Iranian Journal of Management Studies (IJMS) *http://ijms.ut.ac.ir/*
Vol. 8, No. 3, July 2015 *Print ISSN: 2008-7055*
pp: 453-477 *Online ISSN: 2345-3745*

Investigating the Effect of Selected Sustainable Development Indicators on Credit Allocation: the Case of National Development Fund of Iran

Seyed Mahdi Sadatrasoul*, **Mohammadreza Gholamian, Kamran Shahanaghi**

School of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran

(Received: 16 June, 2014; Revised: 23 December, 2014; Accepted: 24 December, 2014)

Abstract

Credit allocation through the usage of Portfolio optimization mainly seeks to maximize return and minimize the risk of the portfolio; but there are other important issues including sustainable development which is important for government/public sectors. This paper presents a novel credit allocation approach based on portfolio optimization and investigates the effects of selected indicators of sustainable development on credit allocation. In order to evaluate this case study, constraint mean-variance was used as the extension of Markowitz portfolio theory. Selected indicators were modeled as the mathematical model's objectives and constraints. In order to show the applicability of the model, experimental results were given based on credit allocation data for National Development Fund of Iran (NDFI). The results show that sustainable development selected indicators exacerbate the return of NDFI portfolio from one side and from the other side, its effect on NDFI risk is somewhat similar but lighter.

Keywords

Credit allocation, National Development Fund of Iran, Portfolio theory, Sustainable development.

* **Corresponding Author, Email:** sadatrasoul@iust.ac.ir

Introduction

Credit allocation focuses mainly on the allocation of credit to applicants, which together precipitates a portfolio of loans. Portfolio selection has attracted considerable attention for decades. Markowitz as a beginner introduced the portfolio problem as an optimization problem (Selection & Diversification, 1952). The main focus of his theory was diversification of assets and a tradeoff between risk and return based on the risk appetite of the investor. There are some major limitations for the application of Markowitz model to the real world. Its sensitivity to perturbations and real world constraints are the major issues (Sadjadi *et al.*, 2012). Through the year the Markowitz model has expanded and additional real world constraints including limitations on the number of assets and bounding of the lower and upper proportion of each asset has been added to the basic model (Chang *et al.*, 2000; Anagnostopoulos & Mamanis, 2011). This model is called cardinality constraint mean-variance portfolio optimization model. These kind of problems which is of feasible space, is changed into a non-convex region and it can also be shown that it belongs to NP-hard problems (Crama & Schyns, 2003; Shaw *et al.*, 2008; Anagnostopoulos & Mamanis, 2011).

There are also many methods which have been introduced to solve the portfolio problem in recent years. Metaxiotis and Liagkouras investigated different multi-objective evolutionary algorithms for portfolio management including Vector Evaluation Genetic Algorithm (VEGA), Niched Pareto Genetic Algorithm (NPGA), Niched Pareto Genetic Algorithm II (NPGA-II), Non-dominated Sorting Genetic Algorithm (NSGA), Non-dominated Sorting Genetic Algorithm II (NSGA-II), Multi-Objective Genetic Algorithm (MOGA), Strength Pareto Evolutionary Algorithm (SPEA), Strength Pareto Evolutionary Algorithm II (SPEA-II), Pareto Archived Evolutionary Strategy (PAES), Pareto Envelope-based Selection Algorithm (PESA) and Pareto Envelope-based Selection Algorithm II (PESA-II) (Metaxiotis & Liagkouras, 2012). There are also mathematical models introduced to solve the model. One of the methods for portfolio selection is by using fuzzy mathematical programming. Non-linear S-shape membership functions for investors aspiration level is introduced and used for a multi-objective portfolio of maximizing short and long term return, dividend and liquidity while minimizing risk (Gupta *et al.*, 2008).

Sustainable Development

Economic development has different challenges and effects on the social, environmental and different aspects of human life. Sustainable development is a theory and philosophy aimed at overcoming and managing the challenges of economic development. The focus is on countries, especially the developing ones. Sustainable development is a widely used phrase, it has many different meanings and therefore faced with many different responses (Dev, 2005). It strongly links and represents compatible development of environmental and socio-economic issues and can be explained in terms of economic, ecological, social and institutional sub-systems (Dev, 2005). Each of the sub-system can be represented by different group of indicators. Some of the indicators of the sub-systems can be found on (Ivanovic *et al.*, 2009). Implementation of sustainable development issues is mostly the exclusive preserve of governments and it's always a case of contradiction between sub-systems. For example, a significant negative correlation between ecological and economic sub-system indicators has been shown and proven (Golusin *et al.*, 2011). There are also many other indicators in literatures to evaluate the sustainability of development. 440 indicators have been introduced for different sub-systems of sustainable development by the work done by the United Nations department of Economic and Social Affairs (Economic & Social Affairs, 2001). There are also other studies which introduced the indicators for special vertical industries, for example, the energy sector (Streimikiene *et al.*, 2007).

Sovereign Wealth Funds (SWFs)

Sovereign wealth funds are state owned financial investment institutions (Yu *et al.*, 2010; Knill *et al.*, 2011), they have been around since the 1950s. SWF's are investing in stocks, bonds, real estate and some of them also lend money to the private sectors engaged in their native economy via agent banks as their broker.

National Development Fund of Iran (NDFI)

Iran's economy is highly dependent on oil revenues. For decades the national economy was faced with high rate of inflation, stagnancy and Dutch disease. Iran's experience on sovereign wealth fund is dated back to 2000, where fluctuations of oil prices affected the government annual budget considerably.

Oil stabilization fund of Iran was established on 1999 as the countries first SWF. The high effects of Dutch disease on the economy because of oil revenues and its use in the annual budget has made the Iran government in conjunction with parliament to enhance the oil stabilization fund missions and establish National Development Fund of Iran (NDFI) in 2011. In the 5^{th} development plan of the country, support for the industrial development of Iran is included in the fund missions. Credit allocation is one of the major issues in financial institutions and SWFs management. There are some important issues including diversifying investments in different asset classes and geographies. SWFs portfolio of investments returns often targets a middle to long term horizon approach and it differs from insurance companies and pension funds, which usually have small to middle horizons for return (Allen & Caruana, 2008). SWFs diversify their investments in a risk adjusted portfolio of stocks, bonds, REIT and other investments.

There are few published works in the literature for SWFs asset allocation. Yu *et al.* introduced a maximum CRRA utility and minimum Value-At-Risk (VAR) objective to optimize strategic assets allocation of SWFs. They used NSGA-II to achieve the Pareto solutions (Yu *et al.*, 2010). Although there is little literature in optimizing SWFs portfolio of assets, there are so many works for portfolio optimization in other areas. There are also studies which investigates portfolios of different asset classes in SWF's excluding credit assets in the literature (Gintschel & Scherer, 2008; Balding &

Yao, 2011). Table 1 describes the key related papers in the literature and their contribution in brief.

Table 1. Key papers in the literature

Authors	Research main contribution
(Markowitz, 1952)	Introducing the basic portfolio theory and model.
(Raik, 1971)	Considering the Alpha-quantile or Value-at-Risk (VaR) as a measure of risk.
(Rockafellar, 2000)	Introducing The Conditional Value-at-Risk (CVaR) as a modification of VaR.
(Chang *et al.*, 2000;Anagnostopoulos and Mamanis, 2011)	Introducing an extended model in which additional real world constraints including limitations on the number of assets and bounding the lower and upper proportion of each asset has been added.
(Yu *et al.*, 2010)	Introducing a new maximum CRRA utility and minimum VAR objective to optimize strategic assets allocation of SWFs
(Gintschel and Scherer, 2008; Balding and Yao, 2011)	Introducing a portfolios of different non-credit asset classes in SWFs.
(Alhashel, 2015)	Reviews the investment behavior of SWFs and concluded that decision making in investment portfolios are based on economic motives rather than political.
(Bertoni, 2014)	Studying the effect of credit default swap (CDS) on credit risk of SWF's target companies and concluding that CDS spread of target companies decreases, on average, following an SWF investment.
(Sun, 2014)	Exploring the relationship between energy security and energy investments of China's SWFs.
(Miao, 2011)	A model is designed to analyze investment strategy of Chinese SWFs and it's found that they prefer to invest in the strategic industries such as petrol and metal aboard.
(Knill, 2012)	Examined the role of bilateral political relations in sovereign wealth fund (SWF) investment decisions and found that they behave differently from rational investors who maximize return while minimizing risk.
(Reiche, 2010)	Illustrating the emergence and outcomes of ethical regulations contributions in Norwegian SWF investments.

This paper investigated credit allocation to industries and provinces by the NDFI. NDFI allocates capital to the agent banks, and these banks lend it to the private sector in terms of loans.

In accordance with the previous researches, NDFI's board of directors' preferences and availability of the data for Iran, the authors were limited and finally decided to use selected sustainable development indicators. Comparative advantage, employment and population work culture indicators of sustainable development were selected; it's obvious that there is no obstacle for selecting other indicators for future studies. Although it's obvious that the consideration of these indicators decreases the short term return of a country, but it grantee's the long term development of it at least partially.

The rest of this study is organized as follows; Section two discusses the modeling objectives and constraints. Section three introduces the model solving methods in brief. In section four, the numerical results for NDFI is presented and discussed and finally the paper is concluded in section five.

Modeling Objectives and Constraints

In this section, Portfolio optimization problems which include Markowitz and cardinality constraint Portfolio optimization are introduced, then Fuzzy multi-objective programming is described for solving the problem.

Portfolio Optimization Problems

The standard Markowitz mean–variance model for the portfolio as an optimization problem can be presented as (Deng *et al.*, 2011):

$$\text{Minimize } \lambda \left[\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \sigma_{ij}\right] - (1-\lambda)\left[\sum_{i=1}^{N} w_i \mu_i\right] \quad (1)$$

Subjected to

$$\sum_{i=1}^{N} w_i = 1 \quad (2)$$

$$0 \le w_i \le 1 \quad i=1,\dots,N \quad (3)$$

$$0 \le \lambda \le 1 \quad (4)$$

where:

N: The number of assets,

μ_i: The expected return of asset i {i=1,…, N},

σ_{ij}: The co-variance between assets i and j {i=1,…, N},{j=1,…, N},

W_i: proportion of the investment in asset i {i=1,…, N}.

λ is the risk aversion parameter; it can change from $\lambda = 0$ for maximizing the effect of expected return, to $\lambda = 1$ for maximizing the effect of risk in the model based on the investor risk appetite. The first component in equation (1) shows the risk which should be minimized and the second component show the expected return which should be maximized; therefore it accompanied the model with negative sign. Equation (2) ensures that the total proportions on investment are equal to one and Equation (3) ensures that the proportions of investment in each asset are between zero and one. Equation (4) shows λ bounds.

An expanded generalized model of standard Markowitz model is used in some previous works (Chang *et al.*, 2000; Fernández and Gómez, 2007). They include cardinality and bounding of constraints to the standard Markowitz model. These constraints are necessary to ensure investment in a given number of assets and limiting the amount of capital to be invested in them. The cardinality constrained portfolio optimization problem can be written as (Chang *et al.*, 2000):

$$\text{Minimize } \lambda\left[\sum_{i=1}^{N}\sum_{j=1}^{N} w_i w_j \sigma_{ij}\right] - (1-\lambda)\left[\sum_{i=1}^{N} w_i \mu_i\right] \quad (5)$$

Subjected to

$$\sum_{i=1}^{N} w_i = 1 \quad (6)$$

$$\sum_{i=1}^{N} Z_i = K \quad (7)$$

$$\varepsilon_i z_i \leq w_i \leq \delta_i z_i \qquad i=1,\ldots,N \quad (8)$$

$$z_i \epsilon [0,1] \qquad i=1,\ldots,N \quad (9)$$

$$0 \leq \lambda \leq 1 \quad (10)$$

where:

N: The number of assets,
μ_i: The expected return of asset i {i=1,…,N},
σ_{ij}: The covariance between assets i and j {i=1,…,N},{j=1,…,N},
K: The desired number of assets in the portfolio,
ε_i: The minimum proportion that must be held of asset i {i=1,…,N},
δ_i: The maximum proportion that can be held of asset i {i=1,…,N},
$z_i \epsilon$ {0,1}, if any asset of i is selected then z_i=1 else z_i=0,
W_i: proportion of the investment in asset i {i=1,…,N}.

Equation (5) seeks to explain the minimizing of the total risk of the portfolio minus the total expected return which was discussed earlier; Equation (6) ensures that the total proportions of investment are equal to one. Equation (11) ensures that k assets are exactly selected and N-K assets are excluded. Equation (8) means that if asset i is selected w_i as its proportion must between ε_i and δ_i; and finally Equation (9) ensures that the proportions of investment in each asset are between zero and one.

In the next subsection the problem formulation using the above mentioned models is described.

Problem formulation

This sub-section is organized as follows, first the notations used to describe the models are described; second sustainable development selected indicators are discussed including its implementation in terms of objective functions and constraints. At last constrained mean-variance model is shown to handle the problem of credit allocation.

Notations

The following notations are used to describe the model under investigation.

Units

$: Million dollars,

Indices and sets

t: index for type of industry; $t \in T=\{1,\ldots,n_t\}$,

g: index for province; $g \in G=\{1,\ldots,n_g\}$,

Decision variables

X_{tg}: credit share allocated to industrial sector t on province g,

Parameters

C: total amount of credit to be paid to agent banks,

ε_{tg}: lower amount of credit allocated to industrial sector t in province g as NDF's tactical credit allocation strategy,

δ_{tg}: upper amount of credit allocated to industrial sector t in province g as NDF's tactical credit allocation strategy,

p_{tg}: Average amount of expected (achievable) profit for industrial sector t in province g (this expected profit is lower for semi developed provinces.),

e_t: Average amount of employment with one million dollar ($)

investment,

E_e: Total amount of employment (direct jobs created),

E_i: Total amount of employment (Indirect and induced job Creation),

E_{tg}: Total amount of employment in industrial sector t in province g,

LQ_{tg}: location quotients in industrial sector t in province g,

J_{dt}: Direct job Creation per \$1 Million Investment in industrial sector t,

J_{it}: Indirect and induced job Creation per \$1 Million Investment in industrial sector t,

L_{tg}: Revealed symmetric comparative advantage (RSCA) index for industrial sector t in province g,

σ^2_{tg}: Variance of loans for asset class industrial sector t in province g,

σ_{tgTG}: Co-variance of loans between asset class industrial sector t in province g and asset class industrial sector T in province G,

BL_{tg}: Blassa value for industrial sector t and province g,

Comparative Advantage

Comparative advantage as the first indicator of sustainable development considered in the paper is the ability of a province producing goods/ services at lower opportunity and marginal costs considering other provinces (Hunt & Morgan, 1995). The revealed comparative advantage (RCA) is a measure use to calculate the comparative advantage in a particular class of goods or services. Balassa presented an advanced measure (index) of RCA later called BL_{RCA} (Utkulu & Seymen, 2004), which is widely accepted in the literature and expressed as equation (11) (Utkulu & Seymen, 2004):

$$BI_{RCA} = (Xij / Xit) / (Xnj / Xnt) \qquad (11)$$

where x represents exports, i represent a country, j is an industry, t is a set of industries and n is a set of countries. RCA measures a country’s exports of an industry relative to its total exports and to the exports of a set of countries, e.g. the world. If BI_{RCA}>1a comparative advantage is “revealed” and one can say that the i*th* country has comparative advantage against the province under investigation. If BI_{RCA} is less than one, the i*th* country is said to have a comparative disadvantage in that industrial sector against the province under investigation. Laursen explained revealed comparative advantage as a measure of specialization in economics, he also explained normalizations of the original index and finally proposed an alternative and more traditional strategy in order to analyze the dynamics of specialization as described in Equation (12) (Laursen, 1998; De Benedictis & Tamberi, 2001).

$$L_{RCA}= (BI_{RCA}-1)/ (BI_{RCA}+1) \quad (12)$$

This index ranges from -1 to +1 and it's therefore symmetric. If $L_{RCA}>0$, a comparative advantage is "revealed" and If $L_{RCA}< 0$, a comparative disadvantage is revealed. In this paper L_{RCA} is used with some modifications in the original formula and provinces are replaced with countries, the final modified equation can be defined as Equation (13):

$$BL_{tg} = (X_{tg} \Big/ \sum_{t=1}^{n_t} X_{tg}) \Big/ (\sum_{g=1}^{n_g} X_{tg} \Big/ \sum_{t=1}^{n_t} \sum_{g=1}^{n_g} X_{tg})$$

And for L_{tg}:

$$L_{tg}= (BI_{tg}-1)/ (BI_{tg}+1) \quad (13)$$

Population Work Culture

Population work culture is another indicator for measuring sustainable development which is usually mentioned by government/ public sector policy makers. From the economic base analysis, the country/province economy is divided into basic and non basic economy. Basic industries are those exporting to other regions and bringing wealth from them; non-basic industries support basic industries in the region. Often the work culture of the province economy is based on the basic industries and the population can have unofficial relations among social networks. Location quotient is used as a measure which can be defined by Equation (14):

$$LQ_{tg} = (E_{tg} \Big/ \sum_{t=1}^{n_t} E_{tg}) \Big/ (\sum_{g=1}^{n_g} E_{tg} \Big/ \sum_{t=1}^{n_t} \sum_{g=1}^{n_g} E_{tg}) \quad (14)$$

Where E_{tg} represents total amount of employment in industry sector t in province g. $\sum_{t=1}^{n_t} E_{tg}$represents total gth province employment, $\sum_{g=1}^{n_g} E_{tg}$represents total provinces employment in industry sector t and at last $\sum_{t=1}^{n_t} \sum_{g=1}^{n_g} E_{tg}$represents total countries employment in the whole industry sectors. If $LQ_{tg}>1$, then the province g is exporter and the industry t is the basic industry. If $LQ_{tg}<1$, then the province g is importer and the industry t is the non basic industry.

Job Creation, Geographical Employment and Population Migration

Employment is one of the most important indicators of sustainable development. Labor intensiveness is a very important issue in credit allocation to industrial sectors. It can be measured through direct, indirect and induced job Creation per $1 Million Investment in different industrial sectors (Heintz *et al.*, 2009). Direct jobs are created by the main projects establishment; indirect jobs are created when supplies are purchased for the projects. When the overall level of spending in the economy rises, the induced jobs are created (SCI, 2011). One of the main issues in allocating resources is the investigation of geographical population balances for job creation. The population tends to migrate to regions where they can find jobs. Therefore stability of the population of a region is deeply dependent on the employment in that region. It can be concluded that a minimum amount of job creation in a province should also be mentioned especially in provinces with high amount of unemployment.

But this is not the whole; all forms of investment create jobs, but infrastructural investment is a more effective engine of job creation as it can increase foreign direct investment and private sector investment. In order to mention this issue, the appropriate constraints should also be included in the mathematical model. The next sub-section described the final mathematical model under investigation.

Mathematical Model

The quadratic multi-objective mathematical programming formulation of the credit allocation problem is presented below:

$$\text{Min}\ \lambda\left[\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}\sigma_{tg}^2c^2x_{tg}^2+\sum_{t=1}^{n_t-1}\sum_{g=1}^{n_g-1}\sum_{T=t+1}^{n_t}\sum_{G=g+1}^{n_g}\sigma_{tgTG}c^2x_{tg}\,x_{TG}\right]$$

$$-(1-\lambda)\left[\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}P_{tg}Cx_{tg}\right] \qquad (15)$$

$$\text{Max}\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}L_{tg}x_{tg} \qquad (16)$$

$$\text{Max}\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}LQ_{tg}x_{tg} \qquad (17)$$

Subjected to

$$\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}j_{dt}Cx_{tg}\geq E_e \qquad (18)$$

$$\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}j_{it}Cx_{tg}\geq E_i \qquad (19)$$

$$\sum_{t=1}^{n_t}\sum_{g=1}^{n_g}x_{tg}=1 \qquad (20)$$

$$\varepsilon_{tg}\leq\ Cx_{tg}\leq\delta_{tg} \qquad (21)$$

$$x_{tg}\geq 0 \qquad (22)$$

$$0\leq\lambda\leq 1 \qquad (23)$$

Objective function (15) shows the total risk of the portfolio minus the total expected return, Objective function (16) is designed to maximize the comparative advantage for each province. Objective function (17) aims to maximize the Location quotient for the provinces. Constraint (18) ensures a total minimum direct job creation of E_e. Constraint (19) ensures a total minimum indirect and induced job creation of E_i. Constraint (20) ensures that the total proportions of credit allocation are equal to one. Constraint (21) means that the credit allocated to the tth industrial sector in the gth province must be between εtg and δtg. Constraint (22) ensures that the proportion of credit allocation in each province is positive. Finally constraint (23) ensures that λ changes between zero and one.

The next section introduces the basics of the two different evolutionary and mathematical methods used to solve the model.

Model Solving

Fuzzy multi-objective programming and multi-objective genetic algorithm are used to solve the model. This section introduces these methods in brief.

Fuzzy Multi-Objective Programming

The first Fuzzy multi-objectives programming formulation (FMOP) using the concept of membership functions is developed by Zimmermann (Zimmermann, 1978). In the following years, its use was developed and also extended to other areas including multi-level non-linear multi-objective problems (Sakawa, 1993; Osman *et al.*, 2004). It is also used for portfolio optimization problems (Gupta *et al.*, 2008). Let a multi-objective programming problem with f_1, f_2,…,f_n objectives equation (24).

$$\max F = \max(f_1, f_2, \dots, f_n)$$
$$\text{s.t. } G = \{(x_i | g_j(x_i) \le 0,\ i = 1,2,\dots,m;\ j = 1,2,\dots,p\} \qquad (24)$$

Goals and tolerances should be determined in order to build membership functions. Therefore the individual best (f_n^+) and the worst solution (f_n^-) for each of objectives f_1, f_2, …, f_n should be found. Then the degree of satisfaction for each goal can be found using the following equation (25) membership function of the fuzzy set theory:

$$\mu_{f_1(x)} = \begin{cases} 1 & \text{if } f_1(x) > f_1^+ \\ \frac{f_1(x) - f_1^-}{f_1^+ - f_1^-} & \text{if } f_1^- \le f_1(x) \le f_1^+ \\ 0 & \text{if } f_1(x) \le f_1^- \end{cases} \qquad (25)$$

Therefore the solution of multi objective problem can be solved by using the following Tchebycheff problem (26) (Shi & Xia 1997, Osman, Abo-Sinna *et al.*, 2004):

$$\max Z = \lambda'$$
$$\text{s.t. } G = \{(x_i | g_j(x_i) \le 0,\ i = 1,2,\dots,m; j = 1,2,\dots,p\}$$
$$\lambda' \le \mu_{f_1(x)}$$
$$\lambda' \in [0,1] \qquad (26)$$

Using this formulation the model described using equation (19-27) converts to the following model (27).

$$\max z = \lambda'$$

Subjected to

$$\lambda' \le (f_1^+(x_{tg}) - (\lambda \left[\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} \sigma_{tg}^2 c^2 x_{tg}^2 + \sum_{t=1}^{n_t-1}\sum_{g=1}^{n_g-1}\sum_{T=t+1}^{n_t}\sum_{G=g+1}^{n_g} \sigma_{tgTG} c^2 x_{tg}\, x_{TG}\right] - (1-\lambda)\left[\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} P_{tg} C x_{tg}\right]) \Big/ \Delta_1$$

$$\lambda' \le (\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} L_{tg} x_{tg} - f_2^-(x_{tg}))\Big/\Delta_2$$

$$\lambda' \le (\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} LQ_{tg} x_{tg} - f_3^-(x_{tg}))\Big/\Delta_3$$

$$\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} j_{dt} C x_{tg} \ge E_e$$

$$\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} j_{it} C x_{tg} \ge E_i$$

$$\sum_{t=1}^{n_t}\sum_{g=1}^{n_g} x_{tg} = 1$$

$$\varepsilon_{tg} \le C x_{tg} \le \delta_{tg}$$

$$x_{tg} \ge 0$$

$$\boldsymbol{\lambda}' \in [\mathbf{0}, \mathbf{1}] \qquad (27)$$

Multi-Objective Genetic Algorithm

Multi-objective genetic algorithm (MOGA) was proposed as a rank-based fitness assignment method for Multiple Objective Genetic Algorithms by Fonseca and Fleming (Fonseca & Fleming, 1993). In this algorithm all of the non dominated individuals were ranked one and population density is used to penalize dominated ones (Metaxiotis & Liagkouras, 2012).As genetic algorithm is generally used for new problem domains and it has partially appropriate results, this method is selected in order to solve the papers problem.

The next section described the parameters of the final numerical model, and computational results.

Computational Results

Computational results are presented in this section. As this paper considers NDFI as a case study and its application in research, data collection is important for the evaluation of results. In this section, first, data collection and parameters are described, the results are presented in the next sub-section, then statistical test are described after which sensitivity analysis is done in order to evaluate the results; lastly discussion and study limitations and their effect on results are discussed.

Data Collection and Parameters Computations

An Iranian commercial bank real loan data set is used to evaluate the results. It includes different applicants, each of which is in a special industrial sector t. The initial data set which includes 1109 corporate applicants' and 46 financial and non-financial data from 2007 to 2012 for 4 industrial sectors include agriculture, "infrastructure and services", "industry and mine" and "petrochemical and oil" sectors. The first step, namely data cleaning, includes missing data handling issues. The data set contains applicants which are at the process of debt repay and some of them haven't applied for loan yet. Therefore the missing value elimination technique is used and a total number of 387 corporate with mentioned characters are excluded. Each applicant is in a special province and industrial sector in the data set. Average, variance (σ^2_{tg}) and co-variance (σ_{tgTG}) of default rates for each sector/province is computed using the data set which are used in the model. These coefficients are used in objective functions (16).

L_Q and L_{tg} and employment are computed from "Iran's statistical year book" which is published by the statistical centre of Iran(SCI, 2011), for computing the two prior ones, equations (13) and (18) are used orderly; final coefficients are used in objective functions (16) and (17) and constraints (18) and (19).

J_{dt} and J_{it} as Parameters of job creation per industrial sector is used from reference (Heintz *et al.*, 2009)calculations, although these costs are associated with job creation in the united states, but it's acceptable after discussion with experts and making of some adjustments. The other parameters are set according to the NDFI board of director's minutes and Iran's fifth development plan; therefore the amount of the C is determined by NDFI tactical credit allocation and is set for 33000 million dollars, the E_e is set for 100000 jobs; E_i is set for 120000 jobs. These coefficients are also used in constraints (18) and (19).

For developing provinces, minimum amount of 600 million dollars allocation is set. There are 31 provinces and 4 industrial sectors under investigation, therefore a total of 124 decision variables are included in the model. The final numerical example was too large to be presented in the model.

Results

In order to better understand the effects of sustainable development selected indicators on the model results and efficient frontier placed on the coordinate axes, six different models were designed, solved and their efficient frontier is illustrated using different λ values. First the Markowitz model is solved without any constraints, and then the constraints and objectives were added until the building of the final full constrained mean-variance (CMV5) model, in this case all of the objective functions and constraints are included in the final model. The six different models components are discussed under the following heading:

- Basic Markowitz (BM) portfolio model, without any constraints;
- Constrained mean-variance portfolio model using BM with employment constraints (CMV1);
- Constrained mean-variance portfolio model using BM with all of constraints including employment and developing provinces minimum credit allocated constraints (CMV2);
- Constrained mean-variance portfolio model using all of constraints and comparative advantage objective function (CMV3);

- Constrained mean-variance portfolio model using all of constraints and Location quotient objective function (CMV4);
- Constrained mean-variance portfolio model using all of constraints and all of objective functions (CMV5).

The models are solved by considering λ =0.1. Therefore each model is solved 11 times; for multi-objective models equation (27) conversion is used. By 66 times of model running with Lingo 8 the results were extracted. In order to evaluate the results the six problems were also solved with single objective and multi-objective genetic algorithm for different values of λ. BM, CMV1, CMV2 models were solved using simple genetic algorithm for different λ. CMV3, CMV4 and CMV5 were solved using multi-objective genetic algorithm. MATLAB 2010a optimization toolbox is used to solve the models. Population size is set at 100 and number of generations is set at 2500 and again 66 times of model running is done. The dominated points are listed and sorted. Figure 1 shows the efficient frontier for each model.

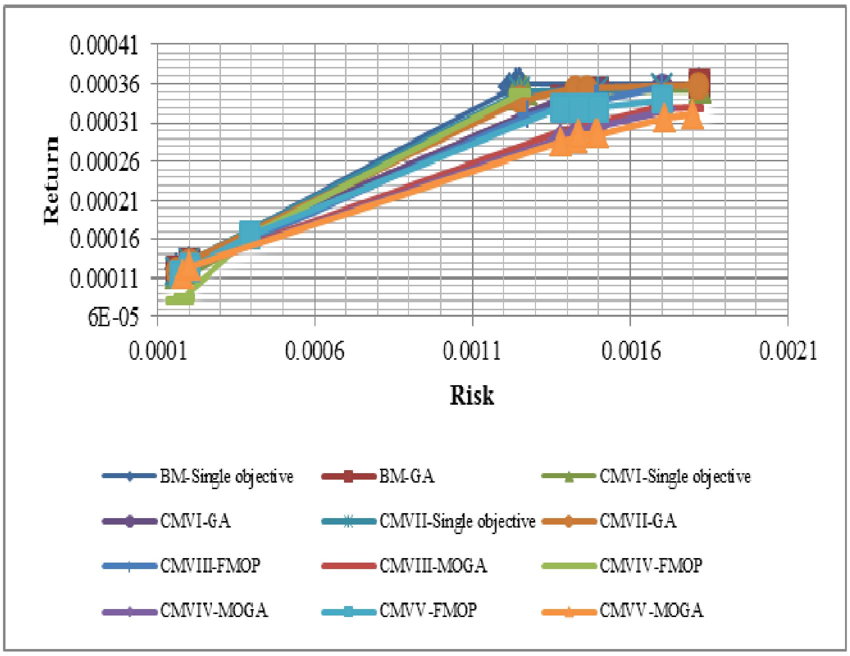


Fig. 1. Efficient frontiers for GA versus single objective OR model and MOGA versus FMOP

The CMV (V) model is placed at the lowest order as it includes all constraints of objective functions. The Location quotient objective function has more effect on the efficient frontier than comparative advantage objective function. Therefore the CMV (VI) efficient frontier is placed lower than CMV (III) for both FMOP and MOGA.

Figure 2 shows the performance of FMOP versus MOGA for two other objective functions.

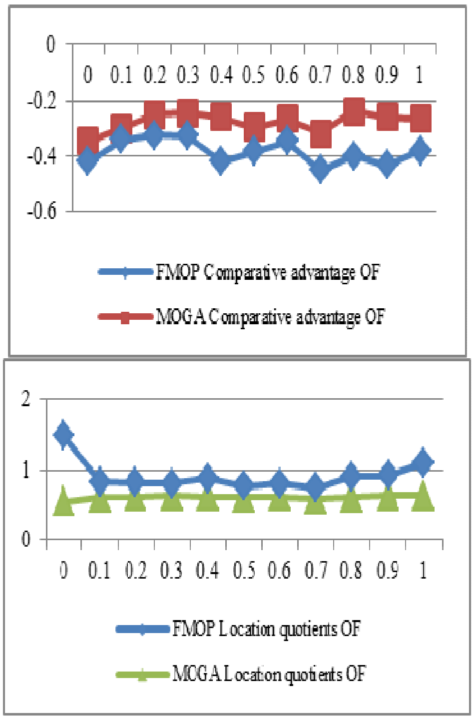


Fig. 2. MOGA versus FMOP for Location quotients (Right) and Comparative advantage (Left) objective functions for CMV (V)

It can be seen from the results that, MOGA shows better results than FMOP for Comparative advantage objective function but FMOP shows better results for MOGA for Location quotient objective function.

Investigating the effect of selected indicators

Seeking the significance of differences between solving methods 3 set Paired T test are done and the results are shown in Table 2. It can be seen that there is no significant difference between solving methods at individual objective functions level and at the total level considering both objective functions.

Table 2. T paired test shows statistically significant(S) versus not significant (N) differences between FMOP and MOGA

Solving method	Return		Risk		Total	
Level of confidence	95%	99%	95%	99%	95%	99%
FMOP & MOGA	N	N	N	N	N	N

Paired sample T test with significant difference at the 5% level is used to compare 6 different methods against each other. Table 3 shows the results for 15 different comparisons rated 5 times. In total 75 experiments was done using SPSS software. Different answers were bolded against both solving methods. Although there are some differences due to the solving methods but the above mentioned test shows that there is no significance. Therefore referring to the last row it’s revealed that all pairs have significant difference against each other excluding BM & CMV1 and CMV4& CMV5.

Table 3. T paired test shows statistically significant(S) versus not significant (N) differences between each pair of models

Scope of Tests	**Solving method**	CMV4& CMV5	CMV3& CMV5	CMV3& CMV4	CMV2& CMV5	CMV2& CMV4	CMV2& CMV3	CMV1& CMV5	CMV1& CMV4	CMV1& CMV3	CMV1 & CMV2	BM & CMV5	BM & CMV4	BM & CMV3	BM & CMV2	BM & CMV1
Return	FMOP	S	S	S	S	S	S	S	S	S	N	S	S	S	S	S
	MOGA	N	N	N	S	S	S	S	S	S	S	S	S	S	S	N
Risk	FMOP	N	S	S	S	S	N	S	S	N	N	S	S	N	S	N
	MOGA	S	S	N	N	N	N	N	N	N	S	N	N	N	S	S
Total	Both	N	S	S	S	S	S	S	S	S	S	S	S	S	S	N

Another 30 Paired sample T test with significant difference at the 5% level is used to compare 6 different methods against each other. Table 4 shows the rank of different methods, the first column shows the rank using the average of objective functions at different lambda values, and the second column shows the ranks including the

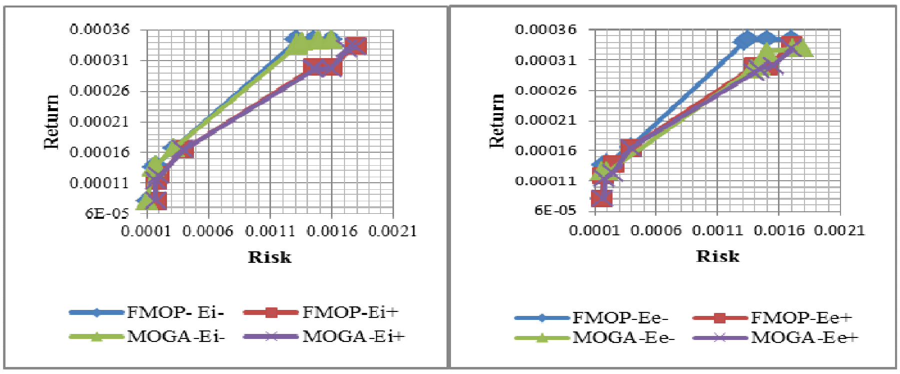
significance difference of models. It is obvious that by adding sustainable development selected indicators in terms of constraints and objective functions, the return decreases significantly, although this order is partially not totally true for the risk objective function.

Table 4. Ranking of different models for different objective functions (The results are described using both solving methods.)

Objective function	Model Rank considering the average	Model Rank considering the average and significance of difference Ttest
Return	BM>CMV1>CMV2>CMV3>CMV4>CMV5	BM,CMV1>CMV2>CMV3>CMV4,CMV5
Risk	CMV2> CMV1>BM > CMV5>CMV4>CMV3	CMV2> CMV1,BM > CMV5,CMV4>CMV3

Sensitivity Analysis

Sensitivity analysis investigates changes in optimum decision as the data changes. In this sub-section, sensitivity analysis was designed and done on the "indirect and induced job creation" parameter which is important for NDFI board of directors and on the final complete model CMV (V). Therefore by shifting E_i +/- 20% upper/lower, two different scenarios are designed and efficient frontier and other two objective functions changes are evaluated. Both FMOP and MOGA must run 44 times, and then the dominated points are listed and sorted. Figure 3 shows the efficient frontier for both methods.



a) FMOP versus MOGA sensitivity analysis results for different indirect and induced job creation (E_i)

b) FMOP versus MOGA sensitivity analysis results for different direct job creation (E_e)

Fig. 2. Sensitivity results for different $E_i$on the CMV (V) model

Figure 3a reveals that for indirect and induced job creation parameter FMOP has shown rather similar but better results for 20% lower amount of Ei; it is also clear that for 20% upper amount of Ei, FMOP shows better results. Figure 3b shows that similar results are obtained from the experiments for Ee. It can be concluded that by limiting the feasible space, both algorithm have shown rather similar answers.

Discussion and Study Limitations

In order to better understand the effect of constraints and other objective functions, different efficient frontiers are illustrated. It is revealed that by considering sustainable development selected indicators, all of the efficient frontiers are considerably placed at a lower place from the basic Markowitz model. Although this means lower return or higher risk for a specified level of risk/ return, but these added constraints and objectives, guarantees the basic requirements of sustainable development which is recognized as important, by NDFI.

There are several limitations for the study. Considering a balanced "Export-oriented industrialization" versus "Import-substituting Industrialization" strategy and implementation using credit allocation is a major issue. Implementation of both strategies needs data for the amounts of appropriate indicators including foreign exchange "savings" versus "income" for each industrial sector; which was not available for researchers.

Conclusion

The purpose of this paper is to provide an insight into applying sustainable development’s selected indicators to credit allocation and its effects on the risk and returns of a portfolio of loans. To serve this purpose, constraint mean-variance portfolio is used for modeling the credit allocation; moreover the remaining indicators of sustainable development were added to the basic CMV model using two other objective functions. The efficient frontiers are drawn for the basic

Markowitz, CMV with single objective, and CMV with one and two other remaining objective functions. The models are solved using Fuzzy multi-objective programming and multi-objective genetic programming. It is revealed that by adding the sustainable development selected indicators, objective functions and constraints, the efficient frontiers are placed lower. The analysis also revealed that the policy makers can guarantee the minimum requirements of sustainable development by considering it in the credit allocation process. It’s also shown that FMOP has better results than MOGA. Although the MOGA results are more robust for different values of λ. Sensitivity analysis is also done and it is revealed that indirect and induced job creation parameter fluctuations have more effect on the model results than direct job creation parameters.

The futures works can be done by implementing other sustainable development sub-systems including environmental and social issues by applying their appropriate indicators. "Export-oriented industrialization" versus "Import-substituting Industrialization" strategy can also be implemented. The amount of credit allocated to “working capital” versus “establishment” can also be included in the model by estimating the amount of countries needs in different sectors.

Acknowledgements

This research has been partially funded by the National Development Fund of Iran (NDFI).

References

Anagnostopoulos, K. P. & G. Mamanis (2011). "The mean–variance cardinality constrained portfolio optimization problem: An experimental evaluation of five multiobjective evolutionary algorithms". *Expert Systems with Applications*, 38(11), 14208-14217.

Balding, C. and Y. Yao (2011). "Portfolio Allocation for Sovereign Wealth Funds in the Shadow of Commodity-Based National Wealth". *International Finance Review*, 12, 293-312.

Chang, T. J.; N. Meade; J. E. Beasley & Y. M. Sharaiha (2000). "Heuristics for cardinality constrained portfolio optimisation". *Computers & Operations Research*, 27(13), 1271-1302.

Crama, Y. & M. Schyns (2003). "Simulated annealing for complex portfolio selection problems". *European Journal of operational research*, 150(3), 546-571.

De Benedictis, L. & M. Tamberi (2001). "A note on the Balassa index of revealed comparative advantage". *Available at SSRN 289602*.

Deng, G. F., W. T. Lin and C. C. Lo (2011). "Markowitz-based portfolio selection with cardinality constraints using improved particle swarm optimization". *Expert Systems with Applications*. 39, 4558-4566.

Dev, S. (2005). *Bill Hopwood*, Mary Mellor and Geoff O'Brien Sustainable Cities Research Institute*. University of Northumbria, Newcastle on Tyne, UK."

Economic, U. N. D. o. & S. Affairs (2001). Indicators of sustainable development: Guidelines and methodologies, United Nations, Economic & Social Affairs.

Fernández, A. & S. Gómez (2007). "Portfolio selection using neural networks". *Computers & Operations Research*, 34, 1177-1191.

Fonseca, C. M. & P. J. Fleming (1993). "Genetic algorithms for multiobjective optimization: Formulation, discussion and generalization". *Proceedings of the fifth international conference on genetic algorithms, San Mateo, California*.

Gintschel, A. & B. Scherer (2008). "Optimal ass*et al*location for sovereign wealth funds". *Journal of Asset Management*, 9(3), 215-238.

Golusin, M.; O. M. Ivanovic & N. Teodorovic (2011). "The review of the achieved degree of sustainable development in South Eastern Europe—The use of linear regression method". *Renewable and Sustainable Energy Reviews*, 15(1), 766-772.

Gupta, P.; M. K. Mehlawat & A. Saxena (2008). "Asset portfolio optimization using fuzzy mathematical programming". *Information*

Sciences, 178(6), 1734-1755.

Heintz, J.; R. Pollin & H. Garrett-Peltier (2009). *How infrastructure investments support the US economy: employment, productivity and growth*. Political Economy Research Institute (PERI), University of Massachussetts Amberst.

Hunt, S. D. & R. M. Morgan (1995). "The comparative advantage theory of competition". *The Journal of Marketing*, (59), 1-15.

Ivanovic, O. D. M.; M. T. Golusin, S. N. Dodic & J. M. Dodic (2009). "Perspectives of sustainable development in countries of Southeastern Europe". *Renewable and Sustainable Energy Reviews*, 13(8), 2079-2087.

Knill, A. M.; B. S. Lee & N. Mauck (2011). "Sovereign wealth fund investment and the return-to-risk performance of target firms". *Journal of Financial Intermediation*, 21(2), 315-340.

Laursen, K. (1998). *Revealed comparative advantage and the alternatives as measures of international specialisation*. DRUID Working Papers.

Metaxiotis, K. & K. Liagkouras (2012). *Multiobjective Evolutionary Algorithms for Portfolio Management: A comprehensive literature review*. Expert Systems with Applications.

Osman, M.; M. Abo-Sinna; A. Amer & O. Emam (2004). "A multi-level non-linear multi-objective decision-making under fuzziness". *Applied Mathematics and Computation*. 153(1), 239-252.

Sadjadi, S. J.; M. Gharakhani & E. Safari (2012). "Robust optimization framework for cardinality constrained portfolio problem". *Applied Soft Computing*, 12(1), 91-99.

Sakawa, M. (1993). *Fuzzy sets and interactive multiobjective optimization*, Plenum Press New York.

SCI, s. c. o. I. (2011). "Iran's statistical yearbook", 2013, from http://www.amar.org.ir/Default.aspx?tabid=133.

Selection, P. & E. Diversification (1952). "Harry Markowitz". *The Journal of Finance*, 7(1), 77-91.

Shaw, D. X.; S. Liu and L. Kopman (2008). "Lagrangian relaxation procedure for cardinality-constrained portfolio optimization". *Optimisation Methods & Software*, 23(3), 411-420.

Shi, X. & H. Xia (1997). "Interactive bilevel multi-objective decision making". *Journal of the operational research society*, 48(9), 943-949.

Streimikiene, D.; R. Ciegis and D. Grundey (2007). "Energy indicators for sustainable development in Baltic States". *Renewable and Sustainable Energy Reviews*, 11(5), 877-893.

Utkulu, U. & D. Seymen (2004). *Revealed Comparative Advantage and Competitiveness: Evidence for Turkey vis-à-vis the EU/15*. European Trade Study Group 6th Annual Conference, ETSG, Nottingham.

Yu, J.; B. Xu; H. Yang & Y. Shi (2010). "The strategic ass*et al*location optimization model of sovereign wealth funds based on maximum CRRA utility & minimum VAR". *Procedia Computer Science,* 1(1), 2433-2440.

Zimmermann, H. J. (1978). "Fuzzy programming and linear programming with several objective functions". *Fuzzy sets and systems,* 1(1), 45-55.