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Capacity Allocation and Route Robust Optimization of the Demand-responsive Rural Passenger Transport System

—Taking Linxia Hui Autonomous Prefecture as an Example

——以临夏回族自治州为例

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Preface

Since the reform and opening up, road passenger transport industry in China has been developed rapidly, which greatly facilitates the people travelling, and powerfully promotes economic and cultural exchanges and cooperation, as well as providing a good transportation atmosphere for the national economy and social development. However, at the same time, we should also be aware that there are still many contradictions and problems in rural passenger transport.

Cultivating and developing rural passenger transport is of great significance for improving the structural adjustment of the road transport industry and achieving great-leap-forward development. In recent years, with rapid development of China's national economic construction, the development of rural passenger transport market is becoming more and more prosperous. However, due to the peculiarities of rural passenger transport and the natural geography of rural areas, coupled with a series of reasons, such as the backwardness of rural road infrastructure, the variety of operating vehicles and vehicle models, the lack of scientific transport organization and management, etc., the rural passenger transport market reveals a low utilization rate of vehicles, high empty driving rate, unsaturated passenger sources, and large difference between

"hot and cold" lines, thus leading to the "scattered, chaotic, mixed, small" performance phenomenon, and low security. Therefore, how to speed up the construction of rural roads and improve the level of passenger transport on rural roads is a urgently required topic.

This book will attempt to solve the problems above and contribute to the revitalization of rural areas and the transportation power strategy.

In the process of writing, the book references a great deal of literatures. We would like to express our high respect and heartfelt thanks to the authors of the literature.

For this book, many thanks go to my students, Lu Xijin, Chen Siyuan, Wang Ke, Zhao Minghui, Guo Jin, Wu Yuankun, Yang Yun and Jiao Yuduan, for their proofreading support.

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Chapter 1

Overview

1.1 Introduction

The Hui nationality is the most widely distributed ethnic group in China. According to the statistics of the seventh national census, the total population of Hui is about 9, 816, 800. Most of the population gather in northwest China, such as Ningxia, Gansu, Qinghai and Xinjiang. There are unique natural landscapes and humanities, as well as huge development potential, market capacity and development prospects here. However, due to the constraints of various factors such as natural, economic and historical development, it is difficult and inconvenient for farmers to travel.

From the beginning time of reform and opening-up, the road passenger demand has developed rapidly. At the same time, we should also be

sober to recognize that there are still many contradictions and problems in rural passenger transport. It is mainly based on the following four aspects. The first is that the company is small, the market is not strong, and the ability to resist risks is poor. The second is that the market is low, the quality of employees is generally not high, and the quality of service is difficult to meet the increasing requirements for people. The third is the lack of safe protection. Major and catastrophic accidents occur from time to time, and the safety of lives and property for people cannot be safeguarded. The forth is low service levels which is difficult to adapt to the needs of the broad masses of the people. Compared with the city passenger transport, the rural passenger transport has many points, long lines, wide surface, low ticket price, unstable passenger flow, and is obviously limited by road conditions and vehicle conditions.

Cultivating and developing rural passenger transport are important for improving the structure adjustment of road transportation industry and achieving leap-forward development. In recent years, with the acceleration of national economic construction of our country, the development of rural passenger transportation is more flourishing. However, rural passenger transport and rural natural geographical conditions have particularity. There are many kinds of rural road infrastructure, many types of operating vehicles, and lacking of scientific transportation organization and management model. As a result, there is a phenomenon that the rural passenger transport market is low, the empty drive rate is high, and it has high passenger and unsaturated, the wire is high, and the overall presence is “scattered,

chaotic, miscellaneous, small", also, the safety is low. There are some problems in the rural passenger market, such as: the vehicle utilization rate is low, the empty drive rate is high, the number of customers is not saturated, and the degree of crowding of the line is different. These overall presented a phenomenon of "scattered, chaotic, miscellaneous, small" which makes low security of the rural passenger market. Therefore, how to speed up the construction of rural roads, enhance rural road passenger transport level, and realize rural rejuvenation is a topic that needs to be studied.

1.2 Literature review

1.2.1 Research status of passenger transportation capability

Capacity delivery is the key content of the optimal allocation for rural passenger transport resources. In a broad sense, transport capacity refers to the comprehensive forces of people, finance, property and management directly related to transportation. The capacity of rural passenger transport refers to the actual direct passenger transport capacity of a vehicle specializing in rural passenger transport on a rural road. Rural passenger transport capacity includes two parts: one is to determine the capacity delivery quota. The other is to determine the capacity delivery mode, i.e., the allocation of transport capacity.

Due to the diverse social and economic backgrounds, different perfection of transportation infrastructure and different coverage of rural passenger transport, the research and research achievements of

rural passenger transport are not identical.

In the 1980s, due to wide and sparsely populated, the number of cars per capita was high in European and American countries. European and American national passenger transport companies had withdrawn from rural areas due to their very low returns. According to statistics, nearly 40 percent of rural areas in the United States had no public transport services in 2002, and 28 percent had very few public transport services[1]. At this time, academia began to study the related transport theory. They advocated providing convenient, flexible and efficient public transportation for rural areas to serve vulnerable groups such as the elderly and the disabled living. Since then, foreign countries began to research the rural passenger transport system. However, the research direction focused on policy improvement[2-3], government subsidies[4-5] and rural passenger service operation[6-7]. In terms of capacity delivery in rural passenger transport system, Taofiki[8] and Sabina[9] studied the impact of car ownership and gender on rural passenger transport demand respectively.

With the construction of a new socialist countryside in China, improving the travel conditions of farmers has become a top priority. After 2004, our rural passenger transport planning and its research began to get wide attention. In terms of transport capacity allocation, in view of the network structure of rural passenger transport market and the travel characteristics of rural residents, Feng used non-aggregate theory to study the travel characteristics of rural population, constructed a multi-target, also, constrained and non-linear transport capacity structure distribution model[10]. Hu put forward the dry and

branch planning method and the method of estimline capacity allocation using the maximum section flow estimation method at peak hour according to the road network structure of rural passenger transport market and residents' travel characteristics[11]. Li studied the allocation scale and structure of rural passenger transport in the western mountainous area, and established the capacity scale allocation scheduling model and regional capacity optimization method with regional operation as the main body[12]. Luo used the gray forecast model and the non-aggregate MNL forecast model to predict the rural passenger volume and residents' travel mode respectively, and put forward the calculation formula of the main trunk distribution and the branch distribution strategy[13]. By analyzing the spatial and temporal characteristics of rural passenger flow, Liu predicted the volume of rural passenger flow, and analyzed the rationality of this method with practical data[14]. Wu and Liu elaborated on the factors affecting the release of rural passenger transport capacity, put forward the new concept of the minimum daily operation shift, and constructed the calculation formula[15]. Guo put forward the decision model of road transport capacity control by studying the influencing factors of highway passenger transport demand and regulating passenger transport capacity[16]. Hu and Tang believed that the study of rural passenger transport capacity allocation should start from the two aspects of transport capacity scale allocation and transport capacity structure allocation, and analyzed the internal and external factors affecting the allocation of rural passenger transport capacity[17]. Wei established and contrasting analyzed the departure interval model of

three rural passenger lines, and then determined the number of lines[18].

The existing researches on the transport capacity release of rural passenger transport system are more inclined to qualitative analysis[19-21] and policy interpretation[22-23], which lacks a degree of rigor, and cannot provide powerful help for the optimization of rural passenger transport resources. Therefore, the construction of a reasonable and accurate rural passenger transport system transport capacity delivery model is the most important task of rural passenger transport system research.

1.2.2 Research status of the demand-responsive rural passenger transport system

The characteristics of rural areas are low road grade, low road density and relatively scattered village layout. Therefore, the rural passenger transport problem cannot directly apply the urban passenger transport planning. Back in the 1960s, western cities began to expand into low-density areas. In 1968, Cole proposed a mode of travel to solve travel problems in low-density areas based on the Dial-a-Bus model. This was considered to be the prototype of demand-responsive buses[24]. In 1984, Daganzo pioneered the basic concept of demand responsive buses and proved that demand responsive buses performed better in low travel density areas than regular bus services[25]. In 1999, Malucelli proposed the Demand adaptive systems (DAS)[26], which has been studied more extensively and deeply by scholars including Crainic[27] and Malucelli[28]. Since then, the demand-responsive bus and the demand-adapted passenger service system have been paid attention to by experts and scholars, and the organization mode of rural passenger

transport system is mostly based on both. Corine Mully pointed that the model can be used as an important model for rural passenger transport recovery due to the flexibility of the demand-responsive systems[29]. Xu summed up the experience and lessons of foreign applied demand-responsive passenger transport system, and analyzed its adaptability, also, he used the method of applicable scenario simulation to simulate the line planning and fare design of the demand-responsive systems in rural areas. However, the case framework selected was quite different from the actual situation in rural areas in China, which cannot truly reflect the performance of the Demand adaptive systems in the passenger transport system in rural areas[30]. Zohora et al. integrated the flexible passenger system sample data in the rural area of Texas. A set of measurement economics is then proposed to provide reference and basis for the size decision of the government's flexible passenger transport system in rural areas[31]. Some scholars had tried to use the demand-responsive systems to combine rural passenger transport and express delivery to improve transport efficiency, this will increase the profits of rural passenger transport companies by addressing the problem of express delivery[33].

At present, there is still little research on the driving path optimization of the passenger transport system in rural areas. A related model and empirical study have been established for the online layout and line planning of flexible operational mode, and the cases, including Dandapat[34] and Lima[35], etc. Zhang et al, optimized the line plan according to the rural area passenger demand, and calculated the radiode mode, the regional line mode, and the cyclic line mode[36].

According to the characteristics of rural areas of our courtry, Zhang Qiang integrated the advantages of demand response bus and demand adaptive passenger service system to design a new rural passenger service system and path optimize it[37].

1.2.3 Literature analysis

To sum up, most of the existing research results of rural passenger transport system focus on operation organization, station layout and station layout, and few literature focuses on the study of rural passenger transport capacity allocation and vehicle path optimization of rural passenger transport system. Moreover, most of the existing literature studies the resource allocation problem of rural passenger transport system from the perspective of economics, and less implements it to the specific vehicle path optimization. Therefore, the study of rural passenger transport system capacity delivery and robust vehicle path optimization can proceed from the needs of rural passenger transport. And it can settle on the specific implementation of the organizational form of the demand-responsive rural passenger transport system, guide the rural passenger transport to the direction in which the service is more efficient and the operating cost is lower and solve the problem of difficulty in travel in rural residents, which makes practical contributions to rural areas, and has strong practical significance.

1.3 Summary

This chapter first analyzes the research background of the demand

responsive rural passenger transport system. Then, the research status of passenger transportation capability and the demand-responsive passenger transport system are reviewed respectively.

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