ciples of socially responsible investing. Expert method was used. Experiments have shown that the use of mathematical models to assess the competence of experts gives good results. This technique allows you to get more accurate results for the determination of the project category.

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СИСТЕМНІ ПРИНЦИПИ СОЦІАЛЬНО-ВІДПОВІДАЛЬНОГО ІНВЕСТУВАННЯ ЕНЕРГЕТИЧНИХ ПРОЕКТІВ УКРАЇНИ

Досліджується новий напрямок інвестування сучасних проектів – соціально відповідальне інвестування (СВІ). Розглядаються системні принципи соціального інвестування, включаючи вибір оптимальних варіантів аналізу ризиків, їх оцінки та мінімізації. Розглядається методика оцінки соціальних проектів в енергетиці України за кожним видом ризику СВІ. Проведено експертну оцінку трьох енергетичних проектів. Побудовано регресійну модель оцінки компетентності кожного експерта і встановлено категорію проектів відповідно до екологічних і соціальних принципів аналізу.

Ключові слова: соціально-відповідальні інвестиції, інвестиційний ризик, принципи соціального інвестування, стратегія модернізації, регресійний аналіз.

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СИСТЕМНЫЕ ПРИНЦИПЫ СОЦИАЛЬНО-ОТВЕТСТВЕННОГО ИНВЕСТИРОВАНИЯ ЭНЕРГЕТИЧЕСКИХ ПРОЭКТОВ УКРАИНЫ

Исследуется актуальное направление инвестирования современных проектов – социально-ответственное инвестирование (СОИ). Рассмотрены принципы построения целостной системы обеспечения, включающие выбор оптимальных вариантов анализа рисков, их оценки и минимизации. Рассматривается методика оценки социальных проектов в энергетике Украины по каждому виду риска СОИ. Проведена экспертная оценка трех энергетических проектов. Построена регрессионная модель оценки компетентности каждого эксперта и установлена категория проектов, соответствующая экологическим и социальным принципам анализа.

Ключевые слова: социально-ответственное инвестирование, инвестиционный риск, принципы социального инвестирлования, стратегия модернизации, регрессионный анализ.

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CASE STUDY IN OPTIMAL TELEVISION ADVERTS SELECTION AS KNAPSACK PROBLEM

Abstract : In this research paper, we shall consider the application of classical 0-1 knapsack problem with a single constraint to selection of television advertisements at critical periods such as prime time news, news adjacencies, break in news and peak times using the WINQSB software. In the end of this paper we shall formulate the task of investigation of the post optimality solution of optimal Television Adverts Selection with respect to time allocated for every group adverts.

Keywords: advertisements, integer programming, knapsack problem, fuzzy linear programming, sensitivity analysis.

Introduction. The Knapsack Problems are among the simplest integer problems. The problems in this class are typically concerned with selecting from a set of given items, each with a specified weight and value. Sum of weights a subset of items does not exceed a prescribed capacity and sum of selected items values is maximum.

Knapsack problems have been intensively studies since the pioneering work of Dantzig [1] in the late 50's, both because of their immediate applications in industry and financial management, but more pronounced for theoretical reasons, as Knapsack problems frequently occur by relaxation of various integer programming problems. In such applications, we need to solve a Knapsack problems each time a bounding function is derived demanding extremely fast solution techniques. The family of Knapsack problems all require a subset of some given items to chosen such that the corresponding profit sum is maximizing without exceeding the capacity of the knapsack(s). In the 0-1 Knapsack problems each item may be chosen at most once, while. The multi-choice Knapsack problems occur when the items should be chosen from disjoint classes. Sinha and Zoltners [2] proposed to use multi-choice Knapsack problems to select which components should be linked in series in order to maximizing fault tolerance.

Moreover Nauss [3] proposed to transform nonlinear knapsack problems to multi-choice Knapsack problems. In the second category we should mention that the 0-1 Knapsack problem appears as sub problem when solving generalized assignment problem, which again is heavily used when solving Vehicle Routing Problem (G.Laport [4]).

Knapsack problems and analysis data. Suppose the producer of a TV program wants to select among numerous adverts for the prime time (news at 19:00 h GMT), which is interspersed with five or six spots of adverts of not more than three minutes each. It is self-evident that the optimal solution of the knapsack problem above will indicate the best possible choice of investment.

The objects to be considered will generally be called items and their number by n. The value and size associated with the j -th item will be called profit (cost of advert) and weight (duration of advert), respectively.

The traditional 0-1 Knapsack Problem (KP) for this case can be mathematically formulated through the following integer linear programming

$$\sum_{j=1}^{n} v_j x_j \to \max \tag{1}$$

subject to

$$\sum_{j=1}^{n} w_j x_j \le W, \quad x_j \in \{0,1\}, \quad j = \overline{1,n}, \tag{2}$$

where v_j is value (cost of advert) and w_j is the weight (duration of advert) of the *j-th* item respectively, $j = \overline{1,n}$, and W is the maximum time allocated for adverts.

If we know quantity of different adverts categories, costs and weights in each category, the model above can be rewrite as

$$\sum_{i=1}^{m} \sum_{j=1}^{n_i} v_j^i x_{ji} \to \max \tag{3}$$

$$\sum_{j=1}^{n_i} w_j^i x_{ji} \le W^i, \quad x_{ji} \in \{0,1\}, \quad j = \overline{1,n_i}, \quad i = \overline{1,m}, \tag{4}$$

where m represented the quantity of categories n_i, $i = \overline{1,m}$, – quantities of advertise in every category.

There are two basic methods for solving the 0-1 knapsack problems: the first, the ideas ofbranch-and-bound techniques have frequently been applied to Knapsack problems since Kolesar [5] and, the second, dynamic programming methods. However we uses the first method in software WINQSB [6] to have been used to solve large scale problems. This study was undertaken using data collected from S.K.Amponsah [7].

TV is a public broadcaster which depends to the greater extent on government subvention. Broadcasting Corporation is however mandated to generate revenue to supplement the government subvention. To this end TV has various ways of generating additional income. These include sponsorship of programs, social and funeral announcements, advertisements among others. However, this research focused on advertisements, which are slotted in the programs schedules prepared quarterly to generate additional income to sustain the operations of the TV station. TV uses an arbitrary method in the selection. In this process an advert is accepted if there is an available time without regard to optimizing revenue. The category of adverts selection studied included:

- prime time news (19.00 h GMT);
- news adjacencies (five minutes before and after news at 12.00, 14.00, 19.00 and 22.30 h GMT);
- other news time (12.00, 14.00, 19.00, 22.30 h GMT);
- break in programs (peak and off peak).

Table 1 shows the various rates for the different categories of adverts at TV. For example Prime time News adverts for 15 sec costs $215 while for 60 sec, the rate is $750. The rates are high for Prime time News and news adjacencies. These are periods where most customers want their adverts televised to reach a larger TV audience. The off peak rates are low compared with the peak periods. Customers usually request for a number of spots for their adverts. Table 2 shows request received by TV for Prime time News (19 h GMT). Customer 1 requested for two spots of adverts for fifteen seconds each at prime time news. The cost of the two adverts is $ 430 (i.e., 215+215) as indicated in the value column. The weight of this advert is 30 sec.

Table 1. **TV adverts rates**

Category ($i = \overline{1,4}$)	Rates in $			
	15 second	30 second	45 second	60 second
Prime times news (19h GMT)	215	375	562	750
News adjacencies	130	250	375	500
Break in news	135	244	362	525
Break in program	91	160	220	360

Table 2. **Prime time news adverts-19:00 h GMT**

Advertise No. j	Time in sec.	No. of spots requested	Category (weight), w_j^1	Cost $ (value), v_j^1
1	15	2	30	430
2	30	3	90	1125
3	45	1	45	562
4	15	1	15	214
5	30	3	90	1125
6	45	2	90	1124
7	60	1	60	750
8	30	2	60	750
9	45	2	90	1124
10	15	1	15	215
11	15	1	15	215
12	30	1	30	375
13	45	2	90	1124

Закінчення табл. 2

Advertise No. j	Time in sec.	No. of spots requested	Category (weight), w_j^1	Cost $ (value), v_j^1
14	15	2	30	430
15	30	2	60	1125
16	45	2	90	1124
17	30	3	90	1125
18	30	3	90	1125
19	45	2	90	1124
20	60	1	60	750
21	45	1	45	562
22	15	1	15	215
23	15	1	15	215
24	15	1	15	215
25	30	2	60	750
26	30	3	90	1125
27	15	2	30	430
28	60	1	60	750
29	30	3	90	1125
30	15	2	30	430

Additionally, customer number 5 requested three spots of 30 sec each, i.e. 90 sec (weight) with a cost of $1125 (value). The total time available for adverts at the prime time news is 20 min (i.e., 1200 sec) but the total time requested is 1710 sec. Other customers opt for the News Adjacencies. This is 5 min before and after the prime time news at 19.00 h GMT. As shown in Table 3, the total time available is 10 min (600 sec) but the customers requested a total of 810 sec. Tables 4 and 5 depicts the weights and the values for the adverts requested for the 22:30 news time and for peak time on week days, respectively. The total time available is 600 sec but the customers requested 720 sec.

***Table 3*. Adverts for news adjacencies -18:55 -19:00 and 20:00-20:05**

Advertise No. j	Time requested (weight), w_j^2	Cost $ (value), v_j^2
1	30	260
2	45	375
3	15	130
4	90	750
5	60	500
6	60	250
7	90	750
8	15	130
9	15	130
10	30	250
11	30	260
12	60	500
13	45	375
14	15	130
15	15	130
16	15	130
17	60	250
18	30	260
19	60	500
20	30	260

***Table 4*. Adverts for Break in News at 22:30 Hours GMT**

Advertise No. j	Time requested (weight), w_j^3	Cost $ (value), v_j^3
1	30	150
2	45	200
3	15	75
4	90	400
5	60	290
6	60	270
7	90	400
8	15	75
9	15	75
10	30	150
11	30	150
12	60	290
13	45	200
14	15	75
15	15	75
16	15	75
17	60	270
18	30	150
19	60	290
20	30	150

Table 5. **Break in program adverts for peak time on week days**

Advertise No. j	Time requested (weight), w_j^4	Cost $ (value), v_j^4
1	15	91
2	15	91
3	30	160
4	90	440
5	30	182
6	90	480
7	90	440
8	90	480
9	60	320
10	15	91
11	15	91
12	15	91
13	60	320
14	90	480
15	30	182
16	60	360
17	90	480
18	30	182

Finally the mathematical problem is formulate as knapsack optimization problem :

$$430x_{1,1}+1125x_{2,1}+562x_{3,1}+214x_{4,1}+1125x_{5,1}+1124x_{6,1}+750x_{7,1}+750x_{8,1}+1124x_{9,1}+215x_{10,1}+215x_{11,1}+375x_{12,1}+$$
$$+1124x_{13,1}+430x_{14,1}+1125x_{15,1}+124x_{16,1}+1125x_{17,1}+1125x_{18,1}+1124x_{19,1}+750x_{20,1}+562x_{21,1}+215x_{22,1}+$$
$$+215x_{23,1}+215x_{24,1}+750x_{25,1}+1125x_{26,1}+430x_{27,1}+750x_{28,1}+1125x_{29,1}+430x_{30,1}+260x_{1,2}+375x_{2,2}+130x_{3,2}+$$
$$+750x_{4,2}+500x_{5,2}+260x_{6,2}+750x_{7,2}+130x_{8,2}+130x_{9,2}+250x_{10,2}+260x_{11,2}+500x_{12,2}+375x_{13,2}+130x_{14,2}+$$
$$+130x_{15,2}+130x_{16,2}+250x_{17,2}+260x_{18,2}+500x_{19,2}+260x_{20,2}+150x_{1,3}+200x_{2,3}+75x_{3,3}+400x_{4,3}+290x_{5,3}+$$
$$+270x_{6,3}+400x_{7,3}+75x_{8,3}+75x_{9,3}+150x_{10,3}+150x_{11,3}+290x_{12,3}+200x_{13,3}+75x_{14,3}+75x_{15,3}+75x_{16,3}+270x_{17,3}+$$
$$+150x_{18,3}+290x_{19,3}+150x_{20,3}+91x_{1,4}+91x_{2,4}+160x_{3,4}+440x_{4,4}+182x_{5,4}+480x_{6,4}+440x_{7,4}+480x_{8,4}+320x_{9,4}+$$
$$+91x_{10,4}+91x_{11,4}+91x_{12,4}+320x_{13,4}+480x_{14,4}+182x_{15,4}+360x_{16,4}+480x_{17,4}+182x_{18,4}\to \max$$

subject to

$$30x_{1,1}+90x_{2,1}+45x_{3,1}+15x_{4,1}+90x_{5,1}+90x_{6,1}+60x_{7,1}+60x_{8,1}+90x_{9,1}+15x_{10,1}+15x_{11,1}+30x_{12,1}+$$
$$+90x_{13,1}+30x_{14,1}+60x_{15,1}+90x_{16,1}+90x_{17,1}+90x_{18,1}+90x_{19,1}+60x_{20,1}+45x_{21,1}+15x_{22,1}+$$
$$+15x_{23,1}+15x_{24,1}+60x_{25,1}+90x_{26,1}+30x_{27,1}+60x_{28,1}+90x_{29,1}+30x_{30,1}\le 1200\ ;$$
$$30x_{1,2}+45x_{2,2}+15x_{3,2}+90x_{4,2}+60x_{5,2}+60x_{6,2}+90x_{7,2}+15x_{8,2}+15x_{9,2}+30x_{10,2}+$$
$$+30x_{11,2}+60x_{12,2}+45x_{13,2}+15x_{14,2}+15x_{15,2}+15x_{16,2}+60x_{17,2}+30x_{18,2}+60x_{19,2}+30x_{20,2}\le 600\ ;$$
$$30x_{1,3}+45x_{2,3}+15x_{3,3}+90x_{4,3}+60x_{5,3}+60x_{6,3}+90x_{7,3}+15x_{8,3}+15x_{9,3}+30x_{10,3}+$$
$$+30x_{11,3}+60x_{12,3}+45x_{13,3}+15x_{14,3}+15x_{15,3}+15x_{16,3}+60x_{17,3}+30x_{18,3}+60x_{19,3}+30x_{20,3}\le 600\ ;$$
$$15x_{1,4}+15x_{2,4}+30x_{3,4}+90x_{4,4}+30x_{5,4}+90x_{6,4}+90x_{7,4}+90x_{8,4}+60x_{9,4}+$$
$$+15x_{10,4}+15x_{11,4}+15x_{12,4}+60x_{13,4}+90x_{14,4}+30x_{15,4}+60x_{16,4}+90x_{17,4}+30x_{18,4}\le 600$$

where

$$x_{j,i}=\begin{cases}1, \text{if j-th advertise of i-th category is selected}, & j=\overline{1,n_i},\ \ i=\overline{1,m},\ m=4, n_1=30,\ n_2=20,\ n_3=20,\ n_4=18,\\ 0, \text{otherwise.}\end{cases}$$

Results of the analysis. By using software WINQSB we obtained the results for the analysis of data from the Table 1 to 5 (Prime Time News, news adjacencies, break in News and break in program) are shown below.

The optimal selection these adverts yielded $26659. From the Table 6, nineteen adverts were selected from the 30 requested to give an optimal value of $15503. The selection for news adjacencies, the break in news, break in program and a peak period yielded $5070, $2860, $3350, respectively.

Table 6. **(Provide self-explanatory caption)**

Advert Category	No. of adverts requested	No. of adverts selected	Time availability, sec	Optimal value, $
Prime times news (19h GMT)	30	23	1200	15379
News adjacencies	20	16	600	5070
Break in news	20	17	600	2860
Break in program	18	13	600	3350
Total				26659

Adverts numbers which selected in categories:

– prime times news: $\{1,2,4,5,8,10,11,12,14,15,17,18,19,20,22,23,24,25,27,28,29,30\}$;

– ews adjacencies: $\{1,2,3,4,7,8,9,11,12,13,14,15,16,18,19,20\}$;

– break in news: $\{1,2,3,5,6,8,9,11,12,13,14,15,16,17,18,19,20\}$;

– break in program: $\{1,2,3,5,6,8,10,11,14,15,17,18\}$.

The resulting solution can be examined for sensitivity. Sensitivity analysis is usually performed by using principles of shadow prices and reduce costs [6]. But in this case we have nonconventional linear programming task. So sensitivity problem can be formulated as the fuzzy mathematical programming problem with fuzzy time values allocated for every group adverts [8]:

$$\sum_{i=1}^{m}\sum_{j=1}^{n_i} v_j^i x_{ji} \to \max \qquad (5)$$

subject to

$$\sum_{j=1}^{n_i} w_j^i x_{ji} \le \tilde{W}^i,\ x_{ji} \in \{0,1\},\ \ j=\overline{1,n_i}\ ,\ i=\overline{1,m}, \qquad (6)$$

where $\tilde{W}^i$, $i=\overline{1,m},$ – fuzzy defined time values allocated for every group adverts. Fuzzy values $\tilde{W}^i$, $i=\overline{1,m},$ can be considered as the right triangular fuzzy numbers (TFN) $\tilde{W}^i=(W^i,W^i,W^i+\Delta W^i)$, $i=\overline{1,m},$ with tolerances $\Delta W^i>0$, $i=\overline{1,m}$. These tolerances determine the values of the boundary changes necessary time resources.

Using the max-min operator (as Zimmermann [9]) crisp linear programming problems for (5), (6) is formulated as follows:

$$\lambda_0 \to \max, \qquad (7)$$

$$\sum_{i=1}^{m}\sum_{j=1}^{n_i} v_j^i x_{ji} - \lambda_0(U-L) \ge L, \qquad (8)$$

$$\sum_{j=1}^{n_i} w_j^i x_{ji} + \lambda_i \Delta W^i \le W^i + \Delta W^i,\ i=\overline{1,m}, \qquad (9)$$

$$x_{ji}\in\{0,1\},\ \ j=\overline{1,n_i},\ i=\overline{1,m},\ \lambda_i\in[0,1],\ i=\overline{0,m},$$

where $U=\sum_{i=1}^{m}\sum_{j=1}^{n_i} v_j^i x_{ji}^0$, $L=\sum_{i=1}^{m}\sum_{j=1}^{n_i} v_j^i x_{ji}^1$, x_{ji}^0, x_{ji}^1, $j=\overline{1,n_i}$, $i=\overline{1,m}$, – optimal solutions of optimization tasks (5), (9) for $\lambda_i=0$ and $\lambda_i=1$, $i=\overline{1,m}$, respectively.

Solving this task as a fuzzy linear programming problem with the several parameters λ_i, $i=\overline{1,m}$, we obtain values that determine possible changes in the right-hand sides of constraints that achieves the optimum value of the objective function.

Conclusion. This publication examines the application of the classical 0-1 knapsack problem with one constraint to the television broadcast adverts selection during critical periods. It is defined the task of obtaining the maximum profit from the advertising, broadcast in four categories of events. The solution of the real example is obtained by using WINQSB software. The problem of the sensitivity analysis study of the television advertising adverts choice solutions depending on the time periods allocated for every group adverts. It is considered fuzzy linear programming problem with multiple parameters, the solution of which allows to get the best choice of broadcasts for the changes in time limits allocated to each of the categories. The proposed approach yields optimal choice adverts and ensures the highest profit in the process of broadcasting. Availability limits and possible changes in the time bands provide the choice variability and allow the obtaining of the optimum value of the objective function subject to the ambiguity of time requests. This approach can be seen as the process of predicting the impact of changes in the input data on the solution obtained.

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ПРИКЛАД ОПТИМАЛЬНОГО ВИБОРУ ТЕЛЕВІЗІЙНОЇ РЕКЛАМИ НА ОСНОВІ ЗАДАЧІ ПРО РЮКЗАК

У цьому дослідженні розглянуто застосування классической задачи 0-1 ранце с одним ограничением для розв'язання задачі вибору пакетів телевізійної реклами у критичні періоди трансляцій, таких як прайм-тайм новини, новини між продовженнями, у перервах новин та у години пик за допомогою програмного забезпечення WINQSB. Сформульовано проблему постоптимального дослідження розв'язків задачі оптимального вибору телевізійної реклами за обсягом часу, відведеному кожній групі об'яв.

Ключові слова: реклама, цілочисельне програмування, задача про рюкзак, нечітке лінійне програмування, аналіз чутливості.

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ПРИМЕР ОПТИМАЛЬНОГО ВЫБОРА ТЕЛЕВИЗИОННОЙ РЕКЛАМЫ НА ОСНОВЕ ЗАДАЧИ О РЮКЗАКЕ

В этом исследовании рассмотрено применение классической задачи 0-1 ранце с одним ограничением для решения задачи выбора пакетов телевизионной рекламы в критические периоды трансляций, таких как прайм-тайм новости, новости между продолжениями, в перерывах новостей и в часы пик с помощью программного обеспечения WINQSB. Сформулирована проблема постоптимального исследования решений задачи оптимального выбора телевизионной рекламы по времени, отведенному каждой группе объявлений.

Ключевые слова: реклама, целочисленное программирование, задача о рюкзаке, нечеткая линейное программирование, анализ чувствительности.