OPAZOVANJE VPLIVA POSAMIČNIH RECIKLAŽNIH TOKOV V RAZŠIRJENI MRP TEORIJI S POMOČJO SIMULACIJ

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MRP teorija

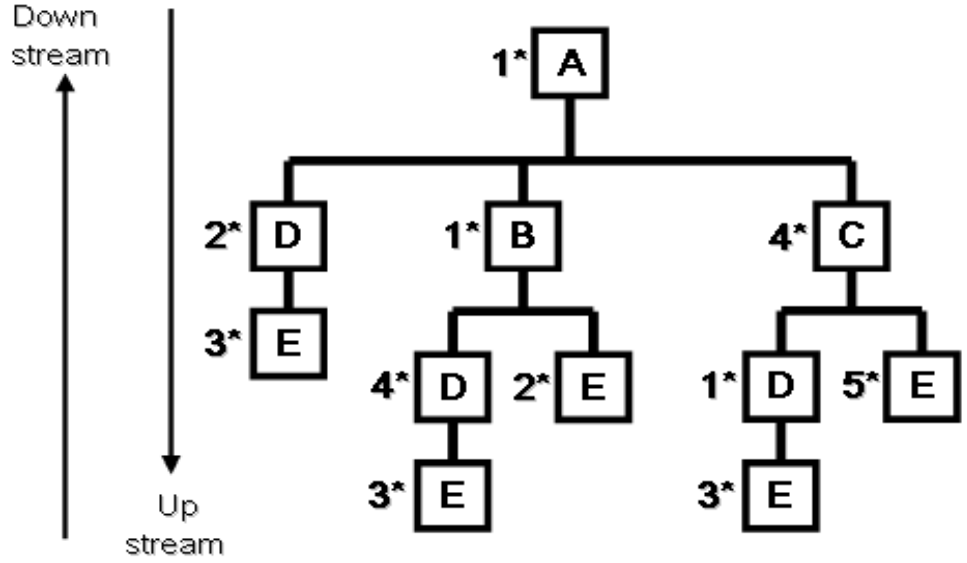
- Grubbström in Ovrin
  - Vpeljava zalog in časovnih razporeditev proizvodnih aktivnosti, ki izhajajo iz časovnih zakasnitev (z-transformacija)
  - Generalizirana vhodna matrika
- Grubbström in Molinder
  - Laplaceova transformacija - prehod iz diskretnega v zvezni čas
  - Temeljne enačbe MRP teorije
- Nadaljnje razširitve
  - Omejitve pri kapacitetah (Grubbström, Huynh)
  - Vključena prostorska komponenta (Bogataj L., Bogataj M.)
  - V dobavno verigo vključena povratna logistika (Grubbström, Bogataj L., Bogataj M., Kovačić)

MRP teorija

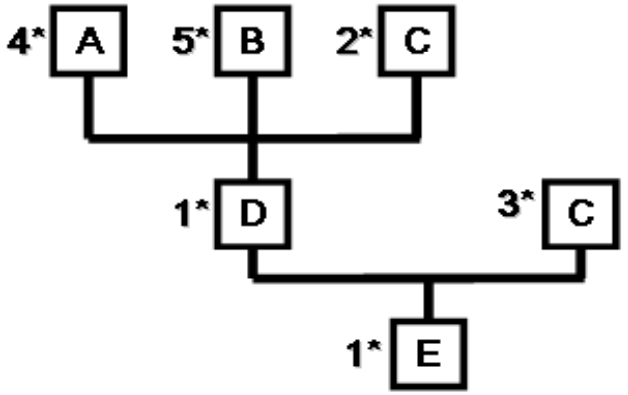
- Input-Output Analiza
- Laplaceova transformacija
- NSV - neto sedanja vrednost (NPV - Net Present Value)

Montažni/razvejani sistemi

Assembly system

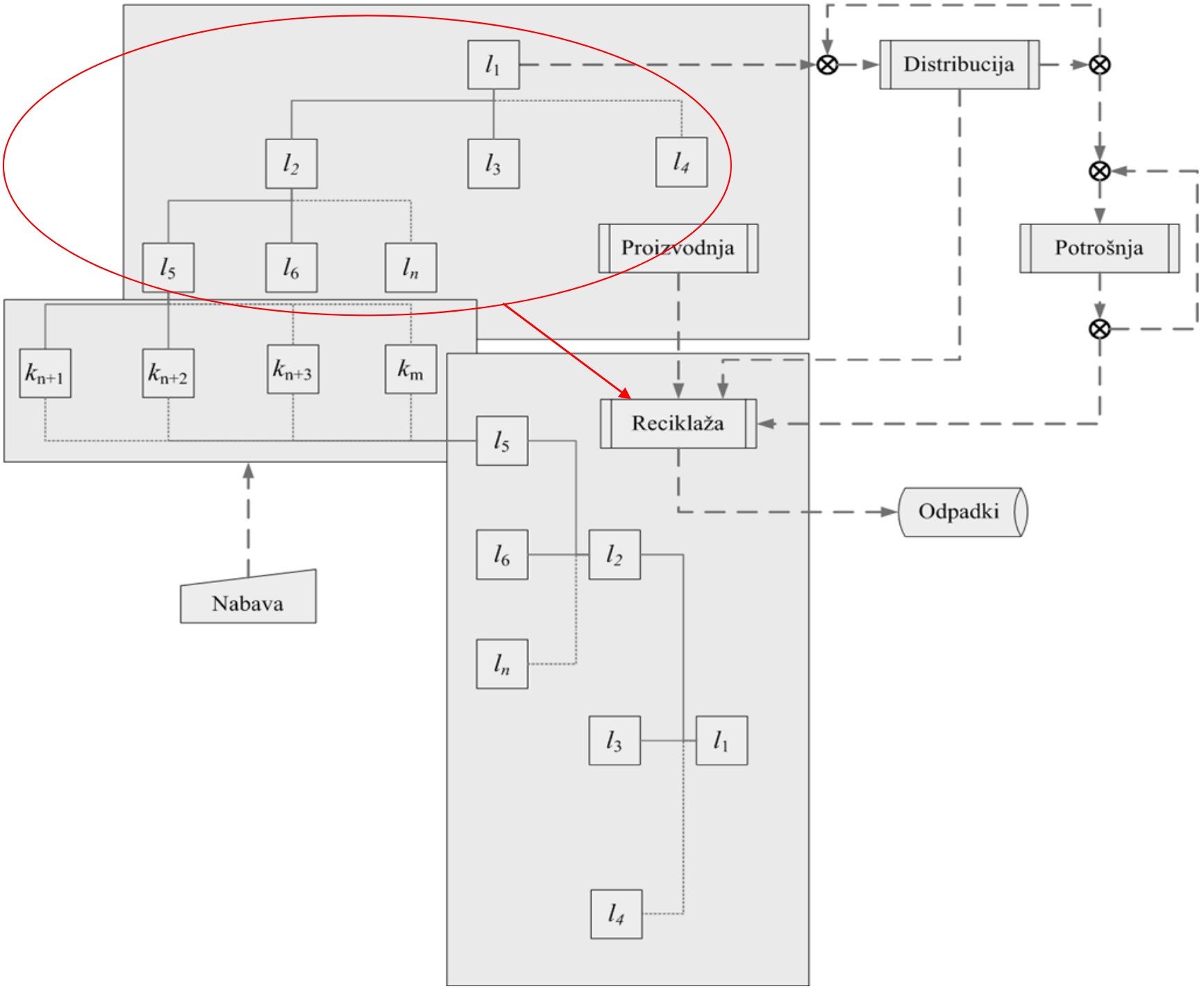


Arborescent system



$$H = \begin{array}{c} \\ A \\ B \\ C \\ D \\ E \end{array} \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 4 & 0 & 0 & 0 & 0 \\ 2 & 4 & 1 & 0 & 0 \\ 0 & 2 & 5 & 3 & 0 \end{bmatrix}$$

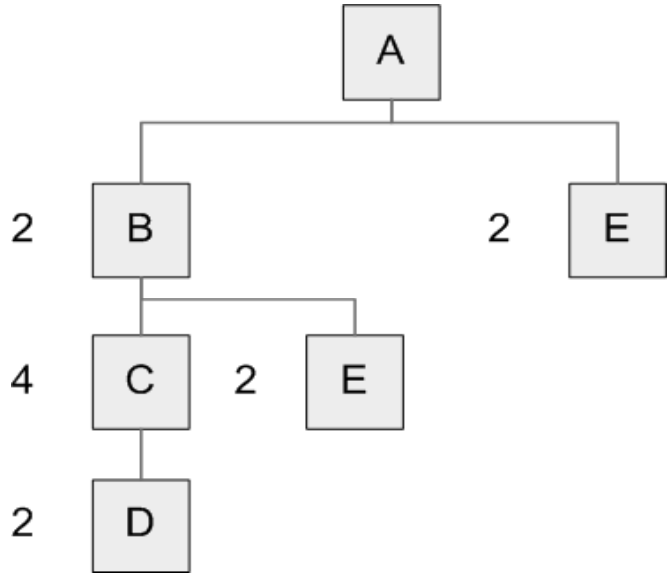
$$G = \begin{array}{c} \\ A \\ B \\ C \\ D \\ E \end{array} \begin{bmatrix} 0 & 0 & 0 & 4 & 0 \\ 0 & 0 & 0 & 5 & 0 \\ 0 & 0 & 0 & 2 & 3 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$


l_1
l_2
l_3
l_4
l_5
l_6
l_n
k_{n+1}
k_{n+2}
k_{n+3}
k_m
Distribucija
Proizvodnja
Potrošnja
Reciklaža
Odpadki
Nabava

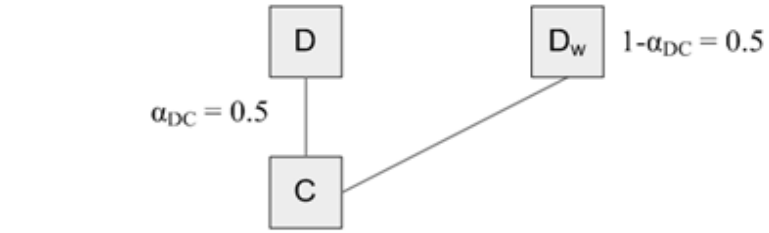
Članek

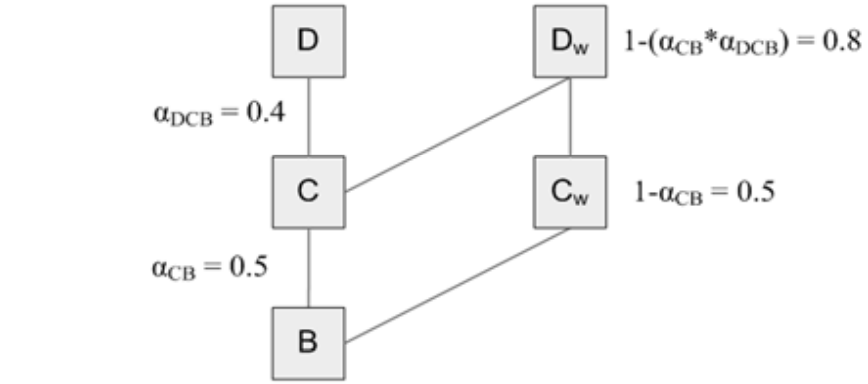
- Simulacije so primerno orodje za proučevanje obnašanja razširjenega modela MRP teorije z vključeno okoljsko komponento, saj omogočajo opazovanje sprememb, ki jih povzročijo modifikacije posamičnih vhodnih parametrov.

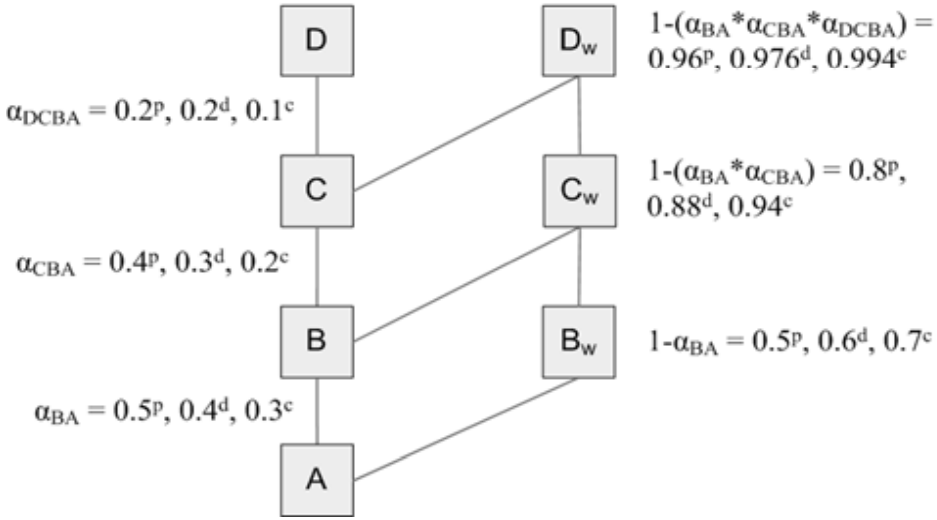
Numerični primer

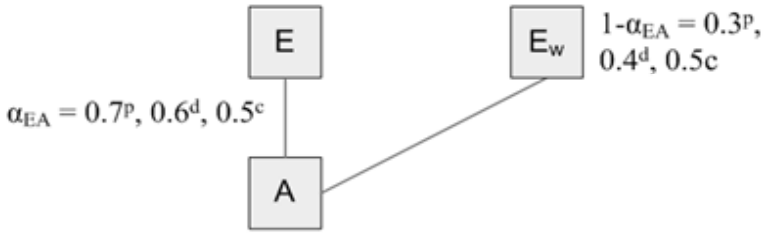


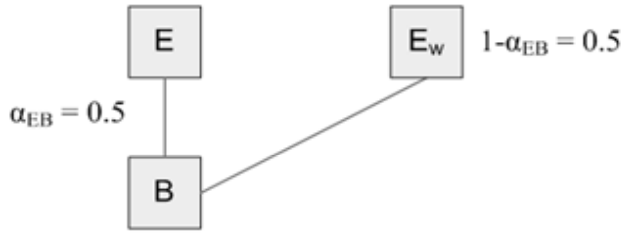
- 20% toka vsake celice aktivnosti gre neposredno v reciklažo
- 75% proizvoda A se distribuira na lokacijo 1 in dodatnih 25% na lokacijo 2

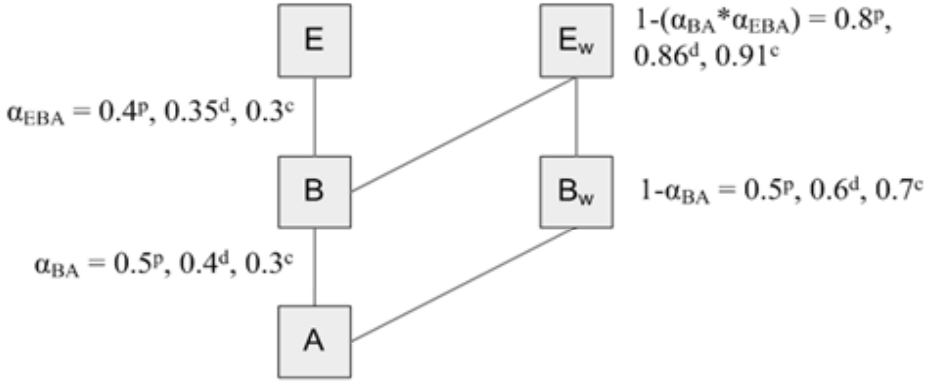

D
D_w
$1-\alpha_{DC} = 0.5$
$\alpha_{DC} = 0.5$
C


D
D_w
$1-(\alpha_{CB}*\alpha_{DCB}) = 0.8$
$\alpha_{DCB} = 0.4$
C
C_w
$1-\alpha_{CB} = 0.5$
$\alpha_{CB} = 0.5$
B


D
D_w
$1-(\alpha_{BA}*\alpha_{CBA}*\alpha_{DCBA}) = 0.96^p, 0.976^d, 0.994^c$
$\alpha_{DCBA} = 0.2^p, 0.2^d, 0.1^c$
C
C_w
$1-(\alpha_{BA}*\alpha_{CBA}) = 0.8^p, 0.88^d, 0.94^c$
$\alpha_{CBA} = 0.4^p, 0.3^d, 0.2^c$
B
B_w
$1-\alpha_{BA} = 0.5^p, 0.6^d, 0.7^c$
$\alpha_{BA} = 0.5^p, 0.4^d, 0.3^c$
A


E
E_w
$1-\alpha_{EA} = 0.3^p, 0.4^d, 0.5c$
$\alpha_{EA} = 0.7^p, 0.6^d, 0.5^c$
A


E
E_w
$1-\alpha_{EB} = 0.5$
$\alpha_{EB} = 0.5$
B


E
E_w
$1-(\alpha_{BA}*\alpha_{EBA}) = 0.8^p, 0.86^d, 0.91^c$
$\alpha_{EBA} = 0.4^p, 0.35^d, 0.3^c$
B
B_w
$1-\alpha_{BA} = 0.5^p, 0.6^d, 0.7^c$
$\alpha_{BA} = 0.5^p, 0.4^d, 0.3^c$
A

Input (vhodna) matrika

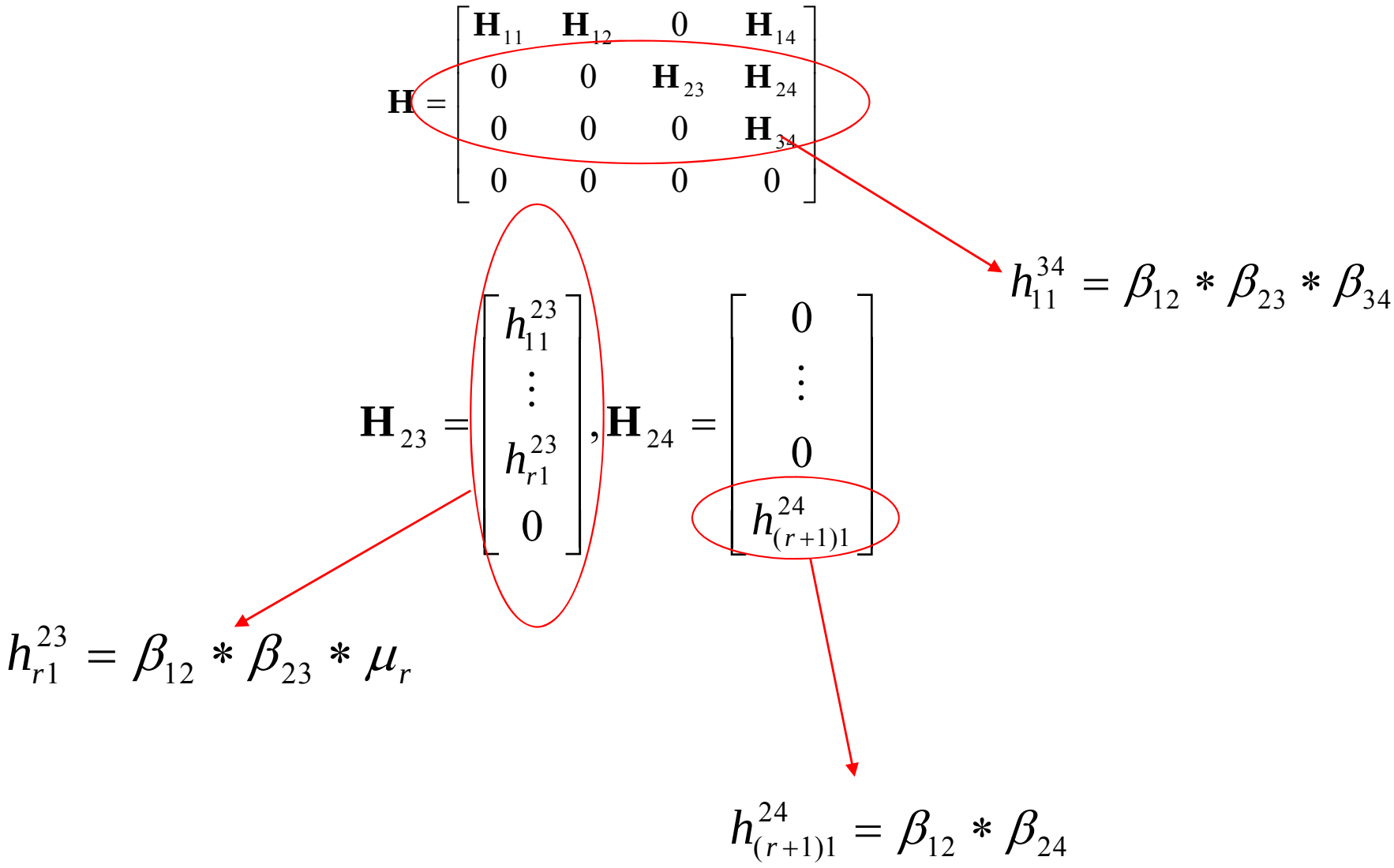
$$\mathbf{H} = \begin{bmatrix} \mathbf{H}_{11} & \mathbf{H}_{12} & 0 & \mathbf{H}_{14} \\ 0 & 0 & \mathbf{H}_{23} & \mathbf{H}_{24} \\ 0 & 0 & 0 & \mathbf{H}_{34} \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

- Podmatrika **H***ij* predstavlja zahtevane enote podsistema *i* zaradi izvajanja aktivnosti znotraj podsistema *j*, kjer indeksi predstavljajo sledeče podsisteme:
  - 1 proizvodnjo,
  - 2 distribucijo,
  - 3 potrošnjo
  - 4 reciklažo.

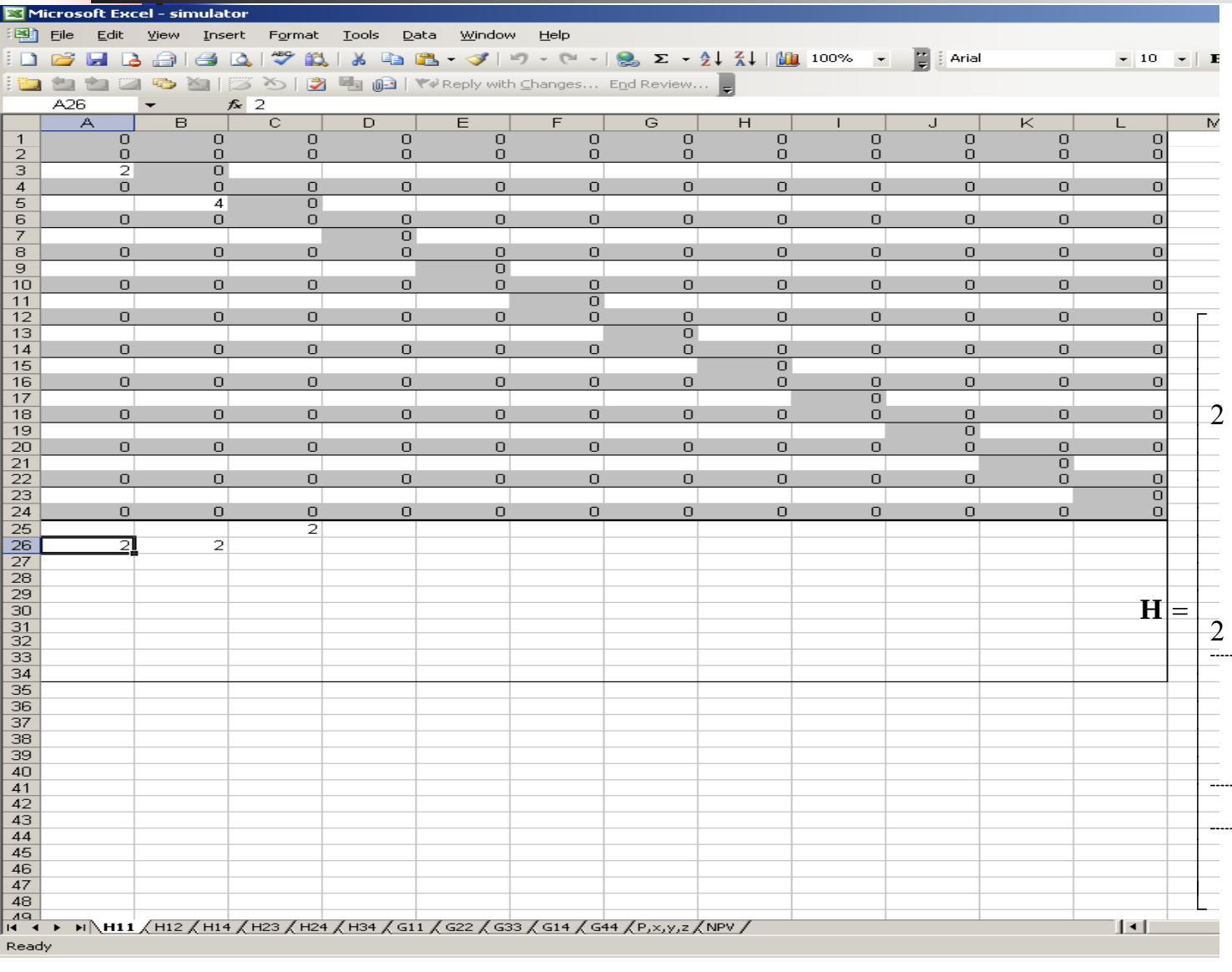
$$\mathbf{H}=\begin{bmatrix}\mathbf{H}_{11} & \mathbf{H}_{12} & 0 & \mathbf{H}_{14}\\ 0 & 0 & \mathbf{H}_{23} & \mathbf{H}_{24}\\ 0 & 0 & 0 & \mathbf{H}_{34}\\ 0 & 0 & 0 & 0\end{bmatrix}$$

$$\mathbf{H}_{11}=\begin{bmatrix}0 & 0 & 0 & \cdots & 0\\ 0 & 0 & 0 & \cdots & 0\\ h_{31}^{11} & 0 & h_{33}^{11} & \cdots & h_{3n}^{11}\\ 0 & 0 & 0 & \cdots & 0\\ h_{51}^{11} & h_{52}^{11} & 0 & \cdots & h_{5n}^{11}\\ 0 & 0 & 0 & \cdots & 0\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ h_{(2n-1)1}^{11} & h_{(2n-1)2}^{11} & h_{(2n-1)3}^{11} & \cdots & 0\\ 0 & 0 & 0 & \cdots & 0\\ h_{(2n+1)1}^{11} & h_{(2n+1)2}^{11} & h_{(2n+1)3}^{11} & \cdots & h_{(2n+1)n}^{11}\\ h_{(2n+2)1}^{11} & h_{(2n+2)2}^{11} & h_{(2n+2)3}^{11} & \cdots & h_{(2n+2)n}^{11}\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ h_{m1}^{11} & h_{m2}^{11} & h_{m3}^{11} & \cdots & h_{mn}^{11}\end{bmatrix},\mathbf{H}_{12}=\begin{bmatrix}h_{11}^{12}\\ 0\\ 0\\ 0\\ 0\\ 0\\ \vdots\\ 0\\ 0\\ 0\\ 0\\ \vdots\\ 0\end{bmatrix},\mathbf{H}_{14}=\begin{bmatrix}0 & 0 & 0 & \cdots & 0\\ h_{21}^{14} & 0 & 0 & \cdots & 0\\ 0 & 0 & 0 & \cdots & 0\\ 0 & h_{42}^{14} & 0 & \cdots & 0\\ 0 & 0 & 0 & \cdots & 0\\ 0 & 0 & h_{63}^{14} & \cdots & 0\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ 0 & 0 & 0 & \cdots & 0\\ 0 & 0 & 0 & \cdots & h_{(2n)n}^{14}\\ 0 & 0 & 0 & \cdots & 0\\ 0 & 0 & 0 & \cdots & 0\\ \vdots & \vdots & \vdots & \ddots & \vdots\\ 0 & 0 & 0 & \cdots & 0\end{bmatrix}$$

$$0 \le \beta_{ij} \le 1$$

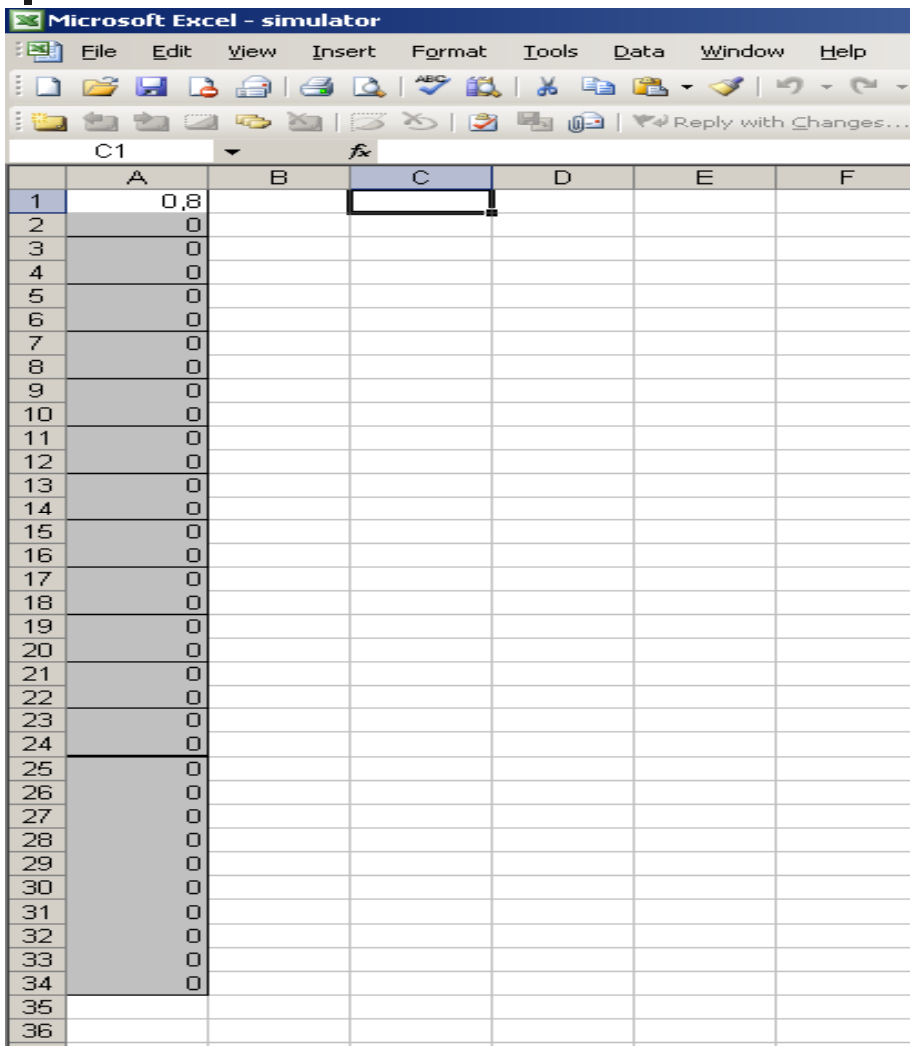

$\mathbf{H} = \begin{bmatrix} \mathbf{H}_{11} & \mathbf{H}_{12} & 0 & \mathbf{H}_{14} \\ 0 & 0 & \mathbf{H}_{23} & \mathbf{H}_{24} \\ 0 & 0 & 0 & \mathbf{H}_{34} \\ 0 & 0 & 0 & 0 \end{bmatrix}$
$h_{11}^{34} = \beta_{12} * \beta_{23} * \beta_{34}$
$\mathbf{H}_{23} = \begin{bmatrix} h_{11}^{23} \\ \vdots \\ h_{r1}^{23} \\ 0 \end{bmatrix}, \mathbf{H}_{24} = \begin{bmatrix} 0 \\ \vdots \\ 0 \\ h_{(r+1)1}^{24} \end{bmatrix}$
$h_{r1}^{23} = \beta_{12} * \beta_{23} * \mu_r$
$h_{(r+1)1}^{24} = \beta_{12} * \beta_{24}$

Simulator (H11)



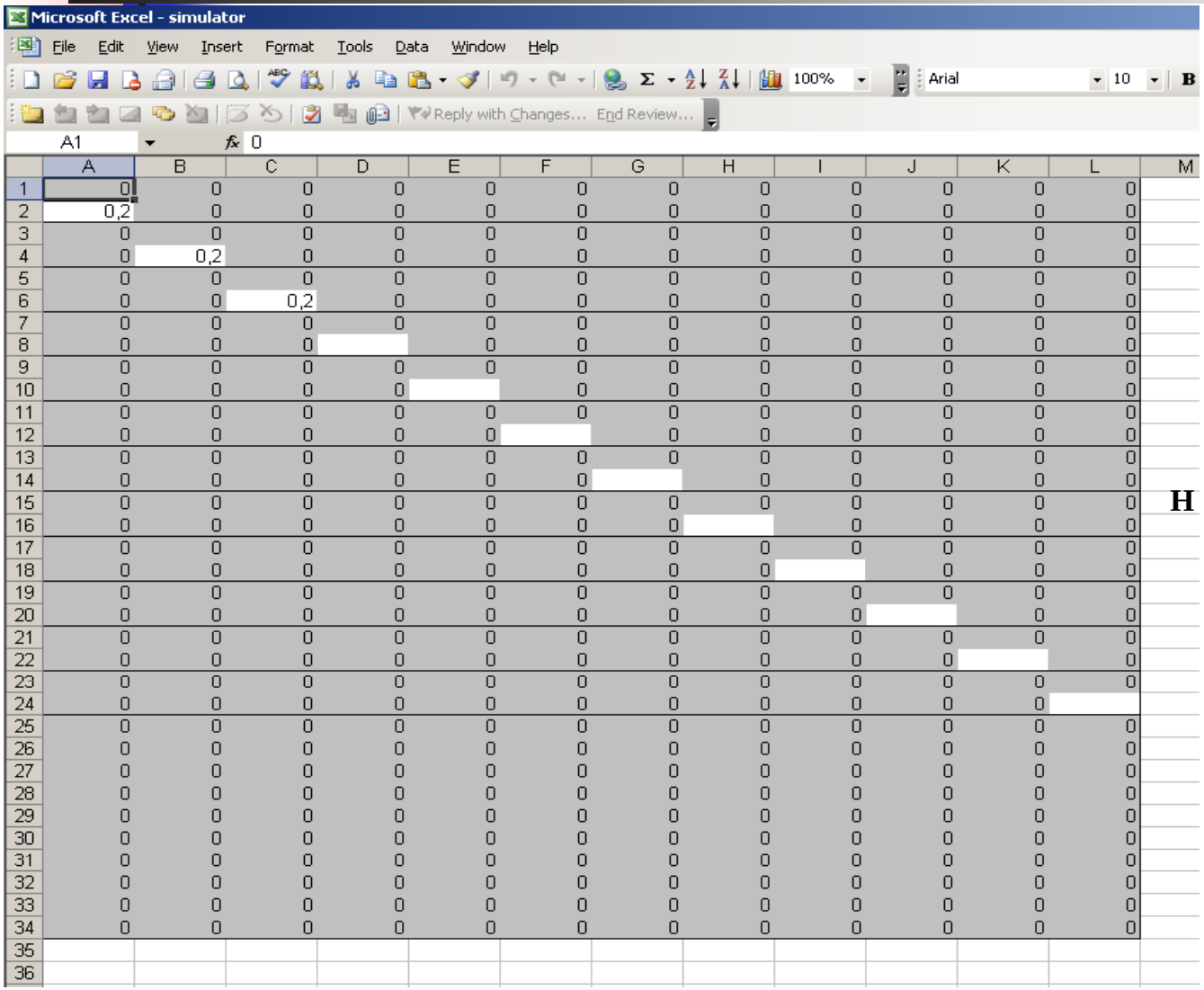
$$\mathbf{H} = \begin{bmatrix} & & 0,8 & & 0.2 & \\ 2 & & & & & 0.2 \\ & 4 & & & & \\ & & & & & 0.2 \\ & & 2 & & & \\ 2 & 2 & & & & \\ \hline & & & 0.8*0.8*0.75 & & \\ & & & 0.8*0.8*0.25 & & \\ & & & & 0.8*0.2 & \\ \hline & & & & 0.8*0.8 & \\ \hline & & & & & \end{bmatrix}$$

H12



$$\mathbf{H} = \begin{bmatrix} & & 0,8 & & 0.2 & \\ 2 & & & & & \\ & & & & 0.2 & \\ & 4 & & & & \\ & & & & & 0.2 \\ & & 2 & & & \\ 2 & 2 & & & & \\ \hline & & & 0.8*0.8*0.75 & & \\ & & & 0.8*0.8*0.25 & & \\ & & & & 0.8*0.2 & \\ \hline & & & & 0.8*0.8 & \\ \hline & & & & & \end{bmatrix}$$

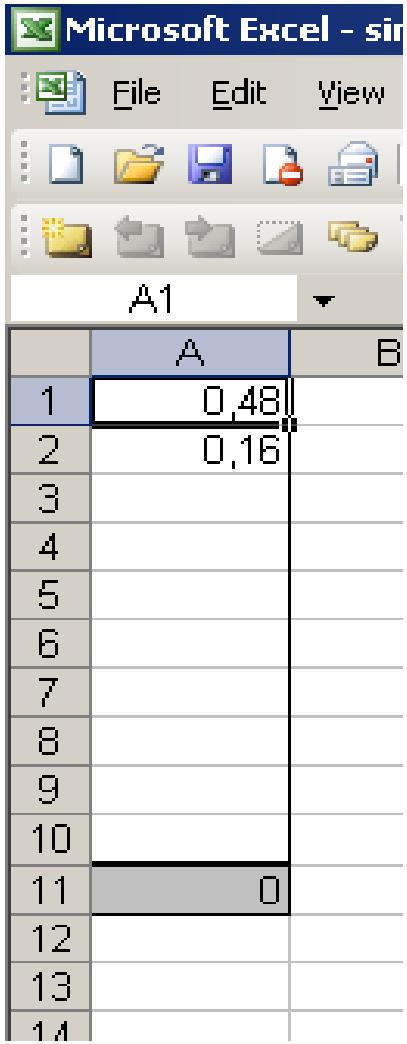
H14



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	0	0	0	0	0	0	0	0	0	0	0	0	
2	0,2	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0,2	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0,2	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0		0	0	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	0	0	0	0	0	
10	0	0	0	0		0	0	0	0	0	0	0	
11	0	0	0	0	0	0	0	0	0	0	0	0	
12	0	0	0	0	0		0	0	0	0	0	0	
13	0	0	0	0	0	0	0	0	0	0	0	0	
14	0	0	0	0	0	0		0	0	0	0	0	
15	0	0	0	0	0	0	0	0	0	0	0	0	
16	0	0	0	0	0	0	0		0	0	0	0	
17	0	0	0	0	0	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0		0	0	0	
19	0	0	0	0	0	0	0	0	0	0	0	0	
20	0	0	0	0	0	0	0	0	0		0	0	
21	0	0	0	0	0	0	0	0	0	0	0	0	
22	0	0	0	0	0	0	0	0	0	0		0	
23	0	0	0	0	0	0	0	0	0	0	0	0	
24	0	0	0	0	0	0	0	0	0	0	0		
25	0	0	0	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	0	0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0	0	0	0	0	0	
32	0	0	0	0	0	0	0	0	0	0	0	0	
33	0	0	0	0	0	0	0	0	0	0	0	0	
34	0	0	0	0	0	0	0	0	0	0	0	0	
35													
36													

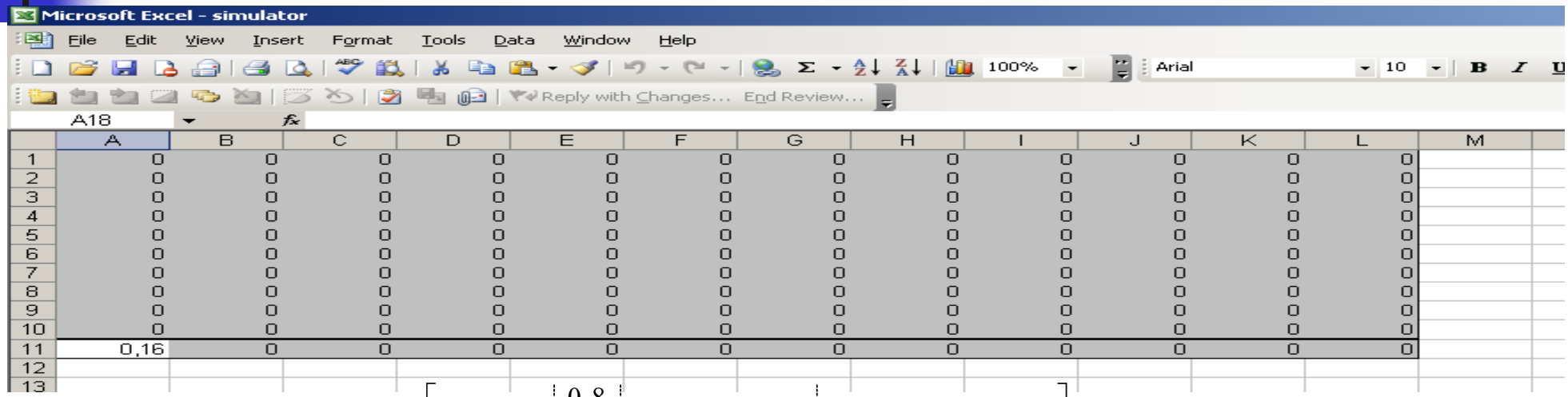
$$\mathbf{H} = \left[\begin{array}{ccc|c|cc} & & & 0{,}8 & & \\ & & & & & 0.2 \\ 2 & & & & & \\ & & & & & 0.2 \\ & 4 & & & & \\ & & & & & 0.2 \\ & & 2 & & & \\ 2 & 2 & & & & \\ \hline & & & 0.8*0.8*0.75 & & \\ & & & 0.8*0.8*0.25 & & \\ & & & & 0.8*0.2 & \\ \hline & & & & 0.8*0.8 & \\ \hline & & & & & \end{array}\right]$$

H23



$$\mathbf{H} = \begin{bmatrix} 2 & & & & 0,8 & & & 0.2 & \\ & 4 & & & & & & & 0.2 \\ & & 2 & & & & & & \\ 2 & 2 & & & & & & & \\ \hline & & & & 0.8*0.8*0.75 & & & & \\ & & & & 0.8*0.8*0.25 & & & & \\ & & & & & & & 0.8*0.2 & \\ \hline & & & & & & & 0.8*0.8 & \\ \hline & & & & & & & & \end{bmatrix}$$

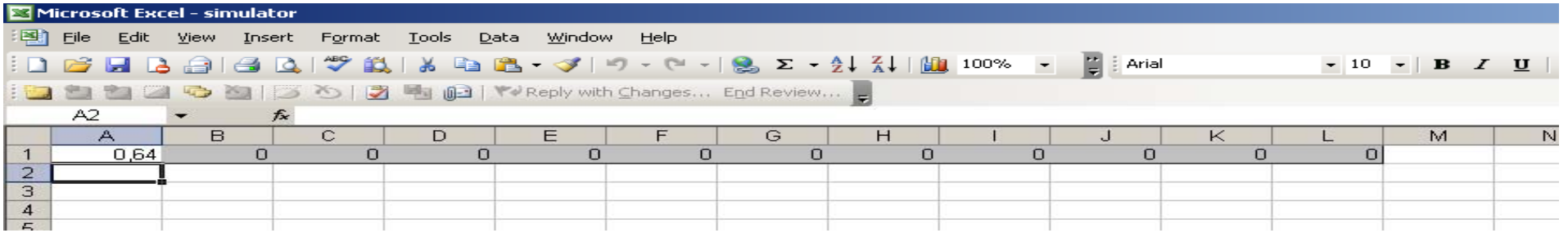
H24



	A	B	C	D	E	F	G	H	I	J	K	L	M
1	0	0	0	0	0	0	0	0	0	0	0	0	
2	0	0	0	0	0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	0	0	0	0	0	
4	0	0	0	0	0	0	0	0	0	0	0	0	
5	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	
7	0	0	0	0	0	0	0	0	0	0	0	0	
8	0	0	0	0	0	0	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	0	0	0	0	0	
10	0	0	0	0	0	0	0	0	0	0	0	0	
11	0,16	0	0	0	0	0	0	0	0	0	0	0	
12													
13													

$$\mathbf{H} = \begin{bmatrix} \begin{matrix} & & & \\ 2 & & & \\ & 4 & & \\ & & 2 & \\ 2 & 2 & & \end{matrix} & 0,8 & \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} & \begin{matrix} 0.2 & & \\ & 0.2 & \\ & & 0.2 \\ & & \\ & & \end{matrix} \\ \hline \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} & & \begin{matrix} 0.8*0.8*0.75 & & \\ 0.8*0.8*0.25 & & \\ & & \\ & & \\ & & \end{matrix} & \begin{matrix} & & \\ & & \\ & & \\ 0.8*0.2 & & \\ & & \end{matrix} \\ \hline \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} & & \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} & \begin{matrix} & & \\ & & \\ & & \\ 0.8*0.8 & & \\ & & \end{matrix} \\ \hline \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} & & \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} & \begin{matrix} & & \\ & & \\ & & \\ & & \\ & & \end{matrix} \end{bmatrix}$$

H34



$$\mathbf{H} = \left[\begin{array}{ccc|c|cc} & & & 0,8 & & \\ & & & & & \\ 2 & & & & & 0.2 \\ & & & & & \\ & 4 & & & 0.2 & \\ & & & & & \\ & & 2 & & & 0.2 \\ 2 & 2 & & & & \\ \hline & & & & 0.8*0.8*0.75 & \\ & & & & 0.8*0.8*0.25 & \\ & & & & & 0.8*0.2 \\ \hline & & & & & 0.8*0.8 \\ \hline & & & & & \end{array}\right]$$

Output (izhodna) matrika

$$\mathbf{G} = \begin{bmatrix} \mathbf{G}_{11} & 0 & 0 & \mathbf{G}_{14} \\ 0 & \mathbf{G}_{22} & 0 & 0 \\ 0 & 0 & \mathbf{G}_{33} & 0 \\ 0 & 0 & 0 & \mathbf{G}_{44} \end{bmatrix}$$

- Podmatrike **G***ij* predstavljajo izhode podsistema *i* pri aktivnostih podprocesa *j*.

$$\mathbf{G}=\begin{bmatrix}\mathbf{G}_{11} & 0 & 0 & \mathbf{G}_{14}\\ 0 & \mathbf{G}_{22} & 0 & 0\\ 0 & 0 & \mathbf{G}_{33} & 0\\ 0 & 0 & 0 & \mathbf{G}_{44}\end{bmatrix}$$

β_{ij}

$$\mathbf{G}_{11}=\begin{bmatrix}
g_{11}^{11} & 0 & 0 & \cdots & 0\\
g_{21}^{11} & 0 & 0 & \cdots & 0\\
\hline
0 & g_{32}^{11} & 0 & \cdots & 0\\
0 & g_{42}^{11} & 0 & \cdots & 0\\
\hline
0 & 0 & g_{53}^{11} & \cdots & 0\\
0 & 0 & g_{63}^{11} & \cdots & 0\\
\hline
\vdots & \vdots & \vdots & \ddots & \vdots\\
\hline
0 & 0 & 0 & \cdots & g_{(2n-1)n}^{11}\\
0 & 0 & 0 & \cdots & g_{(2n)n}^{11}\\
\hline
0 & 0 & 0 & \cdots & 0\\
0 & 0 & 0 & \cdots & 0\\
\vdots & \vdots & \vdots & \ddots & \vdots\\
0 & 0 & 0 & \cdots & 0
\end{bmatrix},\quad
\mathbf{G}_{22}=\begin{bmatrix}g_{11}^{22}\\ \vdots\\ g_{r1}^{22}\\ g_{(r+1)1}^{22}\end{bmatrix},\quad
\mathbf{G}_{33}=\begin{bmatrix}g_{11}^{33}\end{bmatrix}$$

$$g_{r1}^{22}=\beta_{12}*\beta_{23}*\mu_r$$

$$g_{11}^{33}=\beta_{12}*\beta_{23}*\beta_{34}$$

$$g_{(r+1)1}^{22}=\beta_{12}*\beta_{24}$$

$$\mathbf{G}=\begin{bmatrix}\mathbf{G}_{11} & 0 & 0 & \mathbf{G}_{14}\\ 0 & \mathbf{G}_{22} & 0 & 0\\ 0 & 0 & \mathbf{G}_{33} & 0\\ 0 & 0 & 0 & \mathbf{G}_{44}\end{bmatrix}$$

$$\mathbf{G}_{14}=\begin{bmatrix}0 & 0 & \cdots & 0\\ \vdots & \vdots & \ddots & 0\\ 0 & 0 & \cdots & 0\\ \hline g^{14}_{(2n+1)1} & g^{14}_{(2n+1)2} & \cdots & g^{14}_{(2n+1)n}\\ g^{14}_{(2n+2)1} & g^{14}_{(2n+2)2} & \cdots & g^{14}_{(2n+2)n}\\ \vdots & \vdots & \ddots & \vdots\\ g^{14}_{m1} & g^{14}_{m2} & \cdots & g^{14}_{mn}\end{bmatrix},\quad \mathbf{G}_{44}=\begin{bmatrix}g^{44}_{11} & g^{44}_{12} & \cdots & g^{44}_{1n}\\ g^{44}_{21} & g^{44}_{22} & \cdots & g^{44}_{2n}\\ \vdots & \vdots & \ddots & \vdots\\ g^{44}_{(m-2n)1} & g^{44}_{(m-2n)2} & \cdots & g^{44}_{(m-2n)n}\end{bmatrix}$$

$$g^{14}_{kl}=h^{14}_{kl}*\alpha_{kl}$$

$$g^{44}_{(k-2l)l}=h^{11}_{kl}*(1-\alpha_{kl})$$

$$\alpha_{kl}=\sum_{n'=l}^{3}\Big(\prod_{i=k,l,l-1,\ldots n',4}\beta_i\alpha_i\Big)_{n'}$$

G11

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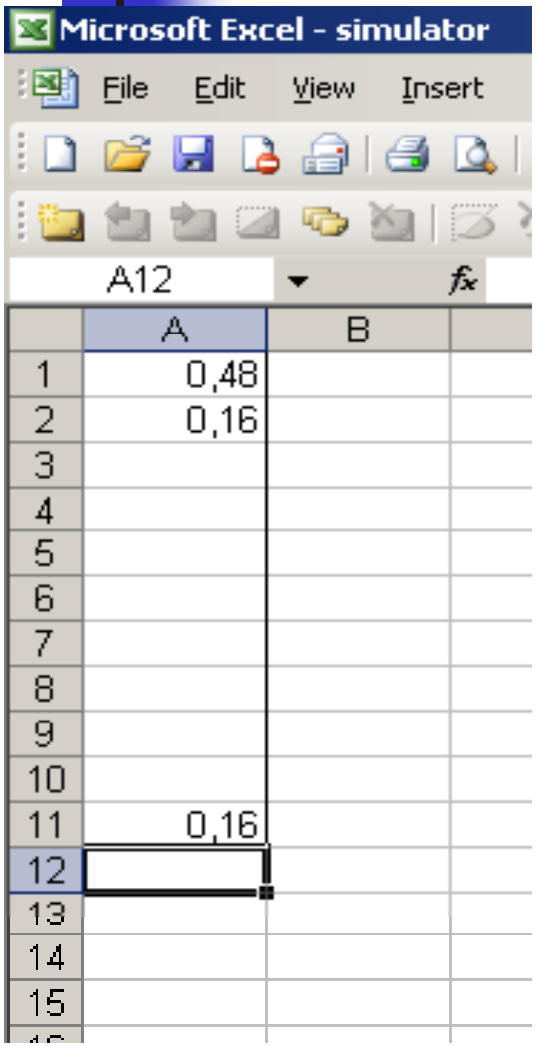
D5 | 0

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	0,8	0	0	0	0	0	0	0	0	0	0	0	
2	0,2	0	0	0	0	0	0	0	0	0	0	0	
3	0	0,8	0	0	0	0	0	0	0	0	0	0	
4	0	0,2	0	0	0	0	0	0	0	0	0	0	
5	0	0	0,8	0	0	0	0	0	0	0	0	0	
6	0	0	0,2	0	0	0	0	0	0	0	0	0	
7	0	0	0		0	0	0	0	0	0	0	0	
8	0	0	0		0	0	0	0	0	0	0	0	
9	0	0	0	0		0	0	0	0	0	0	0	
10	0	0	0	0		0	0	0	0	0	0	0	
11	0	0	0	0	0		0	0	0	0	0	0	
12	0	0	0	0	0		0	0	0	0	0	0	
13	0	0	0	0	0	0		0	0	0	0	0	
14	0	0	0	0	0	0		0	0	0	0	0	
15	0	0	0	0	0	0	0		0	0	0	0	
16	0	0	0	0	0	0	0		0	0	0	0	
17	0	0	0	0	0	0	0	0		0	0	0	
18	0	0	0	0	0	0	0	0		0	0	0	
19	0	0	0	0	0	0	0	0	0		0	0	
20	0	0	0	0	0	0	0	0	0		0	0	
21	0	0	0	0	0	0	0	0	0	0		0	
22	0	0	0	0	0	0	0	0	0	0		0	
23	0	0	0	0	0	0	0	0	0	0	0		
24	0	0	0	0	0	0	0	0	0	0	0		
25	0	0	0	0	0	0	0	0	0	0	0	0	
26	0	0	0	0	0	0	0	0	0	0	0	0	
27	0	0	0	0	0	0	0	0	0	0	0	0	
28	0	0	0	0	0	0	0	0	0	0	0	0	
29	0	0	0	0	0	0	0	0	0	0	0	0	
30	0	0	0	0	0	0	0	0	0	0	0	0	
31	0	0	0	0	0	0	0	0	0	0	0	0	
32	0	0	0	0	0	0	0	0	0	0	0	0	
33	0	0	0	0	0	0	0	0	0	0	0	0	
34	0	0	0	0	0	0	0	0	0	0	0	0	
35													
36													
37													

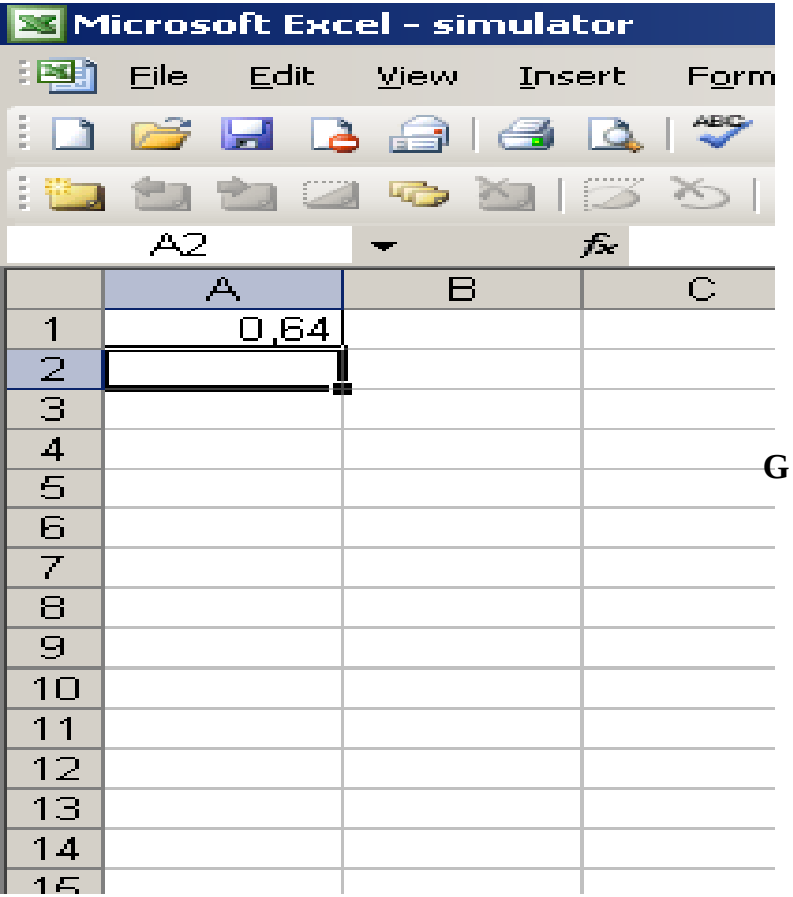
$$\mathbf{G} = \begin{bmatrix} 0.8 & & & & & \\ 0.2 & & & & & \\ & 0.8 & & & & \\ & 0.2 & & & & \\ & & 0.8 & & & \\ & & 0,2 & & & \\ & & & & & 2 * 0.5 \\ & & & 0.8 * 0.8 * 0.75 & & \\ & & & 0.8 * 0.8 * 0.25 & & \\ & & & 0.8 * 0.2 & & \\ & & & & 0.8 * 0.8 & \\ & & & & & \\ & & & & & 2 * (1 - 0. \end{bmatrix}$$

G22



$$\mathbf{G} = \left[\begin{array}{cccc|cc} 0.8 & & & & & \\ 0.2 & & & & & \\ & 0.8 & & & & \\ & 0.2 & & & & \\ & & 0.8 & & & \\ & & 0,2 & & & \\ & & & & & 2*0.1588 \\ & & & & 2*0.556 & 2*0.2579 \\ \hline & & 0.8*0.8*0.75 & & & \\ & & 0.8*0.8*0.25 & & & \\ & & 0.8*0.2 & & & \\ \hline & & & 0.8*0.8 & & \\ \hline & & & & & 2*(1-0.1588) \\ & & & & 2*(1-0.556) & 2*(1-0.2579) \end{array}\right]$$

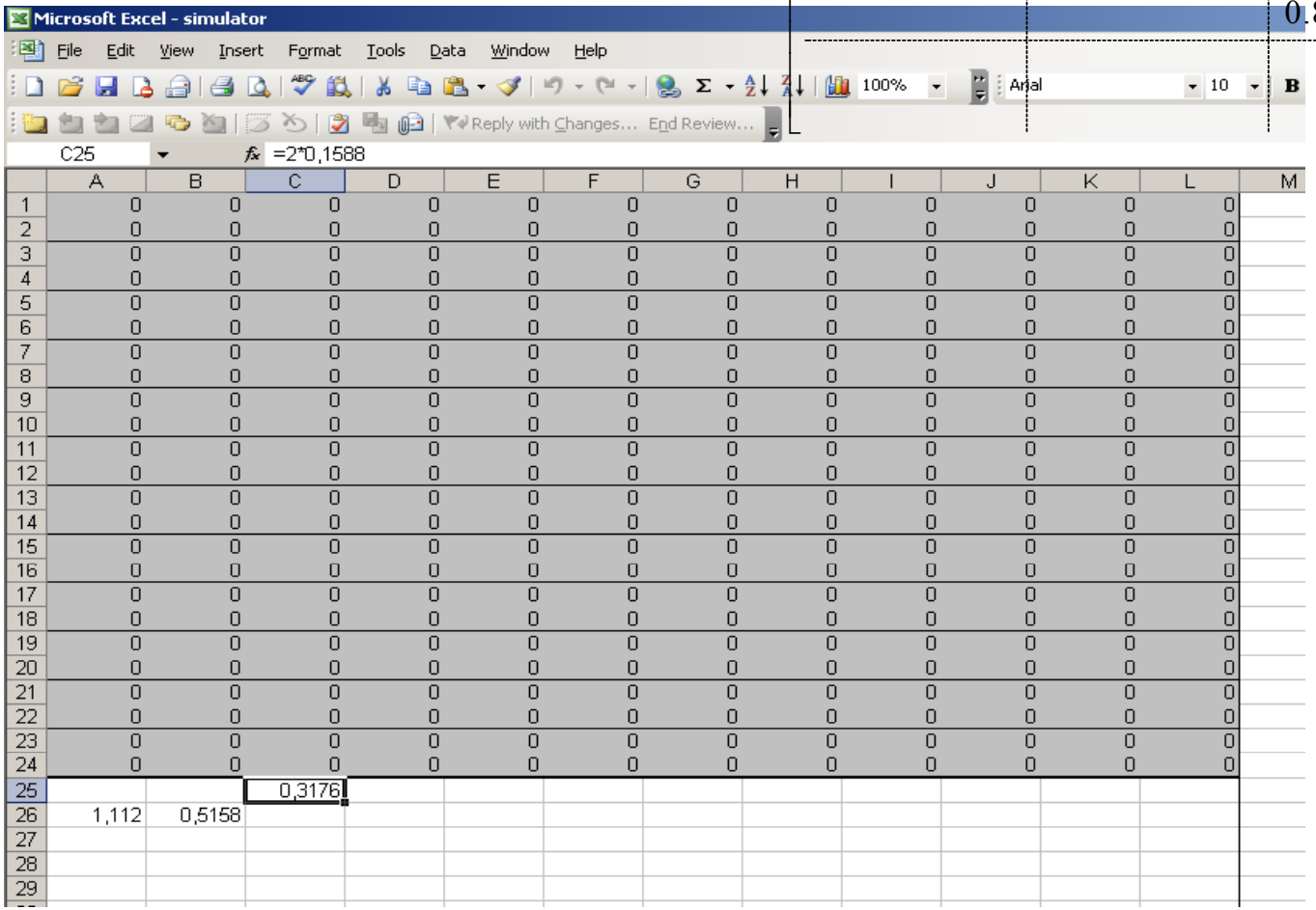
G33



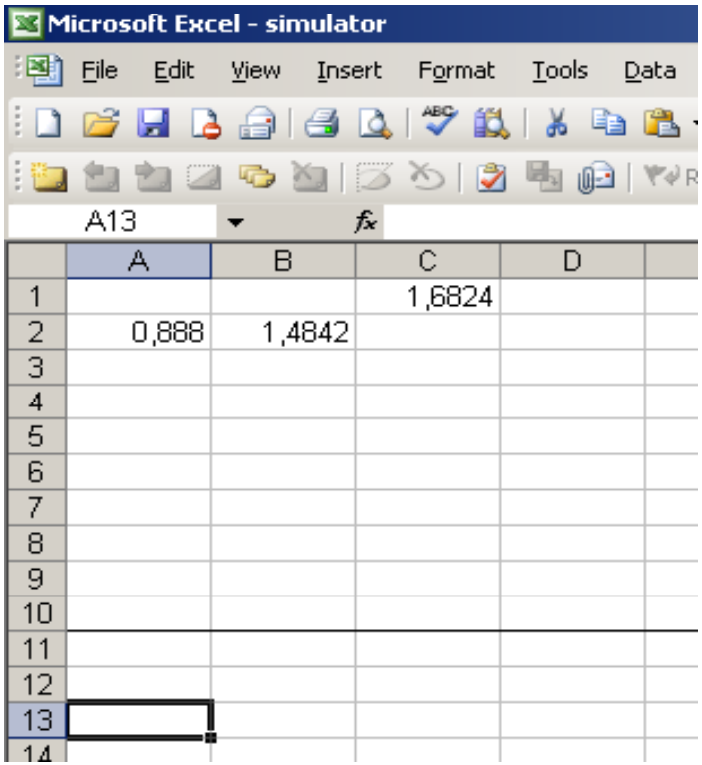
$$\mathbf{G} = \begin{bmatrix} 0.8 & & & & & & \\ 0.2 & & & & & & \\ & 0.8 & & & & & \\ & 0.2 & & & & & \\ & & 0.8 & & & & \\ & & 0,2 & & & & \\ & & & & & & 2 * 0.1588 \\ & & & & & 2 * 0.556 & 2 * 0.2579 \\ \hline & & 0.8 * 0.8 * 0.75 & & & & \\ & & 0.8 * 0.8 * 0.25 & & & & \\ & & 0.8 * 0.2 & & & & \\ \hline & & & 0.8 * 0.8 & & & \\ \hline & & & & & & 2 * (1 - 0.1588) \\ & & & & 2 * (1 - 0.556) & 2 * (1 - 0.2579) & \end{bmatrix}$$

G14

$$
\mathbf{G} = \left[\begin{array}{cccc|cc}
0.8 & & & & & \\
0.2 & & & & & \\
 & 0.8 & & & & \\
 & 0.2 & & & & \\
 & & 0.8 & & & \\
 & & 0,2 & & & \\
\hline
 & & & 0.8*0.8*0.75 & & \\
 & & & 0.8*0.8*0.25 & & \\
 & & & 0.8*0.2 & & \\
\hline
 & & & & 0.8*0.8 & \\
\hline
 & & & & & 2*0.1588 \\
 & & & & 2*0.556 & 2*0.2579 \\
 & & & & & 2*(1-0.1588) \\
 & & & & 2*(1-0.556) & 2*(1-0.2579)
\end{array}\right]
$$



G44



$$\mathbf{G} = \left[\begin{array}{ccc|c|cc} 0.8 & & & & & \\ 0.2 & & & & & \\ & 0.8 & & & & \\ & 0.2 & & & & \\ & & 0.8 & & & \\ & & 0,2 & & & \\ & & & & & 2*0.1588 \\ & & & & 2*0.556 & 2*0.2579 \\ \hline & & & 0.8*0.8*0.75 & & \\ & & & 0.8*0.8*0.25 & & \\ & & & 0.8*0.2 & & \\ \hline & & & & 0.8*0.8 & \\ \hline & & & & & 2*(1-0.1588) \\ & & & & 2*(1-0.556) & 2*(1-0.2579) \end{array}\right]$$

Neto proizvodnja

$$\mathbf{P} = \begin{bmatrix} \mathbf{P}_1 \\ \mathbf{P}_2 \\ \mathbf{P}_3 \\ \mathbf{P}_4 \end{bmatrix} = \begin{bmatrix} Q_1 \\ Q_2 \\ \vdots \\ Q_n \\ \hline Q_n \\ \hline Q_n \\ \hline Q_1 \\ Q_2 \\ \vdots \\ Q_n \end{bmatrix}, \mathbf{z} = \begin{bmatrix} \mathbf{z}_1 \\ \mathbf{z}_2 \\ \mathbf{z}_3 \\ \mathbf{z}_4 \end{bmatrix} = (\mathbf{G} - \mathbf{H})\mathbf{P} = \begin{bmatrix} 0 \\ \vdots \\ 0 \\ Q_{2n+1}^{14} \\ Q_{2n+2}^{14} \\ \vdots \\ Q_m^{14} \\ \hline 0 \\ \vdots \\ 0 \\ \hline 0 \\ \hline Q_{2n+1}^{44} \\ Q_{2n+2}^{44} \\ \vdots \\ Q_m^{44} \end{bmatrix}$$

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	P	=	1000		x=HP	=	800		y=GP	=	800		z=y-x	=	0
2			2500				200				200				0
3			12500				2000				2000				0
4							500				500				0
5							10000				10000				0
6							2500				2500				0
7							0				0				0
8							0				0				0
9							0				0				0
10							0				0				0
11							0				0				0
12							0				0				0
13			1000				0				0				0
14			1000				0				0				0
15			1000				0				0				0
16			2500				0				0				0
17			12500				0				0				0
18							0				0				0
19							0				0				0
20							0				0				0
21							0				0				0
22							0				0				0
23							0				0				0
24							0				0				0
25							25000				3970				-21030
26							7000				2401,5				-4598,5
27							0				0				0
28							0				0				0
29							0				0				0
30							0				0				0
31							0				0				0
32							0				0				0
33							0				0				0
34							0				0				0
35							480				480				0
36							160				160				0
37							0				0				0
38							0				0				0
39							0				0				0
40							0				0				0
41							0				0				0
42							0				0				0
43							0				0				0
44							0				0				0
45							160				160				0
46							640				640				0
47											21030				21030
48											4598,5				4598,5
49											0				0
50											0				0
51											0				0
52											0				0
53											0				0
54											0				0
55											0				0
56											0				0

$$\mathbf{x} = \mathbf{HP} = \begin{bmatrix} 800 \\ 200 \\ 2000 \\ 500 \\ 10000 \\ 2500 \\ 25000 \\ 7000 \\ \hline 480 \\ 160 \\ 160 \\ \hline 640 \\ \hline 0 \\ 0 \end{bmatrix}, \mathbf{y} = \mathbf{GP} = \begin{bmatrix} 800 \\ 200 \\ 2000 \\ 500 \\ 10000 \\ 2500 \\ 3969 \\ 2402 \\ \hline 480 \\ 160 \\ 160 \\ \hline 640 \\ \hline 21031 \\ 4598 \end{bmatrix}, \mathbf{z} = \mathbf{y} - \mathbf{x} = (\mathbf{G} - \mathbf{H})\mathbf{P} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ -21031 \\ -4598 \\ \hline 0 \\ 0 \\ 0 \\ \hline 0 \\ \hline 21031 \\ 4598 \end{bmatrix}$$

H11 H12 H14 H23 H24 H34 G11 G22 G33 G14 G44 P,x,y,z NPV

Ready NUM

Neto sedanja vrednost reciklažnih aktivnosti (NSV)

$$\mathrm{NPV}_{\text{reciklaže}} = \sum_{k=n+1}^{m} \mathrm{NPV}_k$$

$$\mathrm{NSV}_k = \sum_{n'=n}^{3} \frac{\left(p_{2n'}\alpha_{kn'} + p_{7n'}(1-\alpha_{kn'})\right)\hat{P}_{6n'}}{1-e^{-\rho T_{6n'}}} - \frac{p_{6n'}\hat{P}_{6n'}}{\rho T_{6n'}} - \frac{c_L \hat{L}_{n'}}{1-e^{-\rho T_{6n'}}} - \frac{K_{6n'}}{1-e^{-\rho T_{6n'}}}$$

(1) p_2 vrednost vrnjene komponente, (2) p_7 okoljska dajatev, (3) p_6 vrednost izrabljene komponente, (4) $\hat{P}_6$ kontingent vrnjenih komponent, (5) K_6 zagonski strošek, (6) $c_L \hat{L}$ strošek dela, izračunan kot produkt cene dela na enoto c_L in količine porabljenega dela $\hat{L}$, (6) T_6 časovna perioda in (7) A, γ, δ parametri Cobb-Douglasove produkcijske funkcije

NSV za primer simulacije

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Sekvenca		iz 1	iz 2	iz 3
iz C	D,C	0,5		
iz B	D,C,B	0,4		
iz B	C,B	0,5		
iz A	D,C,B,A	0,2	0,2	0,1
iz A	C,B,A	0,4	0,3	0,2
iz A	B,A	0,5	0,4	0,3

Sekvenca		iz 1	iz 2	iz 3
iz B	E,B	0,5		
iz A	E,A	0,7	0,6	0,5
iz A	E,B,A	0,4	0,35	0,3
iz A	B,A	0,5	0,4	0,3

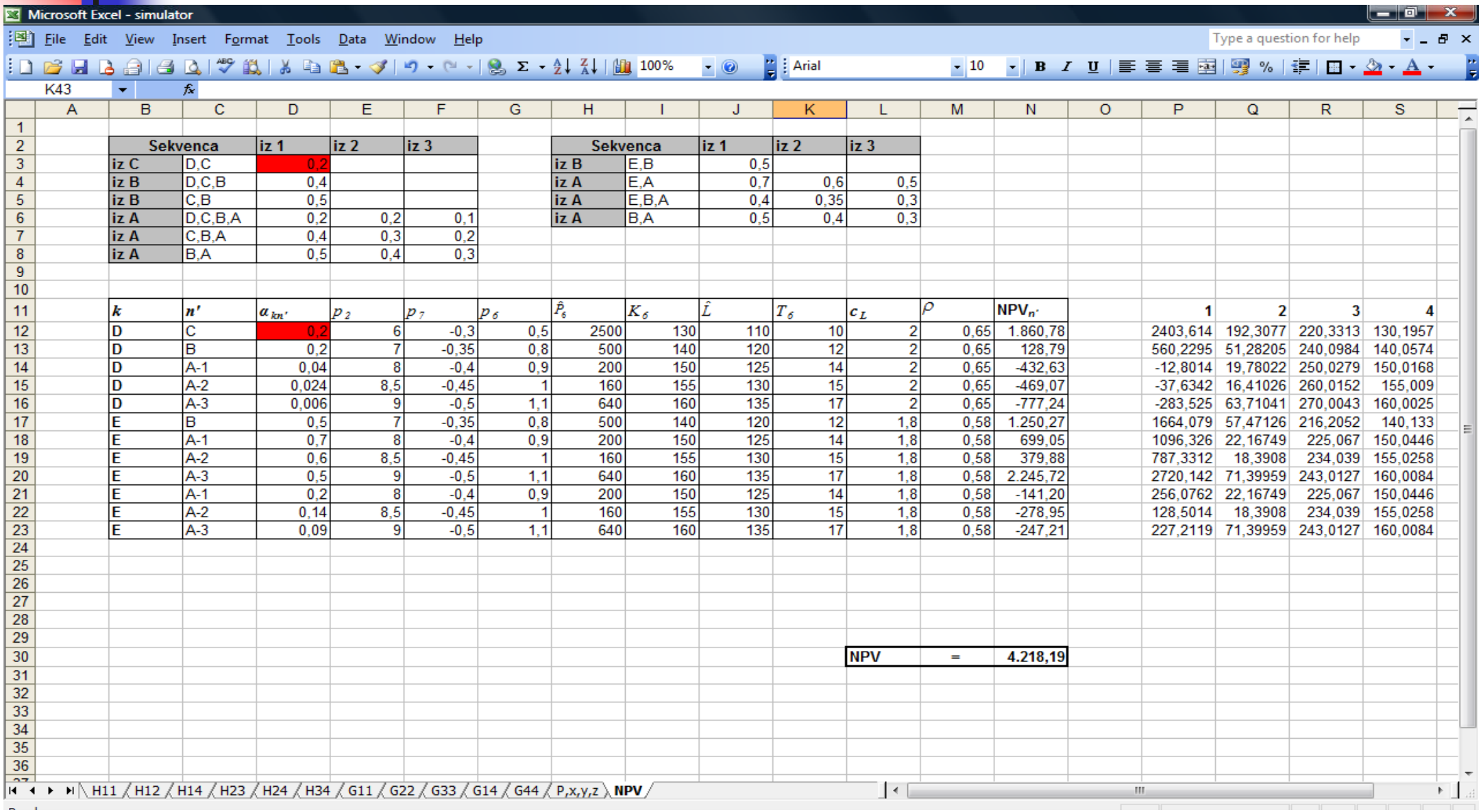
k	n'	$\alpha_{kn'}$	p_2	p_7	p_6	$\hat{P}_6$	K_6	$\hat{L}$	T_6	c_L	ρ	$NPV_{n'}$	1	2	3	4
D	C	0,5	6	-0,3	0,5	2500	130	110	10	2	0,65	6.592,89	7135,728	192,3077	220,3313	130,1957
D	B	0,2	7	-0,35	0,8	500	140	120	12	2	0,65	128,79	560,2295	51,28205	240,0984	140,0574
D	A-1	0,04	8	-0,4	0,9	200	150	125	14	2	0,65	-432,63	-12,8014	19,78022	250,0279	150,0168
D	A-2	0,024	8,5	-0,45	1	160	155	130	15	2	0,65	-469,07	-37,6342	16,41026	260,0152	155,009
D	A-3	0,006	9	-0,5	1,1	640	160	135	17	2	0,65	-777,24	-283,525	63,71041	270,0043	160,0025
E	B	0,5	7	-0,35	0,8	500	140	120	12	1,8	0,58	1.250,27	1664,079	57,47126	216,2052	140,133
E	A-1	0,7	8	-0,4	0,9	200	150	125	14	1,8	0,58	699,05	1096,326	22,16749	225,067	150,0446
E	A-2	0,6	8,5	-0,45	1	160	155	130	15	1,8	0,58	379,88	787,3312	18,3908	234,039	155,0258
E	A-3	0,5	9	-0,5	1,1	640	160	135	17	1,8	0,58	2.245,72	2720,142	71,39959	243,0127	160,0084
E	A-1	0,2	8	-0,4	0,9	200	150	125	14	1,8	0,58	-141,20	256,0762	22,16749	225,067	150,0446
E	A-2	0,14	8,5	-0,45	1	160	155	130	15	1,8	0,58	-278,95	128,5014	18,3908	234,039	155,0258
E	A-3	0,09	9	-0,5	1,1	640	160	135	17	1,8	0,58	-247,21	227,2119	71,39959	243,0127	160,0084

NPV	=	8.950,30

H11 / H12 / H14 / H23 / H24 / H34 / G11 / G22 / G33 / G14 / G44 / P,x,y,z / NPV

Ready

NSV s spremembo parametra



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K43

Sekvenca		iz 1	iz 2	iz 3
iz C	D,C	0,2		
iz B	D,C,B	0,4		
iz B	C,B	0,5		
iz A	D,C,B,A	0,2	0,2	0,1
iz A	C,B,A	0,4	0,3	0,2
iz A	B,A	0,5	0,4	0,3

Sekvenca		iz 1	iz 2	iz 3
iz B	E,B	0,5		
iz A	E,A	0,7	0,6	0,5
iz A	E,B,A	0,4	0,35	0,3
iz A	B,A	0,5	0,4	0,3

k	n'	$\alpha_{kn'}$	p_2	p_7	p_6	$\hat{P}_6$	K_6	$\hat{L}$	T_6	c_L	ρ	$NPV_{n'}$	1	2	3	4
D	C	0,2	6	-0,3	0,5	2500	130	110	10	2	0,65	1.860,78	2403,614	192,3077	220,3313	130,1957
D	B	0,2	7	-0,35	0,8	500	140	120	12	2	0,65	128,79	560,2295	51,28205	240,0984	140,0574
D	A-1	0,04	8	-0,4	0,9	200	150	125	14	2	0,65	-432,63	-12,8014	19,78022	250,0279	150,0168
D	A-2	0,024	8,5	-0,45	1	160	155	130	15	2	0,65	-469,07	-37,6342	16,41026	260,0152	155,009
D	A-3	0,006	9	-0,5	1,1	640	160	135	17	2	0,65	-777,24	-283,525	63,71041	270,0043	160,0025
E	B	0,5	7	-0,35	0,8	500	140	120	12	1,8	0,58	1.250,27	1664,079	57,47126	216,2052	140,133
E	A-1	0,7	8	-0,4	0,9	200	150	125	14	1,8	0,58	699,05	1096,326	22,16749	225,067	150,0446
E	A-2	0,6	8,5	-0,45	1	160	155	130	15	1,8	0,58	379,88	787,3312	18,3908	234,039	155,0258
E	A-3	0,5	9	-0,5	1,1	640	160	135	17	1,8	0,58	2.245,72	2720,142	71,39959	243,0127	160,0084
E	A-1	0,2	8	-0,4	0,9	200	150	125	14	1,8	0,58	-141,20	256,0762	22,16749	225,067	150,0446
E	A-2	0,14	8,5	-0,45	1	160	155	130	15	1,8	0,58	-278,95	128,5014	18,3908	234,039	155,0258
E	A-3	0,09	9	-0,5	1,1	640	160	135	17	1,8	0,58	-247,21	227,2119	71,39959	243,0127	160,0084

NPV	=	4.218,19

H11 H12 H14 H23 H24 H34 G11 G22 G33 G14 G44 P,x,y,z NPV

Hvala za pozornost