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Researches on coal logistics center site selection in Guizhou Province

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RESEARCHS ON COAL LOGISTICS CENTER SITE SELECTION IN GUIZHOU PORVINCE

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DECLARATION

I certify that all the material in this research paper that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this research paper reflect my own personal views, and are not necessarily endorsed by the University.

(Signature): ....

(Date): ....

Supervised by:

Prof. Sha Mei

Professor of Shanghai Maritime University

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ABSTRACT

Title of Dissertation: **Research on coal logistics center site selection in Guizhou province**

Degree: **MSc**

Logistics is one of the key factor in the economic development. But the logistics industry is backward in Guizhou province. Guizhou is a resource province in China. Especially the coal mine is abundance in Guizhou. So, develop the logistics network in Guizhou province for coal is the best way to solve this problem. At the same time, logistics center is the core part in logistics network. How to select the logistics center in Guizhou province is the site is the topic in this dissertation.

This dissertation mainly deals with the issue of how to select the logistics center site in Guizhou province. Chapter three is the general introduction about the situation of transportation, natural resources distribution, coal resources and economic condition in Guizhou province. And then, it will give a basic introduction about the Nonlinear programming model in the chapter four. Later, in the chapter five, it will build the Nonlinear programming model up to solve the site selection problem in Guizhou province. After that, chapter six will be a analysis for the model result. At the same time, in this chapter will be a conclusion and give some suggestions for the logistics center construction.

KEY WORDS：Coal, Logistics Center, Guizhou province, Site Selection

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CHAPTER 1 Introduction:

1.1 Background

Material flow of human society as a basic and important unit in the early development of human society has emerged. With the development of world trade, the logistic industry should play a very important role in the future world. The logistic process in modern society is very huge and complex.

Nowadays, Logistics system can be divided into enterprise level, regional level, national level and international level. In China, most logistics are focus on the enterprise level, and the regional level logistic developing slowly. But the regional level logistic would facilitate regional economic develop and organize the regional logistic in a good way.

Guizhou is undeveloped province in the southwest China. At the same time, Guizhou is a resource province in China. There are many concernful mineral resources were held in Guizhou province. Logistics industry in Guizhou is a undeveloped industry. The old style remained ever since decades before. The trucks belong to private enterprises, the transport to the railway station to load in small quantity. In this kind situation result the high cost of money and time. In 2008, the terrible snowstorm excites people's attention about the coal logistics network building.

Build a good logistics network is the best way to promote the logistics in regional area. In the logistics network, logistics center plays an important role. The logistics center should be the most important part in the logistics network.

The logistics network center means the logistics centers that connected by the logistics process. General speaking, logistics network may improve the service quality and delivery speed. At the same time, the logistics center may provide some other value-added services.

In recent years, Chinese government is focus on building local logistics center. Regional logistics center activities in the region occupy an important position. Logistics center location is one of the important factors in the planning. This factor may influence the management in the future operation.

In this paper, author makes use of the nonlinear programming model to select a site for the coal logistics center in Guizhou province. This is a very popular method in optimize method. In recent years, a lot of research on the Nonlinear programming model show us that this method may be one of the best methods to do research on the logistics center site selection.

1.2 Research objective, meaning and content

The purpose of this research paper is to provide a solution for Guizhou logistics center address by make use of Nonlinear programming model. This paper is actually select the logistics center site in Guizhou, and give some suggestions from my position.

To sum up, I think the research meanings are:

Work out how to do the logistics center site selection from whole management side. Such as problems like how to minimize the building and total logistics cost etc.

Make use of mathematical model to give suggestion about a logistics center sit selection in Guizhou. Due to lack of research on this area, I want to make use of this mathematical model method to solve this problem.

Content

The content of this research paper is divided into introduction, main body and the conclusion. From the very beginning of explaining the basic theory to the end of application into a certain case. Introduction include: the background, Research objective, meaning and content, methodology and literature review of this paper. The main body include: the overview about the logistics situation in Guizhou province. Later, I would explain the basic theory of logistics center address, and build up a model. At last how to solve the logistics center address problem in Guizhou province. Finally, is the conclusion of the paper.

1.3 Methodology

There are two methods being introduced into this paper, one is Nonlinear programming model, one is make use of the lingo software. The Nonlinear programming model is the method which to solve the logistics center site selection problem. The lingo software is the method which to calculate the Nonlinear programming model's result.

Nonlinear programming model is the mathematical method which has a constraint condition. The Nonlinear programming model is an important part in the operational research. Nonlinear programming model is the method which research the extremum. In recent years, this method was used to research the problem like management, engineering design, site selection and military commanding.

LINGO software is the soft called Linearnteractive and General Optimaizer. This software use for solve the nonlinear programming model. It is a convenient and effective to build and solve the full-featured non-linear tools. Including a powerful modeling language, the question of the establishment and full-featured editing environment, read and write Excel and database functions, and a series of completely built-in solver.

1.4 Framework of the research paper

Chapter1 is introduction. Chapter2 is literature review. Chapter3 is the overview about the Guizhou province, include the city, population and the resources distribution and the logistic develop situation. The most important is the three main city in this province. Chapter4 is the Bi-level programming model, include the basic conception, select the variable, and the model establish. Chapter5 is case study, include the data processing, the calculation and the result analysis. The last chapter is the conclusion about the paper and the suggestions for the local government.

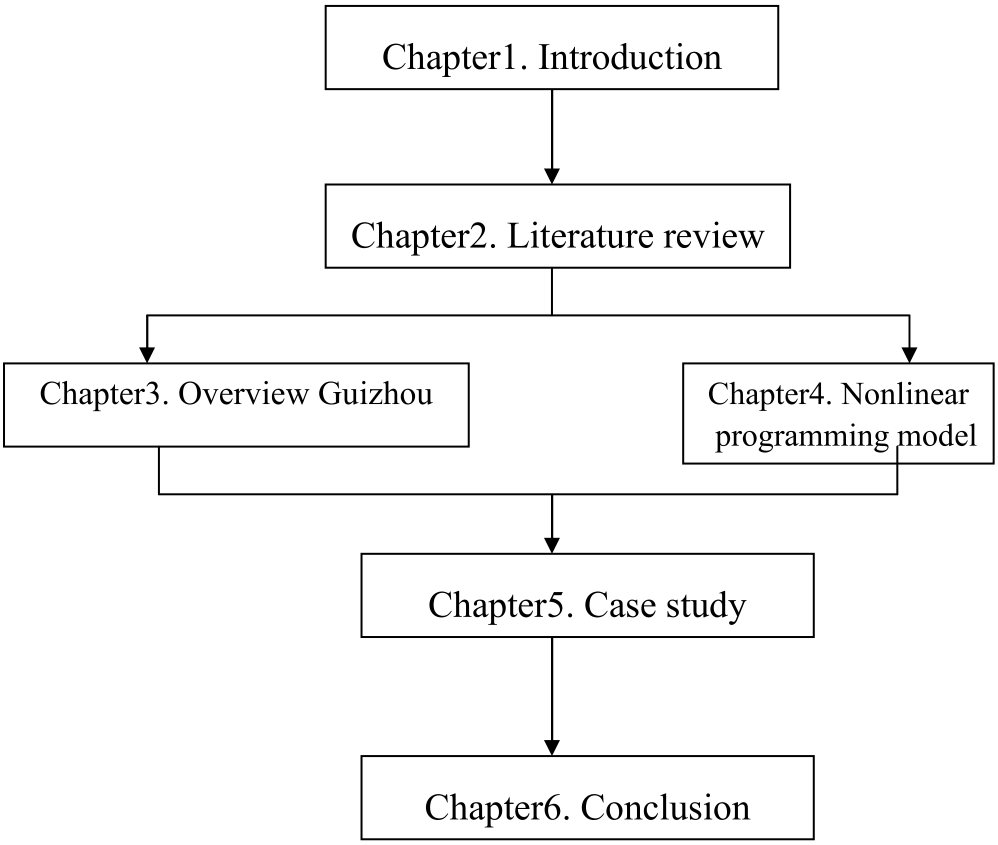

Figure 1.1 Framework of the dissertation

CHAPTER 2 Literature review

2.1 Recent researches:

There are some research findings about how to address a logistics center. We can find the best way to address a logistics center to make the research more comprehensive.

2.1.1 Researches on the logistics center site selection

First, there are a lot of basic theories can be used to do the research about the problem. Tae Hoon Oum and Jong-Hun Park (2003) aims the logistics center should be located by compare the economic data. In the Liu hailong and Li yancheng's article (2008) they cited a variety of methods, for example: qualitative method would depend on the people or group's experience. They cited many quantitative methods later. Those quantitative methods should reflect the site selection by objective data but the subjective experience. At last, authors mentioned that we should carry on this research by combination the quantitative methods and qualitative method. Lixang Yang, Xiaoyu Ji etc had public an article in 2006, they gave us theirs' research finding on the problem which how to reduce the enterprise's cost by set the logistics center at the right place under fuzzy economics. They used the genetic algorithm and fuzzy simulation algorithm to study this problem. Linda K. Nozick and Mark A. Turquist represented the idea (2000) that focus on the transport cost and inventory cost, they think these are the most important factors to address a logistics center. At the same time, a lot of researches are focus on the Bi-level programming model to solve the logistics center site selection problem. For example, Guomei in his article (2008) mentioned this method, and Wang Lianfeng (2006) aims the Bi-level programming Bi-level programming model considered the competitive factors which the most of other models didn't. But we can find that the Bi-level programming model is very hard to calculate form an article wrote by Cui Guangjun and Li Yibing in 2007. In this Wang Huanlian's master thesis (2005), he mentioned the Bi-level programming model have no solved in a lot of cases. And in this article, he mentioned another method to handle the logistics center site selection problem which called Nonlinear programming model.

2.1.2 Nonlinear programming model

Nonlinear programming model is a very popular method on the optimize research. A lot of researchers focus on this topic and got many research findings. Such as He Bo, Yang Chao and Ren Mingming (2008) in their's paper explained what is the Nonlinear programming model and how could this model solve the logistics center site selection problem. And in Wang Huanlian's master thesis (2005) he gave the example to explain how to calculate the mathematical model. Pang Mingbao, Ma Ning and Cui Wuwen published a paper on *International Conference on Transportation Engineering* (2007) aims the nonlinear programming model may handle the logistics center site selection problem, and the simulation result shows this model works quite right in Langfang city. Liu, Nan; Chen, Yuangao and Li, Yumin (2007) aims the Nonlinear programming model could combined with other methods to study this problem. For example, the fuzzy comprehensive evaluation.

2.1.3 Successful example on this research

Third, not only digging into theory research, but researchers applied those research results to actual cases. Liu Qing gave the planning for Guiyang by the AHP model. Xu Wenhua in his master's thesis makes use of the APH method to select the logistics center site during the Olympic Games in Beijing. In Chen Xinyun's master thesis

(2006), he made an analysis about the Haier's logistics center address strategy by centroid method. In the same thesis, he made use of the Bi-level programming model to analyse the Wal-Mart's logistics system by network, logistics center allocation is the most important part in this kind of system. End of the thesis, he make use of the mixed integer programming model to design a logistics center network, especially the address for the China Post.

All in all, there are many research finding would help us to solve the logistics center address problem.

2.2 Existing problem

Although there are a lot of research findings about the logistics center address, many problems still exist.

(1) The researches on this area are too academic to omit the practical meaning after application into real case.

We can see, there are a lot of articles on this problem. But, most of them are based on the academic side. Till now, especially in China, a lot of models were designed, but researchers didn't pay attention on how to make use of those models into real cases. So, there were only a few articles to give some suggestions to how to address a logistics center. Although a lot of methods were used to study this problem, it's rarely to find an article which the author make use of this tool to allocate a logistics center. We can define the reason is this method is very hard to set up this model, and the calculation is very hard. For example, Hou Wenying and Li Xuan (2007) in paper showed how to build a Nonlinear programming model. But in this article, the calculation based on their own assumptions. We can get the idea that the Bi-level programming model is the critical methods without as much practical value as we imagine has been revealed. And in Guizhou, we can find that there are few articles to programming the logistics network and any logistics center site selection, although this is a major province of natural resources.

(2) Most of the methods didn't consider enough factors what would impact the logistics center in the logistics network.

Nonlinear programming model is very useful to solve the logistics center address. Because this method consider the generalized logistics costs, the volume of logistics services, the cost of logistics center, the cost which is sustainable and a variety of constraint condition what the other kind of models didn't do.

(3) There is only few relevant articles to discuss the logistics center site selection in Guizhou province.

Guizhou province is a undeveloped province in China. But this is a major province of energy and natural resources. Due to the economic conditions, the local government did not focus on the logistics problem. Now, a *Guiyang City Logistics Planning* was published in 2008 by local government. But this planning is for Guiyang city, there is no value to the province's logistics system build.

In a word, logistics center address still has a lot of areas waiting us to explore deeply inside. And Research on logistics center address is not that abundant or practically mean well while using into real cases. Especially in Guizhou province, there is few articles about it, although logistics it's important for the economic development. Research of logistics center address still has a long way to go.

CHAPTER 3 Analyzing the Situation and Logistics in Guizhou

3.1 General introduction

Guizhou province is located in southwest in China. East border of Hunan, next to south of Guangxi province, Yunnan province located near the Guizhou province’s west part and the Sichuan province is neighbor to the Guizhou province’s north part. The total area of 176,167 square kilometers.

Guizhou Province is located in Yunnan-Guizhou Plateau. An average elevation of 1100 meters. The province's topography can be summarized into the plateau, hilly and mountainous basin three basic types, of which 92.5 percent of the area of mountains and hills. The province is a typical karst landform, about 109084 square kilometers karst landform, accounted for 61.9 percent of the province's total land area.

Figure 3.1 Map of Guizhou province

Source: http://www.chinaodysseytours.com/guizhou/guizhou-maps.html

3.1.1 Distribution of the City and population

Administrative Region of the province is divided into Guiyang, Zunyi, Liupanshui and Anshun 4 cities, Tongren and Bijie 2 prefectures, Qiannan Buyi and Miao Autonomous Prefecture, Southeast Guizhou Miao and Dong Autonomous Prefecture, Southwest Guizhou Buyi and Miao Autonomous Prefecture three minority autonomous prefectures; and there are 10 county-level cities, 55 counties and 11 autonomous counties, Guiyang is the center of the province's politics, economy and culture. Zunyi, Liupanshui, Anshun, Duyun are the major cities in the province.

According to the fifth National Census Bulletin, Guizhou province's total population is 37.55 million. The population growth rate is 14.26‰. Guizhou is also a ethnic diversity province, The province a total of 49 ethnic groups, In addition to Han, there are 13.339 million minority nationality in Guizhou province.

Distribution of the population in all regions in the table-1

Table-1 Distribution of the population in all regions

prefecture	population(thousand)	area(square kilometer)
Guiyang	370	8032
Zunyi	684	30762
Liupanshui	270	9914
Anshun	/	9246
Tongren	/	18999

Source: *Guizhou province report 2008*

3.1.2 Resource distribution

GuiZhou Province abounds in the natural resources, characterized by the myriads of categories, widespread distribution, richness in the reserves and high value, in particular, the exceptionally rich resources in energy resources, mineral resources as well as the biological resources, which makes GuiZhou account for an conspicuously important position in the nationwide.

(1) Energy resources

Water energy resources and coal energy resources are the main sources of energy in Guizhou province. The water energy resources in GuiZhou province rank the sixth in the richness ranking of water energy resources of China nationwide. Besides, the water resources in GuiZhou province ranks third nationwide with a water energy resource reserve of 106 kilo-watt per square kilometer. Moreover, the developable water resources in Guizhou province ranks seventh nationwide in China with 16,833,000 kilowatt accounting for 4.4% of the total volume in China.

In addition to the rich water resources in GuiZhou province, coal energy resources are another one major resources of building up the regional energy resources. Guizhou province, is nicknamed as the capital of coal in southern China noted for abundant coal resources ranking fifth in the nationwide with the verified deposits of 52.8 billion tons and the recoverable deposits of 53.097 billion tons. Coal reserve for coking in Guizhou province, with some10 billion tons, accounts for 21.8 % of the total coking coal reserve in China, which is the major place of production of coking coal for the large-scale smelter enterprises in Guizhou province, YunNan province, HuNan province, GuangXi province as well as GuangDong province and the so on. And in addition, there are some 40 billion tons of coal resources for non-coking in Guizhou province, which serves as the major coal resources for the use by chemical industries, civil use and use of motive power within Guizhou province and the surrounding provinces and regions. Take for instance, Liu Pan shui coal field is the main base of coal for coking in the southern part of the Yangtze River; ZhiNai coal field is the largest blind coal base in the southern part of the Yangtze River. And moreover, the coal bed abounds in the rich coal bed methane resources here and there. The resource of coal bed methane in the whole Guizhou province lines in the front bank nationwide with its total volume of coal bed methane 3151.1 billion cubic meters.

（2） Mineral Resources

GuiZhou province is one of the provinces rich in mineral resources in China, and there are above

110 categories of mineral products already found, among which 76 categories of mineral products

were already verified its reserves in varying degrees, and the recoverable deposits of 42 categories of mineral products rank in the tenth in China, and the categories of mineral products in the ranking from the first to the third nationwide in China are 22, among them the most abundant resources are just as the following ones: coal, phosphor, mercury, bauxite, manganese, antimony, gold, barite, pyrite, cement and the like.

Guizhou province is a province that abounds in mercury resources as well with recoverable deposits that occupies 38% of the total volume of the mercury resources in China. In addition, the proved reserves of antimony ore is about 492,000 tons in Guizhou province and the recoverable deposits of antimony ore ranks fourth with a 245,100 tons in the nationwide; And the other mineral resources that line in the front rank of the nationwide are sandstone for chemical purposes, sandstone for metallurgical purposes, dolerite for finishing hydrated lime, sandstone for brick and tile purposes and the like. For the time being, there are a couple of ferrous metals that have been already proved as well like iron, vanadium, titanium and the so on; and about 26 construction materials and other non-metalliferous minerals were proved as well; and moreover the found chemical minerals like pyrite, limestone for calcium carbide purpose, dolomite, silica sand, arsenic are also occupy an important position in mineral resources in the nationwide. Rare and dispersed elements are columbium, tantalum, germanium, gallium, indium, nickel, rhenium, selenium; heavy rare earths metal ore are also found there in GuiZhou province.

3.1.3 Overview of the coal mine resources

Gui Zhou province is located at the east part of the YunNan-GuiZhou Plateau. The coal bearing formation that covers an area of some 70,000 square kilometers are widespread in the whole Gui zhou province and accounts for 40% or so of the whole area in Gui zhou province, and the area of coal bearing formation was divided into 20 coal fields in Gui zhou province. There a comparatively higher reliability in the geological stratum along the west part and the middle part at Gui zhou province and the railway lines. Until the end of the year 1993, the recoverable deposits of the coal in the whole Guizhou province is：49, 830, 170, 000 tons. The reserve forecasting (based on the reliable source) is around 86.4 billion tons.

(1) Structural attitude

GuiZhou province is situated at composite position between the southern part of the third belt of folded strata and zone of subsidence as well as Nanling mountain filling-wise tectonic zone in the neo-cathaysian tectonic system, and fold and fracture is both comparatively developed and grown. The coal bearing formation in the upper Permian series is the important coal bearing formation within the boundary of Guizhou province, and its deposition and growth are conspicuously influenced by the following sets of the tectonic zones: The growth in the meridional stratum of the east-west tectonic zone that is widespread from Na Yong to Huang Ping is different. The meridional tectonic system is widespread in the areas, in particular, the area like Zun Yi, Gui Yang and Luo Dian, the tectonic belt in the middle of Guizhou province. The coal layer in the Cathaysian and Neocathaysian tectonic system are both comparatively grown and widespread in the east part of Guizhou province, which have a great influence on each coal field. The north-westward tectonic zone is mainly widespread at WangMo area, the water city in the west part of Guizhou province. The north-westward complex fold and fracture have a great impact on the growth and remoulding of the coal field located in the west of Guizhou province, thus with its impact there is a drastic difference in terms of coal bearing formation and coal bearing property between the southern part and northern part of the coal field at the water city. The minor fault at each coal field is relatively grown and the structure of coal field tends to be more complex due to the influence of mutual incision, combination as well as remoulding between a few sets of tectonic zones (systems).

The table 2 is the coal resources reserves table

Table 2 Coal resources reserves

Diggings	Reserves (thousand ton)							Reserve forecasting (billion ton)			
	Total	Producing	Yet to use	Prospecting				Total	Shallowe-r than 300 meter	300 - 600	600 - 1000
				Estimate	Sift	General survey	Roughly prospect				
Total	49830170	4206310	6594020	39029840	6339720	3191710	29498410	86.4	7.8	31.7	46.9
Liupansh	1468	331278	408296	7286730	360589	764440	2916400	39.9	3.2	15.2	21.5

ui	2470	0	0		0						
Xingyi	1707440	/	/	1707440	/	4770	1702670	4.9	/	1	3.9
Zhina	17190510	151600	2222320	14816590	2433930	1339000	11043660	25.2	1.8	10.2	13.2
Guiyang	495870	281290	3010	211570	10830	96510	6760	2.8	0.8	1	1
Northwest of Guizhou	/	/	/	/	/	/	/	0.1	0.1	/	/
North of Guizhou	15165340	351240	154690	14659410	34140	865140	13760140	12.2	1.4	3.8	7
Northeast of Gzuihou	69120	23670	/	45450	1550	31190	12710	/	/	/	/
Southeast of Guizhou	519420	85730	131040	302650	155920	90660	56070	1.3	0.5	0.5	0.3
North of Guizhou	/	/	/	/	/	/	/	/	/	/	/

Source: http://gzshmy.cn/pages/Page_Info.aspx?News_Id=1237

(2) Overview

Gui Zhou province is located at the east part of the YunNan-GuiZhou Plateau. The geographic coordinates of Gui zhou province, covering an area of 170,000 square kilometers, is located at 104°-109° east longitude and 25°-29° north latitude. The physical features in the whole Gui zhou province, which are made up by the Wu Meng Mountain, Da Lou Mountain, Miao Ling, Wu Ling Mountain as well as Wu Ling Mountain, are from the high in the west part downward to the east. And there are two major valleys: Wu Jiang valley and Bei Pan Jiang Valley, which are respectively belonging to the Yangtze River valley and Pearl River valley that respectively belong to the Yangtze River water system and Pearl River water system. And there are four rail lines which is named Yunnan-Guizhou, Sichuan-Guizhou, Guizhou-Guangxi and the like and the road that connects the surrounding provinces, counties and communes, centering around GuiYang. The coal bearing formation that covers an area of some 70,000 square kilometers are widespread in the whole Gui zhou province and accounts for 40% or so of the whole area in Gui zhou province, and the area of coal bearing formation was divided into 20 coal fields in Gui zhou province. There a comparatively higher reliability in the geological stratum along the west part and the middle part at Gui zhou province and the railway lines. Until the end of the year 1993, the recoverable deposits of the coal in the whole Guizhou province is：49, 830, 170, 000 tons. The reserve forecasting (based on the reliable source) is around 86.4 billion tons.

(3) Characteristics of the coal bearing formation

The ultra anthracite stratum in the lower Paleozoic erathem: it has the sinian system, the Cambrian system, the Ordovician system as well as the Silurian System; among which the NiuTiTang Group in the Cambrian system is the dominating one. It is distributed in the areas like the northern part of Guizhou province, northeastern part of Guizhou province and southeastern part of Guizhou province with the total depth ranging from 26 meters to 313 meters averaging to be some 170 meters. The depth of the coal bearing formation is some 10 to 20 meters with the calorific value of 400 to 800 calorie per gram, and several reach as high as 3,000 calorie per gram. And most often, the dispersed radioactive elements will come into being such as the phosphatic rock, vanadium, titanium, molybdenum, nickel, uranium and the like.

DaTang group in the lower coal measures series: The total depth ranges from 19 meters to 992 meters with an average depth of 200 to 500 meters. It is mainly distributed in the areas of the northwestern part of GuiZhou province such as WeiNing, BiJie, NaiYong and the areas of the southeastern part of GuiZhou province such as GuiDing, LongLi, DuYun and LiBo. And it is made up of the shale, the arenaceous shale and quartz sandstone coal. What is worthy to be mentioned is the good growth of the coal seam at the places like WeiNing, LiBo, DuYun and the like. The coal bearing formation ranges from layer 1 to layer 10, among which the minable is layer 1 to layer 2 with a depth ranging from 1.2 meters to 1.5 meters. Coal type: thick coal—anthracite。

Liang Shan group in the lower Permian series: The other area, except the deficiency in the area of the northeastern part of Guizhou province, is the widespread sedimentation. The total depth ranges from 0 to some 300 meters. It is the littoral facies sedimentation made up of the mud stone, the siltstone, the quartz sandstone, the limestone and the coal bed. The growth of the coal bearing formation tends to be better in the areas located in the west of Guizhou province like ShuiCheng and BiJie as well as the southeastern part of Guizhou province like Kaili, Congjiang, LiPing and the so on. The average depth of stratum is around 10 to 50 meters and the coal bearing formation ranges from layer 0 to layer 7, and generally speaking there is one layer of coal that can be minable with a depth ranging from 0.63 meter to 1 meter, and moreover the coal seam assumes to be transparent and shape of pearls. It is the gas coal—anthracite。

Long Tan group and Chang Xing Group in the upper Permian series: The total depth ranges from 53 meters to 852 meters, with an average depth of 213 meter (Xiuwen County) to 439 meters (GeMuDi). The coal bearing formation is a set of the clastic rocks, the limestone as well as the coal seam that are widely distributed in the whole areas except the southeast corner of Guizhou province. The depth from the north to the south is just as the followed: 113 meters deep at Tongzhi, 229 meters deep at Xi Feng, 320meter deep at GuiYang，852 meters deep at Zhi Yun，332 meters deep at Ce Xiang, which presents the change ranging from thin to thick to thin. And there are three phase area from the west to the east without apparent orderliness in terms of the depth change. And the coal bearing layers range from layer 0 to layer 60, generally speaking, the minable coal layer is from layer one（TianZhu）to layer forty one（GeMuDi）with the depth of the coal ranging from 0.5 meter—34.1 meter.

3.1.2.1 Details about coal mine in Guizhou province

(1) Transitional phase field：It is distributed at the west of Bi Jie, ShuiCheng, Pan Xian County, it mainly contains the clastic rocks sedimentation with few marlite and lentoid siderite rock. Generally speaking, it has 40 to 50 coal layers with ten minable layers which are mainly distributed in upper top layer of the coal group with its depth of 5.16 meters to 32 meters. Coal property: medium grey, low sulfur-medium sulfur. Coal type: gas coal-anthracite.

(2) Ocean-land interaction phase area: It is situated in the east of the transitional phase field, west of the area covering Tongzhi, Guiyang and Xingren. It is made up of the clastic rocks, the limestone as well as the coal seam, and the layers and depth of the limestone increase by degrees from the west to the east. In addition, the depth of the coal-seam group and the layers of the coal seam varies significantly from one another, and the average depth of the coal-seam group is around 360 meters with coals lying at 8 to 32 layer and the average minable layer is around 6 with a depth of some 12 meters. Its main content is medium ash, medium to high-sulphur coal. And the blind coal dominates the contents and soft coal account for a small part of the whole content.

(3) Sea phase area: The area in the east of the area covering Tongzhi, GuiYang, Xingren, gradually transition to Wu Jia ping group west-eastward, and limestone dominates the content which still have a few other contents like the clastic rocks and coal seam. There are coal bearing formation ranging from one layers to certain layers, but there is only one minable layer with a depth of one meter. The content is medium ash, high sulphur coal. Coal type：rich—lean coal.

(4) Er qiao group, Upper Triassic series：The total depth is 70 to1460 meters，distributed in the northern part of Guizhou province, North-western part of Guizhou province as well as GuiYang area. It is divided into Zhen Feng type and Lang Dai type.

(5) Zhen Feng type: The coal is mainly made up of the clastic rock while containing a small amount of limestone and marlite, among them it contains the coal from 2 to 80 layers, among which 0-4 layer can be minale with a depth of 0 to 5 meters. And the coal contains ash content, rich in high sulphur and the gas originates from the fat coal. The depth of coal at XieBen group, Dragonhead mountain is as high as 1,389 meters with 22 coal layers, among which the 5-meter-thick four layers is minable.

(6) Lang Dai type: Clastic rock containing shed coal, flimsy coal, black batt， and generally speaking there is no minable seam. The depth of the coal layer at Lang Dai township, Liuji special zone is 334 meters.

WengShao group in the Neogene system：the conservation of the coal layer is not complete with an visible depth of 60 to 212 meters, which is distributed at the places like WengShao of Xuan Bing area, PingGuan of Pan County, ShuiZhong of WeiNing area and the like, and the continental facies are the sedimentary facies of coal-bearing series with wood coal from layer 1 to 11, among which the layer 1 to 8 is minable with the deepest depth reaches as high as some 30 meters. In addition, the content of ashes is 39.91 and sulfur content accounts for 3.21%[1].

3.1.3.2 Structural feature

GuiZhou province is situated at composite position between the southern part of the third belt of folded strata and zone of subsidence as well as Nanling mountain filling-wise tectonic zone in the neo-cathaysian tectonic system, and fold and fracture is both comparatively developed and grown. The coal bearing formation in the upper Permian series is the important coal bearing formation within the boundary of Guizhou province, and its deposition and growth are conspicuously influenced by the following sets of the tectonic zones: The growth in the meridional stratum of the

[1] Source: http://www.hnxydj.gov.cn/show.aspx?id=2333&cid=17

east-west tectonic zone that is widespread from Na Yong to Huang Ping is different. The meridional tectonic system is widespread in the areas, in particular, the area like Zun Yi, Gui Yang and Luo Dian, the tectonic belt in the middle of Guizhou province. The coal layer in the Cathaysian and Neocathaysian tectonic system are both comparatively grown and widespread in the east part of Guizhou province, which have a great influence on each coal field. The north-westward tectonic zone is mainly widespread at WangMo area, the water city in the west part of Guizhou province. The north-westward complex fold and fracture have a great impact on the growth and remoulding of the coal field located in the west of Guizhou province, thus with its impact there is a drastic difference in terms of coal bearing formation and coal bearing property between the southern part and northern part of the coal field at the water city. The minor fault at each coal field is relatively grown and the structure of coal field tends to be more complex due to the influence of mutual incision, combination as well as remoulding between a few sets of tectonic zones (systems).

3.1.4 Situation of logistics

Guizhou province is an economically underdeveloped area. Logistics cost in the proportion of GDP is high, far higher than the national average level of 16.7%. This Constraint has become one of problem about the province's economic development strategy. Provincial government made strengthen industrial strategy, in particular implementing the western development strategy, Become the province's new hot spot for economic development, This is undoubtedly to the logistics industry in Guizhou has provided a new opportunity. But we can see that Guizhou province is undeveloped in policy, the understanding of logistics concept, management, establishment, technology and economical support. So, how to develop the logistics in Guizhou province by catching the opportunity which called western development strategy is the key problem should be considered by local government.

Guizhou province is the province which full of nature resources, but the logistics were restricted by the low urbanization development. This province lack of technology, logistics establishment and professional to advance the logistics. And in Guizhou province, there are many main railway and express way have been built up.

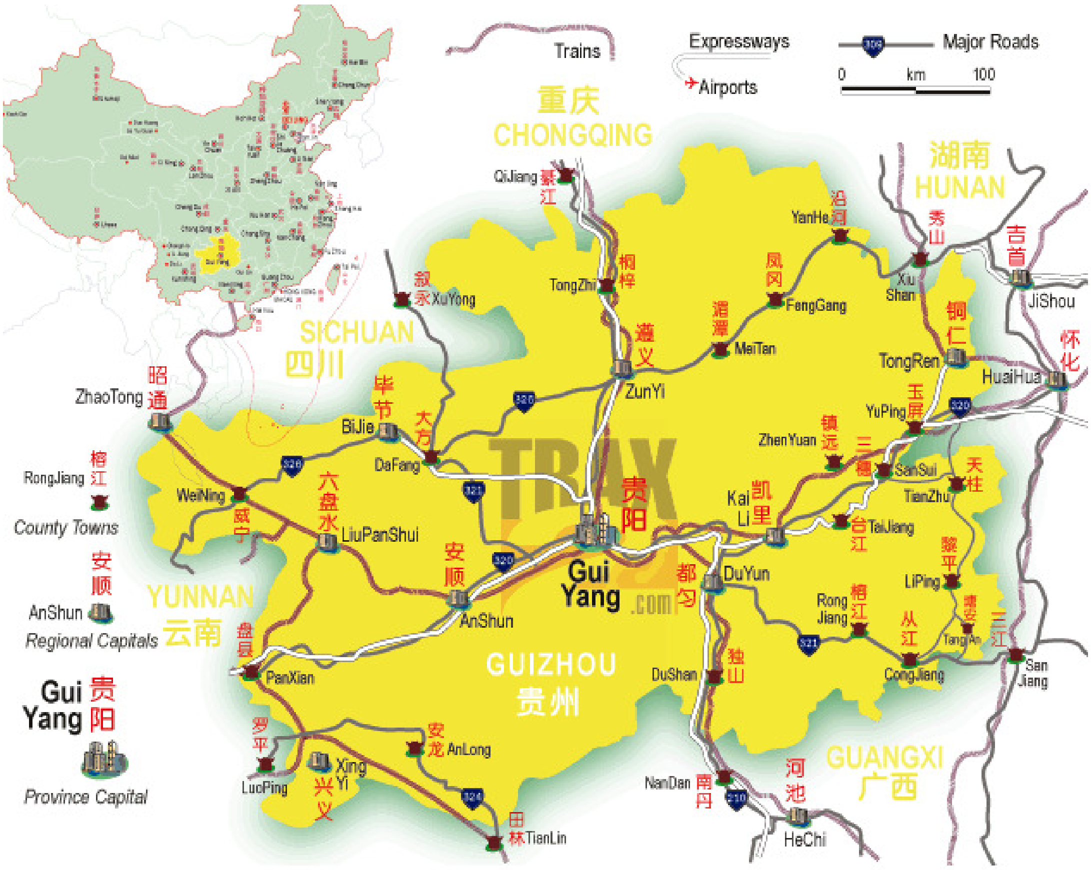

Figure 3.2 Traffic map of Guizhou province

Source: http://www.zhongguolu.com/guizhou/

Guizhou province is an important industry base in China, and the western development strategy which public by central government may boost the professional and establishment import. The result is the logistics development.

We have to say that Guizhou province only the basic knowledge about the modern logistics. Due to this reason, company and government didn’t pay enough attention on this area, there is still a long distance from high profit and win-win result. As the investigation report mentioned, there is no one logistics company of the real meaning in Guizhou province. But this kind of situation could be a good chance to empirical absorption; we can get a good time to develop the logistics industry in Guizhou province.

Build a good logistics network is the best way to promote the logistics in Guizhou province. In the logistics network, logistics center plays an important role. For example, cargo turn over, sorting, store and machining in logistics center. In logistics enter, people may increase the value added about the cargo, and overcome the barriers in transport which coursed by time and space.

3.1.5 Coal logistics situation in Guizhou province

A big share of coal transportation in Guizhou depend on the railway transport due to this province is an interior province. As the last section mentioned, the logistics industry in Guizhou province is an undeveloped industry.

There is no professional logistics enterprise in Guizhou so far is the key factor which impact the coal logistics develop in Guizhou province. We can get the information that most of the coal transportation doesn't have a logistics plan. Buyers have to consume the plan for the railway wagon and find the truck to transit the coal to the strategy loading point from the producing area. In this situation, we can find that buyer have to pay heavy money to buy the plan and find the truck by heself. This is why Guizhou logistics network still draggle while with such a good nature resources.

At the same time, author want to give another example to explain the logistics situation in Guizhou province. In 2008, one of the most serious snowstorm broke out in the south of China. Guizhou faced terrible transport situation. Most of the express way and railway was cut off. In this winter, citizens in Guizhou have to face the cold, at the same time is long-term power failure and cut off the water supply due to the power house lack of coal. Because of the medieval logistics concept, there are only a few stocks in the power plant ware house. Now, local government realize the importance for the safety stock. But there is no plan for the coal logistics center in Guizhou province which is the most efficiency way to prepare the coal resources.

3.2 Qualitative analysis about the main city in Guizhou province

3.2.1 Guiyang

Guiyang is the capital of the Guizhou province. The area of the Guiyang city is about 8032 square kilometers. Furthermore, there are 3.7 million people live in this city, include the Han nationality, the Miao nationality and Dong nationality and so on. Nanming district, Yunyan district, Huaxi district, Wudang district, Xiuwen county, Kaiyang county, Xifeng county and the Qingzhen municipality is the venue of Guiyang city. The cantonal area is more the 70 square kilometers, the population is 1.4 million.

Guiyang is the important traffic hub in the southwest of China. There are 4 railroad start from Guiyang city, and 3 of them are electric railway.

Guiyang railway station is the hub of the cargo railway transportation. This railway station is the biggest distribution center in Guizhou province, and this is the most important marshalling station in the southwest of China. This railway station should marshal 8 thousand trains in one day when it was designed. There is a international container yard was built in this railway station which could handle 400 thousand ton cargo per year. At the same time, Guiyang railway station is the tourism distribution center in Guizhou, which may depart 50 trains per day.

Guiyang is the highway traffic center in Guizhou province, which was got though by 8 main highways, the No.321 national highway and the No. 210 national highway are the important highway for Guiyang city. The traffic net was built based on the center which in the urban covered about 1800 kilometers around Guizhou province. The maximum scale cloverleaf junction in the southwest of China so far is belong

Guiyang which named Huaguoyuan cloverleaf junction. Urban per capita car ownership is amongst the top in the country.

An airport was built in urban which opened 26 air routes to the main city in China. For example, Beijing, Shanghai, Chengdu, Guangzhou, Kunming, Chongqing and Hong Kong. When the modern airport was built in 1997, some international flights were opened. The air transport capacity dramatically increased.

The whole city was covered by the analog, digital mobile phone system, the wireless paging system and the exchange of data communication net system. The express mail service may reach over 200 countries and regions.

Guiyang city is an emerging industrial city. As one of the important bases in southwest of China, which get considerable scale and modernization. Now, Guiyang have been built to food, machinery, chemical industry, metallurgy, electronics, textile, building materials mainly of 14 industrial sectors, 65 categories of comprehensive industrial system. The main industrial products are aluminum, steel chisel, grinder, yellow phosphorus, construction machinery and equipment, power machine, instruments and meters, cutting tool, auto parts, cigarette and Chinese patent medicine. Those products are place top of the same type products. The aluminum industry in Guiyang is the largest production base in China; and the scale of abrading agent production base is the largest in Asia; Guiyang is one of the most important roles in defense industry and the leader of the electronics industry in the western China.[2]

3.2.2 Zunyi

Zunyi in the north of Guizhou province, where on the north side of Guiyang, the west side of Zunyi border the Sichuan province and south side close to the Chongqing. This is a historical and cultural city. Also, Zunyi is a comparatively developed region

[2] Source: http://baike.baidu.com/view/22904.htm

in Guizhou province. Zunyi city located on the main road between Guizhou province and Sichuan province. Zunyi city is away from the Chongqing about 320 kilometers, and the distance between Zunyi and Guiyang is 142 kilometers, Zunyi is 1000 kilometers from the estuary which named Beihai city. Due to the important position about Zunyi, I would like to introduce the traffic condition about this region. The traffic situation for Zunyi city is quite good, the Sichuan-Guizhou railway runs through the whole territory of the Zunyi city; and the waterway should reach the Yangtse River which is the most important river in China; and there are two highway lead people in Zunyi city to Chongqing and Guiyang. Xinzhou and Longping are airports that increased the air transport capacity.

Zunyi is the place which rich in nonferrous mineral resource. To detail them, manganese, hydrargyrum, lead, uranium and other 60 kinds of mineral were distributed in 7 main deposits. There are about 20 thousand ton manganese, 122 million lead and 172 million ton pyrite were found in Zunyi. Besides, Zunyi is rich in dolomite, kaoline, clay, barite and fluorite.

Zunyi city is the second largest city in Guizhou province, which accounted for more than a quarter of Guizhou province in economic volume. The gross domestic product in 2007 was 25 billion yuan; the total financial revenue was 2.62 billion yuan.[3]

3.2.3 Liupanshui

Liupanshui city locate in the western part of Guizhou province. The city covers an area of 9914 square kilometers, the urban covers area of 35.1 square kilometers and the population is about 2.7 million.

Coal and iron distributed in Liupanshui is both in large quantity and good quality. Liupanshui is the biggest coal base in south of China, and is the most important

[3] Source: http://baike.baidu.com/view/23633.htm

energy base and raw material product base in Guizhou province.

In recent years, the gross domestic product from Liupanshui increased 9.1% every year and achieved the target which gross domestic product per capita to quadruple in 1990. The grain output reached 706 thousand ton, actualized the food self-sufficiency for rural population in basic historic leap. The economic structure has been optimized due to the primary, secondary and tertiary industry accounted for the more proportion of gross domestic product. The proportion now is 16.5: 53.9: 29.6. The internal structure of the industry to gradually become more reasonable.[4]

[4] Source: http://baike.baidu.com/view/25384.htm

CHAPTER 4 Analyzing the Nonlinear Programming Based on Guizhou

4.1 Basic introduction about this model:

For the time being, the model and method of the operational research is commonly applied to the quantitative model on site selection of the relevant logistics center, which contains two kinds: one is the continuous type and the other is the discrete type, and just as stated at node 1.2, the site selection in the continuous type mainly includes the gravity model approach, the method of Capacitated Facility Location Problem (CFLP) for the site selection in the discrete type, Baumol-Wolfe method, the mixed-integer programming and so on. We can get to know from the node 1.2 that the above-mentioned several quantitative models have their own advantages and disadvantages, different application conditions as well as different scope of application, but they share one common point, that is, the above-mentioned models are in general only focusing on how to minimize the logistics expenses of the enterprises instead of taking into consideration the differential income which resulted from difference in the site selection of logistics center. As a matter of fact, the volume of logistics brought about and the economic results produced both varies hinging on the differences in the site selection of the logistics center. And in the meantime, with the gradual consummation of the functions at the logistics center, the customers can be offered more and more services and the gap of disparities in terms of economic effects as a result of the difference in the site selection of the logistics centers will be increasingly striking with each passing day. Therefore, the combination of the cost factors and the factors of the economic effects were taken into full account for the site selection of the establishment of the logistics center in this essay, and moreover owing to the non-convexity of warehouse charges function in this model then this model belongs to non-linear planning problem, and in the meantime there is myriads of variables, constraint conditions, thus the polynomial solution algorithmic is excluded and the general method is hard for the solution. And the genetic algorithm is applied for solution in the essay.

4.2 Model building

4.2.1 The basic supposition of the model building

① The enterprise can forecast the number of customers, the quantity demanded by the customers in certain areas.

② Linear function of transport expenses, average transport volume as well as the distance from the freight supply point to the logistics center, and then from the logistics center to the customers.

③ Warehouse charges at the logistics center are the concave function of its cargo flow.

④ The number of logistics centers available for selection can be initially defined and the site of the new logistics center is only chosen from the sites available for selection.

⑤ Different transport means are not taken into consideration.

⑥ The demand of the customers is summed up in accordance with the areas.

4.2.2 The major factors that need to be taken into account in the model building

The site selection of the logistics center is affected by a couple of factors, but the quantitative factors are only taken into account while establishing the quantitative model. Under normal circumstances, the quantitative factors mainly include:

① Incomes resulted from the logistics, which includes the proceeds that can be gained from the basic services such as the transport, the storage of cargoes and so on.

② Transport cost, which includes the transport cost resulted from the supply site to the logistics center as well as the transport cost resulted from the logistics center to the demanding parties.

③ Inventory cost. In addition to the inventory cost, the inventory expenses are the major factor that affects the cost at the logistics center.

④ Initial investment cost and management cost, which includes the construction investment of the logistics centers, purchase of the equipments and the management expenses (water, electricity, personnel, etc) and so on.

⑤ Number of the logistics centers. In accordance with the relevant research, the relationship between the number of the logistics centers and transport cost as well as operational cost (including the inventory cost and initial investment cost as well as the administration cost) can be denoted in Chart 3-1:

It can be seen from the chart that: the concave downward curve refers to the transport cost, which lowers with the increase in the number of the logistics centers; while the operational cost increases with the degressive velocity as addition in the number of the logistics centers. The total cost will increase first then decrease later with the addition in the number of the logistics centers, therefore, that is to say, we can see that the more the number of the logistics centers doesn't follow that it will be beneficial.

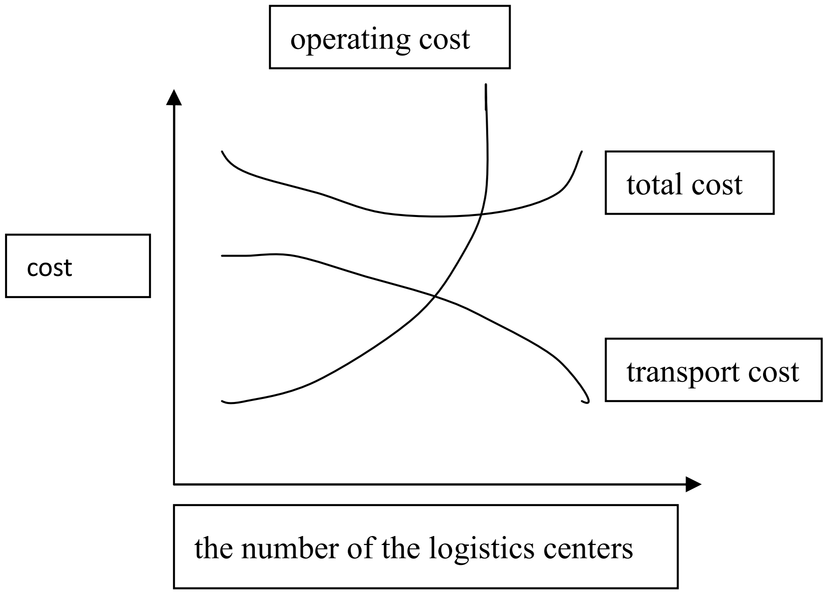

Figure 4.1 Chart of relationship between the number of the logistics centers and the costs

Source: *Models for Logistics Center Address*

⑥ Sites available for selection

While laying out the logistics center, we cannot choose the site at random but select a few sites from limited number of sites available for option due to the limit on the land use and so on. But, site selection for the logistics center in a scientific and reasonable way tends to be more critical with an aim to cater to the need of better operation and effectively offering service to the market after the construction of the logistics center.

4.2.3 Model building

Let us suppose that there a total of i production bases at the enterprise i=1, 2,…,m, and through the collection and straightening out of the data, there are initially j logistics center points available for selection j= 1, 2,…,n, and the customer serviced by the enterprise is divided into k area k=1,2,..l. Namely, we just suppose that there are k customers.

① Selection of the variables

There are a total of three kinds of variables selected in the model of the established model in this essay:

Zj is the integer variables between 0 and1 and there is a total number j of integer variables, which respectively denotes that there is number j of the logistics center points available for selection, and the selection of the proposals in accordance with its different dereferencing, to be more exact, if the Zj is taken as 0, then it indicates that the site available for selection is not chosen, if the Zj is taken as 1, then it indicates that the site available for selection is chosen.

Xij expresses the amount of traffic from the production factory i to the logistics center j, Xjk expresses the amount of traffic from the logistics center j to the customer k.

Uj expresses the flow at the logistics center numbered j through the variables.

② Definition of the target function

The gravity model approach, Baumol-Wolfe method and the like, which are the target functions on the basis of the cost expenses, and the critical defects of this model lies in the mere consideration of the expense issues and the overlook of the problem that return is reduced because of the downsizing of the scale and the decline in the service quality resulted from the shrinking of the expenses. The combination of the cost factors and the return factors were taken into full consideration in this essay, to be more exact, the cost factor not only includes transport cost but also includes the storage cost, from which the target function we can get is just presented as the model (1). Owing to that warehousing cost is the concave function of the flow at the logistics center, so this model is a non-linear planning problem:

$$\max f(x_{ij}, x_{jk}, z_j, U_j) = \sum_{j=1}^{n}\sum_{i=1}^{m} z_j(a_{ij} - c_{ij})x_{ij} + \sum_{j=1}^{n}\sum_{k=1}^{l} z_j(b_{jk} - d_{jk})x_{jk} - \sum_{j=1}^{n} z_j v(U_j)^{\theta} - \sum_{j=1}^{n} z_j(f_j + g_j)$$

(1)

ay expresses the rate of return that can be attained resulting from the processing and transport as well as storage service from the logistics center i to the production factory j

bik expresses the rate of return that can be attained resulting from the basic services like transport, loading and unloading, packing of the cargoes that will be transported to the customer k by the logistics center i

cij respectively expresses the transport expenses per unit from the freight source point to the logistics center

dik expresses the transport expenses per unit from the logistics centre THIS PAPERto the customer k.

v(Uj) expresses storage expenses at the logistics center j, which is the concave function of the flow, 0 is in general taken as 0.5.

fj expresses initial investment expenses at logistics center j.

gj expresses the daily operation cost at logistics center j.

③Analysis into the constraint conditions

A. supply and demand relationship

The summation of the issued quantity of goods to each logistics center by each production factory cannot exceed the quantity available for supply by each production factory.

$$\sum_{j=1}^{n} x_{ij} \leq A_j (2)$$

The demand of every customer must be met, namely, there does not exist the out-of-stock phenomenon

$$\sum_{j=1}^{n} x_{jk} \leq B_k (3)$$

Among them:

Ai is the quantity available for supply by the freight source point.

Bk denotes the maximum quantity demanded by the customers.

B. flow equilibrium

The summation of the purchase quantity from each factory by every logistics center equals the summation of the issued quantity of goods to the customers by the logistics centers, and equals the flow at the logistics center.

$$\sum_{j=1}^{m} x_{ij} = \sum_{k=1}^{l} x_{jk} (4)$$

$$\sum_{j=1}^{m} x_{ij} = z_j U_j (5)$$

C. Volume limit

The flow at each logistics center cannot exceed its maximum volume

$$z_j U_j \le z_j S_j (6)$$

among which:

Sj expresses the largest volume at the logistics center numbered j

D. asset limit

The initial investment cost of the logistics center cannot exceed the limitation on its total investment

$$\sum_{j=1}^{n} z_j f_j \le Q (7)$$

Q shows the limitation on its total investment at the logistics center

E. number limit

The number of logistics center selected from the alternative sites cannot exceed the number

$$\sum_{j=1}^{n} z_j \le P (8)$$

among which:

P expresses the largest number of the logistics centers established

F. nonnegative restriction

$$x_{ij}, x_{jk} \ge 0, U_j \ge 0$$

In summary, the model of site selection of the logistics centers established is just as followed:

$$\max f(x_{ij}, x_{jk}, z_j, U_j) = \sum_{j=1}^{n}\sum_{i=1}^{m} z_j (a_{ij} - c_{ij}) x_{ij} + \sum_{j=1}^{n}\sum_{k=1}^{l} z_j (b_{jk} - d_{jk}) x_{jk} - \sum_{j=1}^{n} z_j v (U_j)^{\theta} - \sum_{j=1}^{n} z_j (f_j + g_j)$$

s.t

$$\sum_{j=1}^{n} x_{ij} \le A_i, i = 1,2,...,m$$

$$\sum_{j=1}^{n} x_{jk} \ge B_k, k = 1,2,...,l$$

$$\sum_{i=1}^{m} x_{ij} = \sum_{k=1}^{l} x_{jk}, j = 1,2,...,n$$

$$\sum_{i=1}^{m} x_{ij} = z_j U_j, j = 1,2,...,n$$

formula 3-1

$$\sum_{i=1}^{m} z_j f_j \le Q, j = 1,2,...,n$$

$$\sum_{i=1}^{m} z_j \le P, j = 1,2,...,n$$

$$z_j U_j \le z_j S_j, j = 1,2,...,n$$

The model is the nonlinear planning model with mixed integer for the model contains the concave function. And we can see that the model has three kinds of variables through the analysis of the models above, namely, it has n×(m+l) variable x, n variable U as well as n variable z and m+l+7n+(m+l) ×n constraint conditions. With the addition in the number of the cargo supply points, alternative points for selection and customers, the complexity level of the solving process is increasing exponentially, which make it impossible to find a solution by means of the conventional arithmetic. So we have to use the genetic algorithm to conduct the calculation in this essay. The prominent characteristics of the genetic algorithm lie in that properties of the specific problems are not taken into consideration, for it is designed not for the solution of the specific kind of problems, but a complex simulation model with nonlinear phenomenon.

4.3 Logistics nodes

At first, this paper want to give a explanation about the logistics center alternatives are the strategic loading point. Because Guizhou province is a interior province, so the most transport depend on the rail way transportation. In this case, would like to choose tow or three strategic loading points to build the coal logistics center in Guizhou province.

4.3.1 Basic introduction about strategic loading point

How to make certain the position of the coal logistics center as well as the site selection of the coal logistics center within the specific area in accordance with the objective conditions, and the interests of the three parties which includes the consignors, decision-maker of the investment in the railway as well as the demanding parties were supposed to be taken into full account in accordance with the conditions of the organization of the rail car flows as well as the requirements of the economic benefits. The coal logistics center selected by the question, the total summation is minimized that includes the transport cost as a result of the cargoes transportation from the freight source point to a certain number of the demanding orientations through the hub freight yard, and the fixed investment as well as the variable cost of coal logistics center construction on the premises of catering to the needs of the rail car flows organizations. The structure of the site selection system includes three static factor layers, there are freight source supply layer, alternative layer for logistics center as well as the layer of cargo demanding parties respectively. The three static variable layers are respectively connected by the two dynamic transport cyberspaces. Let us suppose that freight source supply layer has m original places of freight source, and the decision-making body at the logistics center has n alternative points available for selection, and meanwhile each alternative point can link up one demanding orientation at the demanding layer.

4.3.2 Choosing logistics nodes

In this thesis, author choose 12 strategic loading point to be the logistics nodes. They are the Zun Yi, Liang Shuijing, Nan Muping, Ma Changping, Zha Zuo, Jiu Chang, Xia Tengqiao, Liu Panshu and Xin Pingba. These places locate on the main railway route, which may implode coal to the logistics center. And these places are choices to be the coal supply nodes in Guizhou province. And we can find the geographical position by watching the figure 5.1.

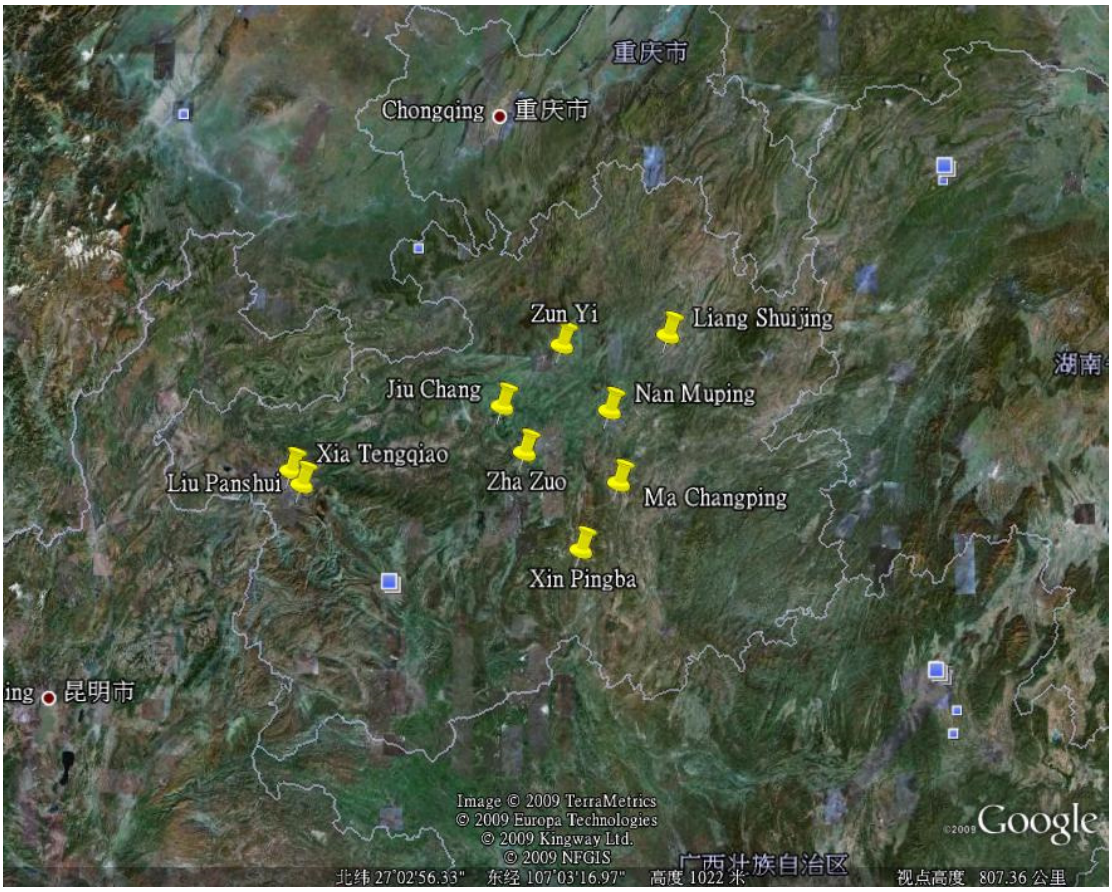

Figure 4.2 Map of the supply points in logistics network

Source: Google earth

As we mentioned, in the picture 4.2, these places are the supply nodes. In the figure 4.3, this paper would give the logistics center candidates. They are the Guiyang, Liupanshui, Zunyi, Fuquan and Anshun. Due to the convenience of transportation situation in these cities and the development of economic, thought they are the candidates.

Figure 4.3 Map of the candidates of logistics center

Source: Google earth

In the figure 4.4 and the figure 4.5, this paper illustrate the most important coal business partner with Guizhou province. They are the Jinchengjiang, Liuzhou, Laibin, Guigang, Nanning and Yubin in Guangxi province and Shunde and Zhongshan in Guangdong province in the picture 4.4. In the picture 4.5, they are the Zhuzhou and Xiangtan in Hunan province. In my model, they are the most important 10 points to deliver coal.

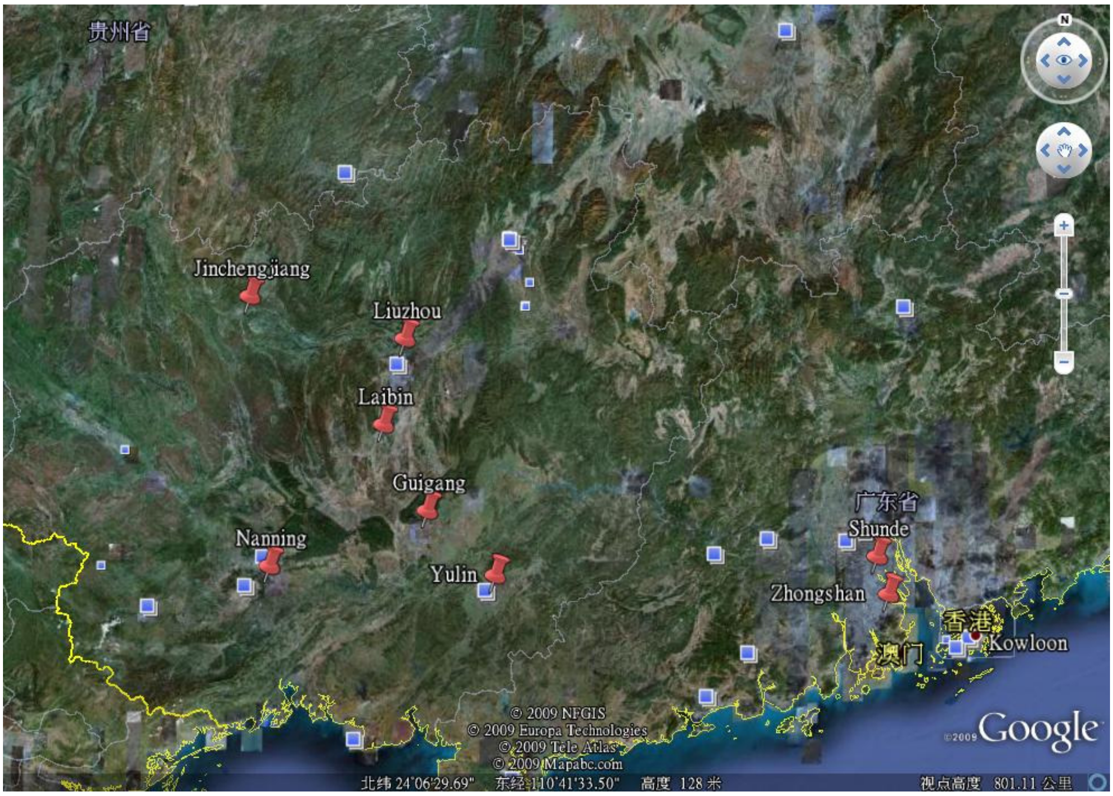

Figure 4.4 Map of the demanding points in Guangdong and Guangxi province

Source: Google earth

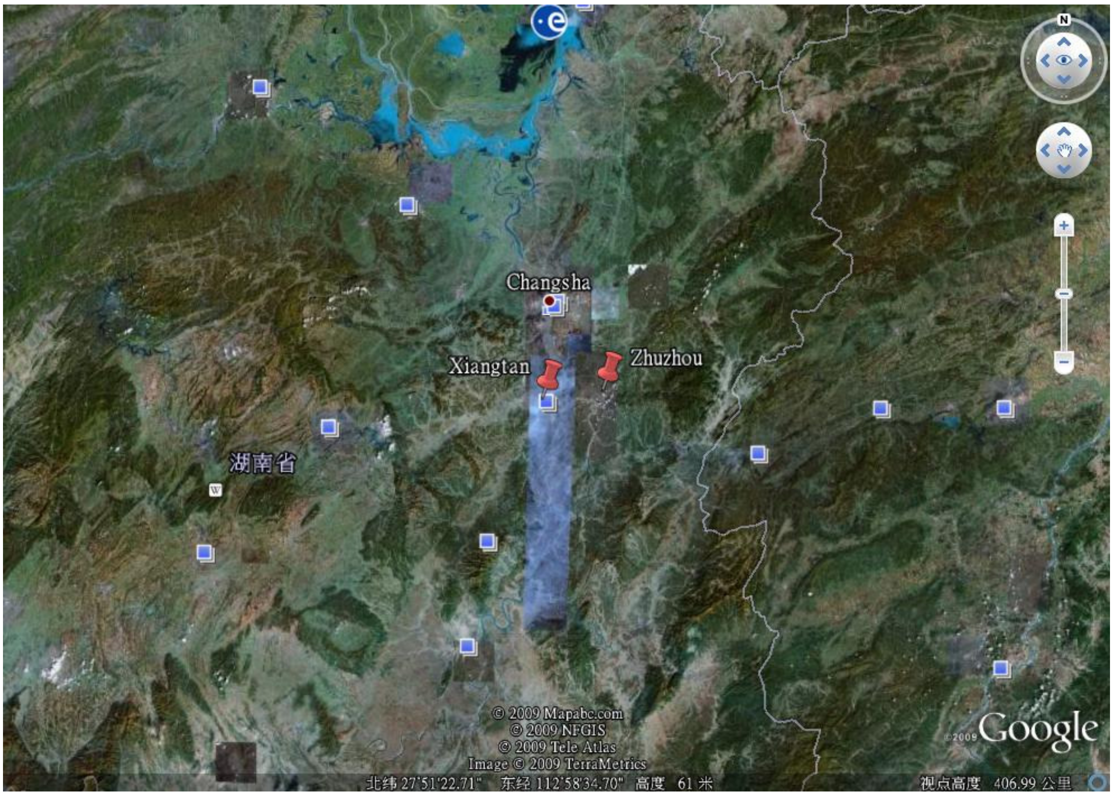

Figure 4.5 Map of the demanding points in Hunan province

Source: Google earth

4.4 Select parameter

We can get the information about what the variables mean in last chapter. And in this section, This dissertation would like to explain what these parameters are in Guizhou province.

As the last chapter mentioned, the mathematical expression about the nonlinear programming model is:

$$\max f(x_{ij}, x_{jk}, z_j, U_j) = \sum_{j=1}^{n}\sum_{i=1}^{m} z_j(a_{ij}-c_{ij})x_{ij} + \sum_{j=1}^{n}\sum_{k=1}^{l} z_j(b_{jk}-d_{jk})x_{jk} - \sum_{j=1}^{n} z_j v(U_j)^{\theta} - \sum_{j=1}^{n} z_j(f_j+g_j)$$

Formula. 1

In formula.1, we can define a_{ij} as the profit which logistics center gain by cargo spaces fee, management fee, clean fee, guard fee and extended service fee from the raw material producing area. Extended services include cargo tracking and business settle accounts.

Second, we can define b_{jk} as the profit which logistics center gain which by loading and unloading fee, transporting agency fee, measure proportion service fee and dehumidification fee.

c_{ij} and d_{lk} are the transporting fee rate. Due to the local State Administration Of Commodity Prices set the fixed price rate. So , we can lookup it in relevant regulations.

The topic of this thesis focus on the logistics center build in Guizhou province. This is a undeveloped province in China. At the same time, high-quality coal mine from Guizhou is a very important strategic resource, the flexibility of freight rate is low due to this condition. So, this paper would like to reasoning of the formula. This paper would give this part in next chapter.

CHAPTER 5 Model Solution in Guizhou

In last chapter, this paper made a basic introduction about the non-linear programming model. In this chapter, my mission is to build the model base on the truthful data. This paper will make use of this nonlinear programming to planning for the coal logistics center site selection in Guizhou province.

5.1 Model building

The selection of the Guizhou coal logistics center is mainly based on the long distance transportation mode of the bulk and primary cargoes, and the first optimal choice is the railway transport, and places like LiuPan shui, Zun Yi, GuiYang An Shun and Fu Quan were selected as the site for the building of the coal logistics center. In accordance with the practical circumstances of the rail transportation and production on the conditions of the supply-demand equilibrium, the site selection for the construction of the coal logistics center points, together with the proposal to build up the coal logistics center by means of the 0-1 nonlinear plan model with multiple points for site selection and mixture of multiple kinds of variables，and the expected attainment is to minimize the total social cost, take into full account the interests of the two parties that include decision-makers in the investment as well as the customers, and the expenses of site selection for the construction of coal logistics center, variable expenses as well as the transport cost that represents the interests of the customers are commonly brought into the target system. And then we are supposed to combine the transport requirements after the construction of the coal logistics center with the common character restraint of the relevant site selection models with an aim to form the constraint conditions, which makes it possible to conform to the characteristics of the coal logistics dispatching and then numerical example will be used to test and verify the model.

5.1.1 Analysis into the structure of site selection model

Basic hypothesis

The basic hypothesis of building the coal logistics center combined with the actual problems is just as the following:

During the period of observation and study the freight source supply and market demand are known, and moreover there is ample and abundant freight source volume within the scope of logistics center that has enough capability to meet the demand. If there is an imbalanced circumstance that supply is not adequate to the demand, then the virtual state of equilibrium can be reached in terms of supply and demand by means of the virtual freight supply points.

The alternative point that is not chosen for site of coal dispatching is not supposed to deal with the coal logistics service any longer, take for example, if Liu Pan shui is chosen the site for the coal logistics dispatching any more, then Zun Yi or Gui Yang will not be chosen as the site for the coal logistics dispatching any more.

Define the relevant parameter and decision-making variables

The relevant parameters involved in the model are just as followed: m, n, l are the freight source, alternative points of site and the number of freight demanding orientations respectively. Ak is the freight volume that freight source k can provide in the process of decision-making, and the unit: t, k=1,2 ,L ,m; Dj is the freight volume demanded at the demanding orientation j in the process of decision-making, and the unit is : t, j = 1,2, L, t; Ckj is the transport expenses from the freight source k to the loading point I, which is the defined expense coefficient in broad sense after taking into account the factors like the transport distance, the transport mode chosen (other transport mode besides the railway) as well as the local transport conditions, and the unit is: yuan / t, i=1,2, L, n; Cij is the transport expenses from the logistics center I to the place of demand j, and the unit is: yuan / t; Vi is the variable expenses from the logistics center i to the relevant workload, and the unit is yuan / t; Mi is the maximum of workload that can be dealt with under the normal conditions in the process of the decision-making at the logistics center, taking into consideration the factors such as the operation capability of loading, storage volume, air supply and passage between nodes and points and the capability to put on reserve, and the unit is: t. Bi is the investment of the alternative point I, which is defined in accordance with some factors such as the construction scale, geographical location and actual conditions and the like; R is the total investment planned, and the unit is ; yuan; The operational life span of the alternative point i being the logistics center is Ti.

The defined model decision-making variables: Xki is the freight volume from the freight source k to the planned construction point i in the process of decision-making, and the unit is :t; Yij is the freight volume from the planned construction point i to the demanding orientation j and the unit is : t; Zi is the 0-1 variable Zi= 1. i is chosen for the construction of logistics center 0 others.

5.1.2 Structure Model

On one hand, the site selection of the logistics center is aimed at covering the freight source supply area and expanding the market demand with maximum as possible as they can, and establish the point in accordance with the quantity demanded to make true the highly efficient and scaled work methods as well as the requirements of the non-stop transport by the whole rail; On the other hand, the general constraint factors for site selection of strategic loading points were supposed to be taken into consideration as well, which mainly includes freight source supply capability, work capability restraint, guarantee of demand, demand and supply of cargo flow as well as the balanced association with the nodes and points.

(1) Let us suppose that the freight source volume attracted is Ni in the process of

decision-making at the logistics center I, and unit: t, then the constraint conditions to meet the freight source volume attracted can be denoted as

(2) The cargo flow volume transported from the logistics center I to the demanding parties is supposed to reach the bench level of the transport by the whole rail at logistics center i. Let us suppose that the trailing weight of the whole rail with non-stop from departure at the logistics center i to the demanding party j is Wij; the coefficient of the whole rail with on-stop service is &ij. We suppose the step function is

then the constraint condition of the whole rail with non-stop departure is：

yij ⩾(yij) δ ij W ij

(3) The workload volume undertaken by the logistics center is supposed to be restraint by a series of relevant capabilities between points and nodes such as the cargoes loading and unloading capability, the dispatching level of the empty rails, and the cargo storage capability, namely

$$\sum_{k=1}^{m} x_{ki} \le z_i M_i \quad \forall_{i,j}$$

Constraint conditions of site selection are just as the followed:

$$\sum_{k=1}^{m} x_{ki} \le A_k \quad \forall k$$

freight source capability constraint；

$$\sum_{i=1}^{n} y_{ij} = \mathrm{D}_j \quad \forall_j$$

demand satisfaction constraint；

$$\sum_{k=1}^{m} x_{ki} = \sum_{j=1}^{l} y_{ij} \quad \forall_{i,j}$$

node balance constraint；

$$\sum_{i=1}^{n} z_i B_i \le R \quad \forall_{k,i,j}$$

total investment volume constraint；

xki , yij ⩾0 $\forall_{k,i,j}$

zi = 1 or 0 $\quad \forall k$

Model objective function is the minimization of the total cost of site selection system, namely

$$\min f = \sum_{k=1}^{m}\sum_{i=1}^{n} c_{ki} x_{ki} + \sum_{i=1}^{n}\sum_{j=1}^{l} c_{ij} y_{ij} + \sum_{i=1}^{n} z_i (B_i / T_i) + \sum_{i=1}^{n} z_i v_i (\sum_{k=1}^{m} x_{ki})^{\alpha}$$

The first item in the right side of the equation is the total transport expenses from the freight source point to the logistics center; the second item in the right side of the equation is the total transport expenses from the logistics center to the demanding party; the third item in the right side of the equation is the referred value of the assets invested in the construction; the fourth item in the right side of the equation is central variable cost, among which the exponential function of variable expenses introduced $0 \leq \alpha \leq 1$, which is used for the consideration of the scale economics of logistics center construction[5].

5.1.3 Construction of coal logistics center at GuiZhou province

Twelve freight source points are intended to be integrated along the four rail way trunk lines between Shanghai and Kunming, Guizhou and Kunming, Sichuan province and GuiZhou province, Guizhou province and GuangXi province within the boundary of the GuiZhou province, and the twelve freight source points are just as followed: MaChangping, XinPingba, XiaTengqiao, LiuPanshui, LiangShuijin, South of Zun Yi, ZaZuo, NanMuping, JiuChang and the like, besides, three or more coal logistics centers are planned to be built (rail strategic loading points). Now let us suppose that the customer demand at each freight supply point is distributed in ten different directions, and every day the loading time at railway is 6:00pm, and the weight of coals in the whole rail is 4,000 tons starting from the loading point to ten different directions as well as the non-stop departure coefficient of the whole railway

[5] *2007 Chengdu Railway Administration, Logistics Planning*

is 1、α=0.5、the total investment is within 8 million yuan, and the transport expenses from the freight supply point to the cargoes loading point, volume of freight, coefficient of the variable costs of each alternative point as well as the construction expenses for the investment in fixed assets are listed just as the followed:

Table-3 the transport expenses from alternative loading point to the unit of the supplying party

node point	Transport Expense per unit/(yuan/T)					Freight volume/T
	O_1	O_2	O_3	O_4	O_5	
A_1	0.2	0.2	0.4	0.5	0.3	6000
A_2	0.3	0.2	0.1	0.3	0.3	7000
A_3	0.2	0.1	0.3	0.4	0.5	9000
A_4	0.4	0.4	0.2	0.3	0.2	10000
A_5	0.2	0.4	0.2	0.3	0.1	8000
A_6	0.2	0.3	0.3	0.4	0.3	4000
A_7	0.3	0.2	0.5	0.4	0.3	5000
A_8	0.5	0.2	0.4	0.3	0.4	7000
A_9	0.4	0.3	0.3	0.2	0.2	4000
A_{10}	0.2	0.4	0.3	0.5	0.4	5000
A_{11}	0.1	0.4	0.2	0.1	0.2	8000
A_{12}	0.3	0.3	0.2	0.2	0.1	7000
Variable Expenses	8	9	10	10	11	

Investment	150	120	300	170	200

Source: *The Rule about Railway Transportation in Guizhou*

Table-3 lists the transport expenses from alternative loading point to the unit of the demanding party, the threshold value (Ni) of freight supply attractions after the building of each alternative loading point and the maximum handling capability (Mi) and the quantity demanded from the each party.

Table-4 the transport expenses from alternative loading point to the unit of the demanding party

node point	Transport Expenses per Unit (yuan/T)											
	D_1	D_2	D_3	D_4	D_5	D_6	D_7	D_8	D_9	D_{10}	N_i / t	M_i / t
O_1	3.0	2.5	1.5	4.0	2.5	3.0	3.5	4.0	2.5	3.0	5000	45000
O_2	2.0	4.0	2.5	3.5	4.0	4.0	3.5	2.5	4.0	5.0	5000	30000
O_3	2.5	1.5	3.5	2.0	3.5	2.5	3.5	4.0	3.5	2.5	4000	42000
O_4	2.5	2.0	4.5	3.0	2.0	2.5	2.5	3.5	4.0	3.5	6000	30000
O_5	5.0	3.0	2.0	4.5	4.0	2.5	2.5	3.5	2.0	2.0	5000	50000
demand	8000	10000	7000	10000	8000	6000	6000	8000	9000	8000	$\sum D_j = 80000$	

Source: *The Rule about Railway Transportation in Guizhou*

5.2 Model solution:

We mentioned the LINGO software. In this section we make use of this software to solve this problem.

We can find those input data form the

LINGO - [LINGO Model - LINGO1-2]

File Edit LINGO Window Help

```
model:
!12货源5收点运输;
sets:
  warehouses/wh1..wh12/:resources;
  logistics/l1..l5/:locations;
  links(warehouses,logistics):cost,volume;
endsets
!目标函数;
  min=@sum(links:cost*volume);
!需求约束;
  @for(logistics(J):
    @sum(warehouses(I):volume(I,J)=logistics(J));
!产量约束;
  @for(warehouses(I):
    @sum(logistics(J):volume(I,J))<=resources(I));

!数据;
data:
  resources=6000 7000 9000 10000 8000 4000 5000 7000 4000 5000 8000 7000;
  locations=150 120 300 170 200;
  cost=0.2 0.2 0.4 0.5 0.3
       0.3 0.2 0.1 0.3 0.3
       0.2 0.1 0.3 0.4 0.5
       0.4 0.4 0.2 0.3 0.2
       0.2 0.4 0.2 0.3 0.1
       0.2 0.3 0.3 0.4 0.3
       0.3 0.2 0.5 0.4 0.3
       0.5 0.2 0.4 0.3 0.4
       0.4 0.3 0.3 0.2 0.2
       0.2 0.4 0.3 0.5 0.4
       0.1 0.4 0.2 0.1 0.2
       0.3 0.3 0.2 0.2 0.1
enddata
end
```

Figure 5.1 The process of LINGO

In this solution process, this model work as the formula which in the last section described:

$$\min f=\sum_{k=1}^{m}\sum_{i=1}^{n}c_{ki}x_{ki}+\sum_{i=1}^{n}\sum_{j=1}^{l}c_{ij}y_{ij}+\sum_{i=1}^{n}z_i(B_i/T_i)+\sum_{i=1}^{n}z_iv_i(\sum_{k=1}^{m}x_{ki})^{\alpha}$$

The optimal site selection program can be drawn from the solution model, that is, logistics center can be built between O2 and O5 by investment, the total expense F is 553618.5 Yuan。The optimized results of the program are just as followed:

Table-5 the optimized results of the program

z_i (0-1 variable)	x_{jk} (goods issue points k quantity) Freight Volume from goods supply points k to loading point i	y_{ij} (goods receive points j quantity) Freight Volume from loading point i to demanding party j
$z_2=1$	$x_{22}=1000$、$x_{32}=9000$、$x_{52}=8000$ $x_{72}=5000$、$x_{82}=7000$、$x_{15}=6000$、 $x_{25}=6000$	$y_{21}=8000$、$y_{24}=10000$、$y_{25}=400($
$z_5=1$	$x_{45}=10000$、$x_{65}=4000$、$x_{95}=4000$ $x_{10.5}=5000$、$x_{11.5}=8000$、$x_{12.5}=7000$	$y_{28}=8000$、$y_{52}=10000$、$y_{53}=700($ $y_{55}=4000$、$y_{56}=6000$、$y_{57}=6000$ $y_{59}=9000$、$y_{5.10}=8000$

The computed results show that the maximized F value of twelve sites that serves as the alternatives for the use of logistics centers has provided the fundamental reference frame for the site selections of the loading points and the transport program within the boundary of GuiZhou province, among which O2 point is the sorting out of data collection and model computing fitting at ZunYi.

CHAPTER 6 Conclusion

Though the above calculation, we can get the optimal places to build the coal logistics center. Because we can find there are tow places got the comparatively lower cost for building the logistics center. They are Liu Panshui and Zun Yi.

Figure 5.2 logistics centers location

Both of them have the lower cost than other candidates. At this two places, we may build the integrate logistics center. Firstly, we may establish a coal distribution center, which concentrate coal to Liu Panshui and Zun Yi to transport to destination by aggregate traffic. Later, the logistics center should provide some value added functions. To detail them:

1. transportation and distribution

2. storing
3. loading and unloading
4. packaging
5. machining
6. information processing
7. settling accounts
8. forecasting the demand of a cargo
9. design logistics system and consultation
10. Training for careers in transport and logistics

These forms of logistics functions may increase of logistics efficiency and reduce the transport service and conform the coal gangue business in Guizzhou province specifications.

The logistics center is a very complex problem. Author make use of the mathematical method to solve this problem is ex parte. Because this kind of problem might be influenced by some unpredictable factors. For example: the political factor, the calamities and the change of nature condition. But this dissertation gave the idea about the logistics center site selection in Guizhou, which enormous energy should be put into so as to continuously explore and study on it.

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Appendix

The important part in the process of the solution in LINGO software:

```
model:
!12货源5收点运输;
sets:
  warehouses/wh1..wh12/:resources;
  logistics/l1..l5/:locations;
  links(warehouses,logistics):cost,volume;
endsets
!目标函数object function;
  min=@sum(links:cost*volume);
!需求约束demand constraint;
  @for(logistics(J):
    @sum(warehouses(I):volume(I,J)=logistics(J));
!产量约束output constraint;
  @for(warehouses(I):
    @sum(logistics(J):volume(I,J))<=resources(I));

!数据;
data:
  resources=6000 7000 9000 10000 8000 4000 5000 7000 4000 5000 8000 7000;
  locations=150 120 300 170 200;
  cost=0.2 0.2 0.4 0.5 0.3
       0.3 0.2 0.1 0.3 0.3
       0.2 0.1 0.3 0.4 0.5
       0.4 0.4 0.2 0.3 0.2
       0.2 0.4 0.2 0.3 0.1
       0.2 0.3 0.3 0.4 0.3
       0.3 0.2 0.5 0.4 0.3
       0.5 0.2 0.4 0.3 0.4
       0.4 0.3 0.3 0.2 0.2
       0.2 0.4 0.3 0.5 0.4
       0.1 0.4 0.2 0.1 0.2
       0.3 0.3 0.2 0.2 0.1
enddata
end
```