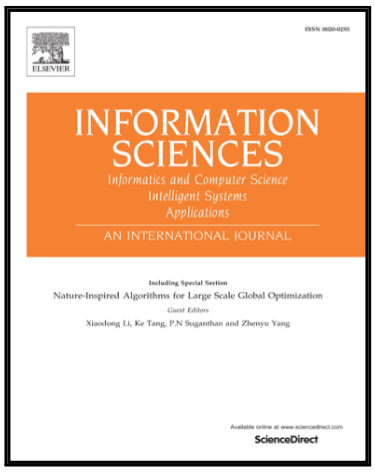

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Fuzzy Incidence Graphs: Applications to Human Trafficking

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Abstract

In this paper, we provide initial results to the development a final area of $(s,t]$-fuzzy type incidence graphs, namely $[\widehat{t},\widehat{s})$-fuzzy incidence for complementary fuzzy incidence graphs. We apply the results to problems involving human trafficking. We are particularly interested in the roll played by countries' vulnerability and their government's response to human trafficking.

Keywords: Fuzzy incidence graph; quasi-fuzzy incidence graph; $[\widehat{t},\widehat{s})$-fuzzy complementary incidence graph; human trafficking; vulnerability; government response.

1 Introduction

The transition from Aristotelian YES or NO logic to Zadeh's fuzzy logic [27] was a very slow process. But Zadeh's logic changed the mind set of people and grown rapidly producing a large number of new mathematical disciplines and related applications. It was in 1975 that Rosenfeld [23] introduced Fuzzy graph theory. Several mathematicians contributed to the growth of the subject there after. Recently, Dinesh [12, 13] introduced a new model called fuzzy incidence to represent systems with external influences. Mordeson and his team [19, 26] applied this model in describing the structure and dynamics of human trafficking chains, slavery and illegal migration effectively.

The purpose of this paper is two-fold. We develop results concerning $[\widehat{t},\widehat{s})$-fuzzy incidence for complementary fuzzy incidence graphs, where $\widehat{t},\widehat{s}\in[0,1]$ are such that $\widehat{t}<\widehat{s}$. We apply the concepts of $(s,t]$-fuzzy graphs to study the impact of a country's vulnerability and their government's response on human trafficking, where $s,t\in[0,t]$ are such that $s<t$.

In Application 1, we measure the similarity between the averages of the vulnerabilities and the averages of the government responses as well as the complements of the vulnerability averages and the government response averages. The data in [29] is provided in a way that the numbers represent high vulnerabilities and high government responses. Consequently, we are mainly interested in the similarity between the complement of the vulnerabilies and the government responses. In the Appendix, we provide a description if the vulnerabilities and the government responses. In Application 2, we use the average of the four vulnerabilities and the average of the four government responses as follows. We let σ denote government response and τ denote vulnerability for the countries listed in the paths from the origin country to the U.S. Then the eccentricity of the origin country is determined. The eccentricity provides us with a number which measures the susceptibility of human trafficking in the paths of the origin country to the U.S. We find that Somalia has the highest eccentricity. In Application 3, we consider the flow of human traffick from countries to the

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