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 | British Pound | Euro | Japanese Yen | Brazilian Real |
| US Dollar | 1 | 0.60639 | 0.88363 | 118.27 | 2.9092 |
| British Pound | 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: | |
|----------------------------------|--|
| Pounds obtained by selling back: | |
| Difference (In – Out): | |

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 | British Pound | Euro | Japanese Yen | Brazilian Real | Total out |
| US Dollar | 0 | 100 | 0 | 100 | 0 | |
| British Pound | 0 | 0 | 0 | 0 | 0 | |
| Euro | 0 | 0 | 0 | 0 | 0 | |
| Japanese Yen | 0 | 0 | 0 | 0 | 0 | |
| Brazilian Real | 0 | 0 | 0 | 0 | 0 | |
| Total in | | | | | | |
| Total out | | | | | | |
| Final net in | | | | | | |

Excel Model Setup:

| | Α | В | С | D | E | F | G |
|----|----------------------|-------------------|----------------------|----------|--------------|----------------|-----------|
| 1 | Foreign currency tr | | C | D | | Г | Ū. |
| 2 | roreign currency tr | aumg | | | | | |
| 3 | Cross currency rates | (from along side | to along ton) | | | | |
| 4 | Cross currency rates | US Dollar | British Pound | Euro | Innanese Van | Brazilian Real | |
| | US Dollar | | 0.60639 | 0.88363 | 118.27 | 2.9092 | |
| 5 | 0.0 2 011111 | 1 | | 3,555,55 | | | |
| 6 | British Pound | 1.6491 | 1 | 1.45751 | 195.07 | | |
| 7 | Euro | 1.1317 | 0.6861 | 1 | 133.77 | | |
| 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 | British Pound | Euro | Japanese Yen | Brazilian Real | Total out |
| 14 | US Dollar | | | | | | |
| 15 | British Pound | | | | | | |
| 16 | Euro | | | | | | |
| 17 | Japanese Yen | | | | | | |
| 18 | Brazilian Real | | | | | | |
| 19 | Total in | | | | | | |
| 20 | Total out | | | | | | |
| 21 | Final net in | | | | | | |
| 22 | | | | | | | |
| 23 | Nonnegative | 0 | 0 | 0 | 0 | 0 | |
| 24 | | | | | | | |
| | Final net \$ in | | | \$ 1.00 | | | |

Specify Solver:

| Set Objective: | | |
|-----------------------------|-------------|--|
| To: ○ Max ○ Min | O Value of: | |
| By Changing Variable Cells: | | |
| Subject to the Constraints: | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

 $\hfill \square$ Make Unconstrained Variables Non-Negative

Select a Solving Method: Simplex LP

Solution to the Foreign Currency Trading model:

| Α | В | С | D | Е | F | G |
|--|---|---|--|---|---|---|
| Foreign currency | trading | | | | | |
| | | | | | | |
| Cross currency rate | es (from along sid | e, to along top) | | | | |
| | US Dollar | British Pound | Euro | Japanese Yen | Brazilian Real | |
| US Dollar | 1 | 0.60639 | 0.88363 | 118.27 | 2.9092 | |
| British Pound | 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 | |
| | | | | | | |
| Opportunity for a | rbitrage? | | | | | |
| Conversion amoun | ts (from along sid | e, to along top) | | | | |
| | | | | | | |
| | US Dollar | British Pound | Euro | Japanese Yen | Brazilian Real | Total out |
| US Dollar | US Dollar 0.00 | | Euro 0.00 | Japanese Yen 0.00 | Brazilian Real 0.00 | Total out 978.10 |
| US Dollar British Pound | | British Pound | | • | | |
| | 0.00 | British Pound 978.10 | 0.00 | 0.00 | 0.00 | 978.10 |
| 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 |
| 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 |
| 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 |
| 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 |
| 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 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 |
| 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 0.00 593.11 593.11 | 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 0.00 864.46 0.00 0.00 2848.36 2848.36 | 978.10 593.11 864.46 0.00 |
| 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 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 |
| 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 | British Pound 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 |
| | Foreign currency Cross currency rate US Dollar British Pound Euro Japanese Yen Brazilian Real Opportunity for a | Foreign currency trading Cross currency rates (from along sid US Dollar US Dollar British Pound 1.6491 Euro 1.1317 Japanese Yen 0.008455 Brazilian Real 0.34374 Opportunity for arbitrage? | Cross currency trading Cross currency rates (from along side, to along top) US Dollar British Pound 1.6491 1 1 1 1 1 1 1 1 1 | Cross currency trading | Foreign currency trading Cross currency rates (from along side, to along top) US Dollar British Pound 1 0.60639 0.88363 118.27 British Pound 1 1.45751 195.07 Euro 1.1317 Japanese Yen 0.008455 0.005126 0.007476 1 Brazilian Real 0.34374 0.20836 Opportunity for arbitrage? | Cross currency rates (from along side, to along top) US Dollar British Pound Euro Japanese Yen Brazilian Real U.S Dollar 1 0.60639 0.88363 118.27 2.9092 British Pound 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 Opportunity for arbitrage? |

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