In-Class Exercise

- You will have 15 minutes to evaluate the two proposals. Work on it by yourself for a few minutes, then work on it with your neighbors

- For each proposal:
  - Write down on your handout precisely what additional binary decision variables and what modifications to the objective function and/or constraints are required
  - Your objective function and constraints must be linear

- We will stop by to answer any questions you may have. Good luck!

Class Exercise - Part 2 Solutions

(Full solutions will be posted to Canvas after class)

Base Formulation

minimize

(total supply cost) $1.78\ s_{A,V} + 2.26\ s_{A,W} + \ldots + 1.95\ s_{C,Z}$

subject to

(capacity at A) $s_{A,V} + s_{A,W} + s_{A,X} + s_{A,Y} + s_{A,Z} \le 4{,}000$

(capacity at B) $s_{B,V} + s_{B,W} + s_{B,X} + s_{B,Y} + s_{B,Z} \le 2{,}000$

(capacity at C) $s_{C,V} + s_{C,W} + s_{C,X} + s_{C,Y} + s_{C,Z} \le 1{,}000$

(demand at V) $s_{A,V} + s_{B,V} + s_{C,V} \ge 1{,}000$

(demand at W) $s_{A,W} + s_{B,W} + s_{C,W} \ge 500$

(demand at X) $s_{A,X} + s_{B,X} + s_{C,X} \ge 1{,}500$

(demand at Y) $s_{A,Y} + s_{B,Y} + s_{C,Y} \ge 1{,}500$

(demand at Z) $s_{A,Z} + s_{B,Z} + s_{C,Z} \ge 500$

(nonnegativity) $s_{A,V}, s_{A,W}, \ldots, s_{C,Z} \ge 0$

Bergamo's Condition Formulation (Answer)

minimize

(total supply cost) $1.78\, s_{A,V} + 2.26\, s_{A,W} + \ldots + 1.95\, s_{C,Z} + 1{,}000\, y_B$

subject to

(capacity at A) $s_{A,V} + s_{A,W} + s_{A,X} + s_{A,Y} + s_{A,Z} \le 4{,}000$

(capacity at B) $s_{B,V} + s_{B,W} + s_{B,X} + s_{B,Y} + s_{B,Z} \le 2{,}000\, y_B$

(capacity at C) $s_{C,V} + s_{C,W} + s_{C,X} + s_{C,Y} + s_{C,Z} \le 1{,}000$

(demand at V) $s_{A,V} + s_{B,V} + s_{C,V} \ge 1{,}000$

(demand at W) $s_{A,W} + s_{B,W} + s_{C,W} \ge 500$

(demand at X) $s_{A,X} + s_{B,X} + s_{C,X} \ge 1{,}500$

(demand at Y) $s_{A,Y} + s_{B,Y} + s_{C,Y} \ge 1{,}500$

(demand at Z) $s_{A,Z} + s_{B,Z} + s_{C,Z} \ge 500$

(nonnegativity) $s_{A,V}, s_{A,W}, \ldots, s_{C,Z} \ge 0$

(binary) y_B is binary

Idea:
y_B = 1 if we continue to supply from Bergamo, and 0 otherwise ...

Bergamo's Condition Spreadsheet Model*

PARAMETERS

Supplier	Cost of supplying 1 ton to Facility					Supplier capacity	Supplier fixed cost
	Valencia	**Wiesbaden**	**Xanten**	**York**	**Zaragoza**		
Amadora	1.78	2.26	2.22	2.30	1.45	4,000	0
Bergamo	1.64	2.70	2.00	2.44	2.30	2,000	1,000
Casablanca	1.70	2.15	2.58	1.28	1.95	1,000	0
Quantity required	1,000	500	1,500	1,500	500		

DECISIONS VARIABLES

From Supplier	To Facility					Quantity supplied	Supply from Bergamo?	Effective capacity
	Valencia	**Wiesbaden**	**Xanten**	**York**	**Zaragoza**			
Amadora	**1,000**	**500**	**1,500**	**500**	**500**	4,000	1	4000
Bergamo	**0**	**0**	**0**	**0**	**0**	0	**0**	0
Casablanca	**0**	**0**	**0**	**1,000**	**0**	1,000	1	1000
Quantity received	1,000	500	1,500	1,500	500			

OBJECTIVE

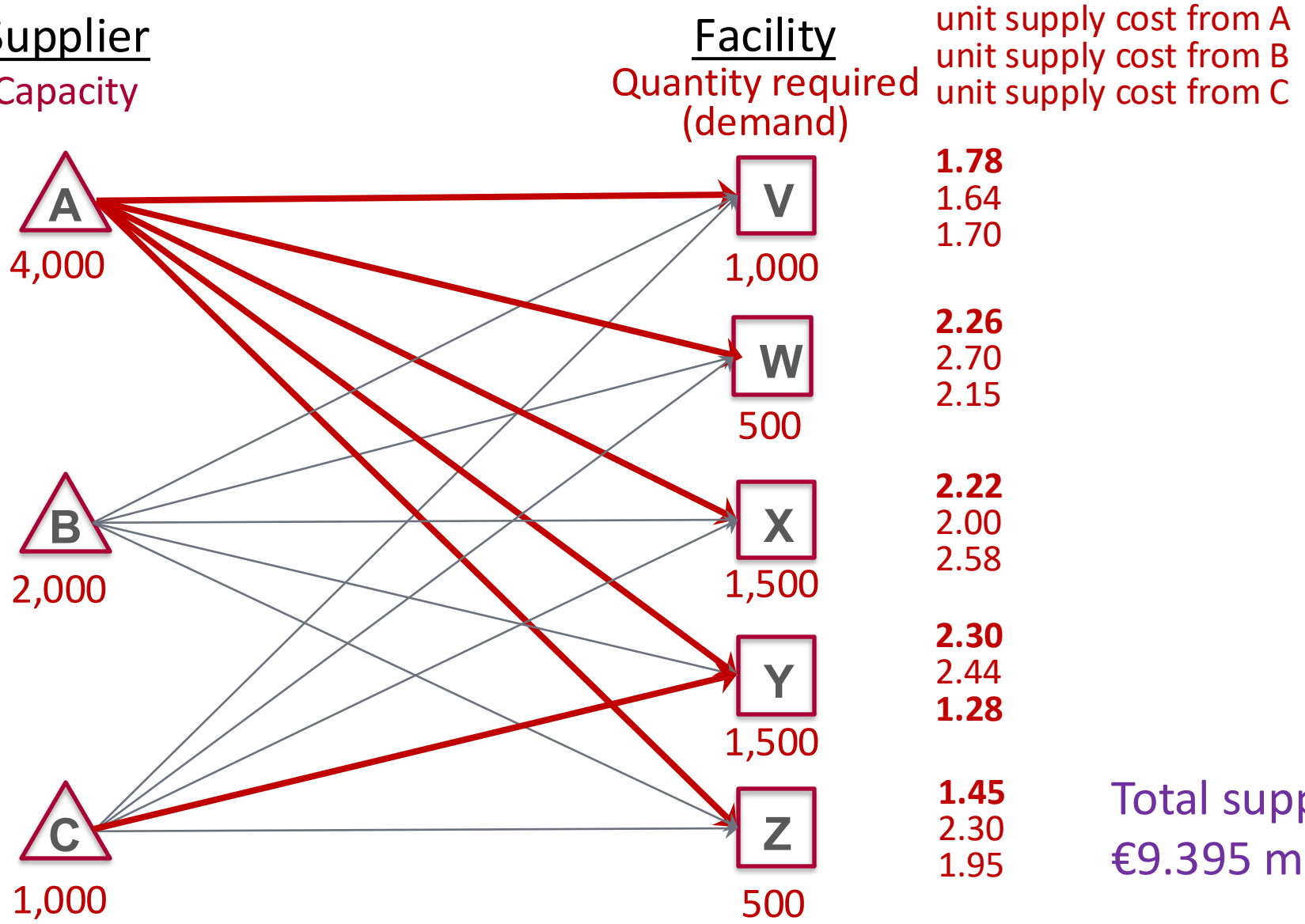
Total Cost	**9,395**	*minimize*

CONSTRAINTS

Supply does not exceed effective capacity
Quantity delivered equals quantity required
Nonegativity
Binary Bergamo supply variable

*will be uploaded after class

Supply Plan under Bergamo's Condition



Total supply cost =
€9.395 million

Amadora's Condition Formulation (Answer)

minimize

(total supply cost) $1.78\, s_{A,V} + 2.26\, s_{A,W} + \ldots + 1.95\, s_{C,Z}$

subject to

(capacity at A) $s_{A,V} + s_{A,W} + s_{A,X} + s_{A,Y} + s_{A,Z} \le 4{,}000\, y_A$

(min order quantity from A) $s_{A,V} + s_{A,W} + s_{A,X} + s_{A,Y} + s_{A,Z} \ge 3{,}000\, y_A$

(capacity at B) $s_{B,V} + s_{B,W} + s_{B,X} + s_{B,Y} + s_{B,Z} \le 2{,}000$

(capacity at C) $s_{C,V} + s_{C,W} + s_{C,X} + s_{C,Y} + s_{C,Z} \le 1{,}000$

(demand at V) $s_{A,V} + s_{B,V} + s_{C,V} \ge 1{,}000$

(demand at W) $s_{A,W} + s_{B,W} + s_{C,W} \ge 500$

(demand at X) $s_{A,X} + s_{B,X} + s_{C,X} \ge 1{,}500$

(demand at Y) $s_{A,Y} + s_{B,Y} + s_{C,Y} \ge 1{,}500$

(demand at Z) $s_{A,Z} + s_{B,Z} + s_{C,Z} \ge 500$

(nonnegativity) $s_{A,V}, s_{A,W}, \ldots, s_{C,Z} \ge 0$

(binary) y_A is binary

Idea:

$y_A = 1$ if we continue to supply from Amadora, and 0 otherwise.

Notice that the modified constraints ensure that if $y_A = 1$ then the supply from Amadora has to be at least 3000. But if $y_A = 0$ then the supply equals 0.

Amadora's Condition Spreadsheet Model*

PARAMETERS

Supplier	Cost of supplying 1 ton to Facility					Supplier capacity	Minimum quantity
	Valencia	**Wiesbaden**	**Xanten**	**York**	**Zaragoza**		
Amadora	1.78	2.26	2.22	2.30	1.45	4,000	3,000
Bergamo	1.64	2.70	2.00	2.44	2.30	2,000	
Casablanca	1.70	2.15	2.58	1.28	1.95	1,000	
Quantity required	1,000	500	1,500	1,500	500		

DECISIONS VARIABLES

From Supplier	To Facility					Quantity supplied	Supply from Amadora?	Effective capacity	Effective min quantity
	Valencia	**Wiesbaden**	**Xanten**	**York**	**Zaragoza**				
Amadora	**1,000**	**500**	**500**	**500**	**500**	3,000	**1**	4,000	3,000
Bergamo	**0**	**0**	**1,000**	**0**	**0**	1,000			
Casablanca	**0**	**0**	**0**	**1,000**	**0**	1,000			
Quantity received	1,000	500	1,500	1,500	500				

OBJECTIVE

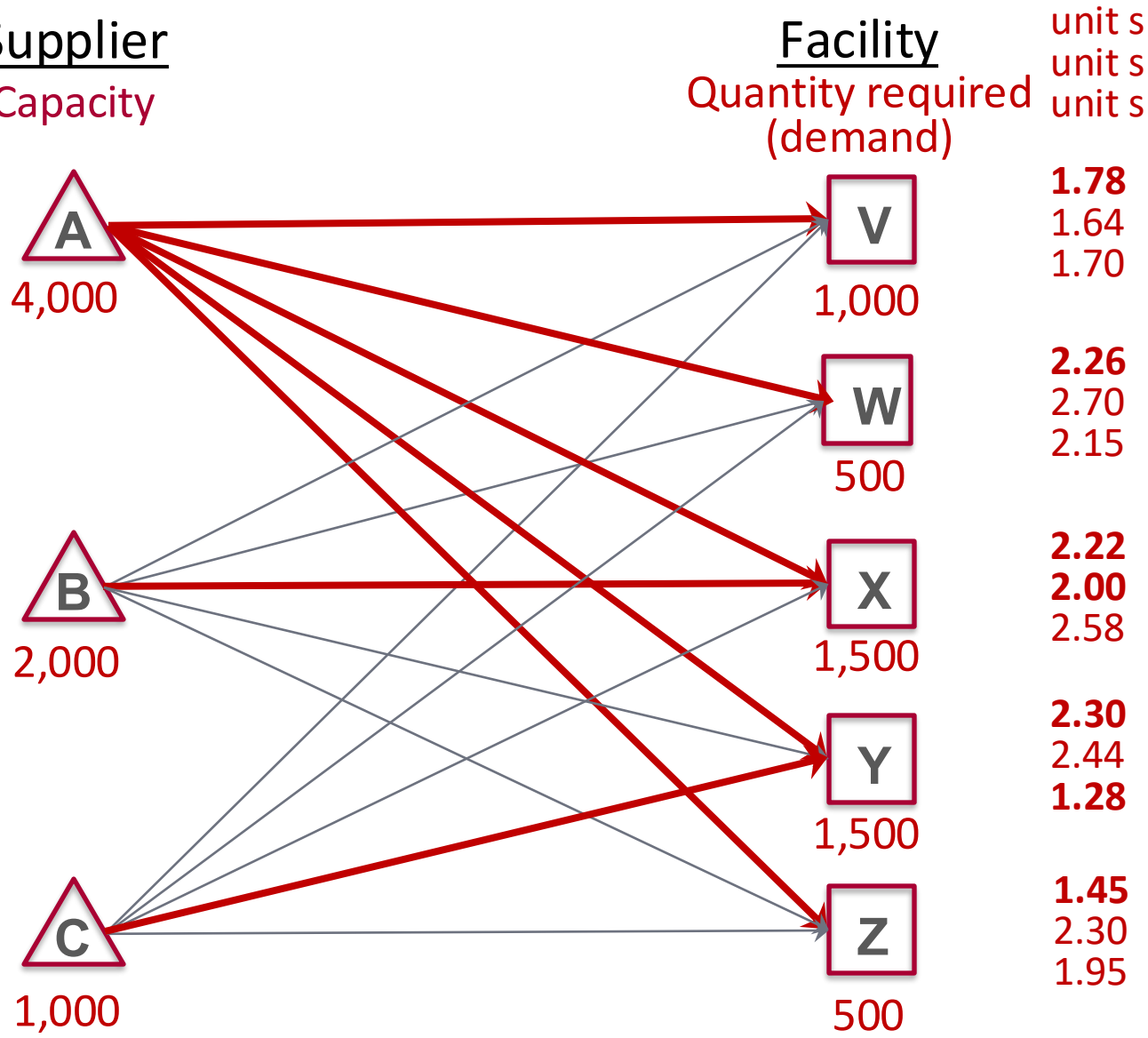
Total Cost	**9,175**	*minimize*

CONSTRAINTS

Supply from Amadora does not exceed its effective capacity
Supply from Amadora at least equal to its effective minimum order quantity
Supply from Bergamo and Casablanca does not exceed supplier capacities
Quantity delivered equals quantity required
Nonegativity
Binary Amadora supply variable

*will be uploaded after class

Supply Plan under Amadora's Condition



Total supply cost = €9.175 million

New Contract Conditions: Cost Implications Summary

	Without Bergamo's condition		With Bergamo's condition
Without Amadora's condition	€8.995 million	*+4.44%* →	€9.395 million (drop Bergamo)
	+2.00% ↓		
With Amadora's condition	€9.175 million (continue to source from Amadora)		(optional)