Multi-objective programming methodology for solving economic diplomacy resource allocation problem

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Abstract. Economic diplomacy is an important prerequisite for achieving the economic goals of any country. The issue is worth analysing from several aspects. Since there is a lack of literature in the field, this paper may be one of the first steps in this direction. It focuses on a clear exposition and explanation of multi-objective programming methodology and its connection with economic diplomacy at the micro-level. This connection is achieved by constructing a model that optimises funds allocation for economic diplomacy costs. The model uses multi-objective programming methodology and takes into account the relevant economic diplomacy funding determinants. It defines measurements of criteria, budget limitation, efficiency maximization, and location. The application of the model is illustrated by a numerical example.

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1. Introduction

New trends are appearing in contemporary business, such as globalization, computerization, and interconnectedness. These cannot be neglected by any country in the world. They should be accepted as mechanisms for achieving higher rates of economic growth. These trends, along with familiar economic categories like development, trade, industry, negotiation, foreign direct investment, tariffs, and many others, are closely connected with economic diplomacy. Economic diplomacy is a broad term, but there is a lack of professional and scientific literature in the field.

Most scientific papers investigate economic diplomacy from a macroeconomic point of view. The macroeconomic perspective includes fields like promotion investment, industry determinants and free trade agreements (FTA) that include competition between two or more countries and their potential abroad. The microeconomic perspective raises other issues, such as what economic diplomacy stakeholders can do to improve the efficiency of economic diplomacy policies and framework, and whether a cost-oriented analysis is the right initiative in such circumstances. This paper is perhaps the first attempt to answer the question. In our analysis, we connect the economic diplomacy cost issue with allocation and multi-objective linear programming issues. We want to discover the most efficient placement of a country's economic diplomats in embassies throughout the world. This will primarily help state institutions, because it is mostly their task to conduct economic diplomacy policies. We provide a numerical example through which, given limited resources, the efficient placement of diplomats can be achieved in the relevant regions using the proposed multi-objective programming methodology.

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The paper is organized as follows. After the introduction, a theoretical review of multi-objective programming methodology and an overview of the main determinants and conceptual framework of economic diplomacy are presented. The third part of the paper gives a model of multi-objective programming methodology applied to economic diplomacy efficiency allocation problem. The application of the model is illustrated by a non-trivial numerical example. The conclusion considers all the research results with their limitations, and makes recommendations for future work.

2. Economic diplomacy resource allocation and multi-objective linear programming

2.1. Economic diplomacy resource allocation

There are many definitions of economic diplomacy, because each definition depends on a variety of terms, such as economic and social development level, geopolitical circumstances, strategic policy, etc. [4]. Bearing all these in mind, there are at least three main points, each fairly wide in scope, that are common to definitions of economic diplomacy:

- facilitating access to foreign markets for national businesses
- attracting foreign direct investment (FDI) to the domestic country
- influencing international regulation to improve domestic interests [10].

All these points should be considered in terms of economic diplomacy. But we can also define it as the use of the full spectrum of a state's economic tools to achieve its national interests. Economic diplomacy covers all economic activities, including but not restricted to exports, imports, investments, lending, aid, free-trade agreements (FTA), business opportunities and terms. It deals with the nexus between power and wealth in international affairs. Three elements are necessary to investigate and understand economic diplomacy:

- political influence
- economic assets and relationships
- ways of consolidating the right climate in the political and international environment.

Obviously, efficiency of economic diplomacy depends on many determinants and there is no single answer which fits them all. Minimizing economic diplomacy costs is a quite different issue. Even if there is no hurry to develop economic diplomacy, the microeconomic perspective will provide more concrete results than the macroeconomic economic diplomacy perspective.

2.2. Multi-objective linear programming

Multi-objective programming is a complex process of determining a set of non-dominated solutions (alternatives) from a set of feasible solutions, and choosing the preferred solution from the set of non-dominated solutions. Many real problems may be presented as multi-objective programming issues. Multi-objective programming (MOP) contains K linear or non-linear objective functions $K \geq 2$ and a set of linear and/or non-linear constraints. According to the hypothesis, the objective functions in the MOP problem conflict to a certain extent. If the objective functions and constraints in the MOP problem are linear, then we have a multi-objective linear programming (MOLP) issue. A MOLP problem can be presented as:

$$\max_{\mathbf{x}\in\mathbf{S}} \left\{ f_k(\mathbf{x}) = \mathbf{x}^\top \mathbf{c}^k \right\}, \quad k = 1, 2, \ldots, K, \tag{1}$$

where $\mathbf{c}^k \in \mathbb{R}^n$, and $\mathbf{S} = \{\mathbf{x} \in \mathbb{R}^n : \mathbf{Ax} \leq \mathbf{b}, \mathbf{x} > \mathbf{0}\}$, where $\mathbf{A} \in \mathbb{R}^{m\times n}$, $\mathbf{b} \in \mathbb{R}^m$, while $\mathbf{0} \in \mathbb{R}^n$ denotes null vector. The following terms are connected with MOLP [6]:

a) *Criterion set*
Each element $\mathbf{x} \in \mathbf{S}$ is associated with the vector $\mathbf{f}(\mathbf{x}) = [f_1(\mathbf{x}), f_2(\mathbf{x}), \ldots, f_K(\mathbf{x})]$, which means that it is possible to map $\mathbf{x}$ to the objective function area $\mathbf{F}$. $\mathbf{F}$ is a criterion set that is defined as

$$\mathbf{F} = \Big\{\mathbf{f}(\mathbf{x}) \in \mathbb{R}^K : \mathbf{x} \in \mathbf{S}\Big\}.$$

b) *Marginal solutions*
The marginal solution is the maximum of each component of the vector $\mathbf{f}(\mathbf{x})$ on the feasible set $\mathbf{S}$, that is

$$\max_{\mathbf{x}\in\mathbf{S}} f_k(\mathbf{x}) = f_k^*, \quad k = 1, 2, \ldots, K.$$

c) *Ideal value of the vector function* $\mathbf{f}(\mathbf{x})$ *(Ideal)*
The vector $\mathbf{f}^*(\mathbf{x}) = [f_1^*, f_2^*, \ldots, f_K^*]^\top$ is called the ideal value of the vector function $\mathbf{f}(\mathbf{x})$.

d) *Non-dominated solution*
$\mathbf{x}^*$ is non-dominated solution of the MOLP problem, if there is no other feasible $\mathbf{x}$ so that $f_k(\mathbf{x}) \geq f_k(\mathbf{x}^*)$ holds for each $k = 1, 2, \ldots, K$, with strict inequality for at least one k.

e) *Preferred solution*
The preferred solution is a non-dominated solution chosen by decision-makers as the final one. As such, it lies in an area acceptable to all objective functions of the given problem. The preferred solution is also known as the best compromise solution.

Several methods have been developed to solve the MOLP problem. They are based on the fundamental theorems from [6]. Here we present one MOLP method based on the fuzzy sets theory: Fuzzy Goal Programming (FGP) method.
Let the achieved value of the objective functions in the MOLP problem be a vague statement such as approximately $\mathbf{f}$. Then, let the decision-maker(s) determine the aspired level of the objective functions ($\overline{f_k}$) with the allowed positive (u_k) and negative (l_k) deviations.
A goal programming problem with linguistic goals of objective functions is

$$\begin{aligned} &\text{Find} && \mathbf{x} \\ &\text{s.t.} && f_k(\mathbf{x}) \cong \overline{f_k},\ k = 1, 2, \ldots, K, \\ & && \mathbf{Ax} \leq \mathbf{b},\ \mathbf{x} \geq \mathbf{0}. \end{aligned} \tag{2}$$

To solve model (2) we have to form the membership functions to model the imprecise nature of the"fuzzy goals". The membership functions ($\mu(f_k(\mathbf{x}))$) are based on the preference concept obtained from the DM(s). They can have a triangular shape. The triangular linear membership functions of the objective functions are calculated as follows (see [2]):

$$\mu_k(f_k(\mathbf{x})) = \begin{cases} 1 & \text{, if } f_k(\mathbf{x}) = \overline{f_k} \\ \left[f_k(\mathbf{x}) - (\overline{f_k} - l_k)\right]/l_k & \text{, if } \overline{f_k} - l_k \leq f_k(\mathbf{x}) < \overline{f_k} \\ \left[(\overline{f_k} + u_k) - f_k(\mathbf{x})\right]/u_k & \text{, if } \overline{f_k} \leq f_k(\mathbf{x}) < \overline{f_k} + u_k \\ 0 & \text{, otherwise} \end{cases} \tag{3}$$

Narasimhan [5] proposes the following 2^k sub-problems that are equivalent to the standard linear programming problem ([2, 7, 8, 9]):

$$\begin{aligned} &\max\left\{\min_k \left[f_k(\mathbf{x}-(\overline{f_k}-l_k)\right]/l_k\right\}, \quad \text{for some } k \\ \text{s.t.} \quad &\mathbf{Ax} \le \mathbf{b},\ \overline{f_k} - l_k \le f_k(\mathbf{x}) < \overline{f_k},\ \mathbf{x} \ge \mathbf{0}, \end{aligned} \tag{4}$$

and

$$\begin{aligned} &\max\left\{\min_k \left[(\overline{f_k}+u_k)-f_k(x)\right]/u_k\right\}, \quad \text{for other } k \\ \text{s.t.} \quad &\mathbf{Ax} \le \mathbf{b},\ \overline{f_k} < f_k(\mathbf{x}) < \overline{f_k} + u_k,\ \mathbf{x} \ge \mathbf{0}. \end{aligned} \tag{5}$$

If we connect models (4) and (5), we obtain

$$\begin{aligned} &\max \alpha \\ \text{s.t.} \quad &\left[f_k(\mathbf{x})-(\overline{f_k}-l_k)\right]/l_k \ge \alpha, \\ &\overline{f_k} - l_k \le f_k(\mathbf{x}) < \overline{f_k}, \\ &\left[(\overline{f_k}+u_k)-f_k(x)\right]/u_k \ge \alpha, \\ &\overline{f_k} < f_k(\overline{x}) < \overline{f_k} + u_k, \\ &\mathbf{Ax} \le \mathbf{b},\ \mathbf{x} \ge \mathbf{0} \text{ and } \alpha \in [0,1]\,. \end{aligned} \tag{6}$$

To solve model (6), Hannan [1] proposes the following model:

$$\begin{aligned} &\max \alpha \\ \text{s.t.} \quad &\mathbf{Ax} \le \mathbf{b}, \\ &f_k(\mathbf{x})/l_k + d_k^- - d_k^+ = \overline{f_k}/l_k,\ \forall k, \\ &f_k(\mathbf{x})/u_k + d_k^- - d_k^+ = \overline{f_k}/u_k,\ \forall k, \\ &\alpha + d_k^- - d_k^+ \le 1, \forall k, \\ &d_k^-,\ d_k^+ \ge 0,\ \forall k,\ d_k^- \cdot d_k^+ = 0,\ \forall k, \\ &\alpha \in [0,1]\,,\ \mathbf{x} \ge \mathbf{0}. \end{aligned} \tag{7}$$

The model (7) is a linear goal programming problem that can be solved by the simplex algorithm. Yang, Ignizio and Kim [11] solve the model (6) using the following auxiliary model:

$$\begin{aligned} &\max \alpha \\ \text{s.t.} \quad &\mathbf{Ax} \le \mathbf{b},\ \left[f_k(\mathbf{x})-(\overline{f_k}-l_k)\right]/l_k \ge \alpha, \\ &\left[(\overline{f_k}+u_k)-f_k(x)\right]/u_k \ge \alpha,\ \alpha \in [0,1]\,, \mathbf{x} \ge \mathbf{0}. \end{aligned} \tag{8}$$

The model (8) is a linear programming problem.

3. Multi-objective linear programming and economic diplomacy resource allocation problem-solving

3.1. Objective functions and constraints of the MOLP problem

We can use the following criteria to solve the economic diplomacy resource allocation problem:

1. Expected exports of goods and services to foreign markets - trade in goods and services is defined as the amount of change in ownership of material resources and services between two countries.

2. Expected investment of foreign capital in the purchase of shares of domestic companies, foreign portfolio investments (FPI) - FPI means investing in financial assets, such as stocks and bonds of entities located in another country. Portfolio investment is investment in bonds and equities where the investor's holding is too small to provide any effective control [3].

3. Foreign direct investment (FDI) occurs when an investor based in one country (the home country) acquires an asset in another country (the host country) with the intention of managing that asset. The management dimension is what distinguishes FDI from portfolio investment in foreign stocks, bonds and other financial instruments. In such cases, the investor is typically referred to as the "parent firm" and the asset as the "affiliate" or "subsidiary".

To solve the economic diplomacy resource allocation problem, we can begin with the following constraints:

1. The budget is limited.
2. The minimum number of employees in agencies is defined.
3. The minimum and maximum number of employees in regions are given.

3.2. MOLP model

Let

A_{ij}	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be j^{th} agency in r^{th} region,
x_{ij}	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be the number of employees in j^{th} agency of r^{th} region,
c^k_{rj}	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r; k = 1, 2, \ldots, K)$ be the coefficient of variable x_{rj} of k^{th} objective function (expected exports of goods and services to foreign markets, foreign portfolio investments, foreign direct investment)
a_{rj}	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be the marginal cost per worker in j^{th} agency of r^{th} region,
d_{rj}	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be the fixed cost in j^{th} agency of r^{th} region,
b	be the amount of funds available for economic diplomacy in one year,
$b_{1,rj}$	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be the minimum number of employees in j^{th} agency of r^{th} region,
$b_{2,rj}$	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be the maximum number of employees in j^{th} agency of r^{th} region,
y_{rj}	$(r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r)$ be the artificial variable connected with variable x_{rj}, $y_{rj} \in \{0, 1\}$.

The MOLP model of the economic diplomacy resource allocation problem can be presented as:

$$\max_{x_{rj}\in\mathbf{S}} \left\{ f_1 = \sum_{r=1}^{R}\sum_{j=1}^{n_r} c^1_{rj}x_{rj},\ f_2 = \sum_{r=1}^{R}\sum_{j=1}^{n_r} c^2_{rj}x_{rj},\ \ldots, f_K = \sum_{r=1}^{R}\sum_{j=1}^{n_r} c^K_{rj}x_{rj} \right\} \tag{9}$$

$$S = \left\{ x_{rj} \;\middle|\; \begin{array}{c} (1)\ \sum_{r=1}^{R}\sum_{j=1}^{n_r} d_{rj}y_{rj} + \sum_{r=1}^{R}\sum_{j=1}^{n_r} a_{rj}x_{rj} \le b; (2)\ -x_{rj} + y_{rj} \le 0; (3)\ x_{rj} - My_{rj} \le 0; \\ (4)\ x_{rj} \ge b_{1,rj}; (5)\ x_{rj} \le b_{2,rj}; (r = 1, 2, \ldots, R;\ j = 1, 2, \ldots, n_r); \\ (6)\ \sum_{j=1}^{n_r} x_{rj} \le \sum_{j=1}^{n_r} b_{2,rj},\ r = 1, 2, \ldots, R; (7)\ x_{rj} \ge 0 \text{ and integer}; (8)\ y_{rj} \in \{0, 1\} \end{array} \right\}$$

Explanation: $f_1, f_2, \dots, f_K$ are objective functions of the model. Constraint (1) refers to the constraint of resources to settle the costs of economic diplomacy. Constraint (2) ensures that if $x_{rj} = 0$, then y_{rj} must also be equal to zero, while constraint (3) ensures that if $x_{rj} > 0$, then y_{kj} must be equal to 1. Constraint (4) refers to the minimum number of employees in j^{th} agency of r^{th} region, while constraint (5) refers to the maximum number of employees in j^{th} agency of r^{th} region. Constraint (6) refers to the number of employees in r^{th} region.

3.3. Numerical example

Suppose a country wants to deploy limited resources of 100 million dollars on economic diplomacy in six regions: Europe, Asia, North America, South America, Africa and Australia. The names of the cities in the regions, the fixed and marginal costs, the minimum and maximum number of employees in the agencies, and the expected efficiency per employee are given in Table 1.

Region	City	d_{rj}	a_{rj}	$b_{1,rj}$	$b_{2,rj}$	c^1_{kj}	c^2_{kj}	c^3_{kj}
Europe (1)	Brussels (1)	120	125	0	3	1550	2100	5200
	Prague (2)	86	98	0	3	1480	2200	3800
Asia (2)	Beijing (1)	156	110	0	3	1380	2300	4500
	New Delhi (2)	88	88	0	2	1250	3200	3670
	Hong Kong (3)	188	126	0	2	1325	2000	3800
Western America (3)	New York (1)	215	165	0	4	1520	3200	8400
	Toronto (2)	165	124	0	2	1480	4500	5300
Southern America (4)	Sao Paolo (1)	112	95	0	3	1230	2800	4550
	Buenos Aires (2)	98	88	0	3	1400	2600	3800
	Montevideo (3)	86	75	0	2	1320	2700	3300
Africa (5)	Pretoria (1)	125	102	0	2	1380	2600	3800
	Algeria (2)	76	68	0	2	2800	2700	3300
	Banjul (3)	55	59	0	2	1280	3000	4400
Australia (6)	Sydney (1)	128	98	0	3	1330	3100	3900
	Melbourne (2)	144	102	0	3	1340	3200	4500
	Perth (3)	136	96	0	3	1395	2750	6000

Table 1: *Numerical example data*

It was also decided that regions 1-6 may have at the least 1 and at the most 6, 6, 4, 6, 6, 4 employees respectively.

Multi-objective linear integer programming (MOLIP) model

Let x_{rj} $(r = 1, \dots, 6; j = 1, \dots, n_j)$ be the number of employees in j^{th} agency of r^{th} region. The MOLIP model of the considered example takes the following form:

$$\max_{x_{rj} \in \mathbf{S}} \left\{ \begin{array}{l} f_1 = \sum_{j=1}^{2} c^1_{1j} x_{1j} + \sum_{j=1}^{3} c^1_{2j} x_{2j} + \sum_{j=1}^{2} c^1_{3j} x_{3j} + \sum_{j=1}^{3} c^1_{4j} x_{4j} + \sum_{j=1}^{3} c^1_{5j} x_{5j} + \sum_{j=1}^{3} c^1_{6j} x_{6j} \\ f_2 = \sum_{j=1}^{2} c^2_{1j} x_{1j} + \sum_{j=1}^{3} c^2_{2j} x_{2j} + \sum_{j=1}^{2} c^2_{3j} x_{3j} + \sum_{j=1}^{3} c^2_{4j} x_{4j} + \sum_{j=1}^{3} c^2_{5j} x_{5j} + \sum_{j=1}^{3} c^2_{6j} x_{6j} \\ f_3 = \sum_{j=1}^{2} c^3_{1j} x_{1j} + \sum_{j=1}^{3} c^3_{2j} x_{2j} + \sum_{j=1}^{2} c^3_{3j} x_{3j} + \sum_{j=1}^{3} c^3_{4j} x_{4j} + \sum_{j=1}^{3} c^3_{5j} x_{5j} + \sum_{j=1}^{3} c^3_{6j} x_{6j} \end{array} \right\} \quad (10)$$

where

$$
\mathbf{S}=\left\{\begin{array}{c}
x_{rj} \mid \sum_{j=1}^{2} d_{1j}y_{1j}+\sum_{j=1}^{2} a_{1j}x_{1j}+\sum_{j=1}^{3} a_{2j}x_{1j}+\sum_{j=1}^{2} d_{3j}y_{3j}+\sum_{j=1}^{2} a_{3j}x_{3j}+\sum_{j=1}^{3} d_{4j}y_{4j} \\
+\sum_{j=1}^{3} a_{4j}x_{4j}+\sum_{j=1}^{3} d_{5j}y_{5j}+\sum_{j=1}^{3} a_{5j}x_{5j}+\sum_{j=1}^{3} d_{6j}y_{6j}+\sum_{j=1}^{3} a_{6j}x_{6j} \leq 100000; \\
-x_{1j}+y_{1j} \leq 0, x_{1j}-My_{1j} \leq 0\,(j=1,2); \\
-x_{2j}+y_{2j} \leq 0, x_{2j}-My_{2j} \leq 0\,(j=1,2,3); \\
-x_{3j}+y_{3j} \leq 0, x_{3j}-My_{3j} \leq 0\,(j=1,2); \\
-x_{4j}+y_{4j} \leq 0, x_{4j}-My_{4j} \leq 0\,(j=1,2,3); \\
-x_{5j}+y_{5j} \leq 0, x_{5j}-My_{5j} \leq 0\,(j=1,2,3); \\
-x_{6j}+y_{6j} \leq 0, x_{6j}-My_{6j} \leq 0\,(j=1,2,3); \\
x_{1j} \geq b_{1,1j}\,(j=1,2);\; x_{2j} \geq b_{1,2j}\,(j=1,2,3);\; x_{3j} \geq b_{1,3j}\,(j=1,2); \\
x_{4j} \geq b_{1,4j}\,(j=1,2,3);\; x_{5j} \geq b_{1,5j}\,(j=1,2,3);\; x_{6j} \geq b_{1,6j}\,(j=1,2,3); \\
x_{1j} \leq b_{2,1j}\,(j=1,2);\; x_{2j} \leq b_{2,2j}\,(j=1,2,3);\; x_{3j} \leq b_{2,3j}\,(j=1,2); \\
x_{4j} \leq b_{2,4j}\,(j=1,2,3);\; x_{5j} \leq b_{2,5j}\,(j=1,2,3);\; x_{6j} \leq b_{2,6j}\,(j=1,2,3); \\
1 \leq \sum_{j=1}^{2} x_{1j} \leq 6; \quad 2 \leq \sum_{j=1}^{3} x_{2j} \leq 6; \quad 1 \leq \sum_{j=1}^{2} x_{3j} \leq 4; \\
2 \leq \sum_{j=1}^{3} x_{4j} \leq 6; \quad 1 \leq \sum_{j=1}^{3} x_{5j} \leq 6; \quad 2 \leq \sum_{j=1}^{2} x_{6j} \leq 4; \\
x_{11},x_{12},x_{21},x_{22},x_{23},x_{31},x_{32},x_{41},x_{42},x_{43},x_{51},x_{52},x_{53},x_{61},x_{62},x_{63} \geq 0 \text{ and integer}; \\
y_{11},y_{12},y_{21},y_{22},y_{23},y_{31},y_{32},y_{41},y_{42},y_{43},y_{51},y_{52},y_{53},y_{61},y_{62},y_{63} \in \{0,1\}
\end{array}\right\}
$$

Model (10) was first solved by using Excel solver for linear programming with integer and binary variables, separately maximizing functions f_1, f_2 and f_3 on the given set $\mathbf{S}$. It should be emphasized that it is necessary to be careful when using the Excel solver in solving problems with integer and binary variables, as with the increased number of variables the program can give local instead of expected global maximum (minimum). The optimal (marginal) solutions are given in Table 2.

Solution	f_1	f_2	f_3
$\max\limits_{x_{rj}\in\mathbf{S}} f_1$	**51095**	85650	148490
$\max\limits_{x_{rj}\in\mathbf{S}} f_2$	44235	**87000**	139290
$\max\limits_{x_{rj}\in\mathbf{S}} f_3$	44570	84050	**155920**

Table 2: *Marginal (optimal) solution of the numerical example*

The objective function values in Table 2 indicate conflict between the objective functions and direct decision-makers(s) to use multi-objective programming methods to obtain a compromise solution. To obtain a compromise preferred solution, we used the fuzzy linear goal programming method presented in section 2.2. First, we set $\overline{f_1}=51095$, $\overline{f_2}=87000$, $\overline{f_3}=155920$, $l_1=6860$, $l_2=2950$, $l_3=16630$. The membership functions $\mu_1(f_1(x_{rj}))$, $\mu_2(f_2(x_{rj}))$, $\mu_3(f_3(x_{rj}))$ of the objective functions f_1, f_2 and f_3 are

$$
\mu_1(f_1(x_{rj}))=\begin{cases} 1 & , f_1 > 51095 \\ (f_1-44235)/6860 & , 44235 \leq f_1 \leq 51095 \\ 0 & , f_1 < 44235 \end{cases}
$$

$$\mu_2(f_2(x_{rj})) = \begin{cases} 1 & , f_2 > 87000 \\ {}^{(f_2-84050)}/_{1950} & , 84050 \le f_2 \le 87000 \\ 0 & , f_2 < 84050 \end{cases}$$

$$\mu_3(f_3(x_{rj})) = \begin{cases} 1 & , f_3 > 5155920 \\ {}^{(f_3-139290)}/_{16630} & , 148490 \le f_3 \le 155920 \\ 0 & , f_3 < 148490 \end{cases}$$

Using Model (8), we solved the following linear integer programming model:

$$\max_{x_{rj},\lambda\in\mathbf{S}'} \lambda \tag{11}$$

where

$$\mathbf{S}' = \left\{ \begin{array}{c} x_{rj}, \lambda \mid \sum_{j=1}^{2} d_{1j}y_{1j} + \sum_{j=1}^{2} a_{1j}x_{1j} + \sum_{j=1}^{3} a_{2j}x_{1j} + \sum_{j=1}^{2} d_{3j}y_{3j} + \sum_{j=1}^{2} a_{3j}x_{3j} + \sum_{j=1}^{3} d_{4j}y_{4j} \\ + \sum_{j=1}^{3} a_{4j}x_{4j} + \sum_{j=1}^{3} d_{5j}y_{5j} + \sum_{j=1}^{3} a_{5j}x_{5j} + \sum_{j=1}^{3} d_{6j}y_{6j} + \sum_{j=1}^{3} a_{6j}x_{6j} \le 100000; \\ -x_{1j} + y_{1j} \le 0, x_{1j} - My_{1j} \le 0\,(j=1,2); \\ -x_{2j} + y_{2j} \le 0, x_{2j} - My_{2j} \le 0\,(j=1,2,3); \\ -x_{3j} + y_{3j} \le 0, x_{3j} - My_{3j} \le 0\,(j=1,2); \\ -x_{4j} + y_{4j} \le 0, x_{4j} - My_{4j} \le 0\,(j=1,2,3); \\ -x_{5j} + y_{5j} \le 0, x_{5j} - My_{5j} \le 0\,(j=1,2,3); \\ -x_{6j} + y_{6j} \le 0, x_{6j} - My_{6j} \le 0\,(j=1,2,3); \\ x_{1j} \ge b_{1,1j}\,(j=1,2);\ x_{2j} \ge b_{1,2j}\,(j=1,2,3);\ x_{3j} \ge b_{1,3j}\,(j=1,2); \\ x_{4j} \ge b_{1,4j}\,(j=1,2,3);\ x_{5j} \ge b_{1,5j}\,(j=1,2,3);\ x_{6j} \ge b_{1,6j}\,(j=1,2,3); \\ x_{1j} \le b_{2,1j}\,(j=1,2);\ x_{2j} \le b_{2,2j}\,(j=1,2,3);\ x_{3j} \le b_{2,3j}\,(j=1,2); \\ x_{4j} \le b_{2,4j}\,(j=1,2,3);\ x_{5j} \le b_{2,5j}\,(j=1,2,3);\ x_{6j} \le b_{2,6j}\,(j=1,2,3); \\ 1 \le \sum_{j=1}^{2} x_{1j} \le 6; \quad 2 \le \sum_{j=1}^{3} x_{2j} \le 6; \quad 1 \le \sum_{j=1}^{2} x_{3j} \le 4; \\ 2 \le \sum_{j=1}^{3} x_{4j} \le 6; \quad 1 \le \sum_{j=1}^{3} x_{5j} \le 6; \quad 2 \le \sum_{j=1}^{2} x_{6j} \le 4; \\ \dfrac{f_1 - 44235}{6860} \ge \lambda;\ \dfrac{f_2 - 84050}{1950} \ge \lambda;\ \dfrac{f_3 - 139290}{16630} \ge \lambda; \\ x_{11}, x_{12}, x_{21}, x_{22}, x_{23}, x_{31}, x_{32}, x_{41}, x_{42}, x_{43}, x_{51}, x_{52}, x_{53}, x_{61}, x_{62}, x_{63} \ge 0 \text{ and integer}; \\ y_{11}, y_{12}, y_{21}, y_{22}, y_{23}, y_{31}, y_{32}, y_{41}, y_{42}, y_{43}, y_{51}, y_{52}, y_{53}, y_{61}, y_{62}, y_{63} \in \{0,1\} \end{array} \right\}$$

Solution	Variable values	f_1	f_2	f_3
$\mathbf{x}^*_{fuzzy}$	$x_{11}=3,\ x_{12}=3,\ x_{21}=3,\ x_{22}=2,\ x_{23}=1,\ x_{31}=4$ $x_{11}=3,\ x_{12}=3,\ x_{21}=3,\ x_{22}=2,\ x_{23}=1,\ x_{31}=4$ $x_{11}=3,\ x_{12}=3,\ x_{21}=3,\ x_{22}=2,\ x_{23}=1,\ x_{31}=4$	49285	85700	152090

Table 3: *Solution of* $\max_{x_{rj},\lambda\in\mathbf{S}'} \lambda$

In this way the presented model offers an impartial preferred non-dominated solution of economic diplomacy resource allocation problem which respects the required criteria.

The obtained solution (Table 3) may be presented to decision-makers, who can then accept the proposed solution or, if they ate not satisfied, determine other values $\overline{f_k}$, $(k = 1, 2, 3)$ to obtain a new compromise solution.

4. Conclusion

In the recent period of growing globalization trends, economic diplomacy has played an important role in improving the economic activity and wealth of many countries. Since diplomacy depends on a limited budget, the optimization of budget allocations to agencies in individual countries and regions is naturally an important task. In order to allocate a limited budget in the optimal way, it is important to select a set of relevant criteria and goals that reflect the efficiency of economic diplomacy in each agency. In this paper, we consider three such criteria: expected exports of goods and services to foreign markets, foreign portfolio investments and foreign direct investment. It is also important to measure the effectiveness of each criterion in each agency. We have assumed linearity of criteria and parameters.

The aim of this paper is to present the efficient application of multi-criteria linear integer programming methodology to resolve the allocation of funds for the optimal functioning of a country's economic diplomacy. In future research, it might be interesting to analyse the efficiency of a country's economic diplomacy by measuring the effectiveness of criteria based on statistical data. Such analyse could serve as a base for improvement the presented linear model by modifying the criteria or by introducing nonlinearity, if such dependence will be detected.

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