Marina is efficient in assets. Whereas the C2C cycles of Yacht manufacturer, Charterer, and Marine-look maker are inefficient in assets.

In its final analysis, because Yacht manufacturer, Charterer, and Marine-look maker become less efficient in assets, the companies are insufficiently competitive as compared with other companies which are included in the same yacht service supply chain. Because the companies have insufficiently competitive as compared with the companies that have sufficiently competitive in the same supply chain, the business of the enterprises go into the red in the same supply chain and then the corporations try to escape the bad situation. So, the all tiers of the yacht service supply chain become unstable and then because the unsettled situation affects all companies of the supply chain, the enterprises which are efficiently operating in assets became precarious. To sum up, it means that all companies regardless of their conditions must simultaneously endeavor to upgrade their yacht service supply chain and competitiveness in order to economically manage a yacht service supply chain in assets. The optimization of a yacht service supply chain, therefore, is necessary to make a strategy to pursue efficiency of all companies in assets.

5. Conclusion and Future Work

This paper underlined that it is necessary to optimize for overall a yacht service supply chain because the pursuit of efficiency of only yacht itself to provide the optimal yacht service has a limit. Also, this paper explained that the optimization which is connected to the concept of time and the assets is efficient because the concept of time is increasingly important in an optimizing process with the previous method.

This paper, also, connected a yacht industry and a service industry, constituted a value chain which increases the value of a yacht service supply chain, and proposed a yacht service network which makes a single yacht service supply chain from yacht manufacturing to customer service. This study parlayed a service which is subsidiary offered with a product into a source with making a profit.

The proposed yacht service supply chain model, in this paper, included all parties from yacht manufacturing to customer service. Each tier included in a yacht service supply chain aims to get the biggest profit but the objective and the method to get a profit are different each other. A yacht manufacturer tries to get the biggest maximum through yacht manufacturing and sales. A financer / insurer wants to maximize interest return and to minimize bad debit during loan of funds. A customer service company wants to maximize a profit while he / she provides service to a customer but the company should additionally reach the service level and satisfy the service quality which is requested by a customer.

This study, therefore, used PSO method and C2C cycle to optimize a yacht service supply chain while reflecting of properties of all tiers. The decision variables of each party were expressed as a swarm and a particle and then reflected in the optimization model. Also, they were reflected in C2C cycle using DOI, DOR, and DOP.

The initial information of the optimization model included financial information and service supply chain information in a yacht service supply chain. The optimization model which is constituted by PSO and C2C cycle run processes, configuration of decision variables using days of inventory, days of receivables, and days of payables, making an optimal pareto front, and stopping conditions of simulation model. Performance measures considered C2C cycle which is composed of DOI, DOR, and DOP.

This paper, that is, used C2C cycle analysis to optimize a yacht service supply chain in assets and evaluated a yacht service supply chain in assets using PSO method. From the results, this paper explained that a company is efficient in assets but a company is inefficient in assets even though they all are included in a same yacht service supply chain. Because all companies included in the same yacht service supply chain are not always effective, the supply chain is shipwrecked anywhere and at any time.

In conclusion, if the differential of efficiency among the companies in same yacht service supply chain is occurred, some companies they have less efficiency in assets are dissatisfied with the situation, do not a feel a sense of belonging, and then their yacht service supply chain becomes weak. The instability of the supply chain is peppered throughout all tiers and then the supply chain must be confronted with destruction. The supply chain, accordingly, must find a method which is always efficient to all parties in assets.

This study proposed an optimization model using PSO method and C2C cycle to optimize a yacht service supply chain. But, the model did not evaluate whether the all parties get a satisfying result or not. The future research, therefore, will present a method which encompasses all companies while all companies of a yacht service supply chain obtain profits in the optimizing process of a yacht service supply chain in assets using the C2C cycle.

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