(1) x_{ij}: ton di cemento da ditta $i \in \{A,B,C\}$ a città $j \in \{1,2,3,4\}$ ***7CFU**

y_i: 1 se si ordina qualcosa a ditta $i \in \{A,B,C\}$

(z_k: 1 se ordino $k \in \{200, 400, 550\}$ ton alla ditta C)*

$$\min\ 120\,x_{A1} + 115\,x_{A2} + 130\,x_{A3} + 125\,x_{A4} + 100\,x_{B1} + 150\,x_{B2} + 110\,x_{B3} + 105\,x_{B4} + 140\,x_{C1} + 95\,x_{C2} + 145\,x_{C3} + 165\,x_{C4} + 1000\,(y_A + y_B + y_C)$$

s.t. $x_{A2} \geq 10$; $x_{B2} \geq 15$

$x_{A1} + x_{B1} + x_{C1} \geq 450$

$x_{A2} + x_{B2} + x_{C2} \geq 275$

$x_{A3} + x_{B3} + x_{C3} \geq 300$

$x_{A4} + x_{B4} + x_{C4} \geq 350$

$x_{A1} + x_{A2} + x_{A3} + x_{A4} \leq 525\,y_A$

$x_{B1} + x_{B2} + x_{B3} + x_{B4} \leq 450\,y_B$

$x_{C1} + x_{C2} + x_{C3} + x_{C4} \leq 550\,y_C$

$x_{A1} + x_{A2} + x_{A3} + x_{A4} \geq 150\,y_A$

($x_{C1} + x_{C2} + x_{C3} + x_{C4} = 200\,z_{200} + 400\,z_{400} + 550\,z_{550}$

$z_{200} + z_{400} + z_{550} = y_C$)*

$x_{ij} \in \mathbb{R}_+$ $\quad y_i \in \{0,1\}$ $\quad z_k \in \{0,1\}$, $i \in \{A,B,C\}$, $j \in \{1,2,3,4\}$, $k \in \{200,400,550\}$

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(2) F. STD: $\min\ -x_1 + x_2 + 3\hat{x}_3$ $\qquad \hat{x}_3 = -x_3$

s.t. $x_1 - 3x_2 + 6\hat{x}_3 + x_4 = 2$

$2x_1 - 4x_2 + 8\hat{x}_3 + x_5 = 1$

$-x_1 + 3x_2 - 6\hat{x}_3 + x_6 = 0$

$x_1, x_2, \hat{x}_3, x_4, x_5, x_6 \geq 0$

	x_1	x_2	$\hat{x}_3$	x_4	x_5	x_6	z	$\bar{b}$	
	-1	1	-3	0	0	0	-1	0	
x_4	1	-3	6	1	0	0	0	2	
x_5	2	-4	8	0	1	0	0	1	
x_6	-1	3	-6	0	0	1	0	0	

	0	-1	1	0	1/2	0	-1	1/2	$+R_2'$
x_4	0	-1	2	1	-1/2	0	0	3/2	$-R_2'$
x_1	1	-2	4	0	1/2	0	0	1/2	$R_2/2$
x_6	0	1	-2	0	1/2	1	0	1/2	$+R_2'$

	0	0	-1	0	1	1	-1	1	$+R_3$
x_4	0	0	0	1	0	1	0	2	$+R_3$
x_1	1	0	0	0	3/2	1	0	3/2	$+2R_3$
x_2	0	1	-2	0	1/2	1	0	1/2	R_3

$\Rightarrow$ ILLIMITATO! (duale NON AMMISS.)

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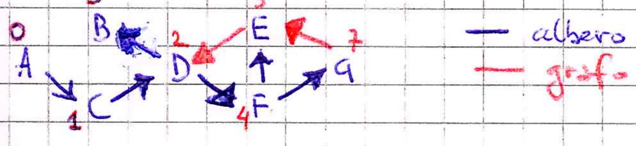
(3)

h	A	B	C	D	E	F	G	Agg
0	0_A	$+\infty_A$	$+\infty_A$	$+\infty_A$	$+\infty_A$	$+\infty_A$	$+\infty_A$	A
1	0_A	5_A	1_A	$+\infty_A$	$+\infty_A$	$+\infty_A$	$+\infty_A$	BC
2	0_A	4_C	1_A	2_C	8_B	6_C	$+\infty_A$	BDEF
3	0_A	3_D	1_A	2_C	7_B	4_D	8_D	BEFG
4	0_A	3_D	1_A	2_C	~~6_B~~ 5_F	4_D	7_F	EG
5	0_A	3_D	1_A	2_C	5_F	4_D	7_F	∅



(d) $A \to C \to B \to E$)*

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(4) $\max\ 2u_1 + 2u_2 - 2u_4$

s.t. $u_1 + u_2 + 2u_3 + u_4 \geq -2$

$2u_1 - u_2 - u_3 = 3$

$2u_1 + u_2 - u_3 - u_4 \leq 0$

$u_1 \geq 0$ u_2 libera $u_3 \leq 0$ u_4 libera

$x_1 = 0 \rightarrow //$

x_2 libera $\rightarrow$ no CCPD

$x_3 > 0 \rightarrow \boxed{2u_1 + u_2 - u_3 - u_4 = 0}$

$u_1(x_1 + 2x_2 + 2x_3 - 2) = 0 \rightarrow u_1 \cdot 2 = 0 \rightarrow \boxed{u_1 = 0}$

$u_2(-x_1 - x_2 + x_3 - 2) = 0$ PER AMM. PRIMALE

$u_3(2x_1 - x_2 - x_3 - 0) = 0 \rightarrow u_3(-2) = 0 \rightarrow \boxed{u_3 = 0}$

$u_4(x_1 - x_3 + 2) = 0$ PER AMM. PRIMALE

sistema CCPD e AD:

$$\begin{cases} 2u_1 + u_2 - u_3 - u_4 = 0 & \text{(CCPD)} \\ u_1 = 0 & \text{(CCPD)} \\ u_3 = 0 & \text{(CCPD)} \\ 2u_1 - u_2 - u_3 = 3 & \text{(AMM. DUALE)} \end{cases}$$

$\Rightarrow u_1 = 0,\ u_2 = -3,\ u_3 = 0,\ u_4 = -3$

$\Rightarrow$ u soddisfa vincoli duali e di dominio $\Rightarrow$ ottimo!

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(5) a) UB decresce ~~se~~ $N \in [108, 118)$

E SA non sempre cresce

$N = 107$ NO: $107 < 108$ (SA AMM.)

b) $[108, 116]$ ((b) $[108, 117]$)*

c) P_3, P_4, P_5, P_6; CHIUDO P_3 e P_4

d) P_6

e) no ((e) $\in [115, 117]$)*

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(6)

```
set I; set J;   (.mod)
param C{I,J}; param R{J}; param P{J};
param F{I}; param N; param M{I};
var x{I,J} >=0 integer;
var y{I} binary; var z{J} binary;
maximize f: sum{j in J} P[j]*z[j]
- sum{i in I, j in J} C[i,j]*x[i,j]
- sum{i in I} F[i]*y[i];
s.t. v1{j in J}: sum{i in I} x[i,j] >=R[j]*z[j]; s.t. v2: sum{i in I, j in J} x[i,j]<=N;
s.t. v3{i in I}: sum{j in J} x[i,j]<=M[i]*y[i];
```

```
(.dat) set I := o1 o2 o3; set J := p1 p2 p3 p4; param N := 15;
param C: p1 p2 p3 p4 :=     param : R P := p1 5 900 p2 9 700 p3 8 600 p4 7 500;
o1 10 11 12 13              param : F M := o1 20 10 o2 10 11 o3 30 12;
o2 18 17 16 15
o3 21 20 19 14;
```

```
(.run) reset; model x.mod; data x.dat; option solver cplex;
solve; display f, x, y, z;
```