СРАВНИТЕЛЬНЫЙ АНАЛИЗ ДЛЯ АЛГОРИТМА РЕШЕНИЯ ДВУХПАРАМЕТРИЧЕСКИХ ИГРОВЫХ МОДЕЛЕЙ

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Аннотация: *в этой статье выполнен сравнительный анализ для алгоритма решения двухпараметрических игровых моделей. В первой части исследования представлены сравнения функциональных значений цены игры и вероятностей стратегий, с численными решениями задачи в разных точках d, t параметров. Такой же анализ выполнен для разных количеств дискретов. Точность и надежность результатов проанализированы с помощью числового примера. Все представленные данные получены с помощью пакета прикладных программ. Окончательные данные представлены в форме таблиц.*

Ключевые слова: *параметрическая игровая модель, дифференциальные преобразования, сравнительный анализ, задача математического линейного программирования, алгоритм решения двухпараметрических игровых моделей.*

COMPARATIVE ANALYSIS FOR TWO-PARAMETRIC GAME MODEL SOLVER ALGORITHM

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Abstract: *in this paper the comparative analysis was performed for two-parametric game model solver algorithm by means of a numeric example. In the first part of this paper the functional meanings of the value of the game and the probabilities of the given strategies were compared with the numerical solutions for the given points of d,t parameters. The same analysis was performed for the different numbers of discrets. The accuracy and reliability of the outcome values was analyzed. All the data shown in this paper were obtained with the help of an applied software package. The final results are given in the form of tables.*

Keywords: *parametric game model, differential transform, comparative analysis, parametric linear programming problem, two-parametric game model solver algorithm.*

UDC 004.052.42

Experimental details

To check the performance and accuracy of the two-parametric game model solver algorithm [1, 2], we consider an example:

The following game model payoff matrix with d, t functional coefficients is presented below:

$$P = \begin{bmatrix} 1+t & 2d & 1 \\ 3-2t & d & 2 \\ 1+3t & 4 & d \end{bmatrix} \qquad (1)$$

The parametric linear programming problem of the game will be the following:

$$F(d,t) = x_1(d,t) + x_2(d,t) + x_3(d,t) \to \max_{x_1(d,t)x_2(d,t).x_3(d,t).}$$

$$\begin{cases} (1+t)x_1(d,t) + 2dx_2(d,t) + x_3(d,t) \le 1, \\ (3-2t)x_1(d,t) + dx_2(d,t) + 2x_3(d,t) \le 1, \\ (1+3t)x_1(d,t) + 4x_2(d,t) + dx_3(d,t) \le 1, \\ x_1(d,t), x_2(d,t), x_3(d,t) \ge 0 : \end{cases} \qquad (2)$$

For solving the game we choose the following parameters: $K_1 = K_2 = 5$, $H_1 = H_2 = 1$ (the parameters needed to apply the method of differential transforms [4, 5]), d=10, t=10. With the help of the applied package of program [3] the following solutions are obtained:

The parametric function of the value of the game:

$$\begin{gathered}
V(d,t)=1/(0.127(d-10)^0(t-10)^0-0.01(d-10)^1(t-10)^0+0.0008(d-10)^2(t-10)^0-\\
-7.16*10^{-5}(d-10)^3(t-10)^0+5.56*10^{-6}(d-10)^4(t-10)^0-4.04*10^{-7}(d-10)^5(t-10)^0+\\
+2.3*10^{-19}(d-10)^0(t-10)^1-1.56*10^{-20}(d-10)^1(t-10)^1+2.96*10^{-21}(d-10)^2(t-10)^1+\\
+9.93*10^{-23}(d-10)^3(t-10)^1+6.6*10^{-24}(d-10)^4(t-10)^1-2.11*10^{-24}(d-10)^5(t-10)^1+\\
+1.86*10^{-20}(d-10)^0(t-10)^2-1.4*10^{-20}(d-10)^1(t-10)^2+1.75*10^{-21}(d-10)^2(t-10)^2-\\
-2.14*10^{-22}(d-10)^3(t-10)^2+2.89*10^{-23}(d-10)^4(t-10)^2-3.25*10^{-24}(d-10)^5(t-10)^2-\\
-8.79*10^{-21}(d-10)^0(t-10)^3+8.54*10^{-22}(d-10)^1(t-10)^3-9.6*10^{-23}(d-10)^2(t-10)^3+\\
+9.46*10^{-24}(d-10)^3(t-10)^3-3.03*10^{-25}(d-10)^4(t-10)^3+2.3*10^{-26}(d-10)^5(t-10)^3+\\
+3.44*10^{-22}(d-10)^0(t-10)^4-8.68*10^{-23}(d-10)^1(t-10)^4+17*10^{-23}(d-10)^2(t-10)^4-\\
-1.68*10^{-24}(d-10)^3(t-10)^4+1.96*10^{-25}(d-10)^4(t-10)^4-2.16*10^{-26}(d-10)^5(t-10)^4+\\
+4.96*10^{-23}(d-10)^0(t-10)^5-7.83*10^{-24}(d-10)^1(t-10)^5+1.03*10^{-24}(d-10)^2(t-10)^5-\\
-7.43*10^{-26}(d-10)^3(t-10)^5+1.26*10^{-26}(d-10)^4(t-10)^5-2.5*10^{-27}(d-10)^5(t-10)^5)
\end{gathered} \tag{3}$$

The functions of the probabilities of the given strategies:

$$X_1(d,t)=0 \tag{4}$$

$$\begin{gathered}
X_2(d,t)=(-0.004d+2.3*10^{-19}t+(d-10)^5(-6.97*10^{-24}t+6.97*10^{-23})-\\
-7.25*10^{-28}(d-10)^5(t-10)^5-2.67*10^{-27}(d-10)^5(t-10)^4-\\
-1.49*10^{-26}(d-10)^5(t-10)^3-5.2*10^{-25}(d-10)^5(t-10)^2-\\
-3.75*10^{-7}(d-10)^5+(d-10)^4(4.54*10^{-23}t+4.54*10^{-22})+\\
+5.55*10^{-27}(d-10)^4(t-10)^5+4.44*10^{-26}(d-10)^4(t-10)^4+\\
+3.03*10^{-25}(d-10)^4(t-10)^3+2.22*10^{-24}(d-10)^4(t-10)^2+\\
+3.77*10^{-6}(d-10)^4+(d-10)^3(-2.11*10^{-22}t+2.11*10^{-21})-\\
-3.63*10^{-26}(d-10)^3(t-10)^5-4.65*10^{-25}(d-10)^3(t-10)^4-\\
-2.68*10^{-24}(d-10)^3(t-10)^3-1.98*10^{-23}(d-10)^3(t-10)^2-\\
-3.86*10^{-5}(d-10)^3+(d-10)^2(2.96*10^{-21}t-2.96*10^{-20})+\\
+5.81*10^{-25}(d-10)^2(t-10)^5+4.85*10^{-24}(d-10)^2(t-10)^2+\\
+2.06*10^{-23}(d-10)^2(t-10)^3+3.57*10^{-22}(d-10)^2(t-10)^2+\\
+0.0004(d-10)^2+(d-10)(-3.55*10^{-20}t+3.55*10^{-19})-\\
-6.61*10^{-24}(d-10)(t-10)^5-4.79*10^{-23}(d-10)(t-10)^4-\\
-7.94*10^{-23}(d-10)(t-10)^3-4.12*10^{-21}(d-10)(t-10)^2+4.96*10^{-23}(d-10)^5+\\
+3.44*10^{-22}(d-10)^4+1.16*10^{-21}(t-10)^3+186*10^{-20}(t-10)^2+0.886)/V(d,t)
\end{gathered} \tag{5}$$

$$\begin{gathered}
X_3(d,t)=(-0.006d+(d-10)^5(4.86*10^{-24}t-4.8*10^{-23})-1.78*10^{-27})(d-10)^5(t-10)^5-\\
-1.86*10^{-26}(d-10)^5(t-10)^4+3.79*10^{-26}(d-10)^5(t-10)^3-2.73*10^{-24}(d-10)^5(t-10)^2-\\
-2.88*10^{-8}(d-10)^5+(d-10)^4(-3.8*10^{-23}t+3.88*10^{-22})+7.12*10^{-27}(d-10)^4(t-10)^5+\\
+1.51*10^{-25}(d-10)^4(t-10)^4-6.07*10^{-25}(d-10)^4(t-10)^3+2.67*10^{-23}(d-10)^4(t-10)^2+\\
+1.7*10^{-6}(d-10)^4+(d-10)^3(3.11*10^{-22}t-3.11*10^{-21})-3.79*10^{-26}(d-10)^3(t-10)^5-\\
-1.21*10^{-24}(d-10)^3(t-10)^4+1.21*10^{-23}(d-10)^3(t-10)^3-1.94*10^{-22}(d-10)^3(t-10)^2-\\
-3.3*10^{-5}(d-10)^3+4.55*10^{-25}(d-10)^2(t-10)^5+1.21*10^{-23}(d-10)^2(t-10)^4-\\
-1.16*10^{-22}(d-10)^2(t-10)^3+1.4*10^{-21}(d-10)^2(t-10)^2+0.00048(d-10)^2+\\
+(d-10)(1.99*10^{-20}t-1.99*10^{-19})-1.21*10^{-24}(d-10)(t-10)^5-\\
-3.88*10^{-23}(d-10)(t-10)^4+9.33*10^{-22}(d-10)(t-10)^3-\\
-9.95*10^{-21}(d-10)(t-10)^2-9.95*10^{-21}(t-10)^3+0.14/V(d,t)
\end{gathered} \tag{6}$$

Results and discussion

In order to check the accuracy of the obtained results, we perform comparative analysis between the values of the $X_1(d,t), X_2(d,t), X_3(d,t), V(d,t)$ functions in selected points of the d,t parameters and the numerical results of the same problem for the $10 <= d < 20.4$, $10 <= t <= 50$ ranges of the given d, t parameters. As we see from table 1 the results obtained by both ways of solving the model are equivalent with the exception of the last points for d parameter, which is explained by the level of bias while determining the bounds of optimality of d,t parameters.

Table 1. Comparative analysis

t	**d**	$X_1(d,t)$	$X_2(d,t)$	$X_3(d,t)$	$V(d,t)$	**X_1**	**X_2**	**X_3**	**V**
10	10	0	0.36	0.64	7.84	0	0.36	0.64	7.84
10	10.1	0	0.359684	0.640316	7.905929	0	0.359	0.6403	7.905
10	10.2	0	0.359375	0.640625	7.971875	0	0.359	0.6406	7.971
10	10.3	0	0.359073	0.640927	8.037838	0	0.359	0.6409	8.037
10	10.4	0	0.358779	0.641221	8.103817	0	0.358	0.641	8.103
10	10.5	0	0.358491	0.641509	8.169811	0	0.358	0.641	8.169
10.1	10	0	0.36	0.64	7.84	0	0.36	0.64	7.84
10.2	10	0	0.36	0.64	7.84	0	0.36	0.64	7.84
10.3	10	0	0.36	0.64	7.84	0	0.36	0.64	7.84
10.4	10	0	0.36	0.64	7.84	0	0.36	0.64	7.84
10.5	10	0	0.36	0.64	7.84	0	0.36	0.64	7.84
11	11	0	0.357143	0.642857	8.500002	0	0.357	0.642	8.5
11	12	0	0.354825	0.645175	9.161417	0	0.354	0.645	9.16
11	13	0	0.352789	0.647211	9.825106	0	0.352	0.647	9.82
11	14	0	0.350512	0.649488	10.49612	0	0.351	0.648	10.48
11	15	0	0.346841	0.653159	11.18979	0	0.35	0.65	11.15
12	12	0	0.354825	0.645175	9.161417	0	0.354	0.645	9.16
13	12	0	0.354825	0.645175	9.161417	0	0.354	0.645	9.16
14	12	0	0.354825	0.645175	9.161417	0	0.354	0.645	9.16
15	12	0	0.354825	0.645175	9.161417	0	0.354	0.645	9.16
20	20	0	0.0955	0.904	19.019	0	0.345	0.654	14.47
20	50	0	0.0955	0.904	19.019	0	0.345	0.654	14.47
20.4	50	0	0.0009	0.999	21.156	0	0.345	0.654	14.738

The values of the function $V(d,t)$ in some d,t points for different K_1,K_2 values of discrets are portrayed in table 2 as well as numerical items of the game value of non parameter game for each d,t point. The research of the experiments shows that the accuracy of the results grows while increasing the numbers of K_1,K_2 discrets. In particular, for the given example the most precise results are achieved in case of the K_1=10,K_2=10 counts of discrets.

Table 2. Accuracy of the results

t	**d**	$V(d,t)$					**V**
		K_1=2,K_2=2	**K_1=3,K_2=3**	**K_1=4,K_2=4**	**K_1=5,K_2=5**	**K_1=10,K_2=10**	

10	10	7.84	7.84	7.84	7.84	7.84	7.84
10	10.1	7.905924	7.905929	7.905929	7.905929	7.905929	7.905
10	10.2	7.971839	7.971876	7.971875	7.971875	7.971875	7.971
10	10.3	8.037716	8.037841	8.037838	8.037838	8.037838	8.037
10	10.4	8.103525	8.103826	8.103817	8.103817	8.103817	8.103
10	10.5	8.169236	8.169834	8.169811	8.169811	8.169811	8.169
10.1	10	7.84	7.84	7.84	7.84	7.84	7.84
10.2	10	7.84	7.84	7.84	7.84	7.84	7.84
10.3	10	7.84	7.84	7.84	7.84	7.84	7.84
10.4	10	7.84	7.84	7.84	7.84	7.84	7.84
10.5	10	7.84	7.84	7.84	7.84	7.84	7.84
11	11	8.495203	8.500375	8.499973	8.500002	8.5	8.5
11	12	9.119901	9.167806	9.16033	9.161417	9.16129	9.16
11	13	9.674784	9.859236	9.815624	9.825106	9.823535	9.82
11	14	10.11665	10.60858	10.45068	10.49612	10.48663	10.48
11	15	10.40509	11.4739	11.03368	11.18979	11.15179	11.15
12	12	9.119901	9.167806	9.16033	9.161417	9.16129	9.16
13	12	9.119901	9.167806	9.16033	9.161417	9.16129	9.16
14	12	9.119901	9.167806	9.16033	9.161417	9.16129	9.16
15	12	9.119901	9.167806	9.16033	9.161417	9.16129	9.16

Conclusion

Comparative analysis was performed between the acquired results and already known solutions. The obtained results was analyzed for the different values of K1, K2 parameters for the function of the game $V(d,t)$ and for the $X_1(d,t), X_2(d,t), X_3(d,t)$ functions in some of the d,t points. The precision of the presented values were substantiate.

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