



# Development of a credit limit allocation model for banks using an integrated Fuzzy TOPSIS and linear programming

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## ARTICLE INFO

### Keywords:

Credit risk concentration  
Credit limit allocation  
Fuzzy TOPSIS  
Linear programming

## ABSTRACT

In this study, a credit risk concentration allocation model is developed for the banks to determine the credit risk concentration limits of their regional head's. The proposed model is based on the Fuzzy TOPSIS (FTOPSIS) and Linear Programming (LP) approaches. FTOPSIS is easy to use and capable to keep tract of decision made in reaching the overall score by combining different types of criteria. LP combines the results of FTOPSIS and other constraints and objectives determined by the bank. Using FTOPSIS and LP together in the same model brings uniformity and a structure in credit risk concentration decisions of the banks. The developed model is tested with a real case banking application and satisfactory results are obtained. An application is also provided in the paper for illustrative purposes.

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## 1. Introduction

The major causes of serious banking problems in the world are directly related to poor portfolio risk management, or to a lack of attention to changes in economical and regional conditions. These circumstances can lead to deterioration in the credit portfolios of the banks. Therefore banks need to manage the credit risk instrument in their portfolio. As exposure to credit risk continues to be the leading source of problems, banks need to identify, measure, manage and control credit risk as well as to determine the level of adequate capital against credit. A bank's portfolio contains different types of customer-related concentrations such as particular economic sector, geographic region, type of credit facility and type of collateral. These concentration types should take into consideration potential changes in the credit portfolio (Risk Management Group of the Basel Committee on Banking Supervision, 2000).

Credit risk concentration is one of the most special topics in finance. Concentrations are probably the single important cause of major credit problems (Uberti & Figini, 2010). Credit concentrations are viewed as any exposure where the potential losses are large relative to the bank's capital and its total assets. Various systematic factors affecting portfolio losses are namely economical, regional or industrial. Therefore credit concentration limits should also be established for particular industries, economic sectors and regions (Risk Management Group of the Basel Committee on Banking Supervision, 2000).

In this study, a regional credit concentration limit allocation model is developed for the banks. The proposed model is used to

determine the credit concentration limits of a bank's regional heads. The paper is organized as follows: In Section 2, a literature survey is presented. In Section 3, steps of the model are shown. In Section 4, a real case study application is illustrated. In Sections 5 and 6, the discussions and conclusions are presented.

## 2. Literature survey

Credit risk forecasting and determination of credit risk concentration limits are the most important areas of the finance. Bank regulation has recently developed and used use internal credit ratings models increasingly (Risk Management Group of the Basel Committee on Banking Supervision, 2000). The aim of a basic credit risk forecasting approach is to measure the ability of a firm to repay its proposed obligation, namely the credit and the interest earned on the credit. In the literature, several studies used financial information in development of credit models (Altman & Saunders, 1998; Babic & Plazibat, 1998; Chen & Huang, 2003; Doumpos & Zopounidis, 2001; Emel, Oral, Reisman, & Yolalan, 2003; Min & Lee, 2008; Ong, Huang, & Tzeng, 2005; Tsaih, Liu, Liu, & Lien, 2004; Tsai & Wu, 2008; Yurdakul & İç, 2004; Zhu, 2000).

On the other hand, concentration risk in credit portfolios has two major aspects namely individual borrowers and industry and geographic regions concentration. In the literature, the concentration risk with respect to the individual borrowers is measured by specific concentration indexes such as the Herfindahl–Hirschman index and the Gini index (Uberti & Figini, 2010). Uberti and Figini (2010) improved the Gini index and the Herfindahl–Hirschman index by taking into account methodological and theoretical issues which are explained in their study. They proposed a new index

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to measure the single-name credit concentration risk. [Uberti and Figini \(2010\)](#) compared their index with the common procedures proposed in the literature on the basis of simulated and real data. [Rosen and Saunders \(2010\)](#) developed an extension of the Euler allocation that applied to nonlinear functions of a set of risk factors. The technique is based on the Hoeffding decomposition, originally developed for statistical applications. Hence, [Bonti, Kalkbrener, Lotz, and Stahl \(2006\)](#) determined the risk of credit concentrations as the impact of stress in one or more systematic risk factors on the loss distribution of a credit portfolio.

The second type, industry and geographic regions concentration, relates to imperfect diversification of a cross systematic components of risk, namely industrial factors. [Kalkbrener \(2005\)](#) discussed the industry concentration and demonstrated a multi-factor model for industry concentration. Seminal contribution to measure credit risk concentrations are given by [Glasserman and Li \(2005\)](#) and [Gordy \(2003\)](#). Therefore Value at Risk (VaR) approaches are used in the literature in determining industry concentration and portfolio optimization models. [Stoughton and Zechner \(2007\)](#) proposed an optimal capital allocation model using RAROC and EVA. On the other hand, [Firth, Lin, Liu, and Wong \(2009\)](#) examined how the Chinese state-owned banks allocated loans to private firms in their capital allocation model.

The literature survey shows that statistical models play an important role in credit risk concentration measurement studies. Despite this strong motivation, the literature on the subject is

insufficient ([Uberti & Figini, 2010](#)). Although there are a great deal of studies on determining credit risk concentration limits, there is still a need for an easy-to-use, adaptable and modifiable model that helps the banks to identify concentration risk factors and to determine the concentration limits that require a more detailed process.

The proposed model in this paper, aims to fill this gap by developing a credit risk concentration limit allocation model for the banks. In the development of this model, regional financial information is used and the Fuzzy TOPSIS (FTOPSIS) ([Hwang & Yoon, 1981; Chen & Hwang, 1992](#)) is used as the ranking method among many different MCDM approaches. The advantage of this method is its simplicity and ability to yield an indisputable preference order. In the traditional TOPSIS, human judgments are presented with crisp values. Therefore, in many practical applications the human preference is uncertain and decision-makers might be unable to assign crisp values to the comparison judgments. FTOPSIS approach is proposed for decision problems where vagueness and imprecision are involved in the literature. There are various studies that incorporated fuzzy numbers into TOPSIS models in the literature ([Amiri, 2010; Chamodrakas, Leftheriotis, & Martakos, 2011; Ertugrul & Karakasoglu, 2009; Ebrahimnejad, Mousavi, & Seyrafiapour, 2010; Secme, Bayrakdaroglu, & Kahraman, 2009](#)).

Therefore, an integration of FTOPSIS and linear programming is proposed to consider both tangible and intangible factors in choosing the best regional heads and in determining the optimum

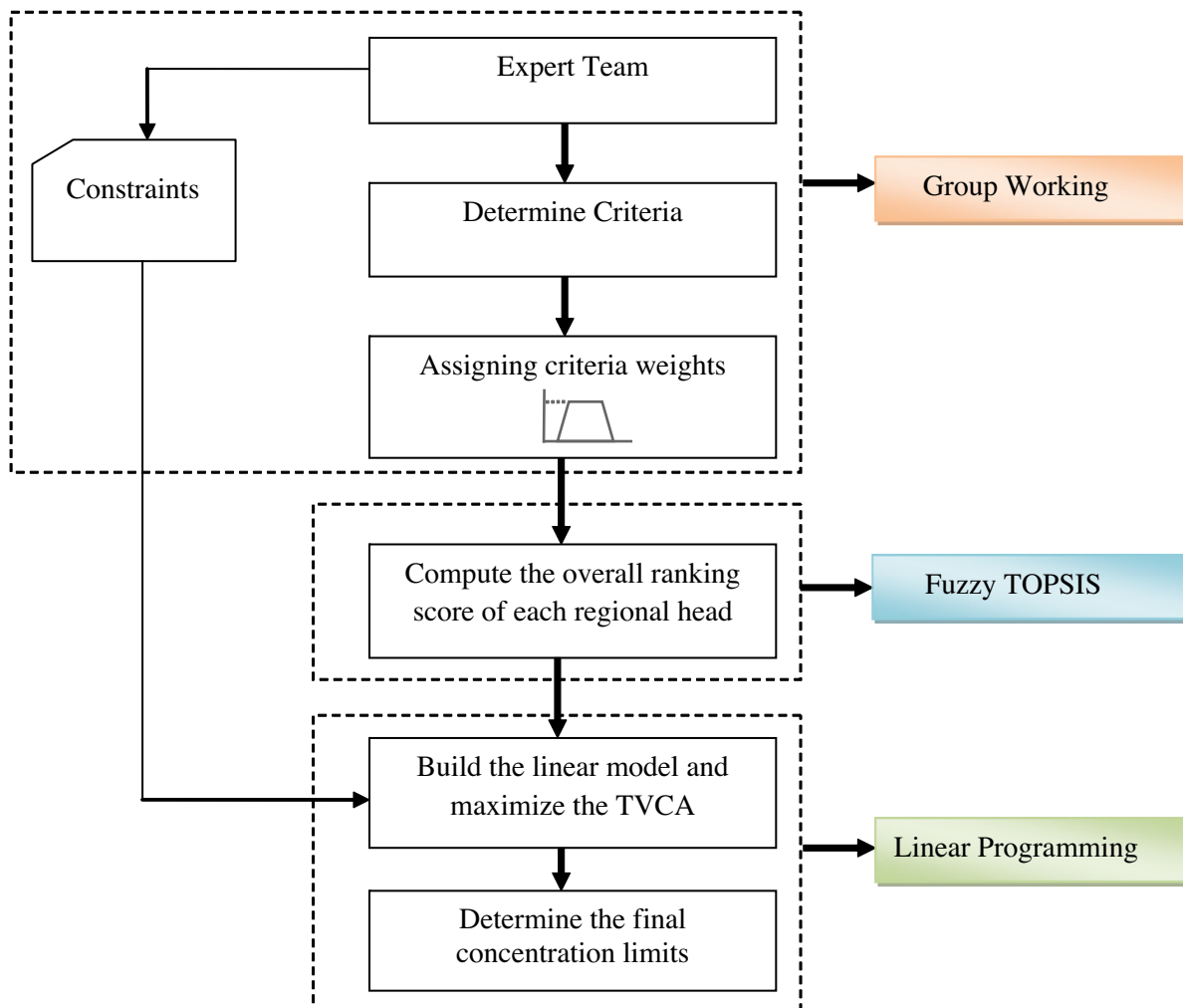


Fig. 1. Flow diagram of the proposed model.

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