Financial Modelling Individual Project

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December 2023

Word count: 1509

1 What is the objective of the case study and what are the main conclusions?

This case study uses time-series monthly exchange rate data (Jan 1993 - Oct 2021) for the USD against the remaining G10 currencies to investigate how a momentum traded FX portfolio's profitability varies with different window lengths.[1] The study's outset employs constructing long and short-run moving averages and defining a momentum trading rule for an equally weighted portfolio of G10 currencies. Before calculating moving averages, we calculate each currencies monthly returns with equation 1 (1). C_{t+1} is the return from investing in a foreign currency between month t and $t+1$ where S_t and S_{t+1} are the FCU/USD exchange rate at time t and $t+1$ respectively.

$$C_{t+1} = \frac{S_{t+1} - S_t}{S_t} = \frac{S_{t+1}}{S_t} - 1 \tag{1}$$

The long-run, $\overline{C}_{t,L}$ and short-run ,$\overline{C}_{t,S}$ moving averages for each exchange rate at month t are given by equations (2) and (3) respectively, where n represents the long-run and m represents the short-run window.

$$\overline{C}_{t,L} = \frac{1}{n}\sum_{i=0}^{n-1} S_{t-1} \tag{2}$$

$$\overline{C}_{t,S} = \frac{1}{m}\sum_{i=0}^{m-1} S_{t-1} \tag{3}$$

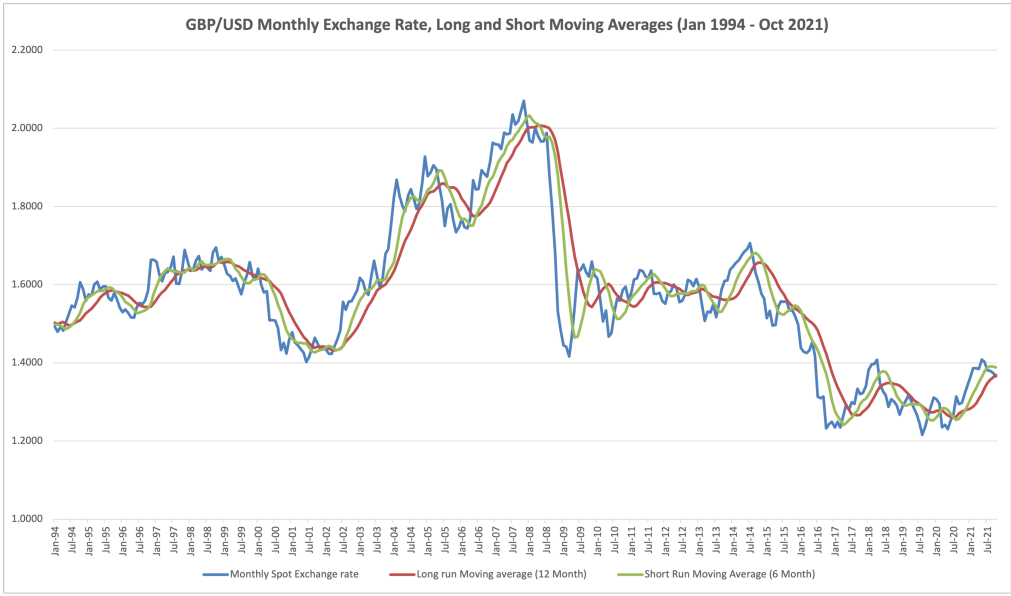


Figure 1: GBP/USD Monthly Spot Exchange rate, long-run Moving Average $\overline{C}_{t,L}$ with $m = 12$ and short-run Moving Average $\overline{C}_{t,S}$ with $n = 6$

Once the exchange rate moving averages, such as the GBP/USD pairing in figure 1, are calculated for each FCU/USD pairing, it is necessary to compose the momentum trading strategy. The trader compares the short-run and long-run moving averages of each exchange rate and accordingly will go long (buy) if the short-run moving average is higher than the long-run and will go short vice versa. This strategy implies that if the rate has increased

[1] Considered to be 10 of the worlds most liquid currencies the G10 are USD, GBP, CAD, JPY, AUD, NZD, SEK, NOK, CHF and EUR.

recently it is likely to increase further in the near future. These trends, emerge from behavioural biases and represent a deviation from market efficiency. The strategy can be represented algebraically as in (4).

$$MA(m,n) = \frac{1}{m}\sum_{i=0}^{m-1} S_{t-1} - \frac{1}{n}\sum_{i=0}^{n-1} S_{t-1} \tag{4}$$

$$\text{where } m < n$$

If $MA(m,n) > 0$ the trader buys and the momentum return at month t is the currencies simple return, or if $MA(m,n) < 0$ the trader sells the currency earning the negative of the simple return. The study prescribed implementing the trading strategy on a equally weighted portfolio so portfolio monthly returns are calculated as the average of all the individual positions. Initialising a portfolio with arbitrary value of 100 in December 1993, we can observe how the portfolio value changes over time. Figure 2 compares a momentum portfolio with 6 month short, 12 month long windows with a passively managed portfolio where returns are the average simple return of each position. The summary statistics in Table 1 compares the profitability and risk of both portfolios.

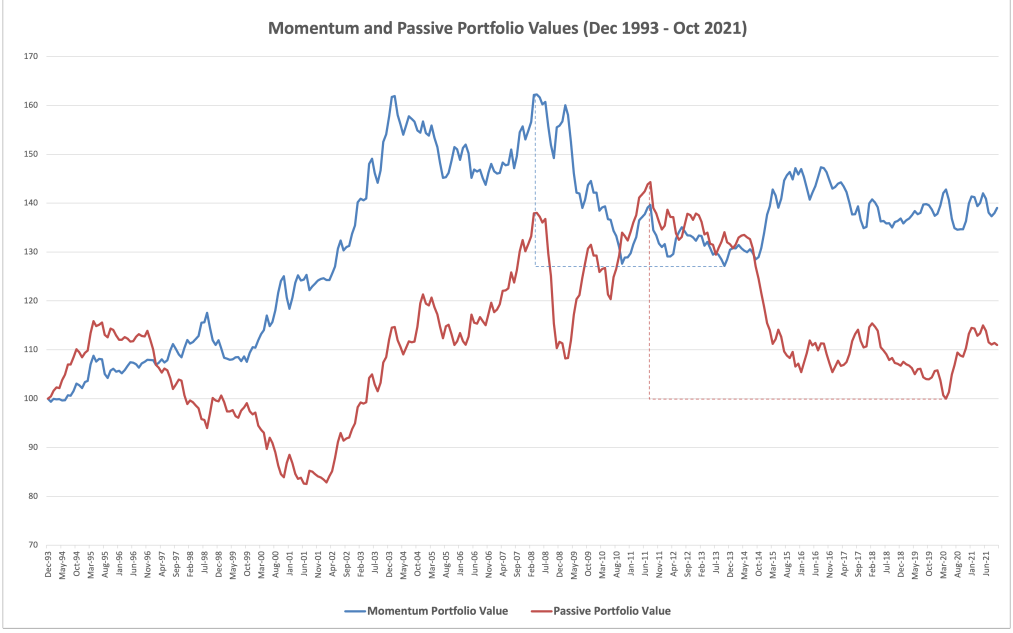


Figure 2: Momentum (6,12) traded and passively managed portfolio values over time. Maximum Drawdown for each portfolio is indicated with dashed line.

Table 1: Performance Metrics for Momentum and Passive Strategies

	Momentum $(6,12)$	**Passive**
Average return	0.11%	0.05%
SD	1.41%	1.75%
Sharpe ratio	0.077	0.027
Maximum drawdown	21.62%	30.71%

It is apparent that simple active strategies can exceed the expected monthly returns from a passively managed portfolio. The standard deviation, describes the average difference of returns from the mean return and is lower for the momentum portfolio indicating less volatility. As a first measure of risk adjusted returns the Sharpe ratio is computed with equation (5).The higher value suggests a higher risk adjusted performance for the momentum portfolio. Maximum drawdown is the largest cumulative reduction in portfolio value V_t, over a period of time is calculated via equation (6) and suggests that the momentum portfolio is less risky.

$$S_p = \frac{E(R_p) - R_f}{\sigma_p} = \frac{E(R_p)}{\sigma_p} \tag{5}$$

$$MDD = \max_{t=1,\ldots,T} \frac{-(V_t - \max_{i=1,\ldots,t-1}(V_{t-i}))}{(\max_i(V_{t-i})} \tag{6}$$

The studies aim is to investigate a class of momentum strategies and find the optimal window length parameters. Conducting a sensitivity analysis identifies the Sharpe ratios for portfolios managed with different parameters. What stands out in table 2 is that by far the the largest sharp ratio and highest risk adjusted monthly returns would be achieved with 1 month short, 2 month long windows.

Table 2: Sharpe Ratios for Momentum Strategies Monthly Returns with Varying Window Lengths for an Equally Weighted G10/USD Portfolio (Dec 1993 - Oct 2021)

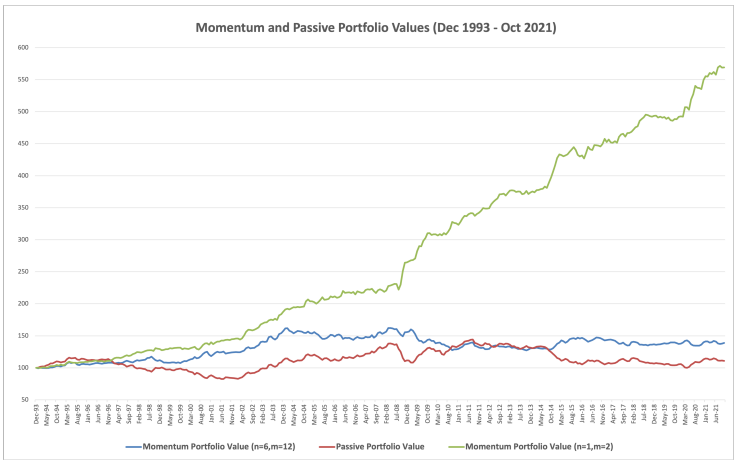
	n **(Long Window)**										
m **(Short Window)**	2	3	4	5	6	7	8	9	10	11	12
1	0.412	0.297	0.292	0.272	0.258	0.242	0.240	0.222	0.205	0.211	0.203
2		0.199	0.164	0.168	0.163	0.159	0.144	0.134	0.126	0.134	0.136
3			0.119	0.110	0.136	0.138	0.121	0.108	0.101	0.104	0.119
4				0.129	0.148	0.131	0.115	0.086	0.082	0.090	0.102
5					0.142	0.129	0.116	0.092	0.059	0.067	0.079
6						0.089	0.085	0.069	0.042	0.055	0.077
7							0.080	0.059	0.043	0.039	0.079
8								0.048	0.030	0.037	0.067
9									0.016	0.030	0.052
10										0.045	0.063
11											0.045

When $m = 1, n = 2$ the momentum strategy amounts to buying if this period's exchange rate is higher than last period's exchange rate, and selling if this period's exchange rate is lower than last period's exchange rate. Table 3 and Figure 3 reveal the dominance and growth in portfolio value under these parameters. Additionally conducting a sensitivity analysis for both the expected monthly returns and maximum portfolio drawdowns confirm that this strategy is optimal when back tested on our historical data (see Appendix A and Appendix B).

Table 3: Performance Metrics for Momentum Strategy ($m = 1, n = 2$)

	Momentum $(1, 2)$
Average return	0.53%
SD	1.29%
Sharpe ratio	0.412
Maximum drawdown	3.95%

Figure 3: Comparison of momentum(1,2) portfolio value over time with momentum (6,12) and passive portfolio



2 How would a practitioner make use of the findings of the case study?

Deutsche-Bank, winners of this year Euromoney FX's award for best global FX provider have emerged as a leading FX investement bank (EUROMONEY, 2023). They report that momentum trading is one of the most extensively used FX investment strategies (DuetscheBank, 2009). Tasked with a quantitative analysts role and responsible in designing strategies for FX traders to implement the study produces a momentum strategy that can be considered elementary compared to industry standards. Yet since individual strategies are subject to alpha decay the case study is beneficial in learning to develop sufficiently general methodologies and frameworks that enable quantitative analysts to generate new trading strategies and adapt existing ones quickly. After designing a class of momentum trading strategies, we back-test the strategies on historical data which is similar to how p-measure quants spend a vast amount of their time (eFinancialCareers, 2023).

The study's findings are important for a wide range of processes and roles within an investment bank. Most striking was the substantial difference in portfolio value growth for the $(1, 2)$ momentum portfolio and the other portfolios. FX markets are the world's largest and most liquid (Scott, 2022). Since they are also open 24 hours a day, from Sunday evening to Friday night, momentum strategies could probably be more profitable at the weekly, daily and even inter-day windows. This finding will be of interest to quantitative researchers and would suggest they should shift their focus into developing and using strategies that generate α (excess returns) with smaller moving average windows given the superiority of the $(1, 2)$ strategy. An FX product salesperson could present the immense portfolio value growth to prospective clients, persuading them to invest with the bank. Portfolio managers with client funds could use the case study findings to communicate the expected performance and risks associated with different momentum strategies to clients. The empirical findings about the portfolios historical volatility could be used by a risk manager to evaluate the value at risk of their divisions investments.

3 What are the limitations of the modelling approaches used in the case study?

The principal limitation of the modelling approach is the omission of interest rates. For an FX investor the currency return remains as in (1) but the investor will likely earn interest on the foreign deposit at rate r_t^* and so the total monthly return is given by (7). Ignoring the return from the foreign deposit the model underestimates the portfolios monthly returns. Furthermore if the investor borrows at rate r_t to finance the portfolios position, the portfolios excess return is given by (8).

$$R_{t+1} = (1 + C_{t+1})(1 + r_t^*) - 1 \tag{7}$$

$$X_{t+1} = (1 + C_{t+1})(1 + r_t^*) - (1 + r_t) = R_{t+1} - r_t \tag{8}$$

It is possible that the studies sharpe ratios do not represent the true risk adjusted return. In the presence of a viable risk free return, the second equality of (5) no longer holds and instead of Sharpe ratios in table (1) the values represent "normalized spot rate changes" (average spot rate changes divided by their standard deviation). It is probable therefore that the study overestimates risk adjusted returns.

One should also not assume that any given volume of a currency could be bought at a rate given throughout the sample period. This is due to transaction costs incurred when buying or selling foreign currencies from an exchange broker/dealer (Kantox, 2023). It is likely that the approach overestimated the portfolios profitability since research ascertains that the size of transaction costs significantly influences FX momentum returns(Menkhoff et al., 2012).

This study uses historical data from 1993, a year after CME group launched Globex, one of the earliest major electronic trading platforms with access to fx markets that aided the growth of widespread electronic trading in the

late 20^{th} and early 21^{st} century (ONIXS, 2022). New technologies and electronic trading have immensely developed over the period our data spans and consequently the size of exchange rate bid-ask spreads and their impact on momentum returns would be an issue for future research.

Additional uncertainty arises as the method does not include any checks for capital restrictions that limit trading of certain currencies at any point in our sample. It is important to check that each currency has been tradable as there may be capital controls or other issues rendering trading infeasible.

4 What improvements could you make to the analysis if you had more time or better data?

To yield more robust conclusions it is important to be able to disclose what the rates in the data represent be it the month start, end or average and the study should use data with known provenance. Secondly I would undertake the approach on data that includes interest rate figures in order to accommodate equations (7) and (8) to compute the returns. This is the most important revision for aforementioned reasons and will promote the model to a level closer to industry practice. A quantitative researcher at a investment bank would likely have Bloomberg terminal access where detailed historical exchange rate and interest rate data is available.

Another improvement that I would make is to incorporate additional currency pairings in the portfolio. Menkhoff et al (2014) demonstrate that including smaller currencies from emerging markets results in large momentum returns. The extension of this change would be to remove the requirement for the FCU to be traded against the USD allowing for further diversification. Given how tradable FX markets are I would look to increase the granularity of the time series data and design a momentum strategy that trades based of weekly or daily returns.

	Momentum (1,2)	**Momentum (6,12)**	**Passive portfolio**
Average Return	6.55%	1.31%	0.56%
Standard Deviation	4.46%	4.87%	6.06%
Normalised spot rate change	1.47	0.27	0.09

Table 4: Annualised Returns and Volatility for different portfolios

Finally, a simple improvement is annualizing the performance of the portfolios as in table (4) given that a historical return for indexes, often used to benchmark performance, such as the S&P 500 are typically measured annually (Kenton, 2022).

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Appendix

A Table 5

Table 5: Expected Monthly Returns for Momentum Strategies with Varying Window Lengths for an Equally Weighted G10/USD Portfolio (Dec 1993 - Oct 2021)

m (Short Window) \ n (Long Window)	2	3	4	5	6	7	8	9	10	11	12
1	0.530%	0.407%	0.393%	0.365%	0.353%	0.337%	0.336%	0.310%	0.291%	0.305%	0.294%
2		0.271%	0.222%	0.230%	0.225%	0.222%	0.203%	0.189%	0.179%	0.191%	0.195%
3			0.160%	0.149%	0.192%	0.194%	0.169%	0.152%	0.145%	0.152%	0.175%
4				0.178%	0.209%	0.184%	0.161%	0.123%	0.117%	0.130%	0.147%
5					0.199%	0.182%	0.165%	0.131%	0.083%	0.095%	0.113%
6						0.127%	0.116%	0.096%	0.059%	0.078%	0.109%
7							0.109%	0.082%	0.060%	0.055%	0.111%
8								0.066%	0.042%	0.051%	0.094%
9									0.022%	0.042%	0.072%
10										0.063%	0.089%
11											0.064%

B Table 6

Table 6: Maximum Portfolio Drawdowns for Momentum Strategies with Varying Window Lengths for an Equally Weighted G10/USD Portfolio (Dec 1993 - Oct 2021)

m (Short Window) \ n (Long Window)	2	3	4	5	6	7	8	9	10	11	12
1	3.954%	4.837%	5.262%	5.944%	7.234%	8.132%	7.629%	7.709%	9.186%	9.278%	10.285%
2		7.416%	13.553%	16.727%	13.105%	11.665%	11.934%	10.676%	12.669%	12.389%	14.137%
3			20.281%	18.022%	17.771%	12.953%	11.854%	12.548%	15.617%	14.955%	18.554%
4				19.385%	13.964%	11.446%	10.230%	15.262%	16.886%	18.920%	19.698%
5					11.230%	9.769%	11.386%	15.599%	18.405%	18.396%	19.323%
6						10.368%	13.181%	17.487%	22.800%	23.237%	21.623%
7							13.940%	21.357%	29.272%	28.963%	24.321%
8								28.442%	32.240%	29.438%	26.038%
9									30.594%	31.638%	27.281%
10										26.988%	27.431%
11											33.461%