The Optimal Migrating Route for Refugees

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Abstract. This paper aims to determine the optimal migrating route for refugees.

Firstly, we develop a Secondary Fuzzy Evaluation Model（SFEM） to evaluate the metrics of refugee crises and allocate the refugees of six routes. Eleven factors are chosen as the primary factors of SFEM such as the number of refugees, the security of routes, the types of transportation and so on. We apply variation coefficient weight method to reduce the subjective influence. Secondly, we establish graph theory model and change the issue of optimal removement into multistage decision. The dynamic programming algorithm is used to solve it. At last, we add one stage in multistage decision and conduct sensitivity analysis of this element.

Introduction

"The world is in the flames of war." in 2014, the world of the displaced population has reached 59.5 million, which is almost with the total population in Italy and Britain. There are 13900000 newly increased refugees who were suffered conflict and persecution in 2014。More than 219000 refugees and immigrants across the Mediterranean came to Europe. The figure turned over four times in nearly four years, and children under the age of 18 accounted for 51% of the total number of refugees in 2014, at new highs of more than 10 years.

Assumption

1. The statistical data is valid.
2. We suppose that true value of every index locates right nearby the statistical data. Consequently, we assume that the data is believable.
3. Secondary factors of Evaluation model can be quantified reasonably.
4. We use the Coefficient of Variation method to distribute the weight which requires factors can be quantified reasonably. We eliminated the effect of the subjective factors in this way.

Create a model of optimal refugee movement.

Aiming to determine the optimal migrating route for refugees, we develop SFEM. Firstly, we choose five factors to determine the metrics of refugee crises. Combined with depth requirements of the above indicators and the actual analysis, this paper uses The Fuzzy Comprehensive Evaluation Model to evaluate the refugee crisis. First, the 11 main factors and indicators considered in this paper established not only the secondary index system of refugee crisis evaluation, but also fuzzy comprehensive evaluation model.

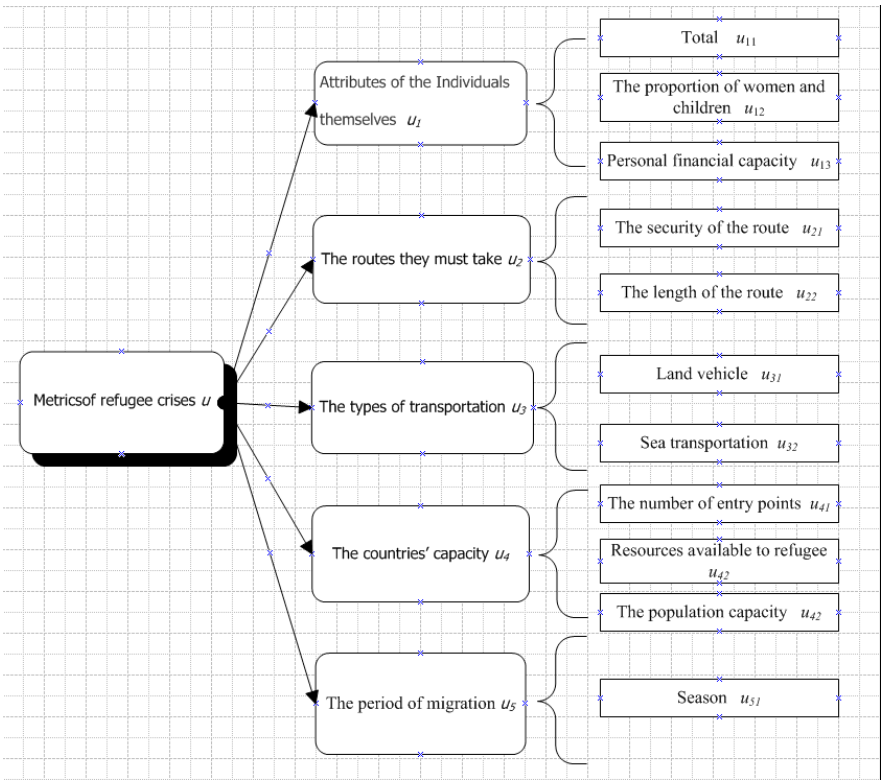

Figure 1. The index of routes

Table 1: determine the weights of secondary factors

Factors	u_{11}	u_{12}	u_{13}	u_{21}	u_{22}	u_{31}	u_{32}	u_{41}	u_{42}	u_{43}	u_{51}
The average	2.173	57.35	613.32	67.74	17.83	46.32	1.621	6.234	32.42	5123.234	79.73
Standard Deviation	1.273	22.882	42.932	51.144	11.786	9.357	0.486	2.687	10.796	1250.069	56.49
Coefficient of variation	0.586	0.399	0.070	0.755	0.661	0.202	0.300	0.431	0.333	0.244	0.708
weighting	0.125	0.085	0.015	0.161	0.141	0.043	0.064	0.092	0.071	0.052	0.151

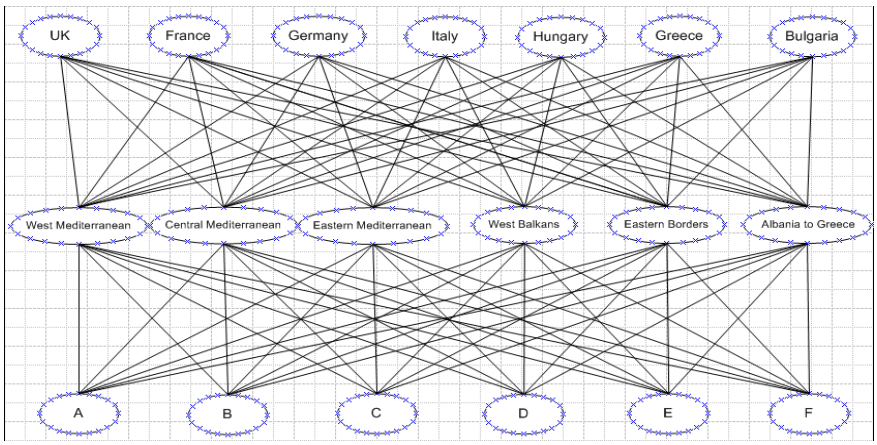

Figure 2. All migration path diagrams

A (Nigeria), B (Eritrea), C (Syria, Iraq), D (Pakistan, Afghanistan),
E (Ukraine), F (Albania, Kosovo, Serbia).

Based on the graph theory model, we determined the number of refugees, as well as the rate and point of entry .we take 6 routes which link between different starting points and destinations as non-empty node set, and draw the picture below(direction is from bottom to up).

In the three stages of the route, we distribute three different weight matrix based on the feasibil-

ity of route， the safety of route and the capacity of the receiving country.

To get the best migration route, we use dynamic programming algorithm; multiplying the length of route from each starting point by its weight.

Then, the figure was calculated by matlab:

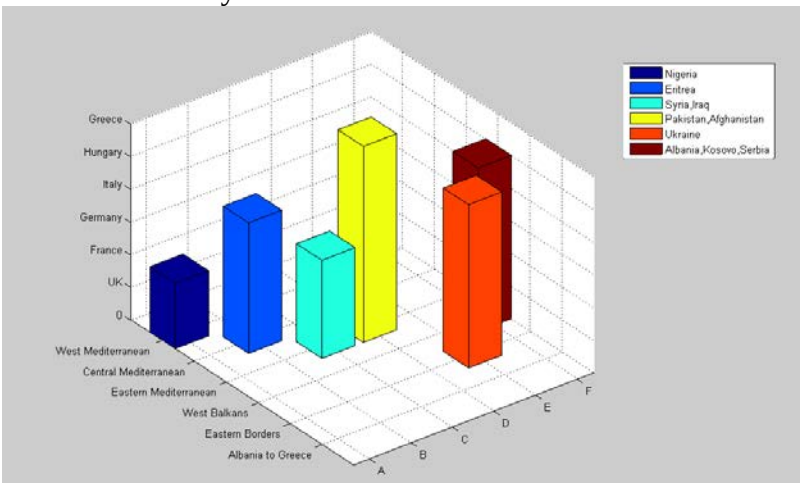

Figure 3: The three dimensional representation of the best route

Conclusion:

According to figure 6, we can get a directed graph which includes the best route of each starting point.

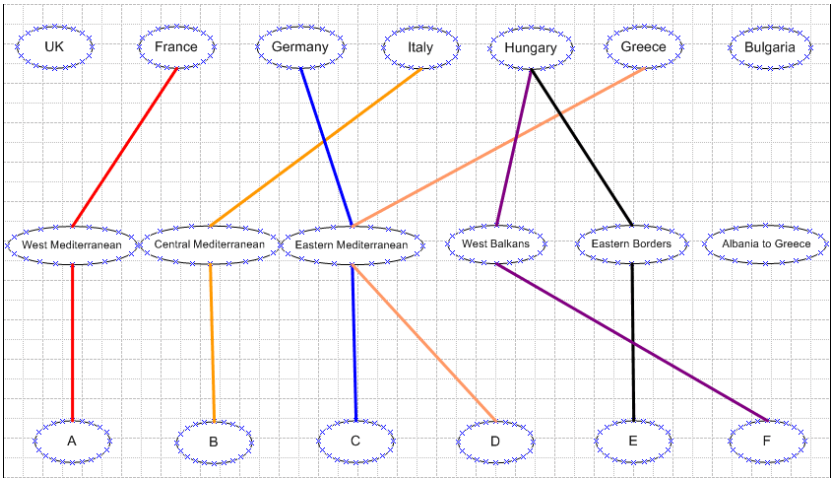

Figure 4: The best path of intuitive schematic diagram

To improve the migration model:

In the second question, only a model to select the best route according to the different starting point is developed. When the contradiction between resources of the best destinations and the increasing number of refugees is considered, we will take the country accepting the most refugees as an example to develop a model, based on the Logistic growth model and Queuing Theory model.

Considered that resources (including residences, food, medicine and so on) provided by receiving country constantly decline. Combined with logistic function, we assume that resources which can be provided by receiving country are constant thus deciding the maximum containment, k, for refugees. When the number of refugees is close to k, the receiving countries don't receive refugees any more.

In view of these changes, we develop a service model based on the Logistic growth model and Permutation theory model to ensure that all refugees can enjoy better resource.

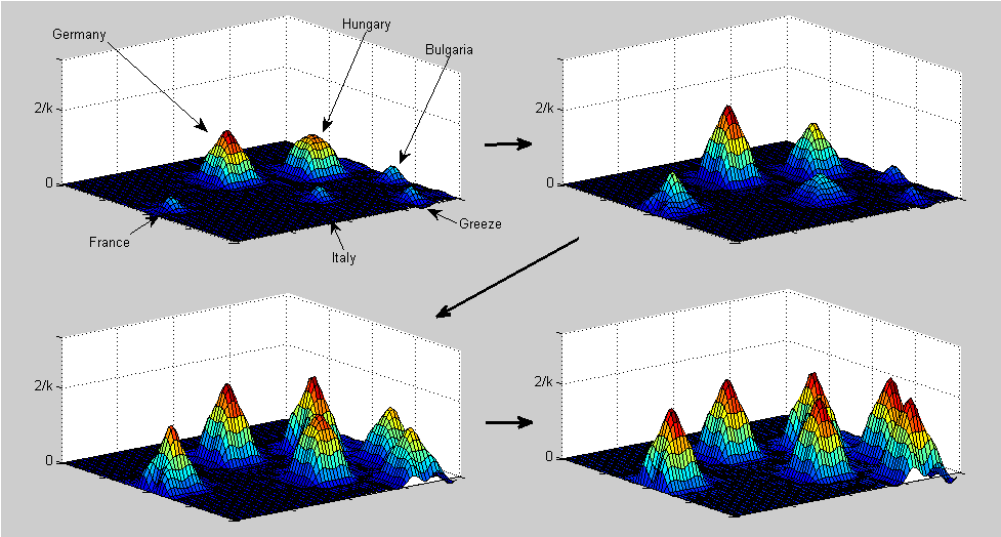

Figure 5.Three dimensional sketch map :to show refugees' transfer.

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