Question 1: Galaxy Industries would like to determine production levels for four of its toy water guns that will maximize the total profit. Galaxy wants to produce at least 100 units and at most 1000 units of each toy water gun. The following table summarizes the profits and the resources requirements. The last row provides the resources available per week.

Product	**Profit**	**Plastic(lbs.)**	**Production time (min)**
Space Ray	€16	2	3
Zapper	€15	1	4
Big Squire	€20	3	5
Soaker	€22	4	6
	Available	3000	6000

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Decisions:

	Product	Profit	Plastic(lbs.)	Production time (min)
x_1	Space Ray	€16	2	3
x_2	Zapper	€15	1	4
x_3	Big Squire	€20	3	5
x_4	Soaker	€22	4	6
		Available	3000	6000

Question 1: Galaxy Industries would like to determine production levels for four of its toy water guns that will maximize the total profit. Galaxy wants to produce at least 100 units and at most 1000 units of each toy water gun. The following table summarizes the profits and the resources requirements. The last row provides the resources available per week.

Decisions:

	Product	Profit	Plastic(lbs.)	Production time (min)
x_1	Space Ray	€16	2	3
x_2	Zapper	€15	1	4
x_3	Big Squire	€20	3	5
x_4	Soaker	€22	4	6
		Available	3000	6000

$$max \quad 16x_1 + 15x_2 + 20x_3 + 22x_4$$

Question 1: Galaxy Industries would like to determine production levels for four of its toy water guns that will maximize the total profit. Galaxy wants to produce at least 100 units and at most 1000 units of each toy water gun. The following table summarizes the profits and the resources requirements. The last row provides the resources available per week.

Decisions:

	Product	Profit	Plastic(lbs.)	Production time (min)
x_1	Space Ray	€16	2	3
x_2	Zapper	€15	1	4
x_3	Big Squire	€20	3	5
x_4	Soaker	€22	4	6
		Available	3000	6000

$$
\begin{aligned}
max \quad & 16x_1 + 15x_2 + 20x_3 + 22x_4 \\
s.t. \quad & 2x_1 + x_2 + 3x_3 + 4x_4 \leq 3000 \\
& 3x_1 + 4x_2 + 5x_3 + 6x_4 \leq 6000 \\
& 100 \leq x_i \leq 1000, \forall i \in \{1, 2, 3, 4\}
\end{aligned}
$$

Question 2: Your company makes a variety of products. A large order for three products has just been received from a customer who also requested a very short due date. A quick calculation revealed that the limiting resource is the labor time; only 200 labor hours are available, and that is not enough to make all the requested units of products. Some units must be outsourced to subcontractors. Two subcontractors are available. Subcontractor A has low prices, but can only provide a maximum of 60 units of all products in total. Sub-contractor B is more expensive, but can provide any number of units of any product. Your company wants to decide how many units of each product to make and how many units to buy from each subcontractor in order to minimize the total cost. The table below summarizes all necessary information.

	Product 1	**Product 2**	**Product 3**
Cost of making a unit	€6	€13	€20
Cost of buying a unit from A	€12	€15	€21
Cost of buying a unit from B	€11	€16	€23
Labor hours/unit	1	2	3
Demand(units)	100	80	70

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Decisions:

M^1, M^2, M^3

A^1, A^2, A^3

B^1, B^2, B^3

	Product 1	**Product 2**	**Product 3**
Cost of making a unit	€6	€13	€20
Cost of buying a unit from A	€12	€15	€21
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Labor hours/unit	1	2	3
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Decisions:

M^1, M^2, M^3

A^1, A^2, A^3

B^1, B^2, B^3

	Product 1	**Product 2**	**Product 3**
Cost of making a unit	€6	€13	€20
Cost of buying a unit from A	€12	€15	€21
Cost of buying a unit from B	€11	€16	€23
Labor hours/unit	1	2	3
Demand(units)	100	80	70

$$min \quad 6M^1 + 13M^2 + 20M^3 + 12A^1 + 15A^2 + 21A^3 + 11B^1 + 16B^2 + 23B^3$$

Question 2: Your company makes a variety of products. A large order for three products has just been received from a customer who also requested a very short due date. A quick calculation revealed that the limiting resource is the labor time; only 200 labor hours are available, and that is not enough to make all the requested units of products. Some units must be outsourced to subcontractors. Two subcontractors are available. Subcontractor A has low prices, but can only provide a maximum of 60 units of all products in total. Sub-contractor B is more expensive, but can provide any number of units of any product. Your company wants to decide how many units of each product to make and how many units to buy from each subcontractor in order to minimize the total cost. The table below summarizes all necessary information.

Decisions:

M^1, M^2, M^3

A^1, A^2, A^3

B^1, B^2, B^3

	Product 1	Product 2	Product 3
Cost of making a unit	€6	€13	€20
Cost of buying a unit from A	€12	€15	€21
Cost of buying a unit from B	€11	€16	€23
Labor hours/unit	1	2	3
Demand(units)	100	80	70

$$min \quad 6M^1 + 13M^2 + 20M^3 + 12A^1 + 15A^2 + 21A^3 + 11B^1 + 16B^2 + 23B^3$$

$$s.t. \quad M^1 + 2M^2 + 3M^3 \leq 200$$

$$A^1 + A^2 + A^3 \leq 60$$

$$M^1 + A^1 + B^1 = 100$$

$$M^2 + A^2 + B^2 = 80$$

$$M^3 + A^3 + B^3 = 70$$

$$M^1, M^2, M^3, A^1, A^2, A^3, B^1, B^2, B^3 \geq 0$$

Question 2: Your company makes a variety of products. A large order for three products has just been received from a customer who also requested a very short due date. A quick calculation revealed that the limiting resource is the labor time; only 200 labor hours are available, and that is not enough to make all the requested units of products. Some units must be outsourced to subcontractors. Two subcontractors are available. Subcontractor A has low prices, but can only provide a maximum of 60 units of all products in total. Sub-contractor B is more expensive, but can provide any number of units of any product. Your company wants to decide how many units of each product to make and how many units to buy from each subcontractor in order to minimize the total cost. The table below summarizes all necessary information.

$P = \{1,2,3\}$

Decisions:

		Product 1	**Product 2**	**Product 3**
M^i	Cost of making a unit	€6	€13	€20
A^i	Cost of buying a unit from A	€12	€15	€21
B^i	Cost of buying a unit from B	€11	€16	€23
	Labor hours/unit	1	2	3
	Demand(units)	100	80	70

Question 2: Your company makes a variety of products. A large order for three products has just been received from a customer who also requested a very short due date. A quick calculation revealed that the limiting resource is the labor time; only 200 labor hours are available, and that is not enough to make all the requested units of products. Some units must be outsourced to subcontractors. Two subcontractors are available. Subcontractor A has low prices, but can only provide a maximum of 60 units of all products in total. Sub-contractor B is more expensive, but can provide any number of units of any product. Your company wants to decide how many units of each product to make and how many units to buy from each subcontractor in order to minimize the total cost. The table below summarizes all necessary information.

$P = \{1,2,3\}$

Decisions:

		Product 1	Product 2	Product 3	
M^i	Cost of making a unit	€6	€13	€20	c_m^i
A^i	Cost of buying a unit from A	€12	€15	€21	c_a^i
B^i	Cost of buying a unit from B	€11	€16	€23	c_b^i
	Labor hours/unit	1	2	3	l^i
	Demand(units)	100	80	70	d^i

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Decisions:

		Product 1	**Product 2**	**Product 3**	
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	Labor hours/unit	1	2	3	l^i
	Demand(units)	100	80	70	d^i

$$min \quad \sum_{i \in P} \left(c_m^i M^i + c_a^i A^i + c_b^i B^i \right)$$

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$P = \{1,2,3\}$

Decisions:

M^i

A^i

B^i

	Product 1	Product 2	Product 3	
Cost of making a unit	€6	€13	€20	c_m^i
Cost of buying a unit from A	€12	€15	€21	c_a^i
Cost of buying a unit from B	€11	€16	€23	c_b^i
Labor hours/unit	1	2	3	l^i
Demand(units)	100	80	70	d^i

$$\min \quad \sum_{i \in P} \left(c_m^i M^i + c_a^i A^i + c_b^i B^i \right)$$

$$s.t. \quad \sum_{i \in P} l^i M^i \leq 200$$

$$\sum_{i \in P} A^i \leq 60$$

$$M^i + A^i + B^i = d^i, \quad \forall i \in P$$

$$M^i, A^i, B^i \geq 0, \quad \forall i \in P$$

Question 3: A trust officer at the Maltese National Bank needs to determine how to invest €100,000 in the following collection of bonds to maximize the annual return.

Bond	Annual return	Maturity	Risk	Tax-Free
A	9.5%	Long	High	Yes
B	8%	Short	Low	Yes
C	9%	Long	Low	No
D	9%	Long	High	Yes
E	9%	Short	High	No

The officer wants to invest at least 50% of the money in short-term issues and no more than 45% in high risk issues. At least 30% of the funds should go into tax-free investments and at least 40% of the total annual return should be tax-free.

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Bond	Annual return	Maturity	Risk	Tax-Free
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C	9%	Long	Low	No
D	9%	Long	High	Yes
E	9%	Short	High	No

The officer wants to invest at least 50% of the money in short-term issues and no more than 45% in high risk issues. At least 30% of the funds should go into tax-free investments and at least 40% of the total annual return should be tax-free.

$$max \quad \frac{9.5}{100}A + \frac{8}{100}B + \frac{9}{100}C + \frac{9}{100}D + \frac{9}{100}E$$

$$\begin{aligned}
s.t. \quad & A + B + C + D + E = 100{,}000 \\
& B + E \geq 50{,}000 \\
& A + D + E \leq 45{,}000 \\
& A + B + D \geq 30{,}000 \\
& 9.5A + 8B + 9D \geq 0.4(9.5A + 8B + 9C + 9D + 9E) \\
& A, B, C, D, E \geq 0
\end{aligned}$$

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The officer wants to invest at least 50% of the money in short-term issues and no more than 45% in high risk issues. At least 30% of the funds should go into tax-free investments and at least 40% of the total annual return should be tax-free.

$$max \quad \frac{9.5}{100}A + \frac{8}{100}B + \frac{9}{100}C + \frac{9}{100}D + \frac{9}{100}E$$

$$
\begin{aligned}
s.t. \quad & A + B + C + D + E = 100{,}000 \\
& B + E \geq 50{,}000 \\
& A + D + E \leq 45{,}000 \\
& A + B + D \geq 30{,}000 \\
& 5.7A + 4.8B + 5.4D - 3.6C - 3.6E \geq 0 \\
& A, B, C, D, E \geq 0
\end{aligned}
$$

Question 4: *Laura's garden* is a leading grower and distributor of citrus products. It has three citrus groves at locations A, B and C. LG currently has 2750 tones of citruses at A, 4000 tones of citruses at B and 3000 tones of citruses at C. LG has citrus processing plants at D, E and F with processing capacities of 2000,6000 and 2250 respectively. The transportation costs per tone per mile is €1.5 and the distances in miles between groves and processing plants are

	D	**E**	**F**
A	21	50	40
B	35	30	22
C	55	20	25

LG wants to determine how many tones to ship from each grove to each plant in order to minimize the total cost.

Question 4: *Laura's garden* is a leading grower and distributor of citrus products. It has three citrus groves at locations A, B and C. LG currently has 2750 tones of citruses at A, 4000 tones of citruses at B and 3000 tones of citruses at C. LG has citrus processing plants at D, E and F with processing capacities of 2000,6000 and 2250 respectively. The transportation costs per tone per mile is €1.5 and the distances in miles between groves and processing plants are

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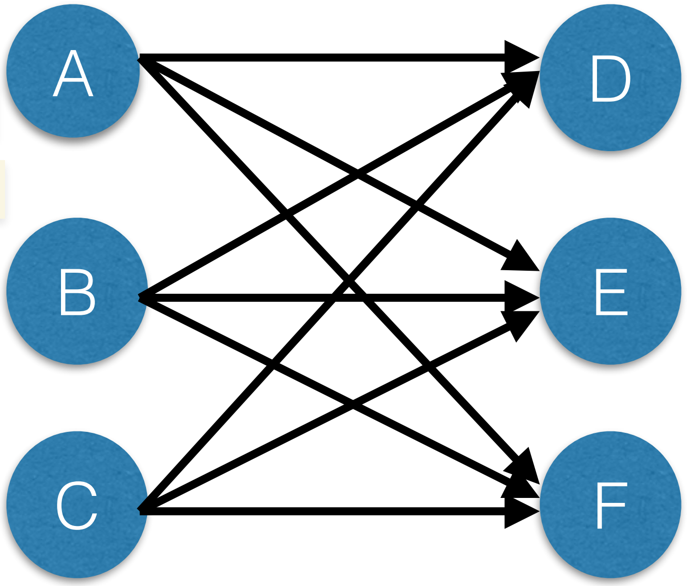

Decisions:

$$x_{ij}, i \in I, j \in J$$
$$I = \{A, B, C\}$$
$$J = \{D, E, F\}$$

costs: c_{ij}

processing capacity: $p_j, j \in J$

grove supply: $g_i, i \in I$

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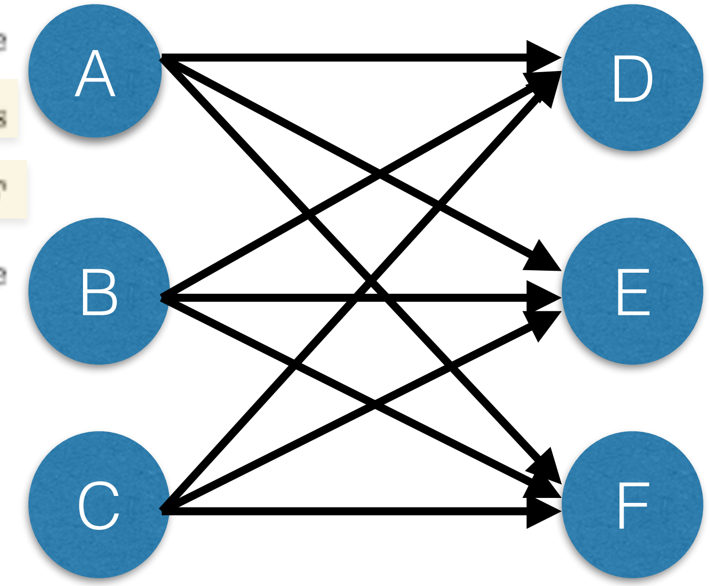

Decisions:

$$x_{ij}, i \in I, j \in J$$
$$I = \{A, B, C\}$$
$$J = \{D, E, F\}$$

$$min \quad 1.5 \sum_{i \in I} \sum_{j \in J} d_{ij} x_{ij}$$

distances: d_{ij}

processing capacity: $p_j, j \in J$

grove supply: $g_i, i \in I$

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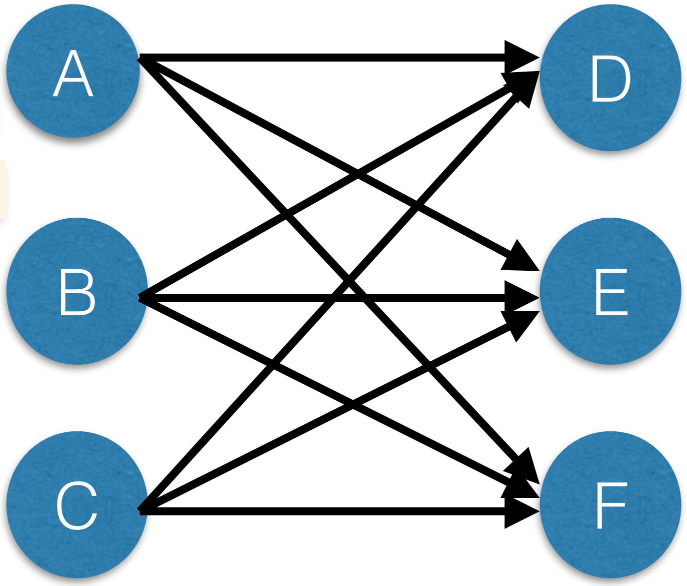

Decisions:

$x_{ij}, i \in I, j \in J$
$I = \{A, B, C\}$
$J = \{D, E, F\}$

$$min \quad 1.5 \sum_{i \in I} \sum_{j \in J} d_{ij} x_{ij}$$

$$s.t. \quad \sum_{j \in J} x_{ij} = g_i, \quad \forall i \in I \qquad (X_{AD} + X_{AE} + X_{AF} = 2750, \ldots)$$

distances: d_{ij}

processing capacity: $p_j, j \in J$

grove supply: $g_i, i \in I$

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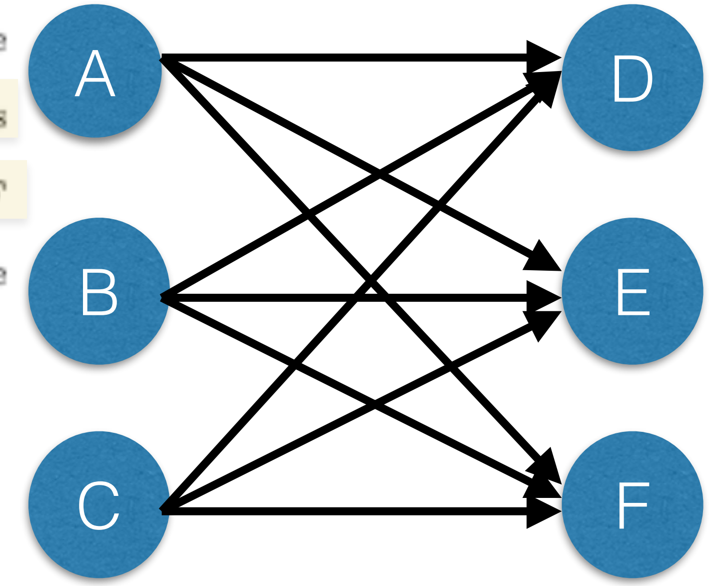

Decisions:

$$x_{ij}, i \in I, j \in J$$
$$I = \{A, B, C\}$$
$$J = \{D, E, F\}$$

$$min \quad 1.5 \sum_{i \in I} \sum_{j \in J} d_{ij} x_{ij}$$

$$s.t. \quad \sum_{j \in J} x_{ij} = g_i, \quad \forall i \in I \qquad (X_{AD} + X_{AE} + X_{AF} = 2750, \ldots)$$

$$\sum_{i \in I} x_{ij} \le p_j, \quad \forall j \in J \qquad (X_{AD} + X_{BD} + X_{CD} \le 2000, \ldots)$$

distances: d_{ij}

processing capacity: $p_j, j \in J$

grove supply: $g_i, i \in I$

Question 4: *Laura's garden* is a leading grower and distributor of citrus products. It has three citrus groves at locations A, B and C. LG currently has 2750 tones of citruses at A, 4000 tones of citruses at B and 3000 tones of citruses at C. LG has citrus processing plants at D, E and F with processing capacities of 2000,6000 and 2250 respectively. The transportation costs per tone per mile is €1.5 and the distances in miles between groves and processing plants are

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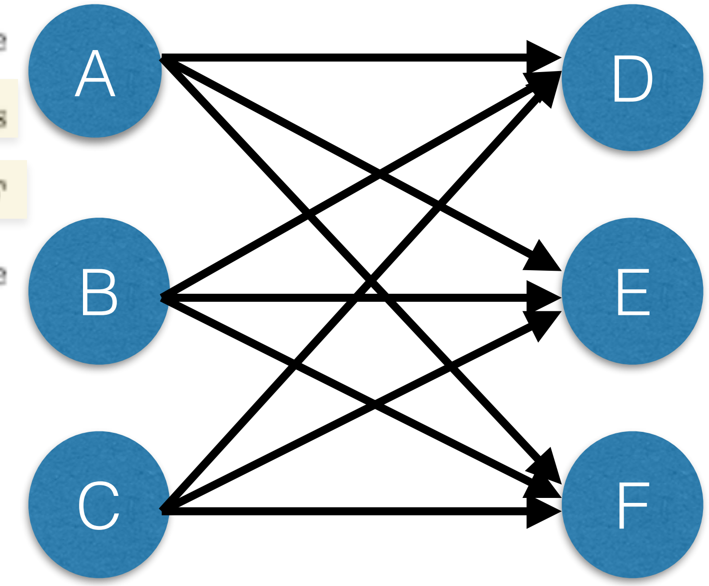

Decisions:

$x_{ij}, i \in I, j \in J$

$I = \{A, B, C\}$

$J = \{D, E, F\}$

$$min \quad 1.5 \sum_{i \in I} \sum_{j \in J} d_{ij} x_{ij}$$

$$s.t. \quad \sum_{j \in J} x_{ij} = g_i, \quad \forall i \in I \qquad (X_{AD} + X_{AE} + X_{AF} = 2750, \ldots)$$

distances: d_{ij}

$$\sum_{i \in I} x_{ij} \leq p_j, \quad \forall j \in J \qquad (X_{AD} + X_{BD} + X_{CD} \leq 2000, \ldots)$$

processing capacity: $p_j, j \in J$

grove supply: $g_i, i \in I$

$$x_{ij} \geq 0, \quad \forall i \in I, j \in J$$

Question 5: Minimum design manufactures lighting products and is about to determine its plan for production and inventory levels for the following 6 months. There are seasonal fluctuations in the prices of raw materials and therefore the production costs are not constant. Production capacity also differs from month to month due to differences of working days, vacations and scheduled maintenance and training. The current inventory of MD is 1800 units. Items that are stored in Inventory at the end of the month incur an inventory cost of €4. At most 6000 units can be held in inventory at any time. To maintain a stable workforce MD wishes to produce at least 50% of its production capacity every month. Furthermore MD wants to keep at least 1500 units in inventory as safety stock to serve unexpected demand.

	Months						
	1	2	3	4	5	6	
Unit production cost (€)	250	253	255	253	250	255	c_i
Demand	1000	4500	6000	4500	3500	4000	d_i
Maximum Production	4000	3500	4000	4500	4000	2500	p_i^{max}

Decisions:

$P_i, i \in \{1,2,3,4,5,6\}$

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	Months						
	1	2	3	4	5	6	
Unit production cost (€)	250	253	255	253	250	255	c_i
Demand	1000	4500	6000	4500	3500	4000	d_i
Maximum Production	4000	3500	4000	4500	4000	2500	p_i^{max}

Decisions:

$P_i, i \in \{1,2,3,4,5,6\}$

Variables:

$P_i, i \in \{1,2,3,4,5,6\}$

$I_i, i \in \{1,2,3,4,5,6\}$

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	Months						
	1	2	3	4	5	6	
Unit production cost (€)	250	253	255	253	250	255	c_i
Demand	1000	4500	6000	4500	3500	4000	d_i
Maximum Production	4000	3500	4000	4500	4000	2500	p_i^{max}

$$min \sum_{i\in\{1,2,3,4,5,6\}} (c_i P_i + 4I_i)$$

Decisions:

$P_i, i \in \{1,2,3,4,5,6\}$

Variables:

$P_i, i \in \{1,2,3,4,5,6\}$

$I_i, i \in \{1,2,3,4,5,6\}$

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	Months						
	1	2	3	4	5	6	
Unit production cost (€)	250	253	255	253	250	255	c_i
Demand	1000	4500	6000	4500	3500	4000	d_i
Maximum Production	4000	3500	4000	4500	4000	2500	p_i^{max}

Decisions:

$P_i, i \in \{1,2,3,4,5,6\}$

Variables:

$P_i, i \in \{1,2,3,4,5,6\}$

$I_i, i \in \{1,2,3,4,5,6\}$

$$min \sum_{i \in \{1,2,3,4,5,6\}} (c_i P_i + 4I_i)$$

$$s.t. \quad I_1 = 1800 + P_1 - d_1$$

$$I_i = I_{i-1} + P_i - d_i, \quad \forall i \in \{2,3,4,5,6\}$$

$$1500 \le I_i \le 6000, \quad \forall i \in \{1,2,3,4,5,6\}$$

$$0.5p_i^{max} \le P_i \le p_i^{max}, \quad \forall i \in \{1,2,3,4,5,6\}$$

Question 6: *As greek as it gets* is a small but growing restaurant chain specializing in Souvlaki. AGAIG is planning to open a new restaurant in Utrecht and wants to establish a construction fund to pay for the new facility. Construction is expected to take 6 months and costs €800,000. Of these, €250,000 have to be payed after 2 months, €250,000 at the end of the 4 months and the remaining €300,000 at the end of the six month period.

AGAIG can use 4 investment options to establish the construction fund. The table below indicates which investments are available in each month, their time to maturity and corresponding yield.

Investment	Available in Month	Months to Maturity	Yield at maturity
A	1,2,3,4,5,6	1	1.8%
B	1,3,5	2	3.5%
C	1,4	3	5.8%
D	1	6	11%

AGAIG wished to determine the optimal investment plan to meet the required schedule of payments with the minimum amount of money.

Question 6: *As greek as it gets* is a small but growing restaurant chain specializing in Souvlaki. AGAIG is planning to open a new restaurant in Utrecht and wants to establish a construction fund to pay for the new facility. Construction is expected to take 6 months and costs €800,000. Of these, €250,000 have to be payed after 2 months, €250,000 at the end of the 4 months and the remaining €300,000 at the end of the six month period.

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D	1	6	11%

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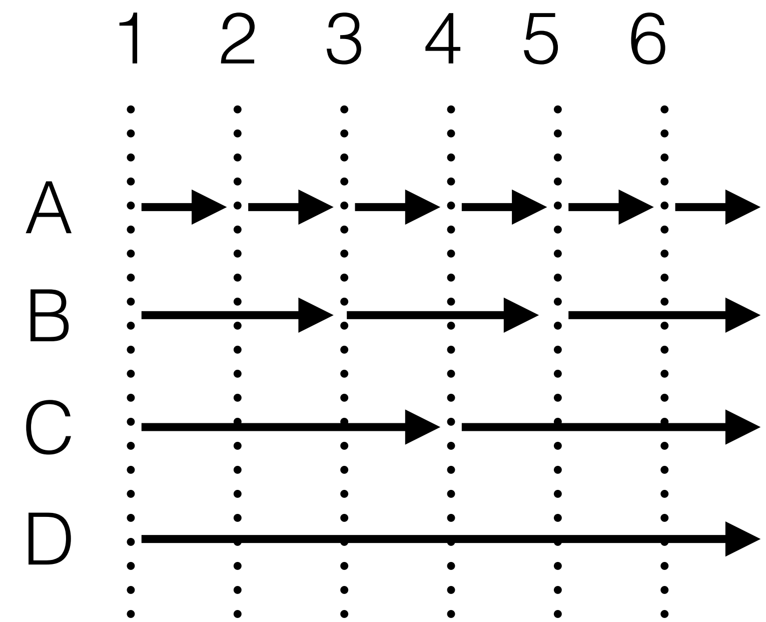

Decisions:

$A_1, A_2, A_3, A_4, A_5, A_6$

B_1, B_3, B_5

C_1, C_4

D_1

Question 6: *As greek as it gets* is a small but growing restaurant chain specializing in Souvlaki. AGAIG is planning to open a new restaurant in Utrecht and wants to establish a construction fund to pay for the new facility. Construction is expected to take 6 months and costs €800,000. Of these, €250,000 have to be payed after 2 months, €250,000 at the end of the 4 months and the remaining €300,000 at the end of the six month period.

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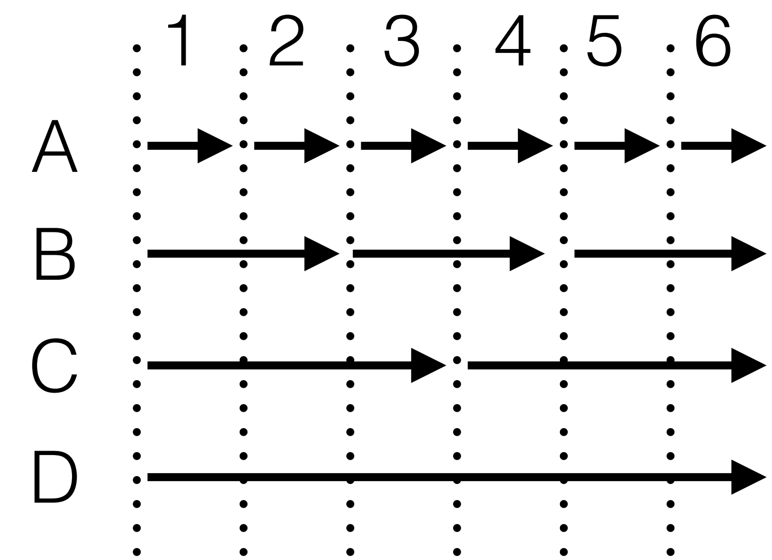


Decisions:

$A_1, A_2, A_3, A_4, A_5, A_6$

B_1, B_3, B_5

C_1, C_4

D_1

$$\min \quad A_1 + B_1 + C_1 + D_1$$

$$s.t. \quad 1.018A_1 - A_2 = 0$$

$$1.018A_2 + 1.035B_1 - A_3 - B_3 = 250{,}000$$

$$1.018A_3 + 1.058C_1 - A_4 - C_4 = 0$$

$$1.018A_4 + 1.035B_3 - A_5 - B_5 = 250{,}000$$

rebalancing at the end of period 4

$$1.018A_5 - A_6 = 0$$

$$1.018A_6 + 1.035B_5 + 1.058C_4 + 1.2D_1 = 300{,}000$$

$$A_1, A_2, A_3, A_4, A_5, A_6, B_1, B_3, B5, C_1, C_4, D_1 \geq 0$$

Staffing a call center

Lenny Davis, the hospital manager, plans to operate the call center from 7AM to 9 PM on weekdays.



Staffing a call center

Lenny Davis, the hospital manager, plans to operate the call center from 7AM to 9 PM on weekdays.

Work Shift	Average number of calls
7am-9am	40/hour
9am-11am	85/hour
11am-1pm	70/hour
1pm-3pm	95/hour
3pm-5pm	80/hour
5pm-7pm	35/hour
7pm-9pm	10/hour



Staffing a call center

Lenny Davis, the hospital manager, plans to operate the call center from 7AM to 9 PM on weekdays.

Work Shift	Average number of calls
7am-9am	40/hour
9am-11am	85/hour
11am-1pm	70/hour
1pm-3pm	95/hour
3pm-5pm	80/hour
5pm-7pm	35/hour
7pm-9pm	10/hour

- 20% of calls are from Spanish speakers
- 6 calls/hour/employee
- Spanish or English speaking employees. Not bilingual.
- FTE work for 8 consecutive hours, 2H phone, 2H paperwork. Can start on phone or paperwork
- PTE work for 4 consecutive hours, all on the phone. Only English speaking part-timers are available.
- Full time employees start work at 7AM, 9AM, 11AM or 1PM.
- Part time employees start at 3PM or 5PM
- Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
- Consider only the labour cost for the time employees spend answering phone calls.



Staffing a call center

-20% of calls are from Spanish speakers

Work Shift	Average number of calls	Average number of english calls	Average number of spanish calls
7am-9am	40/hour	32/hour	8/hour
9am-11am	85/hour	68/hour	17/hour
11am-1pm	70/hour	64/hour	14/hour
1pm-3pm	95/hour	76/hour	19/hour
3pm-5pm	80/hour	64/hour	16/hour
5pm-7pm	35/hour	28/hour	7/hour
7pm-9pm	10/hour	8/hour	2/hour



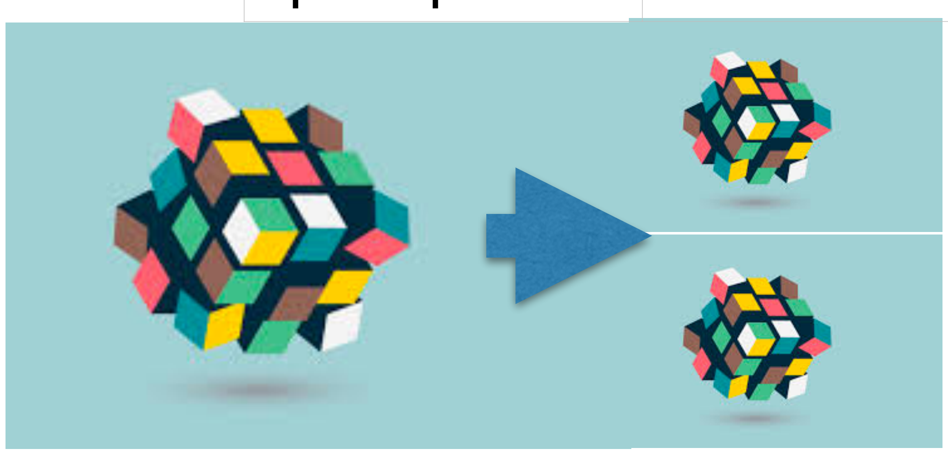
Staffing a call center

-20% of calls are from Spanish speakers

Work Shift	Average number of english calls
7am-9am	32/hour
9am-11am	68/hour
11am-1pm	64/hour
1pm-3pm	76/hour
3pm-5pm	64/hour
5pm-7pm	28/hour
7pm-9pm	8/hour

Work Shift	Average number of spanish calls
7am-9am	8/hour
9am-11am	17/hour
11am-1pm	14/hour
1pm-3pm	19/hour
3pm-5pm	16/hour
5pm-7pm	7/hour
7pm-9pm	2/hour

-Spanish or English speaking employees. Not bilingual.

Staffing a call center

-20% of calls are from Spanish speakers

Work Shift	Average number of english calls
7am-9am	32/hour
9am-11am	68/hour
11am-1pm	64/hour
1pm-3pm	76/hour
3pm-5pm	64/hour
5pm-7pm	28/hour
7pm-9pm	8/hour

Work Shift	Average number of spanish calls
7am-9am	8/hour
9am-11am	17/hour
11am-1pm	14/hour
1pm-3pm	19/hour
3pm-5pm	16/hour
5pm-7pm	7/hour
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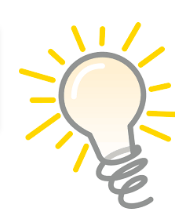

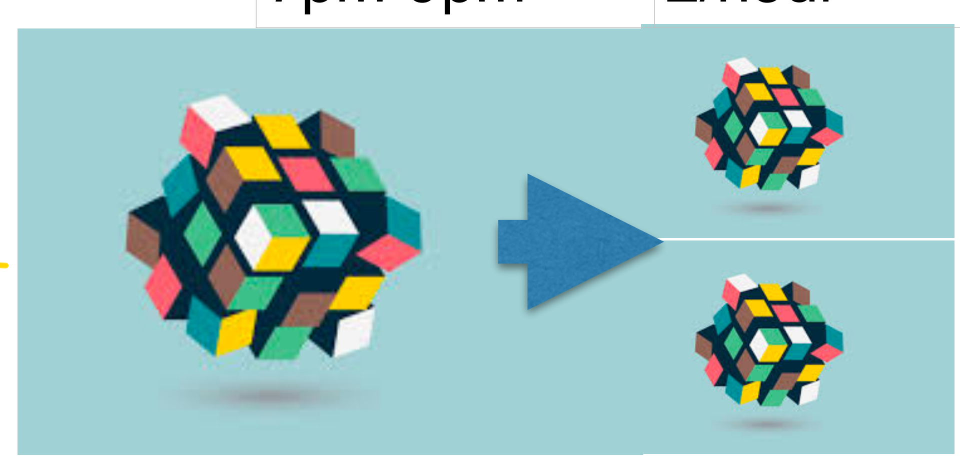

  

Staffing a call center

- FTE work for 8 consecutive hours, 2H phone, 2H paperwork. Can start on phone or paperwork

- Full time employees start work at 7AM, 9AM, 11AM or 1PM.

Work Shift	**Average number of english calls**	**FT 7AM Start**
7am-9am	32/hour	1
9am-11am	68/hour	
11am-1pm	64/hour	1
1pm-3pm	76/hour	
3pm-5pm	64/hour	
5pm-7pm	28/hour	
7pm-9pm	8/hour	

- Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
- Consider only the labour cost for the time employees spend answering phone calls.



Staffing a call center

- FTE work for 8 consecutive hours, 2H phone, 2H paperwork. Can start on phone or paperwork

- Full time employees start work at 7AM, 9AM, 11AM or 1PM.

Work Shift	Average number of english calls	FT 7AM Start 	FT 7AM Start 
7am-9am	32/hour	1	
9am-11am	68/hour		1
11am-1pm	64/hour	1	
1pm-3pm	76/hour		1
3pm-5pm	64/hour		
5pm-7pm	28/hour		
7pm-9pm	8/hour		

- Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
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- FTE work for 8 consecutive hours, 2H phone, 2H paperwork. Can start on phone or paperwork

- Full time employees start work at 7AM, 9AM, 11AM or 1PM.

Work Shift	Average number of english calls	FT 7AM Start	FT 7AM Start	FT 9AM Start
7am-9am	32/hour	1		
9am-11am	68/hour		1	1
11am-1pm	64/hour	1		
1pm-3pm	76/hour		1	1
3pm-5pm	64/hour			
5pm-7pm	28/hour			
7pm-9pm	8/hour			

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Work Shift	Average number of english calls	FT 7AM Start	FT 7AM Start	FT 9AM Start
7am-9am	32/hour	1		
9am-11am	68/hour		1	1
11am-1pm	64/hour	1		
1pm-3pm	76/hour		1	1
3pm-5pm	64/hour			
5pm-7pm	28/hour			
7pm-9pm	8/hour			

- Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
- Consider only the labour cost for the time employees spend answering phone calls.

Staffing a call center

- FTE work for 8 consecutive hours, 2H phone, 2H paperwork. Can start on phone or paperwork

- Full time employees start work at 7AM, 9AM, 11AM or 1PM.

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start
7am-9am	32/hour	1				
9am-11am	68/hour		1			
11am-1pm	64/hour	1		1		
1pm-3pm	76/hour		1		1	
3pm-5pm	64/hour			1		1
5pm-7pm	28/hour				1	
7pm-9pm	8/hour					1

- Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
- Consider only the labour cost for the time employees spend answering phone calls.



Staffing a call center

- Part time employees start at 3PM or 5PM

- PTEwork for 4 consecutive hours, all on the phone.

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1

- Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
- Consider only the labour cost for the time employees spend answering phone calls.



Staffing a call center

-Part time employees start at 3PM or 5PM

-PTEwork for 4 consecutive hours, all on the phone.

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1
Cost		$40	$40	$40	$44	$44	$44	$48

-Both full time and part time employees get paid 10$/hour before 5pm and 12$/hour after 5pm.
-Consider only the labour cost for the time employees spend answering phone calls.



Staffing a call center

Decisions: F^7 F^9 F^{11} F^{13} F^{15} P^{15} P^{17}

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1
Cost		$40	$40	$40	$44	$44	$44	$48

Staffing a call center

Decisions: F^7 F^9 F^{11} F^{13} F^{15} P^{15} P^{17}

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1
Cost		$40	$40	$40	$44	$44	$44	$48

$$min \quad 40(F^7 + F^9 + F^{11}) + 44(F^{13} + F^{15} + P^{15}) + 48P^{17}$$



Staffing a call center

Decisions: F^7 F^9 F^{11} F^{13} F^{15} P^{15} P^{17}

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1
Cost		$40	$40	$40	$44	$44	$44	$48

-6 calls/hour/employee

$$\begin{aligned} min \quad & 40(F^7 + F^9 + F^{11}) + 44(F^{13} + F^{15} + P^{15}) + 48P^{17} \\ s.t. \quad & F^7 \geq 6 \end{aligned}$$



Staffing a call center

Decisions: F^7 F^9 F^{11} F^{13} F^{15} P^{15} P^{17}

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1
Cost		\$40	\$40	\$40	\$44	\$44	\$44	\$48

-6 calls/hour/employee

$$\min \quad 40(F^7 + F^9 + F^{11}) + 44(F^{13} + F^{15} + P^{15}) + 48P^{17}$$

$$s.t. \quad F^7 \geq 6$$

$$F^9 \geq 12$$

$$F^7 + F^{11} \geq 11$$

$$F^9 + F^{13} \geq 13$$

$$F^{11} + F^{15} + P^{15} \geq 11$$

$$F^{13} + P^{15} + P^{17} \geq 5$$

$$F^{15} + P^{17} \geq 2$$



Staffing a call center

Decisions: F^7 F^9 F^{11} F^{13} F^{15} P^{15} P^{17}

Work Shift	Average number of english	FT 7AM Start	FT 9AM start	FT 11AM Start	FT 1PM Start	FT 3PM Start	PT 3PM Start	PT 5PM Start
7am-9am	32/hour	1						
9am-11am	68/hour		1					
11am-1pm	64/hour	1		1				
1pm-3pm	76/hour		1		1			
3pm-5pm	64/hour			1		1	1	
5pm-7pm	28/hour				1		1	1
7pm-9pm	8/hour					1		1
Cost		$40	$40	$40	$44	$44	$44	$48

-6 calls/hour/employee

$$\min \quad 40(F^7 + F^9 + F^{11}) + 44(F^{13} + F^{15} + P^{15}) + 48P^{17}$$

$$s.t. \quad F^7 \geq 6 \qquad F^{11} + F^{15} + P^{15} \geq 11$$

$$F^9 \geq 12 \qquad F^{13} + P^{15} + P^{17} \geq 5$$

$$F^7 + F^{11} \geq 11 \qquad F^{15} + P^{17} \geq 2$$

$$F^9 + F^{13} \geq 13$$

$$F^7, F^9, F^{11}, F^{13}, F^{15}, P^{15}, P^{17} \geq 0$$

The golfer's link (TGL)

TGL specializes in the production of quality sets of golf clubs

Rick

The golfer's link (TGL)

Club types

For men
For women
For juniors

Manufacturing plants

Daytona Beach
Memphis
Tempe

Materials

Titanium
Aluminium
Rock Maple

Distribution centers

Sacramento
Denver
Pittsburgh

The golfer's link (TGL)

Club types

For men
For women
For juniors

$$\mathscr{C} = \{M, W, J\}$$

Manufacturing plants

Daytona Beach
Memphis
Tempe

$$\mathscr{P} = \{D, M, T\}$$

Materials

Titanium
Aluminium
Rock Maple

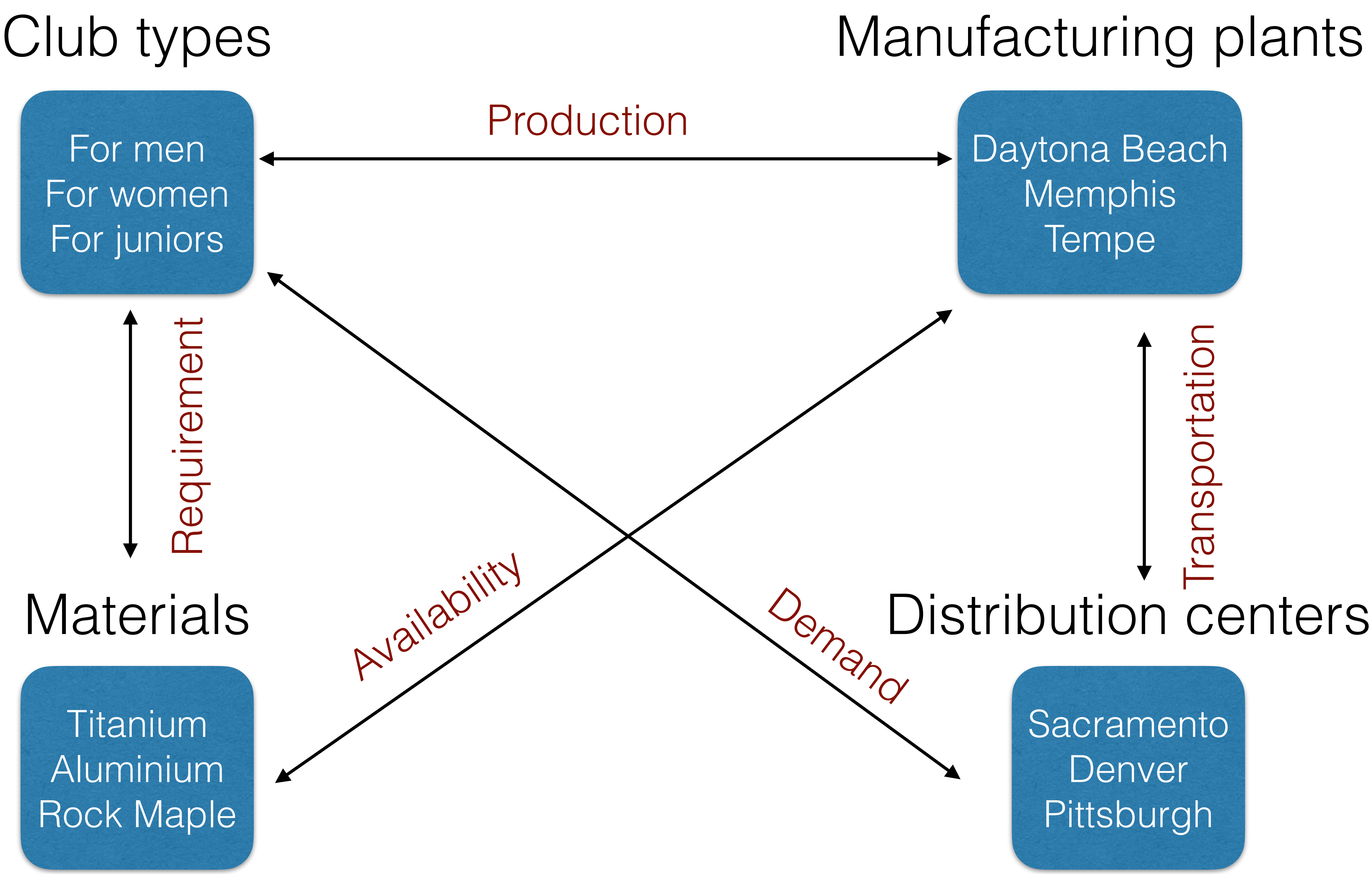
$$\mathscr{M} = \{T, A, R\}$$

Distribution centers

Sacramento
Denver
Pittsburgh

$$\mathscr{D} = \{S, D, P\}$$

The golfer’s link (TGL)



The golfer's link (TGL)

Club types

For men	$225
For women	$195
For juniors	$165

The golfer's link (TGL)

Club types

For men	\$225
For women	\$195
For juniors	\$165

$$p_i, i \in \mathscr{C}$$

The golfer's link (TGL)

Club types

For men
For women
For juniors

	Number of Club Sets Ordered		
	Men's	Women's	Juniors'
Sacramento	700	900	900
Denver	550	1,000	1,500
Pittsburgh	900	1,200	1,100

Demand

Distribution centers

Sacramento
Denver
Pittsburgh

-Must fill at least 90% of all orders

-But no more than 100%

The golfer's link (TGL)

Club types

For men
For women
For juniors

	Number of Club Sets Ordered		
	Men's	Women's	Juniors'
Sacramento	700	900	900
Denver	550	1,000	1,500
Pittsburgh	900	1,200	1,100

$$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$$

Demand

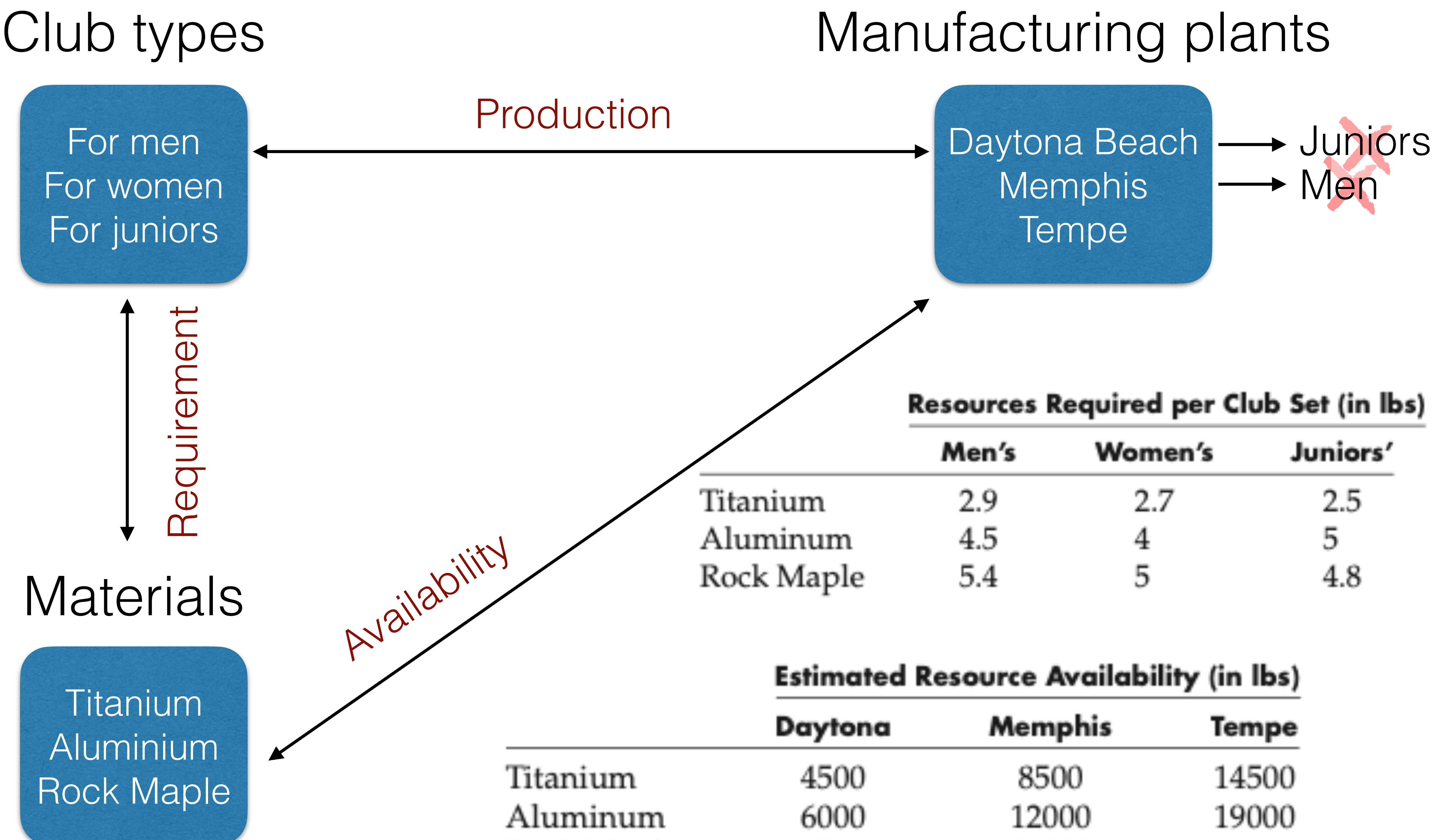
Distribution centers

Sacramento
Denver
Pittsburgh

-Must fill at least 80% of all orders

-But no more than 100%

The golfer's link (TGL)



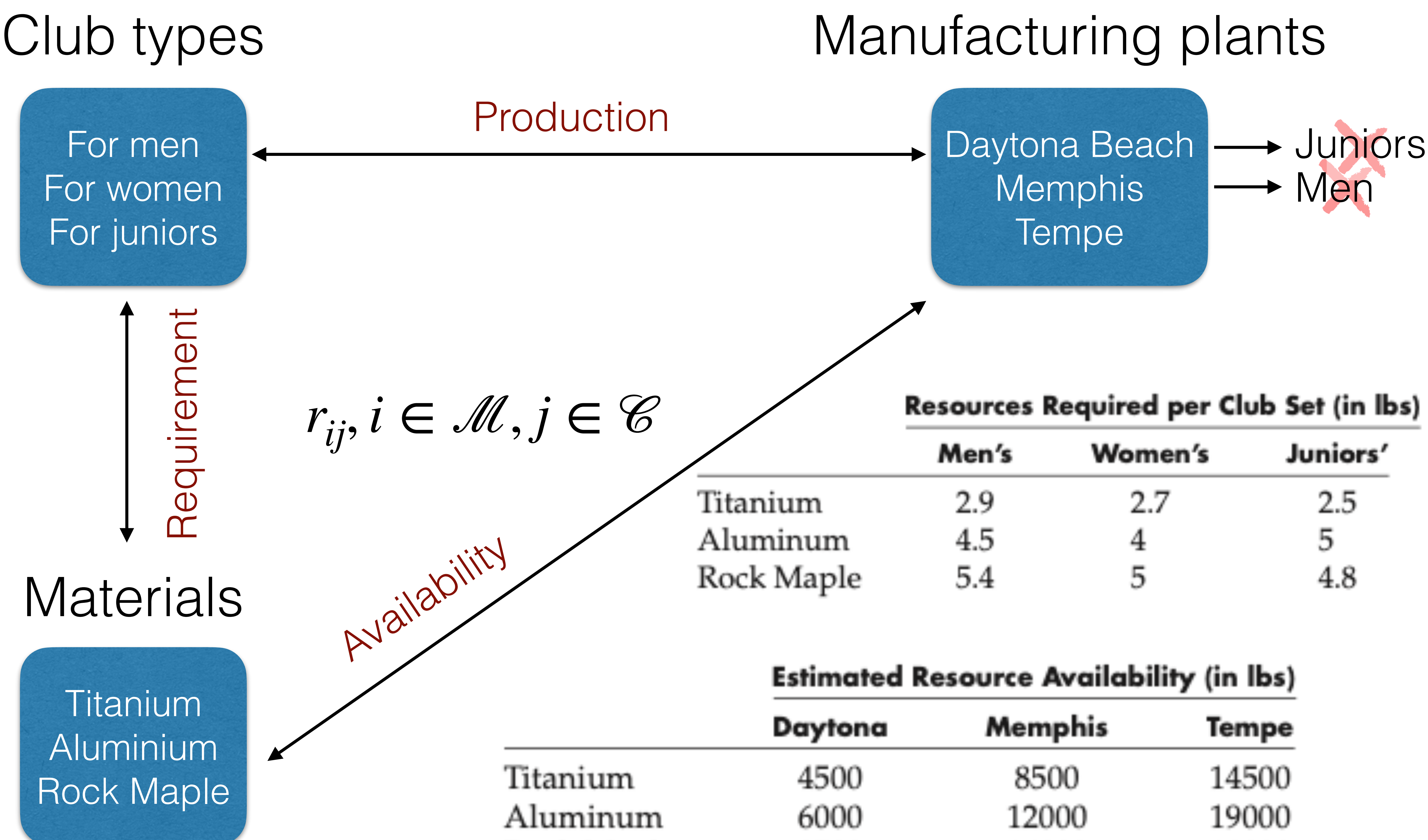
Resources Required per Club Set (in lbs)

	Men's	Women's	Juniors'
Titanium	2.9	2.7	2.5
Aluminum	4.5	4	5
Rock Maple	5.4	5	4.8

Estimated Resource Availability (in lbs)

	Daytona	Memphis	Tempe
Titanium	4500	8500	14500
Aluminum	6000	12000	19000
Rock Maple	9500	16000	18000

The golfer's link (TGL)



$$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$$

$$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$$

Resources Required per Club Set (in lbs)

	Men's	Women's	Juniors'
Titanium	2.9	2.7	2.5
Aluminum	4.5	4	5
Rock Maple	5.4	5	4.8

Estimated Resource Availability (in lbs)

	Daytona	Memphis	Tempe
Titanium	4500	8500	14500
Aluminum	6000	12000	19000
Rock Maple	9500	16000	18000

The golfer's link (TGL)

Manufacturing plants

Daytona Beach
Memphis
Tempe

Transportation

Distribution centers

Sacramento
Denver
Pittsburgh

Shipping Costs

	Men's		Women's			Juniors'	
To/From	**Daytona**	**Tempe**	**Daytona**	**Memphis**	**Tempe**	**Memphis**	**Tempe**
Sacramento	\$51	\$10	\$49	\$33	\$9	\$31	\$8
Denver	\$28	\$43	\$27	\$22	\$42	\$21	\$40
Pittsburgh	\$36	\$56	\$34	\$13	\$54	\$12	\$52

The golfer's link (TGL)

Manufacturing plants

Daytona Beach
Memphis
Tempe

Transportation

Distribution centers

Sacramento
Denver
Pittsburgh

Shipping Costs

	Men's		Women's			Juniors'	
To/From	**Daytona**	**Tempe**	**Daytona**	**Memphis**	**Tempe**	**Memphis**	**Tempe**
Sacramento	$51	$10	$49	$33	$9	$31	$8
Denver	$28	$43	$27	$22	$42	$21	$40
Pittsburgh	$36	$56	$34	$13	$54	$12	$52

$$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

The golfer's link (TGL)

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\not\rightarrow$ Juniors

Memphis $\not\rightarrow$ Men

The golfer's link (TGL)

Decisions:

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\cancel{\rightarrow}$ Juniors

Memphis $\cancel{\rightarrow}$ Men

The golfer's link (TGL)

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona ~~→~~ Juniors

Memphis ~~→~~ Men

The golfer's link (TGL)

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i \in \mathscr{P}} \sum_{j \in \mathscr{C}} p_j P_{ij} - \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} c_{ijk} S_{ijk}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\cancel{\longrightarrow}$ Juniors

Memphis $\cancel{\longrightarrow}$ Men

The golfer's link (TGL)

Material availability

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i \in \mathscr{P}} \sum_{j \in \mathscr{C}} p_j P_{ij} - \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} c_{ijk} S_{ijk}$$

$$\sum_{k \in \mathscr{C}} r_{ik} P_{jk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\not\rightarrow$ Juniors

Memphis $\not\rightarrow$ Men

The golfer's link (TGL)

Ship all production

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i \in \mathscr{P}} \sum_{j \in \mathscr{C}} p_j P_{ij} - \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} c_{ijk} S_{ijk}$$

$$\sum_{k \in \mathscr{C}} r_{ik} P_{jk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k \in \mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\not\rightarrow$ Juniors

Memphis $\not\rightarrow$ Men

The golfer's link (TGL)

Satisfy orders

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i\in\mathscr{P}} \sum_{j\in\mathscr{C}} p_j P_{ij} - \sum_{i\in\mathscr{D}} \sum_{j\in\mathscr{P}} \sum_{k\in\mathscr{C}} c_{ijk} S_{ijk}$$

$$\sum_{k\in\mathscr{C}} r_{ik} P_{jk} \le a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k\in\mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \le \sum_{k\in\mathscr{P}} S_{ikj} \le o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

Daytona $\not\rightarrow$ Juniors

Memphis $\not\rightarrow$ Men

The golfer's link (TGL)

Decisions:

$$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

$$max \sum_{i \in \mathscr{P}} \sum_{j \in \mathscr{C}} p_j P_{ij} - \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} c_{ijk} S_{ijk}$$

$$\sum_{k \in \mathscr{C}} r_{ik} P_{jk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k \in \mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \leq \sum_{k \in \mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$P_{DJ} = 0, P_{MM} = 0$$

Data summary:

$$\mathscr{P} = \{D, M, T\} \quad \mathscr{M} = \{T, A, R\}$$

$$\mathscr{C} = \{M, W, J\} \quad \mathscr{D} = \{S, D, P\}$$

$$p_i, i \in \mathscr{C}$$

$$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$$

$$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$$

$$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$$

$$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Daytona $\not\rightarrow$ Juniors

Memphis $\not\rightarrow$ Men

Positivity

The golfer's link (TGL)

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i \in \mathscr{P}} \sum_{j \in \mathscr{C}} p_j P_{ij} - \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} c_{ijk} S_{ijk}$$

$$\sum_{k \in \mathscr{C}} r_{ik} P_{jk} \le a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k \in \mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \le \sum_{k \in \mathscr{P}} S_{ikj} \le o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$P_{DJ} = 0, P_{MM} = 0$$

$$P_{ij} \ge 0 \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk} \ge 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\cancel{\longrightarrow}$ Juniors

Memphis $\cancel{\longrightarrow}$ Men

The golfer's link (TGL)

Easier if I eliminate P variables

Decisions:

$$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

$$max \sum_{i \in \mathscr{P}} \sum_{j \in \mathscr{C}} p_j P_{ij} - \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} c_{ijk} S_{ijk}$$

$$\sum_{k \in \mathscr{C}} r_{ik} P_{jk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k \in \mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \leq \sum_{k \in \mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$P_{DJ} = 0, P_{MM} = 0$$

$$P_{ij} \geq 0 \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk} \geq 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Data summary:

$$\mathscr{P} = \{D, M, T\} \quad \mathscr{M} = \{T, A, R\}$$

$$\mathscr{C} = \{M, W, J\} \quad \mathscr{D} = \{S, D, P\}$$

$$p_i, i \in \mathscr{C}$$

$$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$$

$$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$$

$$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$$

$$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Daytona $\cancel{\longrightarrow}$ Juniors

Memphis $\cancel{\longrightarrow}$ Men

The golfer's link (TGL)

$$max \sum_{i\in\mathscr{P}} \sum_{j\in\mathscr{C}} p_j P_{ij} - \sum_{i\in\mathscr{D}} \sum_{j\in\mathscr{P}} \sum_{k\in\mathscr{C}} c_{ijk} S_{ijk}$$

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i\in\mathscr{D}} \sum_{j\in\mathscr{P}} \sum_{k\in\mathscr{C}} (p_j - c_{ijk}) S_{ijk}$$

$$\sum_{k\in\mathscr{C}} r_{ik} P_{jk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k\in\mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \leq \sum_{k\in\mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$P_{DJ} = 0, P_{MM} = 0$$

$$P_{ij} \geq 0 \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk} \geq 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\not\longrightarrow$ Juniors

Memphis $\not\longrightarrow$ Men

The golfer's link (TGL)

$$\sum_{k \in \mathscr{C}} r_{ik} P_{jk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

Decisions:

$$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

$$max \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} (p_j - c_{ijk}) S_{ijk}$$

$$\sum_{k \in \mathscr{C}} \sum_{l \in \mathscr{D}} r_{ik} S_{ljk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k \in \mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \leq \sum_{k \in \mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$P_{DJ} = 0, P_{MM} = 0$$

$$P_{ij} \geq 0 \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk} \geq 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

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$$p_i, i \in \mathscr{C}$$

$$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$$

$$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$$

$$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$$

$$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Daytona $\cancel{\longrightarrow}$ Juniors

Memphis $\cancel{\longrightarrow}$ Men

$P_{DJ} = 0, P_{MM} = 0$

The golfer's link (TGL)

Decisions:

$P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i\in\mathscr{D}} \sum_{j\in\mathscr{P}} \sum_{k\in\mathscr{C}} (p_j - c_{ijk})S_{ijk}$$

$$\sum_{k\in\mathscr{C}} \sum_{l\in\mathscr{D}} r_{ik}S_{ljk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\sum_{k\in\mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$0.8\, o_{ij} \leq \sum_{k\in\mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$S_{iDJ} = 0, S_{iMM} = 0, \forall i \in \mathscr{D}$$

$$P_{ij} \geq 0 \quad \forall i \in \mathscr{P}, j \in \mathscr{C}$$

$$S_{ijk} \geq 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

$\mathscr{C} = \{M, W, J\}$ $\mathscr{D} = \{S, D, P\}$

$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\cancel{\rightarrow}$ Juniors

Memphis $\cancel{\rightarrow}$ Men

The golfer's link (TGL)

Decisions:

$\cancel{P_{ij}, i \in \mathscr{P}, j \in \mathscr{C}}$

$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

$$max \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} (p_j - c_{ijk}) S_{ijk}$$

$$\sum_{k \in \mathscr{C}} \sum_{l \in \mathscr{D}} r_{ik} S_{ljk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$\cancel{\sum_{k \in \mathscr{D}} S_{kij} = P_{ij} \quad \forall i \in \mathscr{P}, j \in \mathscr{C}}$$

$$0.8\, o_{ij} \leq \sum_{k \in \mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$S_{iDJ} = 0, S_{iMM} = 0, \forall i \in \mathscr{D}$$

$$\cancel{P_{ij} \geq 0 \quad \forall i \in \mathscr{P}, j \in \mathscr{C}}$$

$$S_{ijk} \geq 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Data summary:

$\mathscr{P} = \{D, M, T\}$ $\mathscr{M} = \{T, A, R\}$

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$p_i, i \in \mathscr{C}$

$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$

$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$

$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$

$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$

Daytona $\cancel{\rightarrow}$ Juniors

Memphis $\cancel{\rightarrow}$ Men

The golfer's link (TGL)

Decisions:

$$S_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

$$max \sum_{i \in \mathscr{D}} \sum_{j \in \mathscr{P}} \sum_{k \in \mathscr{C}} (p_j - c_{ijk}) S_{ijk}$$

$$\sum_{k \in \mathscr{C}} \sum_{l \in \mathscr{D}} r_{ik} S_{ljk} \leq a_{ij} \quad \forall i \in \mathscr{M}, j \in \mathscr{P}$$

$$0.8\, o_{ij} \leq \sum_{k \in \mathscr{P}} S_{ikj} \leq o_{ij} \quad \forall i \in \mathscr{D}, j \in \mathscr{C}$$

$$S_{iDJ} = 0, S_{iMM} = 0, \forall i \in \mathscr{D}$$

$$S_{ijk} \geq 0 \quad \forall i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Data summary:

$$\mathscr{P} = \{D, M, T\} \quad \mathscr{M} = \{T, A, R\}$$

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$$p_i, i \in \mathscr{C}$$

$$o_{ij}, i \in \mathscr{D}, j \in \mathscr{C}$$

$$r_{ij}, i \in \mathscr{M}, j \in \mathscr{C}$$

$$a_{ij}, i \in \mathscr{M}, j \in \mathscr{P}$$

$$c_{ijk}, i \in \mathscr{D}, j \in \mathscr{P}, k \in \mathscr{C}$$

Daytona $\not\longrightarrow$ Juniors

Memphis $\not\longrightarrow$ Men