Study on distribution centre's location selection of internal supply chain for large group manufacturing companies

Lifei Yao, Ruimin Ma, Maozhu Jin*, Peiyu Ren

Business School, Sichuan University, 610064, Chengdu, Sichuan, China

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Abstract

The purpose of this paper is to study what distribution centre's location selection can bring to the internal supply main management for large group manufacturing companies. This paper chooses the analytic hierarchy process to select an optional location for internal distribution centre', and evaluate it through the simulation method. Internal distribution centre construction can effectively shorten the delivery time, reduce the logistics intensity, and improve utilization rate of transport equipment. Therefore, the distribution centre's location selection is necessary and reasonable. This paper simplified some information when running the simulation and it is not all the same as the actual situation. This paper provides a good internal supply main management method for large group manufacturing companies. This paper put forward the importance of internal supply chain for a large group manufacturing company and studied the internal distribution centre's location selection.

Keywords: manufacturing, internal supply chain, distribution centre, simulation

1 Introduction

Scientific and reasonable distribution centre's location plays a vital role for balancing the entire supply chain logistics, the logistics service reliability and management level of ascension. Appropriate location can effectively reduce the cost of supply chain, improve the overall efficiency of the supply chain and reduce the impact of the bullwhip effect. Therefore, the internal distribution centre's location is very important. The evaluation of distribution centre's location selection includes evaluation system and evaluation method and a lot of scholars at home and abroad have studied about the problem in the literatures [1-6].Nine basic location models were given by Alkenes, which included the simple incapacitated facility location model, the capacitated facility location model, the dynamic and stochastic capacitated facility location models etc. [7]. Holmberg [8] studied the exact solution method for the incapacitated facility location problem in which the transportation costs were nonlinear. An integer programming model for the plant location was presented by Badalona and Jensen [9]. It considered not only the fixed costs and transportation costs, but also the inventory costs, which had been solved by the Danzig-Wolfe (D-W) decomposition method. All the objective functions of these models were to minimize the transportation costs and fixed investment costs.

In the literature, many existing research studies for determining a multi-objective logistics distribution centre location have mainly focused on calculating the index weight of the influence factors by using particular approaches, such as barycentre theory, the osculating value method [10]. Barycentre theory is calculated on the minimum cost as the goal for best location, but the location is likely to be unable to use (e.g., in the middle of the river, streets, etc.). The osculating value method is to select a best solution from many available options under certain constraints. Its disadvantage is that if the situation is more complex, it is hard to establish a proper programming model.

In general, the overall goal these methods above was all transportation cost minimum or poor feasibility. This paper studied distribution centre's location selection of the internal supply chain in enterprise. Its main goal is to improve the distribution speed and reduce logistics intension, relatively low requirement on distribution cost, so the several methods above are not applicable for this study. Taking the confirmed factory layout into consideration, selection method of this paper is mainly to find an optimal location within a few eligible alternative locations in the factory area, so we just considered several special constraint conditions. Finally, the paper chose the analytic hierarchy process to score several alternatives locations, and evaluate it through the simulation.

2 Problem descriptions

In general, the internal supply chain is simple, only includes three parts: purchasing, product, and products sale. However, for large-scale manufacturing enterprises have big production scale, complex process and need a number of raw materials, spare parts and production

* ***Corresponding author*** email: jinmaozhu@scu.edu.cn

equipment, meanwhile, the complex process results in the logistics direction variously, And the large-scale logistics, such as production logistics and distribution logistics, are done internally, the scale of internal logistics is huge, the task of internal material supply logistics system is burdensome. In order to improve logistics efficiency and reduce delivery time, it is necessary to change the distribution mode, which is a passive mode to active distribution mode according to the plan.

Scientific and reasonable distribution centre's location plays a vital role for balancing the entire supply chain logistics, the logistics service reliability and management level of ascension. Appropriate location can effectively reduce the cost of supply chain, improve the overall efficiency of the supply chain and reduce the impact of the bullwhip effect. Therefore, the internal distribution centre's location is very important.

Distribution centre's location has some constraints: First, the site must locate inside the factory. For confidentiality reasons, the distribution centre construction within the scope of the company's existing plant area is very necessary. In addition, distribution centre locates inside the factory is convenient for unified management, real-time monitoring and real-time updates for logistics information can be more convenient, and also can shorten the distance of distribution, increase the speed of delivery. Second, the construction of the distribution centre cannot impact on the present layout. The change of present layout will damage the direction of logistics and improve the cost. Third, Transportation around the distribution centre is convenient. In order to facilitate the material transportation, roads surrounding the selected site should be built perfect, can lead to various professional plants. In addition, the surrounding roads can hold big enough traffic.

3 Evaluation indicators for selection of internal distribution centre's location

The internal supply chain distribution centre's location problem is different from the external distribution centre or the third party logistics distribution centre location problem, the selected location must be within the plant, only in accordance with the requirements of the warehouse construction alternatives in the screening, so when determining the selection indicator does not need to consider the cost of the land itself and its use (except for planning of land). And for the internal supply chain, logistics process is relatively fixed, so the relatively fixed on distribution route, too. The detail indicators are introduced as follows:

1) Supply speed: Special manufacturer requests, after their demand is sent out, distribution centre can deliver material in the shortest possible time. Especially when there is urgent demand, supply speed is particularly important.
2) Logistics intension: Logistics intension is the product of logistics capacity and the distance, Logistics intension of the selected location should as small as possible.
3) Degree of traffic convenience: Degree of traffic convenience directly affects the delivery speed.
4) Warehouse terrain: The site must is higher than the surrounding terrain and has good drainage, in case of a severe climate led to water.
5) Peripheral equipment: Mainly includes the roads surrounding site, communication and other public facilities complete, with plenty of power, water, gas, etc.
6) Size of location: Site must be large enough to meet the needs of its business development.

4 Case study

Company H is a large group aircraft manufacture enterprise. There exists large materials distribution among its warehouse and professional factories. These professional form factories an internal supply chain. However, its logistics system is not perfect and balanced due to the existing low level supply chain management. In order to improve the internal supply chain management, and realize the targets of process optimization, reducing costs, it becomes very important to construct an internal distribution centre.

4.1 DISTRIBUTION MANAGEMENT STATUS OF COMPANY H

Now raw materials and components of Company H are temporarily stored in the material warehouse. Once the production plan is issued, the warehouse will distribute all raw materials and spare parts to the temporary storage location according to the material requirements of each professional plant in a lump sum. However, the production plan is rough and some materials stack up to a long time. This often results in heavy inventory.

In such a distribution management, materials management and distribution of company H appeared to be very disorderly. Since distribution is unreasonable, the use of materials and logistics information cannot be effectively monitored.

4.1.1 Layout diagram

To select a good logistics distribution centre's location, we must know about the layout of company. Layout diagram of Company H is shown in Figure1. The shadow line represents rarely developed area and the solid line represents the existing workshop of each professional plant.

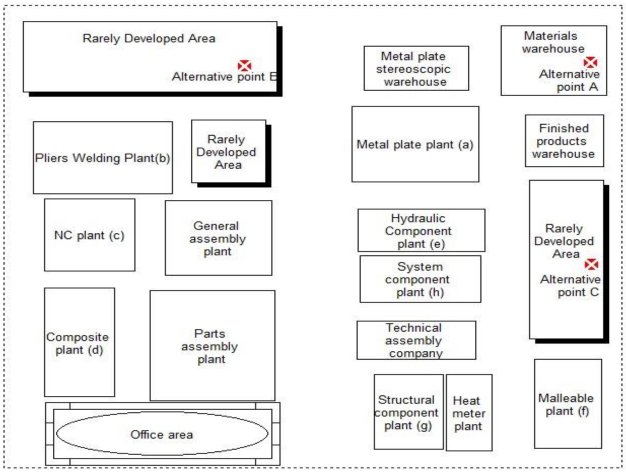

FIGURE 1 Layout diagram of Company H

4.1.2 Logistics processes

All required materials are distributed from the materials warehouse and their main distribution processes are shown in Figure 2.

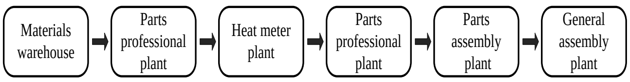

FIGURE 2 Materials main processes of Company H

4.1.3 Distribution condition of materials

According to the statistics data, the number and the average weight of parts and materials which are distributed to each professional plant from the materials warehouse are both shown in Table 1.

TABLE 1 Distribution condition from warehouse to professional plant/per year

Professional plant	Number of materials	Average weight of materials\kilo	Total weight of materials\kilo
Metal plate plant	38313	52.7	2020776
Pliers Welding Plant	46846	51.6	2429236
NC plant	6523	186.2	1214443
Composite plant	15700	68.1	1069840
Hydraulic Component plant	89459	12.7	1133690
Malleable plant	26440	30.5	805807
Structural component plant	23524	546.6	12858043
System component plant	583894	0.11	86228.34

4.2 SELECTION OF ALTERNATIVE LOCATIONS

4.2.1 Initially determine alternative locations

Selection criteria of alternative location is stated as follows: (a) It must be selected within the company; (b) Alternative location does not change the existing layout of the company; (c) The space is big enough to meet the storage requirement; (d) Surrounding transportation is convenient and material supply is convenient and quick; (e) It should be flat and has a good drainage system. Considering the five standards above, we determined three alternative locations initially which are signed as small rectangle in Figure 1.

Alternative location A: Namely, the existing warehouse. Do not need to move and the traffic is quite convenient. However, the space is small and it is unlikely to enlarge the warehouse area.

Alternative location B: The space is very large. B is close to the existing material so it is easy to move. Moreover, roads surrounding are developed and materials can be distributed quickly. However, the surrounding power facilities are penurious.

Alternative location C: The space is enough to use, but transportation around is not so convenient, and the terrain is not too flat. Besides, drainage facilities are poor.

4.2.2 Evaluation index weight calculation

Evaluation index has been written in Section3.Use AHP to calculate the evaluation index weight. Relevant tales are shown in Table 2-5.

TABLE 2 Classification of importance

Importance	Definition
1	A and B have the same importance
3	A is slightly important than B
5	A is important than B
7	A is much more important than B
9	A is extremely important than B

In order to reflect the importance of various factors more objectively and accurately, this paper adopted Delphi method. Select each logistics personnel respectively from 15 professional plants, 4 personnel who are responsible for the warehouse and distribution from Purchasing Department, and 1production department manager, a total of 20 people forma panel of experts. Let they fill out the importance of the various factors. Calculate the average value and get the factors comparison matrix of distribution centre location selection. Then normalize the matrix, and calculate the weight vector.

Let the factors comparison matrix of distribution centre location selection be B and weight vector be W, then

$$G = BW = (g_1, g_2, \ldots, g_n) . \quad (1)$$

TABLE 3 Factors comparison matrix of distribution centre location selection

	Supply speed	Logistics intension	Degree of traffic convenience	Warehouse terrain	Peripheral Equipment	Size of location
Supply speed	1	3	3	5	7	3
Logistics intension	1/3	1	3	5	5	3
Degree of traffic convenience	1/3	1/3	1	3	5	3
Warehouse terrain	1/5	1/5	1/3	1	3	1/3
Peripheral Equipment	1/7	1/5	1/5	1/3	1	1/3

TABLE 4 Comparison matrix after normalization

	Supply speed	Logistics intension	Degree of traffic convenience	Warehouse terrain	Peripheral Equipment	Size of location	Sort weight vector
Supply speed	0.4268	0.5921	0.3814	0.2885	0.2917	0.2813	0.3769
Logistics intension	0.1423	0.1974	0.3814	0.2885	0.2083	0.2813	0.2498
Degree of traffic convenience	0.1423	0.0658	0.1271	0.1731	0.2083	0.2813	0.1663
Warehouse terrain	0.0854	0.0395	0.0424	0.0577	0.1250	0.0313	0.0635
Peripheral Equipment	0.0610	0.0395	0.0254	0.0192	0.0417	0.0313	0.0363
Size of location	0.1423	0.0658	0.0424	0.1731	0.1250	0.0938	0.1070

TABLE 5 Average random consistency table (RI)

Size of matrix	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

Results can be calculated as follows after inquiring average random consistency table.

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n} g_i / w_i = 6.4367, \quad (2)$$

$$CI = \frac{\lambda_{\max} - n}{n-1} = 0.0873, \quad (3)$$

$$CR = \frac{CI}{RI} = 0.0704 < 0.1. \quad (4)$$

TABLE 6 Yearly Logistics intension of alternative locations

Professional plant	Distance to A(meter)	Logistics intension to A(kilo*meter)	Distance to B(meter)	Logistics intension to B(kilo*meter)	Distance to C(meter)	Logistics intension to C(kilo*meter)
Metal plate plant (a)	400	808310400	360	727479360	595	1202361720
Pliers Welding Plant (b)	890	2162020040	25	60730900	1570	3813900520
NC plant (c)	1680	2040264240	705	856182315	1180	1433042740
Composite plant (d)	2150	2300156000	1025	1096586000	1200	1283808000
Hydraulic component plant (e)	800	906952000	810	918288900	150	170053500
Malleable plant (f)	1430	1152304010	1630	1313465410	400	322322800
Structural component plant (g)	1340	17229777620	1420	18258421060	340	4371734620
System component plant (h)	850	73294089	860	74156372.4	145	12503109.3
Total	-	26673078399	-	23305310317	-	12609727009

It complies with the consistency judgment; therefore the judgment matrix can be thought to have satisfactory consistency. Thus the weight of each factor has also been determined, namely the importance of supply speed, logistics intension, degree of traffic convenience, warehouse terrain, peripheral equipment , size of location is respectively: 0.3769, 0.2498, 0. 1663,0.0635, 0.0363, 0.1070.

4.2.3 Score of alternative locations

Calculate logistics intension firstly. The logistics intension is the sum of logistics weight multiplied by the distance from alternative location to each plant.

From Table 6 we can see the logistics intension of alternative location C is the smallest and A is the largest. The logistics intension of alternative location A, B, C respectively occupies 42.6%, 37.2%, 20.2% of the sum of the three, and then the logistics intension score of A, B, C is respectively given 57.4、62.8、79.8.

Invite the panel of experts to grade the remaining five evaluation index to the alternative locations, full mark is 100 points and the score is the average value of the panel of experts scoring. Then calculate the total score of each alternative location according to the weight of each factor, which is shown in Table 7.

TABLE 7 Score of each alternative location (Full mark: 100)

Evaluation index	Score of location A	Score of location B	Score of location C
Supply speed(0.3769)	80.3	84.5	86.4
Logistics intension(0.2498)	57.4	62.8	79.8
Degree of traffic convenience(0. 1663)	86.7	92.4	79.4
Warehouse terrain(0.0635)	88.1	90.6	73.8
Peripheral equipment(0.0363)	84.9	80.3	81.3
Size of location(0.1070)	64.8	90.4	72.7
Total score	74.6	81.3	81.1

From Table 7 we find that alternative location B got the highest score, therefore select alternative location B to construct logistics distribution centre.

4.3 SIMULATION OF LOCATION SELECTION PLANNING

4.3.1 Simulation evaluation index

In order to evaluate the effect of after locating the distribution centre at B, simulate the processes running to the current distribution planning and the distribution centre respectively through Software Promodel. The goal of company H establishing distribution centre is to improve the distribution speed and reduce the logistics intensity. Therefore, distribution time and total logistics intensity are selected to be the simulation evaluation index.

4.3.2 The status quo simulation

Now raw materials and components of company H are temporarily stored in the material warehouse, shown in Figure 3. Once the production plan is issued, the warehouse will distribute all raw materials and spare parts to the temporary storage location according to the material requirements of each professional plant in a lump sum. Therefore, we collected part distribution record of materials warehouse in 2011 to carry on the simulation.

(1) Resource-transportation equipment. The warehouse of Company H has three kinds of transportation equipment-manual hydraulic carrier, internal combustion balance forklift and medium-sized truck. Their number is respectively 47, 35, 8, and maximum load is 2,8,18 (t). Carry on group distribution to the materials of each professional plant in the simulation, and the total weight of each group of materials must be less than the maximum load for the selected device.

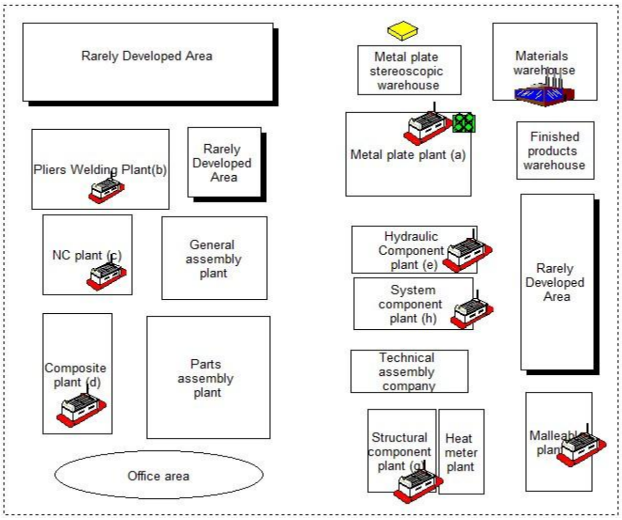

FIGURE 3 The status quo simulation model

(2) Relevant distribution data. Data related to distribution mainly includes distribution distance, quantity and weight of deliver materials, etc. This article only carried the simulation of the distribution from material warehouse to each professional plant, so the collected materials data are all the data from material warehouse to each professional plant, not including logistics information between various professional plants. It is shown in Table 8.

(3) Running the simulation model .With the data above, carry on the simulation according to the actual time of distribution tasks. Running process of the simulation model is shown as in the figure below.

TABLE 8 Relevant distribution data

Professional plant	Distance from material warehouse (meter)	Yearly average distribution material weight (Kg/year)	Average distribution material number/year (Actual data)	Average distribution material number/year (Simulation data)
Metal plate plant (a)	400	2020776	38313	3831
Pliers Welding Plant (b)	890	2247691	46846	4685
NC plant (c)	1680	1214443	6523	625
Composite plant (d)	2150	1069840	15700	1570
Hydraulic component plant (e)	800	1133690	89459	8946
Malleable plant (f)	1430	1065807	31440	3144
Structural component plant (g)	1340	16528043	33524	3352

4.3.3 Internal distribution centre simulation

Simulation data is based on the current plan. So the simulation of running effect for the distribution centre is based on the assumptions as follows: (a) all production plans and scheduling is precise and detailed. (b) The plan information and logistics information of distribution centre and each distribution point can be real-time monitored effectively. (c) All raw materials, spare parts, semi-finished products of distribution centre are enough, not existing out of stock problem. Setting up and running process of the simulation model is shown as in Figure 4.

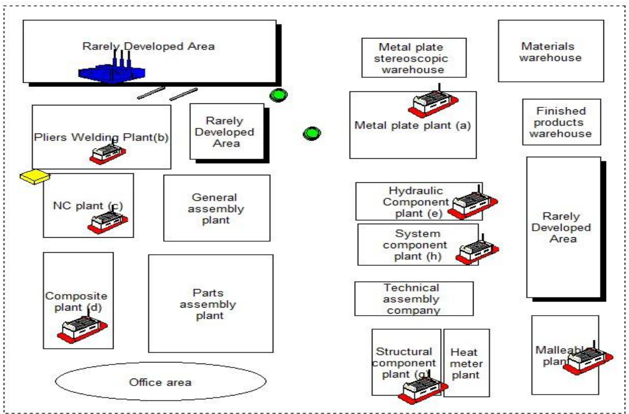

FIGURE 4 Internal distribution centre simulation model

4.4 SIMULATION RESULTS AND COMPARATIVE ANALYSIS

In order to guarantee the reliability of the simulation results, both simulation models run for five times and all the results are the average of five running results. According to the evaluation index, we select the following data for analysis.

(1) Conveyance\resource data

Table 9 and 10 show conveyance relevant data, which are respectively the running results of the status quo simulation and simulation of after constructing distribution centre. The Name, Units, Scheduled Time (MIN), Number Times Used, Average Time Per Usage (MIN), Total Time used (MIN), Utilization rate, Idle rate of each conveyance are all listed in the table above. After constructing a distribution centre at location B and adopting active distribution way of variable granularity, the usage of handling tools will be greatly reduced. What's more, the total use time of three kinds of transportation tools respectively shortened 18109 min, 5073 min and 42925 min.

TABLE 9 Resources for simulation-- The status quo (Avg. of 5 replications)

Name	Units	Scheduled Time	Number Times used	Avg. Time Per Usage	Utilization%
Pallet truck	47	5640000	18165.4	14.6	4.70%
Truck	8	960000	3692.6	6.31	2.43%
Forklift	35	4200000	1185.8	3549.14	91.75%

TABLE 10 Resources for simulation-- The status quo (Avg. of 5 replications)

Name	Units	Scheduled Time	Number Times Used	Avg. Time Per Usage	Utilization%
Pallet truck	47	5640000	9462.1	15.01	4.38%
Truck	8	960000	1872.4	6.35	1.90%
Forklift	35	4200000	385	4854.44	90.73%

(2) Logistics intension

Handling tools that all kinds of materials use are set in the simulation. Hydraulic parts and structural components use carts. Materials of Metal plate plant, Pliers Welding Plant and Composite plant use forklift. In addition, materials of NC plant, malleable plant and Structural component plant use truck. The speed of three handling tools is respectively set 50 m/min, 120 m/min and 300 m/min. According to the information, logistics intension can be calculated combining with the distribution time and weight of the materials in the tables.

The logistics intensity of distribution centre simulation is far more less than the logistics intensity of the status quo simulation from Table 11 and 12. The overall logistics intensity decreased by 17024145983 kg·m.

5 Conclusions

This paper studied distribution centre's location selection of the internal supply chain in enterprise. The selection method of this paper is mainly to find an optimal location within a few eligible alternative locations, the paper chose the analytic hierarchy process to score several alternatives locations, and selected the optional location. Then evaluated it through the simulation compared with the status quo.

TABLE 11 Logistics intension - The status quo simulation

Professional plant	Number	Time(min)	Speed(m/min)	Weight(kg)	Logistics intension (kg·m)
Metal plate plant (a)	3807	3.3	120	52.7	794490444
Pliers Welding Plant (b)	4672	7.38	120	51.6	2134961971
NC plant (c)	620	5.28	300	186.2	1828632960
Composite plant (d)	1557	17.88	120	68.1	2275016155
Hydraulic component plant (e)	8946	23.33	50	12.7	1325309643
Malleable plant (f)	3144	10.1	300	30.5	2905527600
Structural component plant (g)	3350	9.85	300	546.6	54109300500
System component plant (h)	58311	26.6	50	0.11	853089930

TABLE 12 Logistics intension - Internal distribution centre simulation

Professional plant	Number	Time(min)	Speed(m/min)	Weight(kg)	Logistics intension (kg·m)
Metal plate plant (a)	3822	11.8	120	52.7	2852098704
Pliers Welding Plant (b)	4674	15.01	120	51.6	4344105341
NC plant (c)	620	16.18	300	186.2	5603651760
Composite plant (d)	1563	37.77	120	68.1	4824300157
Hydraulic component plant (e)	8943	52.87	50	12.7	3002384204
Malleable plant (f)	3144	43.58	300	30.5	12536920080
Structural component plant (g)	3346	37.96	300	546.6	2.08278E+11
System component plant (h)	58343	37.49	50	0.11	1203003489

The results indicate that internal distribution centre construction can effectively shorten the delivery time, reduce the logistics intensity, and improve utilization rate of transport equipment. Therefore, the distribution centre's location selection is necessary and reasonable.

Acknowledgements

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Authors

Lifei Yao, born in December, 1988, Qinhuangdao, China

Current position, grades: A Graduate student
University studies: Sichuan University
Scientific interest: Industry Engineering , prediction, evaluation and decision control
Publications: 1
Experience: She is a Graduate student in Sichuan University for majoring in management science and engineering, and a member of Information and Business Management Institute of Sichuan University.

Ruimin Ma, born on September, 1989, Shaoyang, China

Current position, grades: A doctoral student
University studies: Sichuan University
Scientific interest: simulation, multi-objective decision, and vehicle scheduling
Publications: 2
Experience: He is a doctoral student in Sichuan University for majoring in management science and engineering, and a member of Information and Business Management Institute of Sichuan University. His researches mainly relate to simulation, multi-objective decision, and vehicle scheduling, etc.

Maozhu Jin, born on December, 1978, Nanchong, China

Current position, grades: Instructor of Business School, the tutor of MBA operations management and innovation and entrepreneurship management in Sichuan University
University studies: Huazhong University of Science and Technology
Scientific interest: operations management, organizational process reengineering, strategic management, service operations management, and platform-based mass customization.
Publications: 15
Experience: He has been engaged in the teaching of core curriculums such as operations management and management consulting. As a main researcher, he has participated in and completed three projects supported by National Natural Science Foundation of China and two surface projects. He has published two books and over ten research papers in authoritative journals of high quality both at home and abroad, and ten of them are retrieved by SCI and EI.

Peiyu Ren, born on December, 1952, Chongqing, China

Current position, grades: Professor, PhD Supervisor, currently acting as the Director of Information and Business Management Research Institute of Sichuan University.
University studies: Sichuan University
Scientific interest: Industrial Enterprise Management, scenic area management and Informatization integration management
Publications: 120
Experience: He has presided over and completed five surface projects of National Natural Science Foundation of China, being in charge of project research of Projects 863, 985 and 211, having published 15 books, monographs and more than 100 academic papers, including SCI, EI and CSSCI