

Figure 1: An SMA crossover strategy

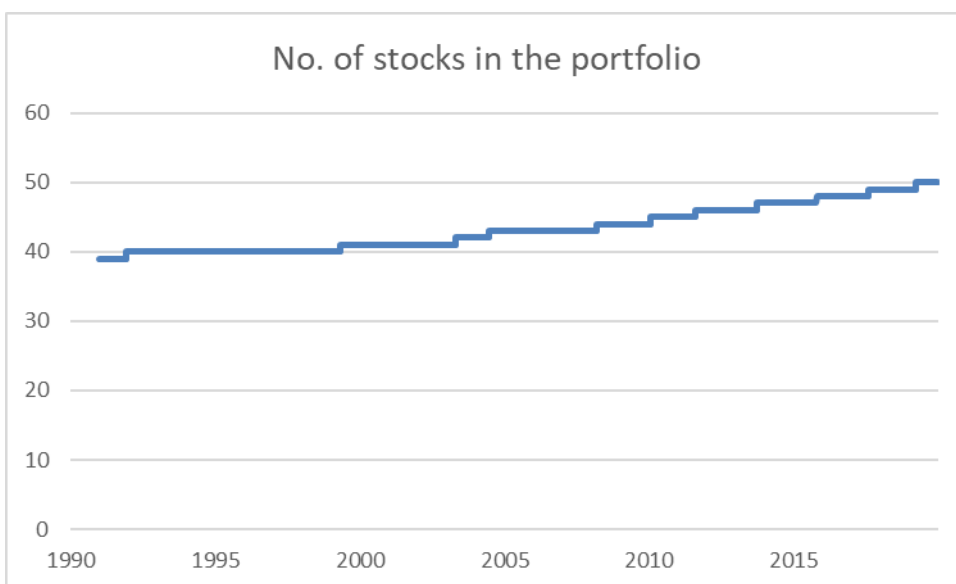


Figure 2: Number of stocks in the portfolio over the 30 years

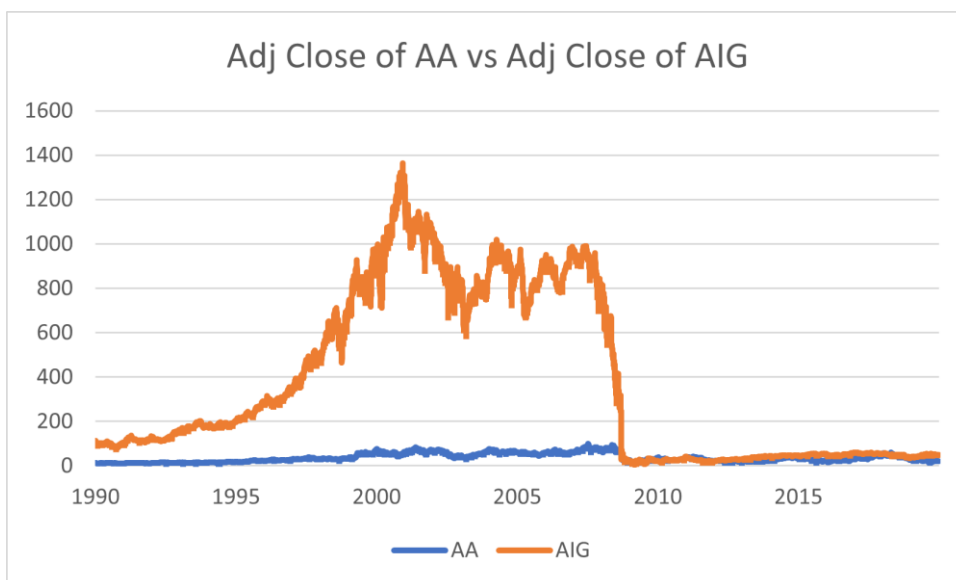


Figure 3: Adjusted Close of Alcoa Corporation (AA) vs American International Group (AIG)

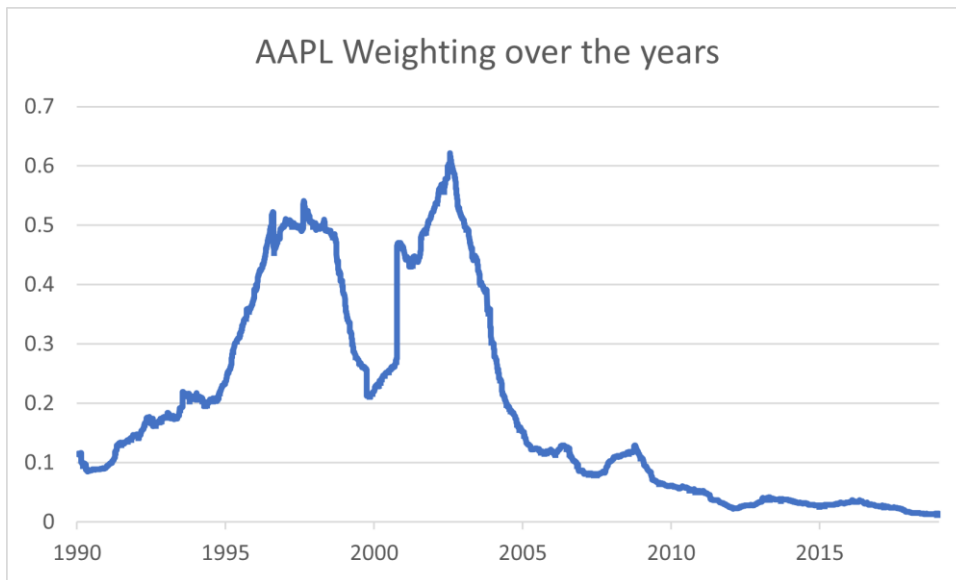


Figure 4: Apple Weighting over the years



Figure 5: Performance of the "Carry" Strategy

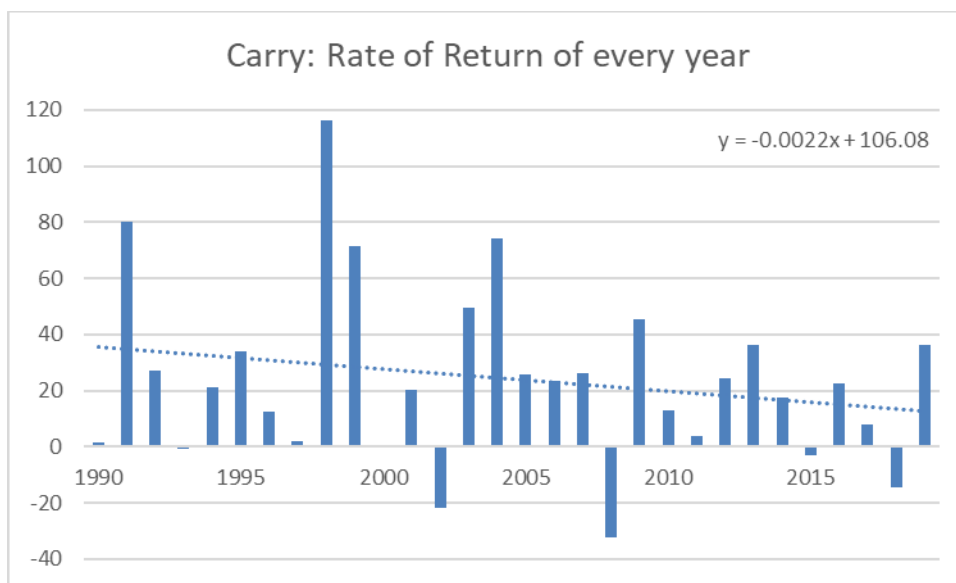


Figure 6: Carry Strategy Rate of Return every year

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Date	AAPL	AMGN	AXP	BA	CAT	CRM	CSCO	CVX	DIS	DOW	GS	HD	HON
2														
3														
4	02/01/1990	0.267666	0.849021	5.178864	11.04363	3.457712			5.466557	6.968283			1.17862	4.132151
5	03/01/1990	0.269462	0.869628	5.234553	11.31299	3.494417			5.377589	6.983367			1.182522	4.146751
6	04/01/1990	0.270361	0.886114	5.178864	11.26809	3.509099			5.308391	6.975823			1.190328	4.278165
7	05/01/1990	0.271259	0.898479	5.123179	11.11097	3.487075			5.22931	6.998448			1.174717	4.336567
8	08/01/1990	0.273055	0.896418	5.086053	11.24565	3.465051			5.278734	7.058542			1.163009	4.336567
9	09/01/1990	0.270361	0.877871	4.974679	11.11097	3.443029			5.239194	7.050993			1.131787	4.248961
10	10/01/1990	0.258684	0.881992	4.937554	11.15586	3.450367			5.239194	6.824514			1.139593	4.205157
11	11/01/1990	0.247906	0.863446	5.011803	10.99874	3.450367			5.249078	6.824514			1.147398	4.175953
12	12/01/1990	0.247906	0.849021	4.900431	10.77427	3.391639			5.081028	6.628235			1.104469	4.102949
13	15/01/1990	0.246109	0.853142	4.88187	10.66204	3.376958			5.110684	6.635784			1.09276	4.088347

Figure 7: Screenshot of the data file "DJ_data"

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Date	XOM	XOM	P&L	SMA1	SMA2	Pos							
2		Adj Close	Weighting		220	255	0	0	0	0				
3														
4	02/01/1990	4.440291	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
5	03/01/1990	4.395888	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
6	04/01/1990	4.351486	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
7	05/01/1990	4.329282	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
8	08/01/1990	4.395888	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
9	09/01/1990	4.307079	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
10	10/01/1990	4.329282	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
11	11/01/1990	4.351486	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
12	12/01/1990	4.240479	#DIV/0!	0.00%	#REF!	#REF!	#REF!							
13	15/01/1990	4.295979	#DIV/0!	0.00%	#REF!	#REF!	#REF!							

Figure 8: Screenshot of one of the strategy files "SMA"

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Run			76384			Date	VAMI	Return		AAPL	AMGN	AXP	BA	CAT
2	Process			100.00%											
3								1000							
4	Use data from		DJ_data	File must be open			02/01/1990	1000	0.00%		0	0	0	0	0
5	Number of stocks		50				03/01/1990	1000	0.00%		0	0	0	0	0
6							04/01/1990	1000	0.00%		0	0	0	0	0
7	Calculate P&L of		2SMA	File must be open			05/01/1990	1000	0.00%		0	0	0	0	0
8	Using parameters		260				08/01/1990	1000	0.00%		0	0	0	0	0
9			275				09/01/1990	1000	0.00%		0	0	0	0	0
10			0				10/01/1990	1000	0.00%		0	0	0	0	0
11			0				11/01/1990	1000	0.00%		0	0	0	0	0
12			0				12/01/1990	1000	0.00%		0	0	0	0	0
13			0				15/01/1990	1000	0.00%		0	0	0	0	0
14	Open, High, Low & Close?		Y				16/01/1990	1000	0.00%		0	0	0	0	0
15	Display VAMI-chart?		N				17/01/1990	1000	0.00%		0	0	0	0	0
16							18/01/1990	1000	0.00%		0	0	0	0	0
17	Annual Return			13.83%			19/01/1990	1000	0.00%		0	0	0	0	0
18	Annualized Volatility			17.26%			22/01/1990	1000	0.00%		0	0	0	0	0
19	Sharpe Ratio			0.801			23/01/1990	1000	0.00%		0	0	0	0	0
20							24/01/1990	1000	0.00%		0	0	0	0	0

Figure 9: Screenshot of the "Cockpit" Sheet

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	F		
1	900	30	30	1	1	1	1	Number of parameter values for every variable										
2	Total combinations (30 x 30)	Par 1	Par 2	Par 3	Par 4	Par 5	Par 6											
3		30	30	0	0	0	0	The optimised table										
4								5	15	25	35	45						
5	Chosen parameter values	1	5					1	-0.278	0.113	0.106	0.187	0.179					
6		10	15					10	0.015	0.002	0.066	0.211	0.338					
7		20	25					20	-0.025	-0.069	0.108	0.194	0.179					
8		30	35					30	-0.021	-0.216	-0.011	0.163	0.016					
9	Button to start optimisation	40	45					40	-0.143	-0.261	-0.146	0.071	-0.113					
10		50	55					50	-0.220	-0.281	-0.075	0.123	-0.143					
11		60	65					60	-0.291	-0.300	-0.099	-0.146	-0.311					
12		70	75					70	-0.327	-0.243	-0.148	-0.193	-0.273					
13		80	85					80	-0.315	-0.293	-0.186	-0.239	-0.272					
14		90	95					90	-0.377	-0.296	-0.234	-0.282	-0.252					
15		100	105					100	-0.332	-0.297	-0.249	-0.217	-0.172					

Figure 10: Screenshot of the "Optimiser" Sheet

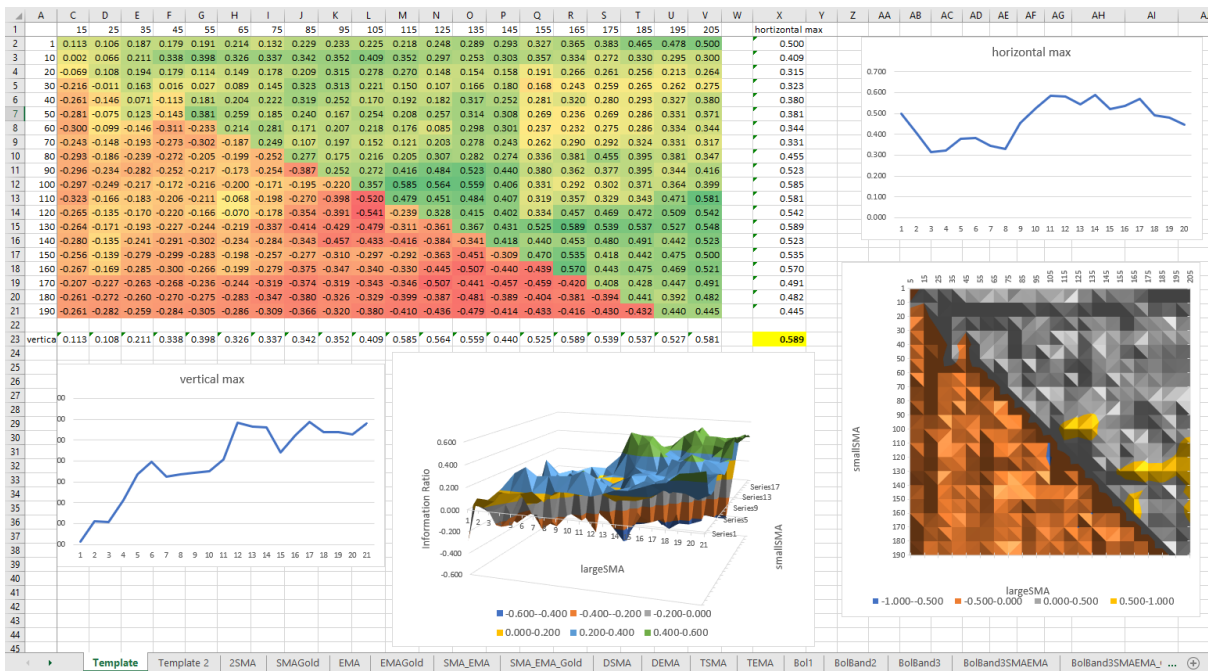


Figure 11: Screenshot of the results file "DJ_opt"

	A	B	C	D	E	F	G	H	I	J	K	L	M
1			Carry	Ultimate	max	SMA	SMA	SMA	SMAGold	SMAGold	SMAGold	EMA	EMA
2	Parameter 1					260	220	110	220	260	1	170	200
3	Parameter 2					275	255	245	255	275	205	255	225
4	Parameter 3												
5													
6	Average Daily Return		0.083%	0.078%	0.099%	0.052%	0.049%	0.043%	0.067%	0.067%	0.059%	0.038%	0.038%
7	Annual Return		23.08%	21.56%	28.19%	13.83%	13.10%	11.47%	18.11%	18.19%	15.82%	10.05%	9.92%
8	Annualized Volatility		21.71%	13.29%	19.81%	17.26%	17.45%	17.45%	14.99%	15.11%	14.03%	17.67%	17.69%
9													
10	Sharpe Ratio		1.063	1.622	1.46	0.801	0.751	0.657	1.209	1.203	1.128	0.569	0.561
11													
12	Hit Ratio		52.69%	53.82%	53.66%	51.86%	52.14%	51.49%	52.81%	52.44%	52.43%	52.11%	52.18%
13	Net Profit		261136	279666	#####	31035	25057	15794	108392	109859	62156	10251	9833
14	Net Return												
15	Expectancy												
16	Profit Factor												
17	Average Gain		0.51%	0.32%	0.473%	0.37%	0.37%	0.37%	0.33%	0.33%	0.31%	0.38%	0.38%
18	Average Loss		-0.43%	-0.24%	-0.374%	-0.32%	-0.32%	-0.33%	-0.27%	-0.26%	-0.25%	-0.34%	-0.34%
19	Largest Gain		18%	10%	17.758%	18%	12%	13%	12%	18%	18%	7%	7%
20	Largest Loss		-14%	-8%	-17.019%	-12%	-17%	-17%	-13%	-13%	-6%	-17%	-17%
21	Realized RR												
22	Minimum		955	988		1000	954	968	953	1000	958	963	965
23	Maximum		263228	282643		49976	35528	20315	116974	124399	63156	12842	12370
24													
25	Maximum Drawdown (MDD)		0%	0%	0.000%	0%	0%	0%	0%	0%	0%	0%	0%
26	Calmar Ratio		#DIV/0!	#DIV/0!	0.000%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
27													
28	Sharpe Ratio												
29	Downside Annualized Volatility		12.83%	7.58%		10.80%	11.15%	11.04%	8.97%	9.05%	8.18%	11.64%	11.67%
30	Sortino Ratio		1.799	2.845	2.596	1.281	1.175	1.039	2.019	2.009	1.933	0.863	0.850
31													
32													
33													
34													
35													
36													
37	Total trades		7559	7559		7559	7559	7559	7559	7559	7559	7559	7559
38													
39	Profitable Trades		3983	4068		3920	3941	3892	3992	3964	3963	3939	3944
40	Not profitable Trades		3325	3240		3367	3366	3416	3267	3285	3327	3369	3364
41	No Trades		251	251		272	252	251	300	310	269	251	251
42													
43	Prof - Not Prof Trades		658	828		553	575	476	725	679	636	570	580
44													
45	Final VAMI		262136	280666		32035	26057	16794	109392	110859	63156	11251	10833
46													
47	Count? 1 = count				5								
48					0								
49													

Figure 12: Screenshot of "DJ_Overview" file

	Carry	Ultimate	SMA	SMA Gold	EMA	EMA Gold	SMA EMA	SMA EMA Gold	DSMA	DEMA	T SMA	TEMA
Parameter 1			260	220	170	170	170	170	120	220	160	330
Parameter 2			275	255	255	255	250	250	405	235	445	415
Sharpe Ratio	1.1	1.6	0.8	1.2	0.6	1.1	0.8	1.2	0.6	0.6	0.4	0.6
Sortino Ratio	1.8	2.8	1.3	2.0	0.9	1.8	1.2	2.1	1.1	0.9	0.7	1.0
Hit Ratio	0.53	0.54	0.52	0.53	0.52	0.53	0.52	0.53	0.46	0.50	0.43	0.50
Net Return	262136	280666	32035	109392	11251	71953	30715	116705	15264	10800	5213	11606
Annual Return	23%	22%	14%	18%	10%	16%	14%	18%	11%	10%	7%	10%
Annualized Volatility	22%	13%	17%	15%	18%	14%	18%	15%	17%	18%	16%	17%
Downside Annualized Volatility	13%	8%	11%	9%	12%	9%	11%	9%	10%	11%	10%	10%
Largest Gain	18%	10%	18%	12%	7%	8%	13%	12%	18%	18%	18%	18%
Largest Loss	-14%	-8%	-12%	-13%	-17%	-13%	-17%	-7%	-10%	-10%	-9%	-10%
Counted for the Ultimate Strategy	Total 5											

	Carry	Ultimate	Bol Band 2	Bol Band 3	Bol Band 3 SMA EMA	Keltner	Keltner SMA EMA	Keltner SMA EMA Gold	Donchian	Donchian SMA	Donchian SMA Gold	Aroon Oscillator
Parameter 1			80	190	180	20	180	140	5	1	4	5
Parameter 2			50	50	5	50	60	60	200	80	80	140
Sharpe Ratio	1.1	1.6	1.0	1.4	1.4	0.9	1.3	1.3	1.1	1.2	1.4	0.6
Sortino Ratio	1.8	2.8	1.6	2.4	2.5	1.4	2.3	2.2	1.9	2.0	2.3	1.1
Hit Ratio	0.53	0.54	0.51	0.53	0.53	0.52	0.53	0.53	0.53	0.53	0.54	0.49
Net Return	262136	280666	61229	480753	965389	48450	309475	312250	214104	314741	314741	13523
Annual Return	23%	22%	16%	25%	28%	15%	23%	23%	20%	21%	23%	10%
Annualized Volatility	22%	13%	17%	18%	20%	17%	18%	18%	17%	18%	17%	16%
Downside Annualized Volatility	13%	8%	10%	10%	11%	11%	10%	10%	10%	11%	10%	9%
Largest Gain	18%	10%	18%	18%	18%	9%	18%	18%	18%	18%	18%	17%
Largest Loss	-14%	-8%	-13%	-13%	-7%	-17%	-7%	-7%	-13%	-13%	-14%	-13%
Counted for the Ultimate Strategy	Total 5		1		1	1					1	1

Figure 13: Overview of the Results of the most important strategies

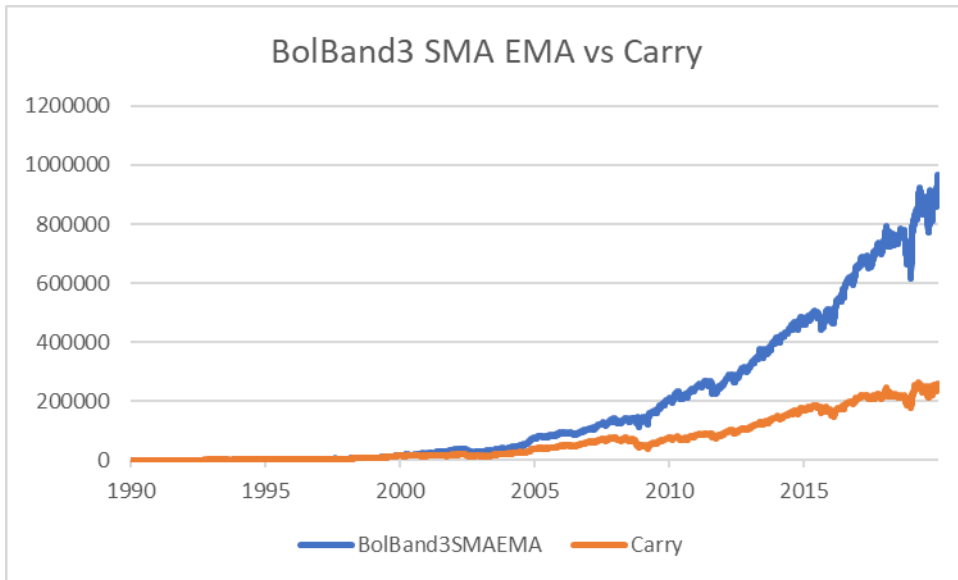


Figure 14: The best single strategy “BolBand 3 SMA EMA” vs “Carry” Strategy

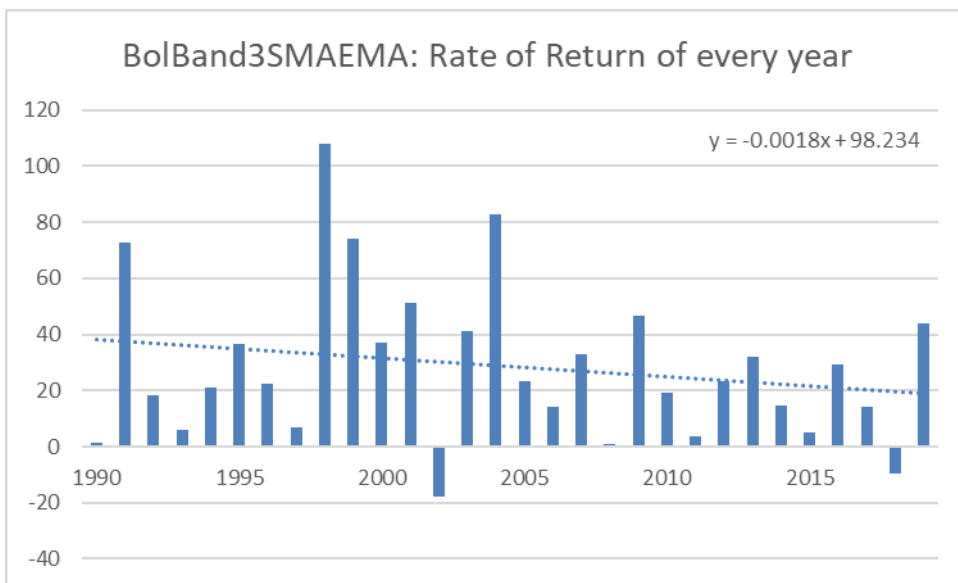


Figure 15: “BolBand 3 SMA EMA” Strategy Rate of Return every year

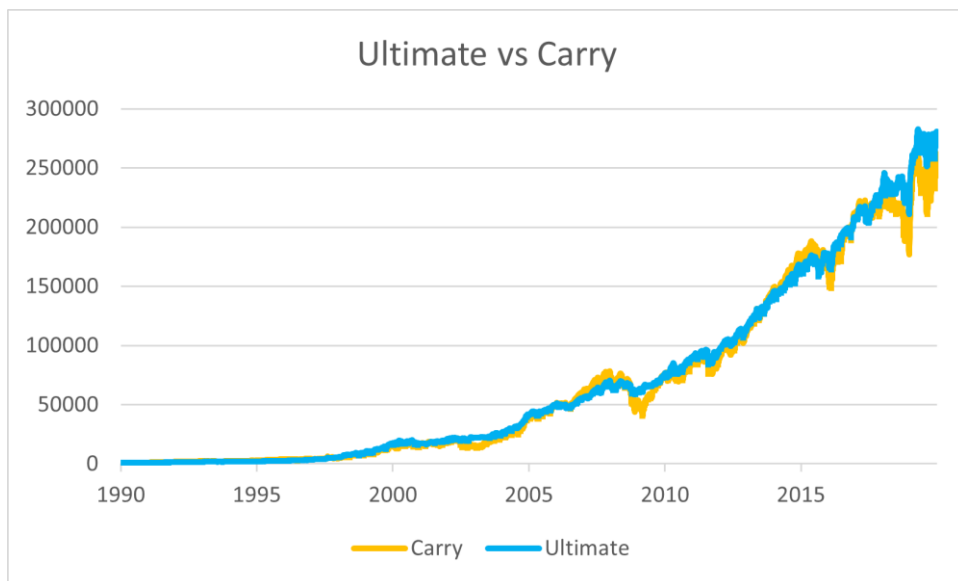


Figure 16: “Ultimate” Strategy vs “Carry” Strategy

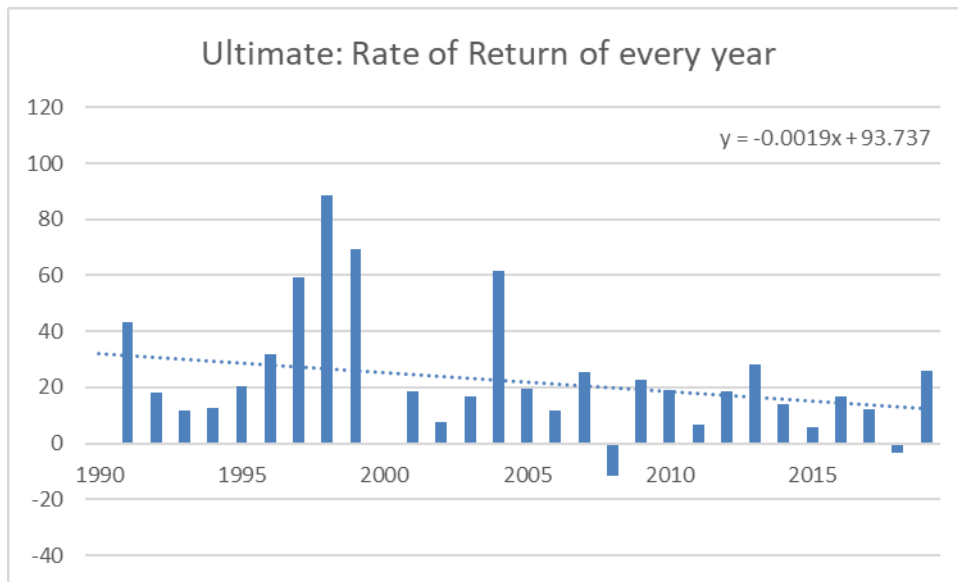


Figure 17: "Ultimate" Strategy Rate of Return every year

	Carry (buy and hold)	BolBand3SMAEMA	Ultimate
Annual Return	23%	28%	22%
Annualized Volatility	22%	20%	13%
Downside Annualized Volatility	13%	11%	8%
Hit Ratio	53%	53%	54%
Sortino Ratio	1.8	2.5	2.8
Sharpe Ratio	1.1	1.4	1.6

Figure 18: Comparison of the strategies according to evaluation metrics

	SMA	SMA Gold	EMA	EMA Gold	SMA EMA	SMA EMA Gold	DSMA	DEMA	TSMA	TEMA
Lookback for shorter MA	260	220	170	170	170	170	120	220	160	330
Lookback for longer MA	275	255	255	255	250	250	405	235	445	415

Figure 19: Lookbacks for various MAs

Backtesting	Chosen Dataset (50 DJI stocks)	Different Dataset (e.g. 50 S&P500 stocks)
Chosen Timeframe (1990-2019)	Done	Pending
Different Timeframe (e.g. 2020-21)	Pending	Pending

Figure 20: Possible backtesting on unoptimised data

Overview of chosen stocks

	Stock	In current DJI	Data available from	Data available till
1	AAPL	Yes	1990	2019
2	AMGN	Yes	1990	2019
3	AXP	Yes	1990	2019
4	BA	Yes	1990	2019
5	CAT	Yes	1990	2019
6	CRM	Yes	2004	2019
7	CSCO	Yes	1990	2019
8	CVX	Yes	1990	2019
9	DIS	Yes	1990	2019
10	DOW	Yes	2019	2019
11	GS	Yes	1999	2019
12	HD	Yes	1990	2019
13	HON	Yes	1990	2019
14	IBM	Yes	1990	2019
15	INTC	Yes	1990	2019
16	JNJ	Yes	1990	2019
17	JPM	Yes	1990	2019
18	KO	Yes	1990	2019
19	MCD	Yes	1990	2019
20	MMM	Yes	1990	2019
21	MRK	Yes	1990	2019
22	MSFT	Yes	1990	2019
23	NKE	Yes	1990	2019
24	PG	Yes	1990	2019
25	TRV	Yes	1990	2019
26	UNH	Yes	1990	2019
27	V	Yes	2008	2019
28	VZ	Yes	1990	2019
29	WBA	Yes	1990	2019
30	WMT	Yes	1990	2019
31	AA	No	1990	2019
32	AIG	No	1990	2019
33	BAC	No	1990	2019
34	C	No	1990	2019
35	GE	No	1990	2019
36	GT	No	1990	2019
37	HPE	No	2015	2019
38	INCO	No	2011	2019
39	IP	No	1990	2019
40	JBSAY	No	2010	2019
41	KODK	No	2013	2019
42	MO	No	1990	2019
43	NAV	No	1990	2019
44	OI	No	1991	2019
45	PFE	No	1990	2019
46	RTX	No	1990	2019
47	SHLDQ	No	2003	2019
48	T	No	1990	2019
49	VNTR	No	2017	2019
50	XOM	No	1990	2019

Formulas for stock weighting

General formula for Standard Deviation

$$\text{Standard Deviation} = \sqrt{\frac{\sum_{i=1}^n (x_i - x)^2}{n - 1}}$$

where:

x_i = Value of the i^{th} point in the data set

x = The mean value of the data set

n = The number of data points in the data set

Step 1: Price delta

$$A_{\text{delta } n} = A_n - A_{n-1}$$

where:

A_n = Adjusted Close today

A_{n-1} = Adjusted Close yesterday

Step 2: Standard deviation of price delta (price difference of today and yesterday) of the last 250 days

$$\text{STD} = \sqrt{\frac{\sum_{n=1}^{250} (A_{\text{delta } n} - A_{\text{delta mean}})^2}{250 - 1}}$$

where:

$A_{\text{delta } n}$ = Value of the delta on n^{th} day

A_{mean} = The mean value of the delta of the past 250 days

Step 3: Inverse of STD

$$\text{STD}_{\text{inv } n} = \frac{1}{\text{STD } n}$$

Step 4: Final weighting of day n

$$\text{Weighting on day } n = \frac{\text{STD}_{\text{inv } n}}{\text{Sum of all } \text{STD}_{\text{inv } n}}$$

Formula for Value Added Monthly Index (VAMI)

$$\text{VAMI}_n = \text{VAMI}_{n-1} * (1 + \text{Current Month's Net Return})$$

Formula for Sharpe Ratio (SR)

$$\text{SR} = \frac{\text{Annual return rate} - \text{Risk free rate}}{\text{Annualised volatility rate}}$$

$$\text{Annual return rate} = (\text{Average daily return rate} - 1)^{250} - 1$$

$$\text{Annualised volatility rate} = (\text{Standard deviation of the return rate}) * \sqrt{250}$$

Python program to acquire historical data

```
1 # 1. Importing necessary packages
2
3 import csv
4 from pandas_datareader import data
5
6
7 # 2. Defining the csv file as "DataFiles"
8
9 DataFiles = ['DJ_tickers.csv']
10
11
12 # 3. Creating a names list
13
14 names = []
15
16
17 # 4. Appending the symbols from the csv to the list "names[]"
18
19 with open('DJ_tickers.csv', 'r') as file:
20     reader = csv.reader(file, delimiter = ',')
21     next(reader)
22     for row in reader:
23         symbol = str(row[0])
24         names.append(symbol)
25
26 print(names)
27
28
29 # 5. Specifying time range
30
31 start_date = '1990-01-01'
32 end_date = '2020-01-01'
33
34
35 # 6. Use pandas_datareader.data.DataReader to load the desired data.
36 #     Finds: 'Adj Close', 'Close', 'High', 'Low', 'Open', 'Volume'
37
38 S = data.DataReader(names, 'yahoo', start_date, end_date)
39
40
41 # 7. Save adjusted close to CSV.
42
43 filename = 'DJ_data_'+start_date+'_to_'+end_date+'.csv'
44
45
46 # 8. If only the Adj Close (or High, Low, Close, Open) is needed
47 #     one can add this last command to append only the chosen values
48
49 S['Adj Close'].to_csv(filename) # for only adjusted closing prices
```