## **Example: Foreign currency trading**

Suppose you have 1 million US dollars to invest in currency markets. The cross-currency rates are showed in the Excel file "Currency Trading.xlsx". Develop an LP (linear programming) model to determine whether there are any arbitrage opportunities with the given currency rates.

An example to help understand *cross currency rates*:

Cross currency ra	ites (from along sid	le, to along top)			
	US Dollar	<b>British Pound</b>	Euro	Japanese Yen	Brazilian Real
US Dollar	1	0.60639	0.88363	118.27	2.9092
<b>British Pound</b>	1.6491	1	1.45751	195.07	4.79931
Euro	1.1317	0.6861	1	133.77	3.29496
Japanese Yen	0.008455	0.005126	0.007476	1	0.02462
Brazilian Real	0.34374	0.20836	0.30349	40.62285	1

- 0.20836 in the cross currency rate table means that 1 Brazilian real can purchase 0.20836 pound.
- If you purchase 1 million Brazilian real with British pounds, then converting it back to pounds:

Pounds required to purchase:  $\frac{1,000,000/4.79931 = 208363}{1,000,000*0.20836 = 208360}$ 

Difference (In – Out): 208360-208363 = -3

An example to help understand conversion amounts:

• Suppose you spend 100 US dollars to purchase British Pound and 100 US dollars to purchase Japanese Yen. Fill out the following conversion table.

Conversion amou	nts (from along sid	e, to along top)				
	US Dollar	<b>British Pound</b>	Euro	Japanese Yen	Brazilian Real	Total out
US Dollar	0	100	0	100	0	200
<b>British Pound</b>	0	0	0	0	0	0
Euro	0	0	0	0	0	0
Japanese Yen	0	0	0	0	0	0
Brazilian Real	0	0	0	0	0	0
Total in	0	60,639	0	11,827	0	
Total out	200	0	0	0	0	
Final net in	-200	60,639	0	11,827	0	

## **Excel Model Setup:**

	Α	В	С	D	Е	F	G
1	Foreign currency tr	ading	_	_	_	-	_
2		Ū					
3	Cross currency rates	(from along side,	to along top)				
4		US Dollar	<b>British Pound</b>	Euro	Japanese Yen	Brazilian Real	
5	US Dollar	1	0.60639	0.88363	118.27	2.9092	
6	British Pound	1.6491	1	1.45751	195.07	4.79931	
7	Euro	1.1317	0.6861	1	133.77	3.29496	
8	Japanese Yen	0.008455	0.005126	0.007476	1	0.02462	
9	Brazilian Real	0.34374	0.20836	0.30349	40.62285	1	
10							
11	Opportunity for arb	itrage?					
12	Conversion amounts	(from along side,	to along top)				
13		US Dollar	<b>British Pound</b>	Euro	Innanosa Van	Duagilian Dool	Total out
13		US Dollar	Diffusii Pounu	Euro	Japanese Ten	Brazilian Real	Total out
	US Dollar	US Donar	Dittish Pound	Euro	Japanese Ten	Draziliali Real	=sum(B14:F14)
	US Dollar British Pound	US Donar	British Found	Euro	<b>Барапезе Теп</b>	Бгадшан Кеаг	
14 15		US Donar	Dittish Pound	Euro	Japanese 1en	Drazman Kear	
14 15	British Pound	US Donar	Dittish Pound	Euro	Japanese 1en	Drazinan Keai	
14 15 16	British Pound Euro Japanese Yen Brazilian Real				Japanese 1en	Drazinan Keai	
14 15 16 17	British Pound Euro Japanese Yen Brazilian Real	=sumproduct(B	5:B9,B14:B18	) <del>&gt;</del>	Japanese 1en	Drazinan Keai	
14 15 16 17 18	British Pound Euro Japanese Yen Brazilian Real Total in		5:B9,B14:B18		Japanese 1en	Drazinan Keai	
14 15 16 17 18 19	British Pound Euro Japanese Yen Brazilian Real Total in Total out	=sumproduct(B =transpose(G14	5:B9,B14:B18	) → +shift+enter	Japanese 1ch	Draziliali Kcal	
14 15 16 17 18 19 20	British Pound Euro Japanese Yen Brazilian Real Total in Total out Final net in	=sumproduct(B =transpose(G14	:5:B9,B14:B18 4:G18) ctrl	) <del>&gt;</del>	Japanese 1ch	Draziliali Keal	
14 15 16 17 18 19 20 21	British Pound Euro Japanese Yen Brazilian Real Total in Total out	=sumproduct(B =transpose(G14	:5:B9,B14:B18 4:G18) ctrl	) → +shift+enter	0	0	
14 15 16 17 18 19 20 21 22	British Pound Euro Japanese Yen Brazilian Real Total in Total out Final net in	=sumproduct(B =transpose(G14 =B19-B20 -	5:B9,B14:B18 4:G18) ctrl	) → +shift+enter ≥			

## **Specify Solver:**

Set Objective: <u>B25</u>

To: X Max O Min O Value of: \_\_\_\_\_

By Changing Variable Cells: <u>B14:F18</u>

Subject to the Constraints:

B21:F21  $\geq$  B23:F23 B25  $\leq$  D25 (= works too)

X Make Unconstrained Variables Non-Negative Select a Solving Method: Simplex LP

## **Solution to the Foreign Currency Trading model:**

	А	В	С	D	E	F	G
1	Foreign currency	trading					
2							
3	Cross currency rate	es (from along sid	le, to along top)				
4		US Dollar	<b>British Pound</b>	Euro	Japanese Yen	Brazilian Real	
5	US Dollar	1	0.60639	0.88363	118.27	2.9092	
6	British Pound	1.6491	1	1.45751	195.07	4.79931	
7	Euro	1.1317	0.6861	1	133.77	3.29496	
8	Japanese Yen	0.008455	0.005126	0.007476	1	0.02462	
9	Brazilian Real	0.34374	0.20836	0.30349	40.62285	1	
10							
11	Opportunity for a	rbitrage?					
12	Conversion amoun	ts (from along sid	e, to along top)				
13		US Dollar	<b>British Pound</b>	Euro	Japanese Yen	Brazilian Real	Total out
13 14	US Dollar	US Dollar 0.00	British Pound 978.10	<b>Euro</b> 0.00	Japanese Yen 0.00	Brazilian Real 0.00	Total out 978.10
	US Dollar British Pound						
14 15		0.00	978.10	0.00	0.00	0.00	978.10
14 15	British Pound	0.00 0.00	978.10 0.00	0.00 593.11	0.00 0.00	0.00 0.00	978.10 593.11
14 15 16	British Pound Euro	0.00 0.00 0.00	978.10 0.00 0.00	0.00 593.11 0.00	0.00 0.00 0.00	0.00 0.00 864.46	978.10 593.11 864.46
14 15 16 17	British Pound Euro Japanese Yen	0.00 0.00 0.00 0.00	978.10 0.00 0.00 0.00	0.00 593.11 0.00 0.00	0.00 0.00 0.00 0.00	0.00 0.00 864.46 0.00	978.10 593.11 864.46 0.00
14 15 16 17 18	British Pound Euro Japanese Yen Brazilian Real	0.00 0.00 0.00 0.00 2848.36	978.10 0.00 0.00 0.00 0.00	0.00 593.11 0.00 0.00 0.00	0.00 0.00 0.00 0.00 0.00	0.00 0.00 864.46 0.00 0.00	978.10 593.11 864.46 0.00
14 15 16 17 18	British Pound Euro Japanese Yen Brazilian Real Total in	0.00 0.00 0.00 0.00 2848.36 979.10	978.10 0.00 0.00 0.00 0.00 593.11	0.00 593.11 0.00 0.00 0.00 864.46	0.00 0.00 0.00 0.00 0.00 0.00	0.00 0.00 864.46 0.00 0.00 2848.36	978.10 593.11 864.46 0.00
14 15 16 17 18 19 20	British Pound Euro Japanese Yen Brazilian Real Total in Total out	0.00 0.00 0.00 0.00 2848.36 979.10	978.10 0.00 0.00 0.00 0.00 593.11 593.11	0.00 593.11 0.00 0.00 0.00 864.46	0.00 0.00 0.00 0.00 0.00 0.00	0.00 0.00 864.46 0.00 0.00 2848.36 2848.36	978.10 593.11 864.46 0.00
14 15 16 17 18 19 20 21	British Pound Euro Japanese Yen Brazilian Real Total in Total out	0.00 0.00 0.00 0.00 2848.36 979.10 978.10	978.10 0.00 0.00 0.00 0.00 593.11 593.11 0.00	0.00 593.11 0.00 0.00 0.00 864.46 864.46	0.00 0.00 0.00 0.00 0.00 0.00 0.00	0.00 0.00 864.46 0.00 0.00 2848.36 2848.36 0.00	978.10 593.11 864.46 0.00
14 15 16 17 18 19 20 21 22	British Pound Euro Japanese Yen Brazilian Real Total in Total out Final net in	0.00 0.00 0.00 0.00 2848.36 979.10 978.10 1.00	978.10 0.00 0.00 0.00 0.00 593.11 593.11 0.00	0.00 593.11 0.00 0.00 0.00 864.46 864.46 0.00 >=	0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.0	0.00 0.00 864.46 0.00 0.00 2848.36 2848.36 0.00	978.10 593.11 864.46 0.00

Based on the above results, what's your best currency trading strategy?

<u>US Dollar</u> → British Pound → Euro → Brazilian Real → US Dollar