Excel Backtesting System

22 Jan 2022

Backtesting on Momentum Trading Strategy

Interview Candidate:

Andy Chan
andyinter1@gmail.com
+852 9603 3105

Strategy Backtesting

Logic

Due to strong economic recovery, supply chain disruption and energy shortage, inflation rate of most western countries rise rapidly. For example, UK inflation rate has been increased to > 5%, way above its 2% inflation target. Accordingly central banks rise interest rate to tackle inflation problem.

Investment opportunities may be emerged as western countries enter rate hike cycle, investors switch investments from growth stocks to value stocks, especially stocks that can benefit from rate hike such as banking.

To capture the opportunities, two momentum strategies will be accordingly tested:

- Moving average crossover RSI
- Moving average crossover ROC

Methodology

Backtest will be conducted on iShares STOXX Europe 600 Banks ETF, as it closely replicates the STOXX Europe 600 Banks TR index which represents banking stock components in STOXX 600.

Data from Apr 2020 to Feb 2022 will be used. Given the relatively short data sample size after COVID-19 outbreak, single holdout cross validation rather than rolling window test will be used.

A 50:50 split is applied to separate data into two segments: 20-21 data will be used in in-sample test while the remaining 21-22 data will be used for out-of-sample test. Feb and Mar data in 2020 are excluded due to COVID-19 distortion.

Test Assumptions

In the back-test:

- commission cost is ignored,
- slippage cost is ignored,
- closed price is used, not consider bid-ask spread
- no lot size restriction for trading.

Buy and hold strategy is used as benchmark.

Strategy Components

STOXX components	Banking stocks
Proxy instrument	iShares STOXX Europe 600 Banks ETF **Represents return performance of investing bank stocks in STOXX 600*
Evaluation metric	Annualized sharpe ratio
Momentum strategies	• Moving average crossover (SMA & EMA) • EMA crossover with RSI/ROC
Indicators	• SMA • EMA • Relative strength (hereafter “RSI”) • Rate of change (hereafter “ROC”)
Parameters to optimize	MA period (5/15, 15/30, 5/30)

Indicators

Due to excel limitation, period of MA is the only parameter to be optimized here for simplification. 3 sets of MA period parameters are tested: 5/15, 15/30, and 5/30. Period of RSI and ROC will use 14 days and 12 days respectively. A full simulation test can be carried out with programming in the future if necessary.

The rationales of using MA include 1) detecting turning point of trend and 2) acting as potential support and resistance levels.

The main rationale of using ROC is to monitor price growth pace, and help closing position if the price growth is decelerating, even the market is still an uptrend market.

The rationale of using RSI is to ensure trades are made only if the ETF performance enters the momentum accelerating zone.

Trading Rules

For pure MA crossover, entry and exit decisions are based on the same trading rule. Whenever the shorter-term MA cross above the longer-term MA, buy order will be made. Position will be closed whenever the shorter-term MA cross below the longer-term MA.

For EMA with RSI (hereafter "EMARSI"), apart from EMA signal, buy order will only be made if RSI is also within 55 to 70, while sell order will be made if RSI stays above 80 for 2 consecutive days. The logic behind is that RSI from 50 to 70 represents uptrend market, and an additional "5" on top of 50 to provide safe buffer. On the other hand, we take RSI above 80 as a strong overbought signal.

For EMA with ROC (hereafter "EMAROC"), apart from EMA signal, buy order will only be made if ROC is above 0, while sell order will be made if ROC has been decreasing for 3 consecutive days. The logic behind is that position will be closed if the price momentum is decelerating even the market is still an uptrend market. It should be noted that either ROC or EMA signal alone is enough to trigger the selling action.

Due to excel limitation, we keep the trading rules less sophisticated and straight forward.

Back-test Stats and Findings

3 set of MA period to be tested are relatively short, and thus EMA, instead of SMA, is the testing focus because of its increased sensitivity to price movement.

In-Sample Test

In-sample tests are carried out with 20-21 sample data to optimize period parameters to be used in EMA strategy.

Figure 1 In-sample test (5/15)

EUR	5/15 SMA Crossover	5/15 EMA Crossover	EMA Crossover & RSI Refinement	EMA Crossover & ROC Refinement	Benchmark - Buy and Hold
Realized					
Gross Profit (profitable trades)	1360.9	1034.8	971.2	999.7	0.0
Gross Loss (lossing trades)	-1429.0	-1713.3	-688.9	-1107.9	0.0
Gross Profit (all trades)	-68.2	-678.5	282.3	-108.2	0.0
Commission Paid	0.0	0.0	0.0	0.0	0.0
Slippage Cost	0.0	0.0	0.0	0.0	0.0
Realized Net Profit	-68.2	-678.5	282.3	-108.2	0.0
Open Positions					
Gross Profit (profitable trades)	258.0	226.1	276.4	160.6	2090.1
Total Net Profit	189.9	-452.4	558.6	52.4	2090.1
Trades made	10	12	5	10	1
Open Positions	1	1	1	1	1
Win Trades	3	2	1	2	0
Win Trades of Open Positions	1	1	1	1	1
Loss Trades	6	9	3	7	0
Even Trades	0	0	0	0	0
Percent Profitable	30.0%	16.7%	20.0%	20.0%	100.0%
Percent Profitable (adjusted for unrealized trades)	40.0%	25.0%	40.0%	30.0%	100.0%
Loss Rate (adjusted for unrealized trades)	60.0%	75.0%	60.0%	70.0%	0.0%
Avg. Net Profit per Trade	19.0	-37.7	111.7	5.2	2090.1
Sharpe Ratio	0.27	-0.25	0.66	0.24	0.97
Annualized Sharpe	0.29	-0.26	0.71	0.26	1.03
Period Return	3.8%	-9.0%	11.2%	1.0%	41.8%
Annualized Return	4.3%	-10.2%	12.8%	1.2%	48.9%
Profit Factor	1.0	0.6	1.4	0.9	N.A
Profit Factor (inc. open positions)	1.1	0.7	1.8	1.0	N.A
Max Drawdown	-1207.9	-1635.3	-662.1	-1242.2	N.A
Max Drawdown (%)	-22.7%	-30.6%	-11.6%	-23.2%	N.A
Trading Period (days)	221.0	221.0	221.0	221.0	221.0
Time in the Market (days)	114.0	124.0	78.0	70.0	221.0
Market Exposure Duration	51.6%	56.1%	35.3%	31.7%	100.0%

Figure 2 In-sample test (15/30)

EUR	15/30 SMA Crossover	15/30 EMA Crossover	EMA Crossover & RSI Refinement	EMA Crossover & ROC Refinement	Benchmark - Buy and Hold
Realized					
Gross Profit (profitable trades)	1920.1	920.6	920.6	965.1	0.0
Gross Loss (lossing trades)	-574.8	-235.8	-235.8	-35.1	0.0
Gross Profit (all trades)	1345.3	684.8	684.8	930.0	0.0
Commission Paid	0.0	0.0	0.0	0.0	0.0
Slippage Cost	0.0	0.0	0.0	0.0	0.0
Realized Net Profit	1345.3	684.8	684.8	930.0	0.0
Open Positions					
Gross Profit (profitable trades)	0.0	297.4	297.4	194.7	2090.1
Total Net Profit	1345.3	982.2	982.2	1124.7	2090.1
Trades made	5	3	3	3	1
Open Positions	0	1	1	1	1
Win Trades	3	1	1	1	0
Win Trades of Open Positions	0	1	1	1	1
Loss Trades	2	1	1	1	0
Even Trades	0	0	0	0	0
Percent Profitable	60.0%	33.3%	33.3%	33.3%	100.0%
Percent Profitable (adjusted for unrealized trades)	60.0%	66.7%	66.7%	66.7%	100.0%
Loss Rate (adjusted for unrealized trades)	40.0%	33.3%	33.3%	33.3%	0.0%
Avg. Net Profit per Trade	269.1	327.4	327.4	374.9	2090.1
Sharpe Ratio	1.04	0.85	0.85	1.34	0.97
Annualized Sharpe	1.11	0.90	0.90	1.43	1.03
Period Return	26.9%	19.6%	19.6%	22.5%	41.8%
Annualized Return	31.2%	22.7%	22.7%	26.0%	48.9%
Profit Factor	3.3	3.9	3.9	27.5	N.A
Profit Factor (inc. open positions)	3.3	5.2	5.2	33.1	N.A
Max Drawdown	-1127.8	-887.3	-887.3	-688.3	N.A
Max Drawdown (%)	-18.6%	-15.8%	-15.8%	-12.3%	N.A
Trading Period (days)	221.0	221.0	221.0	221.0	221.0
Time in the Market (days)	110.0	109.0	109.0	26.0	221.0
Market Exposure Duration	49.8%	49.3%	49.3%	11.8%	100.0%

Figure 3 In-sample test (5/30)

EUR	5/30 SMA Crossover	5/30 EMA Crossover	EMA Crossover & RSI Refinement	EMA Crossover & ROC Refinement	Benchmark - Buy and Hold
Realized					
Gross Profit (profitable trades)	1055.4	1173.5	1181.5	951.7	0.0
Gross Loss (lossing trades)	-1066.8	-192.1	-155.4	-153.6	0.0
Gross Profit (all trades)	-11.4	981.4	1026.1	798.1	0.0
Commission Paid	0.0	0.0	0.0	0.0	0.0
Slippage Cost	0.0	0.0	0.0	0.0	0.0
Realized Net Profit	-11.4	981.4	1026.1	798.1	0.0
Open Positions					
Gross Profit (profitable trades)	220.6	312.9	315.3	190.4	2090.1
Total Net Profit	209.2	1294.4	1341.4	988.5	2090.1
Trades made	9	5	4	4	1
Open Positions	1	1	1	1	1
Win Trades	2	2	2	2	0
Win Trades of Open Positions	1	1	1	1	1
Loss Trades	6	2	1	1	0
Even Trades	0	0	0	0	0
Percent Profitable	22.2%	40.0%	50.0%	50.0%	100.0%
Percent Profitable (adjusted for unrealized trades)	33.3%	60.0%	75.0%	75.0%	100.0%
Loss Rate (adjusted for unrealized trades)	66.7%	40.0%	25.0%	25.0%	0.0%
Avg. Net Profit per Trade	23.2	258.9	335.4	247.1	2090.1
Sharpe Ratio	0.29	1.04	1.07	1.14	0.97
Annualized Sharpe	0.30	1.11	1.14	1.21	1.03
Period Return	4.2%	25.9%	26.8%	19.8%	41.8%
Annualized Return	4.8%	30.0%	31.1%	22.8%	48.9%
Profit Factor	1.0	6.1	7.6	6.2	N.A
Profit Factor (inc. open positions)	1.2	7.7	9.6	7.4	N.A
Max Drawdown	-1064.1	-869.6	-833.5	-889.5	N.A
Max Drawdown (%)	-19.5%	-15.3%	-14.6%	-15.6%	N.A
Trading Period (days)	221.0	221.0	221.0	221.0	221.0
Time in the Market (days)	116.0	113.0	111.0	34.0	221.0
Market Exposure Duration	52.5%	51.1%	50.2%	15.4%	100.0%

Based on all the back-test results shown in figure 12-14, although buy and hold strategy outperforms all other strategy in terms of total net profit, the risk-adjusted return metric tells another story.

Annualized sharpe ratio is the evaluation metric of the tests. In terms of annualized sharpe ratio, benchmark outperforms every EMA strategy with 5/15 period. It is because MA strategy with short-term period is actually trying to detect trend movement earlier at the cost of suffering many false signals, which is proven by the percent profitable of trades metric: under 50% for all MA strategies. The shorter-term MA momentum trading strategy is particularly subject to noise, signaling buy only to signal sell soon afterwards.

In the remaining 15/30 and 5/30 tests, EMAROC records a better annualized sharpe ratio with 15/30 EMA period. The 1.43 annualized sharpe EMAROC recorded does not only outperform the 1.03 sharpe ratio of benchmark, but also the highest among every sharpe ratio recorded. On the other hand, EMARSI performs best with 5/30 EMA period, with an annual sharpe ratio of 1.14 which also outperform the 1.03 of benchmark.

Out of sample Test

Based on the in-sample test results, 5/15 period parameters are no longer considered in the following off-sample-tests. EMARSI and EMAROC strategy will be respectively tested with 5/30 and 15/30 period parameters using 21-22 sample data.

EMARSI strategy

Figure 4 Out-of-sample test (5/30)

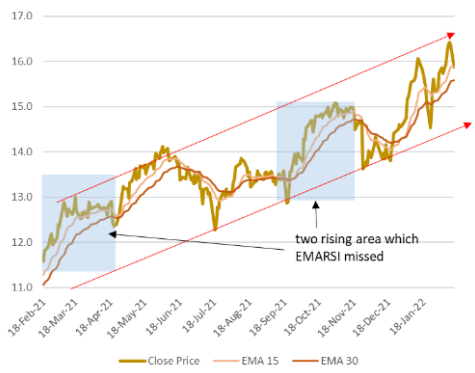
EUR	5/30 SMA Crossover	5/30 EMA Crossover	EMA Crossover & RSI Refinement	EMA Crossover & ROC Refinement	Benchmark - Buy and Hold
Realized					
Gross Profit (profitable trades)	338.5	607.8	224.6	1222.1	0.0
Gross Loss (lossing trades)	0.0	-290.3	-10.2	-282.2	0.0
Gross Profit (all trades)	338.5	317.4	214.4	939.9	0.0
Commission Paid	0.0	0.0	0.0	0.0	0.0
Slippage Cost	0.0	0.0	0.0	0.0	0.0
Realized Net Profit	338.5	317.4	214.4	939.9	0.0
Open Positions					
Gross Profit (profitable trades)	465.0	502.2	492.5	0.0	1854.9
Total Net Profit	803.5	819.6	706.8	939.9	1854.9
Trades made	4	6	3	6	1
Open Positions	1	1	1	0	1
Win Trades	3	2	1	4	0
Win Trades of Open Positions	1	1	1	0	1
Loss Trades	0	3	1	2	0
Even Trades	0	0	0	0	0
Percent Profitable	75.0%	33.3%	33.3%	66.7%	100.0%
Percent Profitable (adjusted for unrealized trades)	100.0%	50.0%	66.7%	66.7%	100.0%
Loss Rate (adjusted for unrealized trades)	0.0%	50.0%	33.3%	33.3%	0.0%
Avg. Net Profit per Trade	200.9	136.6	235.6	156.7	1854.9
Sharpe Ratio	1.12	1.05	1.12	1.54	1.45
Annualized Sharpe	1.12	1.05	1.12	1.54	1.44
Period Return	16.1%	16.4%	14.1%	18.8%	37.1%
Annualized Return	16.0%	16.3%	14.1%	18.7%	36.9%
Profit Factor	n.a	2.1	22.0	4.3	N.A
Profit Factor (inc. open positions)	n.a	3.8	70.3	4.3	N.A
Max Drawdown	-558.6	-560.1	-549.3	-463.4	N.A
Max Drawdown (%)	-9.5%	-10.1%	-9.5%	-8.5%	N.A
Trading Period (days)	253.0	253.0	253.0	253.0	253.0
Time in the Market (days)	138.0	150.0	102.0	89.0	253.0
Market Exposure Duration	54.5%	59.3%	40.3%	35.2%	100.0%

EMARSI fails to beat benchmark in almost every aspect. Not only does it yield a sharpe ratio 0.32 lower, but also an annualized return 22.8ppt lower than benchmark. Furthermore, EMA signal does not capture the two rising waves of the ETF as shown in figure 17, although it generates fewer losing trades when comparing with the pure EMA Crossover strategy.

Figure 5 Trades made under EMA 5/30 + RSI

EMA 5/30 + RSI							
	Date	EMA Signal	RSI Signal	EMA 5	EMA 30	RSI	RSI t-1
Entrance	27-Dec-22	Y	Y	14.29	14.24	56.4	
Exit	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Entrance	4-Aug-21	Y	Y	13.17	13.13	55.3	
Exit	10-Sep-21	Y	N	13.39	13.42	44.7	48.2
Entrance	27-Apr-21	Y	Y	12.64	12.56	57.9	
Exit	21-Jun-21	Y	N	13.59	13.64	42.9	40.5

Figure 6 EMARSI Graph 5/30



EMAROC strategy

Figure 7 Out-of-sample test (15/30)

EUR	15/30 SMA Crossover	15/30 EMA Crossover	EMA Crossover & RSI Refinement	EMA Crossover & ROC Refinement	Benchmark - Buy and Hold
Realized					
Gross Profit (profitable trades)	423.1	0.0	0.0	759.5	0.0
Gross Loss (lossing trades)	-80.6	-421.9	-421.9	-117.4	0.0
Gross Profit (all trades)	342.5	-421.9	-421.9	642.2	0.0
Commission Paid	0.0	0.0	0.0	0.0	0.0
Slippage Cost	0.0	0.0	0.0	0.0	0.0
Realized Net Profit	342.5	-421.9	-421.9	642.2	0.0
Open Positions					
Gross Profit (profitable trades)	430.5	406.3	406.3	0.0	1854.9
Total Net Profit	772.9	-15.7	-15.7	642.2	1854.9
Trades made	4	3	3	3	1
Open Positions	0	1	1	0	1
Win Trades	3	0	0	2	0
Win Trades of Open Positions	1	1	1	0	1
Loss Trades	1	2	2	1	0
Even Trades	0	0	0	0	0
Percent Profitable	75.0%	0.0%	0.0%	66.7%	100.0%
Percent Profitable (adjusted for unrealized trades)	100.0%	33.3%	33.3%	66.7%	100.0%
Loss Rate (adjusted for unrealized trades)	0.0%	66.7%	66.7%	33.3%	0.0%
Avg. Net Profit per Trade	193.2	-5.2	-5.2	214.1	1854.9
Sharpe Ratio	1.23	0.06	0.06	1.46	1.45
Annualized Sharpe	1.23	0.06	0.06	1.46	1.44
Period Return	15.5%	-0.3%	-0.3%	12.8%	37.1%
Annualized Return	15.4%	-0.3%	-0.3%	12.8%	36.9%
Profit Factor	5.2	0.0	0.0	6.5	N.A
Profit Factor (inc. open positions)	10.6	1.0	1.0	6.5	N.A
Max Drawdown	-582.1	-505.1	-505.1	-246.7	N.A
Max Drawdown (%)	-9.5%	-10.0%	-10.0%	-4.9%	N.A
Trading Period (days)	253.0	253.0	253.0	253.0	253.0
Time in the Market (days)	177.0	108.0	108.0	64.0	253.0
Market Exposure Duration	70.0%	42.7%	42.7%	25.3%	100.0%

EMAROC continues "outperforming" the benchmark in terms of annualized sharpe ratio, with an annualized sharpe ratio of 1.46 vs 1.44 of benchmark. While its annualized return is worse than benchmark, the better sharpe ratio is mainly due to taking lower market risk. Unlike the buy & hold strategy having fully market exposure, the market exposure duration of EMAROC is only 25.3%.

It is hard to justify that EMAROC is actually performing better just because of a sharpe ratio 0.02 higher than that of benchmark, especially when its total net profit gained is just 34.6% of benchmark's net profit.

Figure 8 Trades made under EMA 15/30 + ROC and EMA 15/30 + RSI

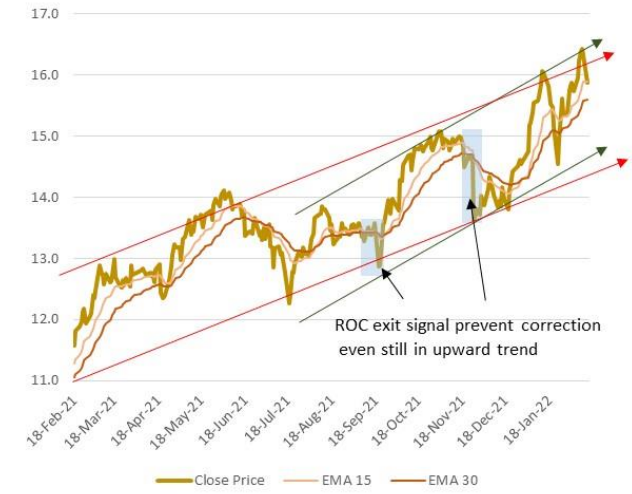
EMA 15/30 + ROC									
	Date	EMA Signal	ROC signal	EMA 15	EMA 30	ROC	ROC t-1	ROC t-2	ROC t-3
Entrance	30-Dec-22	Y	Y	14.31	14.30	5.3	3.6		
Exit	12-Jan-22	N	Y	14.94	14.47	10	10.2	10.3	12.7
Entrance	27-Sep-21	Y	Y	13.45	13.42	4.3	1.7		
Exit	18-Nov-21	N	Y	14.93	14.84	-1.1	-0.7	0.8	1.5
Entrance	9-Aug-21	Y	Y	13.25	13.22	7.5	7		
Exit	30-Aug-21	N	Y	13.53	13.32	-2.9	-2.6	-1.9	-1

EMA 15/30 + RSI							
	Date	EMA Signal	RSI Signal	EMA 15	EMA 30	RSI	RSI t-1
Entrance	30-Dec-22	Y	Y	14.31	14.30	57.5	
Exit	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Entrance	27-Sep-21	Y	Y	13.45	13.42	62.2	
Exit	26-Nov-21	Y	N	14.72	14.80	27.9	48.6
Entrance	9-Aug-21	Y	Y	13.25	13.22	63.8	
Exit	20-Sep-21	Y	N	13.42	13.48	35.9	55.5

As buy & hold strategy theoretically makes only one trade (at least in this back test), Trades of EMAROC will be compared with those of EMARSI for better evaluation. EMAROC successfully prevents 2 loss trades (fig. 20) by closing position when ROC records decrease for 3 consecutive days, even the ETF price is still in its uptrend tunnel. The reason is that EMAROC reacts much faster and even closes position before price correction starts.
In contrast, when the market uptrend reverses before hitting RSI 80, EMARSI fails to stop loss until the 15 EMA cross below the 30 EMA, losing all the profit originally gained. A more

sophisticated RSI rule or additional indicators may be needed in order to improve the strategy's performance.

Figure 9 ROC exit signal prevent correction during upward trend



Conclusion

It is not surprising that both EMAROC and EMARSI do not truly beat the benchmark as the market is a strong uptrend market (fig. 20) which is particularly suitable for buy-and-hold strategy. Momentum investing seeks to benefit from market volatility rather than a steady, strong uptrend. Strategic in and out actually lead to reduced return compared to buy-and-hold strategy if the market continues its uptrend.

Another possible reason is that the data used in in-sample test does not exhibit a strong trend (fig.21). As a result, the trading parameters trained are not that suitable during the period of strong uptrend in out-of-sample test and fail to capture two rising waves in both strategies (fig.17).

Figure 10 Price of iShares STOXX Europe 600 Banks UCITS ETF