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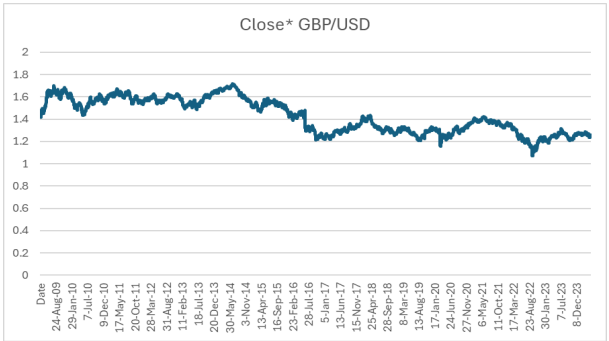
Systematic Trading Strategies for Currencies

In this report, we will present a few trading strategies built using tools taught in class for several currencies futures and currencies spot (for triangular arbitrage and pairs trading). The currencies used are EUR/USD, GBP/USD, AUD/USD, CAD/USD, JPY/USD, CHF/USD and MXN/USD. The strategies covered are trend following, counter trend, some macro strategy related to uncovered interest parity, triangular arbitrage, and pairs trading. Triangular arbitrage and pairs trading are performed for the following pairs: EUR/USD and GBP/USD.

Data for futures is micro futures June - 2024 data, since this is the historical data available on yahoo.com/finance. Spot data was also retrieved from yahoo.com/finance. I have researched other resources, including the WRDS database mentioned in class, but yahoo/finance data seemed easier to access and use for this report. Macroeconomic indicators used in the report have been downloaded from FRED database (https://fred.stlouisfed.org). Futures data from yahoo.com for MXN/USD is not suitable for trading strategies (since open, low, close, high values are all the same); so, spot MXN/USD is used instead. For JPY/USD there is no available data for futures in yahoo.com so spot is used instead.

The goal of this project is to investigate which type of strategies (trend, countertrend, macro) will yield the highest Sharpe ratios for the above mentioned currencies. Additional triangular arbitrage and pairs/spread trading are illustrated for the 2 currency pairs mentioned above. Since we will not be building a portfolio, we can use different historical periods for different currencies. A reasonable historical period is nevertheless still needed to make sure the results are representative. Below there are the plots of time series for the currencies (Figure 1):



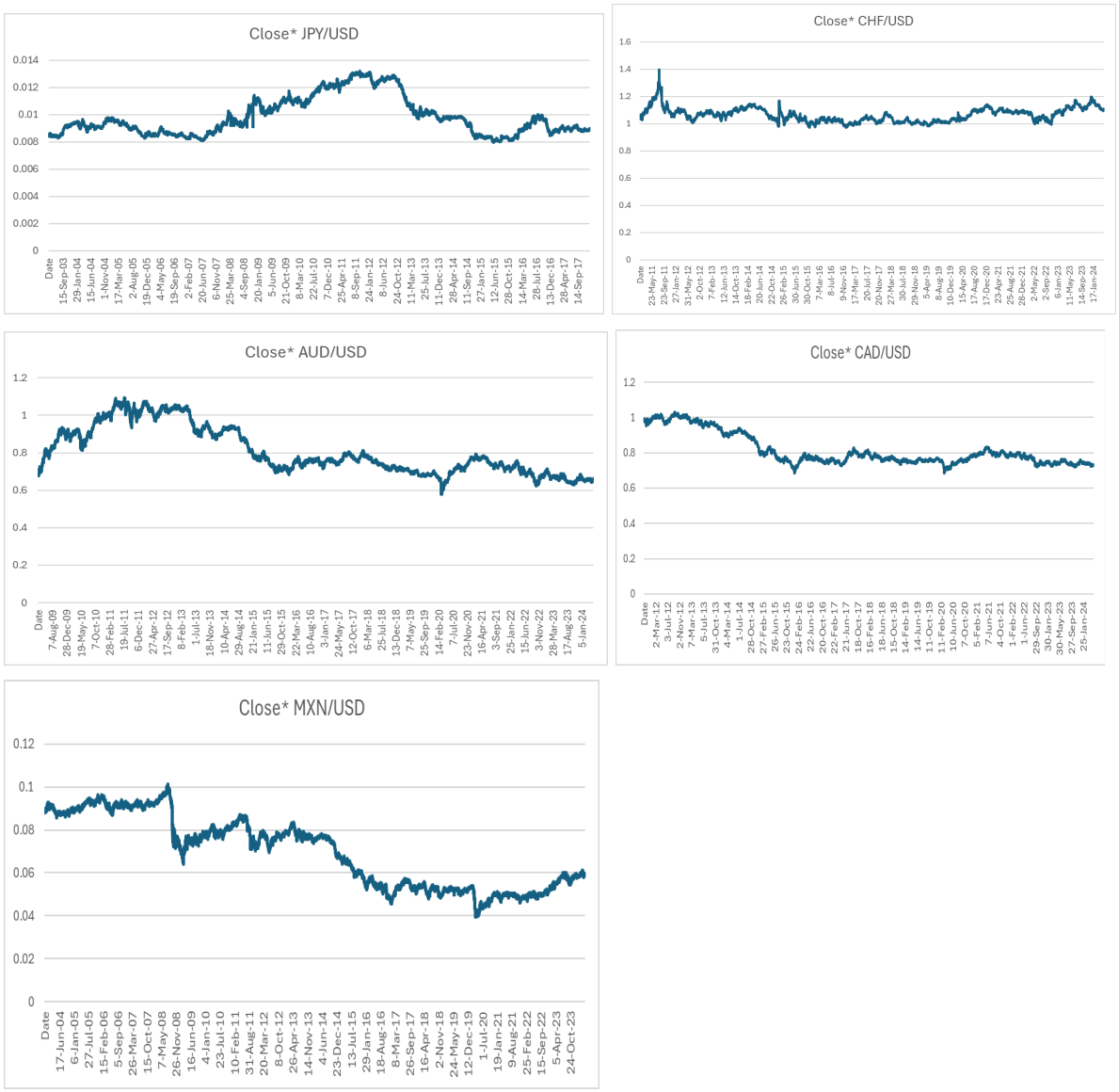


Figure 1. Plots of historical data for currencies' prices.

Trend Following Strategy

(file name: Currency_TS (i.e. EURUSD_TS), sheet Trend or Trend+'something', where something indicates a shorter period used)

We used the methodology described in class, to calculate both simple moving averages and exponential moving averages. If the fast (exponentially or simple) moving average is higher than the slow (exponentially or simple) moving average, we enter a long position, otherwise we enter a short position. It has been observed that trend following strategy is very sensitive to time period. We aim to include an adequate historical time period. If all Sharpe ratios are negative in the most extensive period, we used a slightly modified start for the time horizon (which is more relevant), but the results for the entire historical period are also available in Excel files. The

starting point is indicated in Table 1. The end point is May 9, 2024 or around. For EUR/USD and GBP/USD we present only the results using historical data post-Brexit until May 9, 2024. These results are presented in Table 1. Other results for longer historical periods are contained in Excel files. We marked with red the strategy with the highest Sharpe ratio for each currency.

Sharpe ratio	**EUR/USD Aug 1,2016**	**GBP/USD Aug 1,2016**	**JPY/USD* May 1, 2003**	**CHF/USD Jan 1, 2020**	**AUD/USD Jan 1, 2012**	**CAD/USD Nov 1, 2011**	**MXN/USD* Jan1, 2020**
Ret 10/30 ma	0.08	0.11	0.02	-0.22	0.02	0.19	-0.16
Ret 30/100 ma	0.19	0.26	0.14	-0.21	-0.28	-0.26	0.27
Ret 80/160 ma	0.25	-0.21	-0.009	-0.18	0.08	-0.10	-0.43
BreakOut	-0.001	0.05	-0.26	-0.15	-0.12	0.03	-0.08
Ret 10/30 Ema	0.06	0.09	0.08	-0.60	0.13	-0.02	-0.18
Ret 30/100 Ema	0.12	0.1	0.21	-0.12	-0.05	-0.07	-0.21
Ret 80/160 Ema	0.08	-0.19	0.18	0.11	-0.15	0.0013	-0.07

Table 1. Sharpe ratios for Trend following strategies; *Spot prices used instead (explanations why have been given before); Ema - exponential moving average; ma - simple moving average; for MXN/USD if the start point is Jan 1, 2014, for Ret 30/100 we have 0.07.

Sharpe ratios in trend following strategies seem to be low for all currencies. In descending order, we have GBP/USD (Ret 30/100), EUR/USD (Ret 80/160) and JPY/USD (Ret 30/100 ema). MXN/USD (Ret 30/100) has the highest ratio, but the period considered is only 4 years.

Counter Trend Strategy

(file name: Currency_TS (i.e. EURUSD_TS), sheets CounterTrend Long and CounterTrend Short, followed by Currency name (i.e. EUR_USD))

We used the methodology described in class, but illustrated both long and short choices. A retracement level P is an input for this strategy. The average 20 day range (high-low) is calculated and denoted by A. For the long version, the signal is triggered and we go long if the currency trades (low price) below previous day high minus P*A. We enter either at the low price of the day or open price, if the open price is lower than the low of the day. We exit the position at the end of the day. A short version which flips the steps is also tested (details are presented in

Excel files). Both cases – where we use '0' or 'blanks' for returns, when no position is taken – are discussed. The 'blank' case corresponds to the case where no capital is held, so Sharpe ratios are higher than Sharpe ratios in the '0' case. In Excel files, signal quality is investigated as a function of retracement level P and the Sharpe ratio (when the '0' case is used for return in days with no position) is plotted versus the number of signals for each given retracement level P. We use a range of P from 2.2 to 0.8, incrementing by 0.2. As expected, the Sharpe ratios are sensitive to retracement level P across each case. In Table 2, we present the optimal results for each strategy, when varying P in the previous mentioned range. The first number is P and the second number is Sharpe ratio.

Sharpe ratio	**EUR/USD**	**GBP/USD**	**JPY/USD***	**CHF/USD**	**AUD/USD**	**CAD/USD**	**MXN/USD***
Long with 0	N/A	P=0.8; 0.17	P=1.4; 2.56	N/A	P=2.2; 0.39	P=2.2; 0.84	N/A
Short with 0	P=1; 0.64	P=2.2; 0.65	P=1.2; 2.58	N/A	P=2; 0.81	P=1.2; 0.32	P=0.8; 1.8
Long with Blanks	N/A	P=0.8; 0.23	P=2.2; 9	N/A	P=2.2; 1.9	P=2.2; 3.65	N/A
Short with Blanks	P=2.2; 1.98	P=2.2; 3.54	P=2.2; 8.9	N/A	P=2.2; 4.31	P=1.2; 0.56	P=2; 3.94

Table 2. Sharpe ratios for Counter trend strategies; *Spot prices used instead

In Table 2, we marked with red the highest for '0' case for each currency.In descending order, we have JPY/USD (short), MXN/USD (short), CAD/USD (long), AUD/USD (short), GBP/USD (short) and EUR/USD (short). Also, take into account that both JPY/USD (short), MXN/USD (short) strategies have been applied for daily spot prices, since this is the data found on yahoo.com/finance. This may explain the higher Sharpe ratios in contracts to CAD/USD (long), AUD/USD (short), GBP/USD (short) and EUR/USD (short) strategies which involve micro futures for June 2024 from yahoo.com/finance**.**

'Uncovered Interest' Parity (Macro type strategy)

(file name: Currency_TS (i.e. EURUSD_TS), sheet Macro UIP followed by Currency name (i.e. EUR_USD), and Regression_Currency (i,e, Regression_EUR_USD))

This strategy uses monthly spot prices from yahoo.com/finance, since we only have monthly data for our macroeconomic variable (Fed Funds Rate for US and Immediate Interest Rate for other countries). Theoretically, this strategy works better at high time frequency. It is based on following relation called uncovered interest parity: $(1 + i_{USD}) = (1 + i_{foreign})\frac{E[S_{t+1}]}{S_t}$, where

i_{USD} is the Fed Funds rate, $i_{foreign}$ is immediate rate (<24h) call money/interbank rate taken from the FRED website; S_t is the spot price for currency under consideration (foreign/USD). This strategy has a threshold as an input.

We implement 3 strategies Ret1, Ret2 and Ret3. The Ret1 strategy is based on a regression (with no intercept) between $\frac{S_{t+1}}{S_t}$ and $\frac{1+i_{USD}}{1+i_{foreign}}$. Then, based on this regression, we calculated the predicted $\frac{S_{t+1}}{S_t}$, and the difference between predicted $\frac{S_{t+1}}{S_t}$ and actual $\frac{S_{t+1}}{S_t}$, together with the threshold is considered further in the decision process to generate signals. The Ret2 strategy is based on the difference between $\frac{S_{t+1}}{S_t}$ and $\frac{1+i_{USD}}{1+i_{foreign}}$, and the threshold is then considered when taking a sell, buy or no position (since at t+1, we expect that these quantities will be equal). The Ret3 strategy decision is based on the difference between immediate rate (<24h) call money/interbank rate $i_{foreign}$ and Fed Funds Rate i_{USD}, both downloaded from the FRED website. In each of these strategies, we take a long or short position if the absolute value of the difference exceeds the threshold, otherwise we enter no position. The position is held for a month and at the end of the month, we exit, taking losses or gains. Since we hold for a month, we incorporate carry trade in the returns. Results are presented in Table 3. The threshold influences the resulting Sharpe ratios. We present the results for the optimal threshold which gives the highest Sharpe ratio. In Table 3, for each currency, the first number is the threshold T and the second number is Sharpe ratio. We marked with red the strategy with the highest Sharpe ratio.

Sharpe ratio	**EUR/USD**	**GBP/USD**	**JPY/USD**	**CHF/USD**	**AUD/USD**	**CAD/USD**	**MXN/USD**
Ret1	T=0; 0.29	T=0.06; 0.31	T= 0.03; 0.34	T=0; 0.02	T= 0.01; 0.11	T=0.04; -0.16	T=0.03; 0.20
Ret 2	T=0; 0.17	T=0.06; 0.41	T =0.05; 0.18	T=0; -0.24	T=0.02; 0.013	T=0.06; 0.08	T=0.06; 0.06
Ret3	T=0.09 (%); 0.42	T=0.04(%); 0.37	T=0.01 (%); 0.55	T=0.02(%) 0.45	T= 0.4(%); 0.26	T=0.1(%); 0.35	T=0.02(%); -0.1

Table 3. Sharpe ratios for Macro trading strategies; the first number is the threshold T and second is Sharpe ratio

Briefly, the specifics of the three strategies will be explained. In the Ret1 strategy, since

actual $\frac{S_{t+1}}{S_t}$ < predicted $\frac{S_{t+1}}{S_t}$, and assuming predicted $\frac{S_{t+1}}{S_t}$ is 'correct' (our view), we more or less have actual $S_{t+1} < E[S_{t+1}]$, so we sell since we are below 'expectations'. We buy if actual $\frac{S_{t+1}}{S_t}$ > predicted $\frac{S_{t+1}}{S_t}$, since actual $S_{t+1} > E[S_{t+1}]$ and we are above 'expectations'. In the Ret2 strategy, $\frac{E[S_{t+1}]}{S_t} = \frac{1+i_{USD}}{1+i_{foreign}}$ is 'our view', if $\frac{S_{t+1}}{S_t} < \frac{1+i_{USD}}{1+i_{foreign}}$, this implies that $\frac{S_{t+1}}{S_t} < \frac{E[S_{t+1}]}{S_t}$, and we sell since we are below 'expectations'. We buy if $\frac{S_{t+1}}{S_t} > \frac{1+i_{USD}}{1+i_{foreign}} = \frac{E[S_{t+1}]}{S_t}$ because we are above 'expectations'. Regarding the Ret3 strategy, if $i_{foreign}$ - i_{USD} < 0, then $\frac{E[S_{t+1}]}{S_t} = \frac{1+i_{USD}}{1+i_{foreign}} > 1$, so $\frac{E[S_{t+1}]}{S_t}$ >1 or $E[S_{t+1}] > S_t$. Therefore the price is expected to increase, indicating a buy signal. Otherwise, $i_{foreign}$ - i_{USD} > 0, $\frac{E[S_{t+1}]}{S_t} = \frac{1+i_{USD}}{1+i_{foreign}} < 1$, so $\frac{E[S_{t+1}]}{S_t}$ < 1 or $E[S_{t+1}] < S_t$, therefore the price is expected to decrease, indicating a sell signal.

Triangular Arbitrage and Pairs/Spread Trading

(file name: TriangularArbitrage_EURUSD_GBPUSD, sheet Triangular Arbitrage; file name: PairsTrading_EURUSD_GBPUSD, sheet PairTrading)

For these strategies we used spot prices, since we could only find spot data for GBP/USD on yahoo.com, which is needed for triangular arbitrage strategy. I used spot prices for pairs/spread trading since these two strategies are more or less related, for the ease of comparison. We use only data starting Sep 2008, as some data was missing in Aug 2008. Below is a graph of historical daily spot prices for EUR/USD and GBP/USD on the left (Figure 2) and the spread Between EUR/USD and GBP/USD on the right (Figure 3):

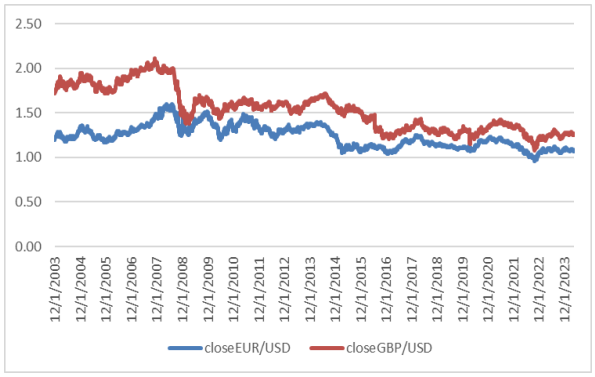


Figure 2. Historical daily spot prices for EUR/USD & GBP/USD

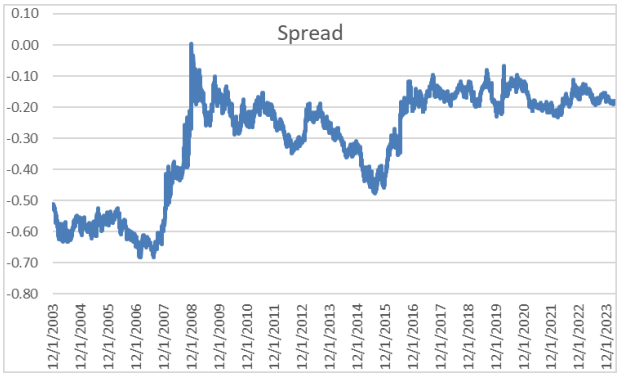


Figure 3. EUR/USD and GBP/USD spread.

Triangular arbitrage strategy creates a synthetic pair from EUR/USD and GBP/USD (via synthetic EUR/GBP= (EUR/USD)/(GBP/USD)) and compares this synthetic value EUR/GBP with traded EUR/GBP. In reality, it is an interplay between bid and ask for synthetic and actual EUR/GBP. Here, since we only have one set of Close prices (not bid and ask prices), we use a threshold, which very broadly can be used as a proxy for the bid-ask spread. The figure below shows the historical difference in percentage returns between synthetic EUR/GBP and actual EUR/GBP (left - Figure 4) and historical difference between synthetic spot and actual spot for EUR/GBP (right - Figure 5).

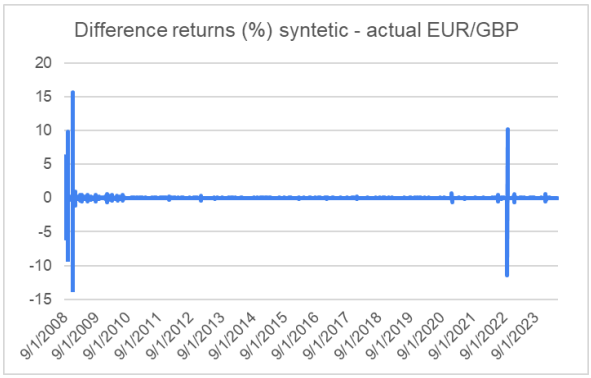


Figure 4. Historical difference in % returns between synthetic and actual EUR/GBP

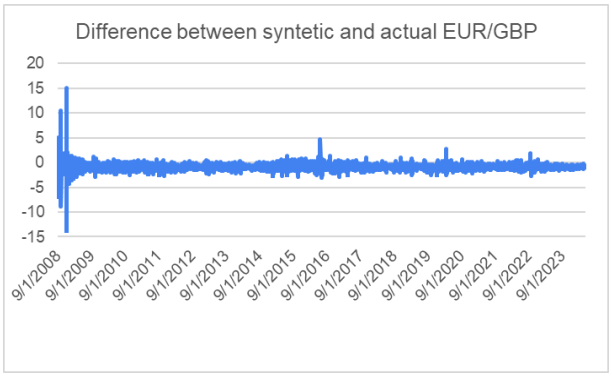


Figure 5. Historical difference between synthetic and actual spot for EUR/GBP

Below there is a snapshot for a short period for the historical difference in percentage returns between synthetic EUR/GBP and actual EUR/GBP to see the magnitude when no big jumps are present (left - Figure 6) and the plots of the equity synthetic EUR/GBP and the equity actual EUR/GBP (right - Figure 7):

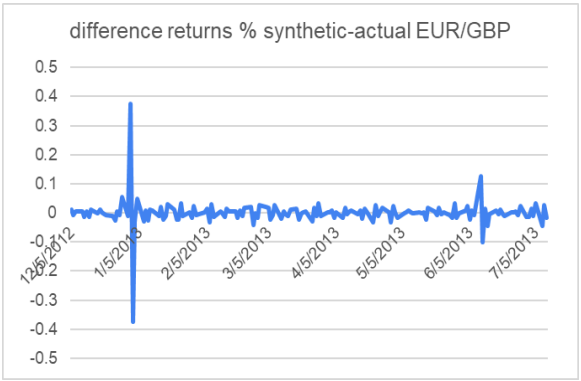


Figure 6. Snapshot of difference in % returns between synthetic & actual EUR/GBP

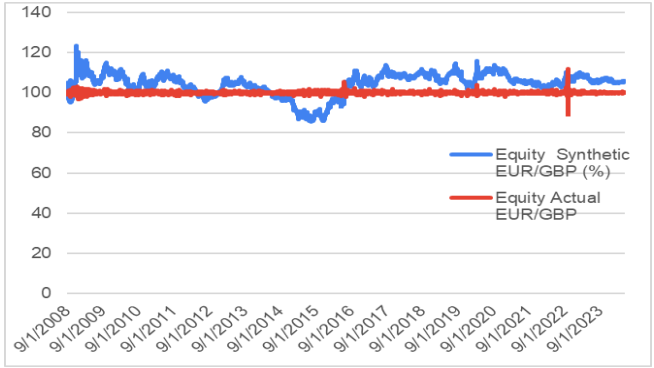


Figure 7. Equity synthetic and actual EUR/GBP

We propose 3 strategies: Ret1, Ret2 and Ret3. Ret1 strategy is as follows: if the absolute value of the difference between previous day synthetic EUR/GBP and actual EUR/GBP is

higher than the threshold, we either buy GBP/USD and sell EUR/USD (if the difference is positive, i.e. sell synthetic EUR/GBP), or sell GBP/USD and buy EUR/USD (if the difference is negative, i.e. buy synthetic EUR/GBP) on the current day; otherwise, we do not take a position. This is assumed to close at the end of the current day. It can also be implemented with a Holding Days period; but here, we present only this simplified version. Ret2 strategy is as follows: if the absolute value of the difference between previous day synthetic EUR?GBP and actual EUR/GBP is higher than the threshold, we either sell actual EUR/GBP and buy synthetic EUR/GBP (if the difference is negative) or buy actual EUR/GBP and sell synthetic EUR/GBP (if the difference is positive) on the current day; otherwise we do not take a position. This is assumed to close at the end of the current day. It can also be implemented with a Holding Days period; but here, we present only this simplified version. We do assume selling or buying synthetic EUR/GBP can be done without any other fees - which it may not be realistic). Ret3 is merely a combination of Ret1 and Ret2. The difference is as follows: if the absolute value of the difference between previous day synthetic EUR/GBP and actual EUR/GBP is higher than the threshold, we either buy GBP/USD and sell EUR/USD and buy actual EUR/GBP (if the difference is positive) or sell GBP/USD and buy EUR/GBP and sell actual EUR/GBP (if the difference is negative) on the current day; otherwise, we do not take a position. The results are presented in Table 4 and the strategies with highest Sharpe ratios for each threshold are marked with red. Threshold seems to influence the Sharpe ratios.

Sharpe ratio	**Threshold**	**EUR/USD and GBP/USD triangular arbitrage**
Ret1	0	0.64
Ret2	0	0.67
Ret3	0	0.70
Ret1	0.001	0.40
Ret2	0.001	0.57
Ret3	0.001	0.58
Ret1	0.01	0.41
Ret2	0.01	0.48
Ret3	0.01	0.49

Table 4. Sharpe ratios for Triangular arbitrage strategies.

Pair/spread trading follows the ideas presented in class for a similar strategy over a pair of stocks. We have 5 inputs: LongEntry Threshold:-1, Long Cap: 1, ShortEntry Threshold: 1,

ShortCap:-1, Holding days: 1 day (it is kept fixed, due to carry trade; if holding for more days, we will need to introduce the carry trade). The Dickey-Fuller test has been performed for the spread using the last 1401 days till May 14, and based on the t-statistic value of -3.46 being lower than any Dickey- Fuller critical value for AR model (either with constant (-2.57), or with constant and time trend (-3.13)) at significance level 10% , we support that the pair is cointegrated at 10% significance level. We calculated 5-day, 10-day and 20-day normalized returns for both currencies, taking the difference respectively. The main approximate idea is that if the difference between normalized returns exceeds ShortEntry Threshold, we short the spread, hold for Holding days and/or exit when we hit ShortCap; if the difference between normalized returns is below LongEntry Threshold, we long the spread, hold for Holding days and/or exit when we hit LongCap. For this strategy, an equally weighted combination is also calculated. The inputs have been varied to optimize our Sharpe ratios and the above set of parameters seem satisfactory. It seems that the z10ret strategy has the highest Sharpe ratio, 0.58. The results are presented in Table 5, and the strategy with highest Sharpe ratio is marked with red.

Sharpe ratio	**EUR/USD and GBP/USD spread trading**
z5ret	0.15
z10ret	0.58
z20ret	0.23
combo	0.49

Table 5. Pair Trading Sharpe ratios results for various normalized N-day returns and an equally weighted combo.

Overall, it seems that triangular arbitrage strategies, pairs trading and counter trend (long and/or short) strategies give higher Sharpe ratios than pure trend following strategies for the currencies discussed in this report. Our macro trade strategies also seem to yield reasonable Sharpe ratios, but adjustments for economic conditions and supply and demand may be able to improve these results. Also, some strategies use futures prices and others use spot prices, which should be important when making the decision on which strategy to use. Of course, each strategy also has various assumptions which must be satisfied and the choice of one must depend on specific context and views.