Exploring the relationship between Bitcoin and MicroStrategy

Word Count: 2199

Introduction:

The purpose of the model is to explore the relationship between the price growth of Bitcoin (BTC) and MicroStrategy (MSTR) from 11/08/2020 to 09/12/2023 (dates based on BTC raw dataset), with some references to NASDAQ composite to explore how the volatility of MSTR and price behaviour differs from other stocks. MicroStrategy is a business intelligence company that provides mobile software and cloud-based services. MicroStrategy also owns over 174,000 Bitcoin or 0.83% of the total supply of Bitcoin, and is valued at over $5 billion with regular purchases pushing this value even higher (Tuwiner, 2023). This is significant because such a large portion of the companies net worth is invested into Bitcoin, to such an extent that every 1 in 120 Bitcoin is owned by MicroStrategy. Therefore the rationale behind the model is to explore whether the price growth of Bitcoin impacts the price growth of MSTR, due to their large holding of Bitcoin. This can be described as a business analytics issue and is suitable for modelling because MSTR may be at risk of fluctuations in the cryptocurrency market, therefore impacting financial performance regardless of true company performance, and shareholder value and confidence. The key aim of the model and report is to not only explore the relationship between BTC and MSTR but also provide the stakeholders of MSTR with the empirical impact of the price growth of BTC on the price growth of MSTR, so they can make more informed financial decisions.

Objectives of the model:

1. Determine the strength of the relationship between the price growth of BTC and the price growth of MSTR
    a. Measured using Pearson's Correlation Coefficient (r), and the Coefficient of Determination (r^2) to determine how well the statistical model explains the variance of the dependent variable (MSTR) (Brooks, 2018)
    b. Visualised using a Line Graph and Scatter Plot
2. Compare the daily volatility of MSTR to NASDAQ
    a. Measured using summary statistics such as mean and standard deviation
    b. Visualised using Histograms, Normal Q-Q Plots and Detrended Normal Q-Q Plots
3. Draw empirical conclusions to provide stakeholders with useful insights for decision-making

Data sources, types, units, pre-processing and data cleaning:

Sources:

The source used to collect BTC data is Coinmetrics, and the source used to collect MSTR and NASDAQ data is Yahoo Finance. Both sources are highly trusted and reliable platforms for financial trading data.

Types & Units:

Each dataset uses the date data type to represent the daily data. All other variables in each dataset are floating points that allow the variables to be continuous, meaning that they can

take any value. This is particularly useful for trading related data as this data type reflects small price changes, enabling accurate and insightful calculations and visualisations. The units used for the date variable is DD/MM/YYYY, the units used for all other variables are USD and are either positive, negative or zero. As part of the pre-processing steps in Excel, all variables excluding Date/Time are transformed into a different unit: percentage, and are still the floating point/continuous data type. The process is broken down in the next section.

Pre-processing steps in Excel:

1. Raw data in Excel:

BTC dataset

Time	BTC / Price, USD
11/08/2020	11392.64
12/08/2020	11575.51
13/08/2020	11773.45
14/08/2020	11774.41
15/08/2020	11866.91
16/08/2020	11899.64
17/08/2020	12315.76
18/08/2020	11992.7
19/08/2020	11736.85
20/08/2020	11867.52
21/08/2020	11524.7
22/08/2020	11682.29
23/08/2020	11665.61
24/08/2020	11771.41
25/08/2020	11358.45
26/08/2020	11472.05
27/08/2020	11314.67
28/08/2020	11527.88
29/08/2020	11490.76
30/08/2020	11698.98
31/08/2020	11678.35
01/09/2020	11970.36
02/09/2020	11414.52
03/09/2020	10261.49
04/09/2020	10471.97
05/09/2020	10128.64
06/09/2020	10253.3
07/09/2020	10367.88
08/09/2020	10108.64
09/09/2020	10223.11
10/09/2020	10334.63

BTC_Raw_Data

MSTR dataset

Date	Open	High	Low	Close	Adj Close	Volume
11/08/2020	141.99	145.43	134.79	134.89	134.89	333900
12/08/2020	135.02	140.75	135.02	137.04	137.04	180700
13/08/2020	138.48	139.35	136.85	137	137	75200
14/08/2020	137.62	146.75	137.5	146.63	146.63	285700
17/08/2020	148.01	151.7	141.84	143.84	143.84	229500
18/08/2020	144.44	145.98	141.75	143.14	143.14	121800
19/08/2020	143.39	143.39	139.72	141.67	141.67	156000
20/08/2020	141.75	145.06	141.75	144.14	144.14	100700
21/08/2020	144.4	145.92	143.54	145.08	145.08	73500
24/08/2020	146.5	149.28	145.36	148.58	148.58	88000
25/08/2020	148.7	150.29	146.55	146.96	146.96	116500
26/08/2020	148.68	148.96	145.76	146.06	146.06	82000
27/08/2020	147.33	147.62	144.14	146.52	146.52	76100
28/08/2020	147.49	150.46	146.68	146.89	146.89	83900
31/08/2020	147.26	147.96	143.99	144.44	144.44	80300
01/09/2020	145.01	149.1	145.01	148.82	148.82	86300
02/09/2020	148.46	151.23	147.74	150	150	100500
03/09/2020	148.75	148.75	143.91	144.28	144.28	79000
04/09/2020	144.41	144.41	136.89	142.19	142.19	124800
08/09/2020	140.61	143.15	138.82	138.82	138.82	88400
09/09/2020	139.83	142.35	139	141.15	141.15	140700
10/09/2020	141.72	143.09	139.44	139.72	139.72	148700
11/09/2020	140.87	141.41	138.84	141.13	141.13	116400
14/09/2020	141.63	143.04	140.21	142.62	142.62	69400
15/09/2020	145	155.99	143.81	155.75	155.75	262100
16/09/2020	158.94	176.56	157.75	174.9	174.9	459600
17/09/2020	173.4	173.4	162.59	163.61	163.61	179700
18/09/2020	165.52	166.17	157.44	159.59	159.59	347000
21/09/2020	157.7	157.7	149.21	152.16	152.16	159700
22/09/2020	153.37	154.65	149.39	154.25	154.25	89700
23/09/2020	153.8	154.77	148.11	148.28	148.28	111700

MSTR_Raw_Data

NASDAQ dataset

Date	Open	High	Low	Close	Adj Close	Volume
11/08/2020	10942.66	10989.42	10762.71	10782.82	10782.82	4.33E+09
12/08/2020	10878.12	11036.72	10877.16	11012.24	11012.24	3.75E+09
13/08/2020	11026.86	11124.85	11007.5	11042.5	11042.5	3.48E+09
14/08/2020	11042.24	11058.44	10972.06	11019.3	11019.3	3.51E+09
17/08/2020	11083.25	11144.53	11080.3	11129.73	11129.73	3.21E+09
18/08/2020	11170.75	11230.62	11103.83	11210.84	11210.84	3.23E+09
19/08/2020	11214.8	11257.42	11132.1	11146.46	11146.46	3.5E+09
20/08/2020	11096.4	11283.62	11090.03	11264.95	11264.95	4.22E+09
21/08/2020	11258.44	11326.21	11245.44	11311.8	11311.8	3.93E+09
24/08/2020	11449.25	11462.05	11297.53	11379.72	11379.72	3.91E+09
25/08/2020	11370.23	11468.26	11343.04	11466.47	11466.47	3.48E+09
26/08/2020	11516.62	11672.05	11507.46	11665.06	11665.06	3.47E+09
27/08/2020	11688.19	11730.01	11551.01	11625.34	11625.34	3.55E+09
28/08/2020	11689.28	11708.77	11634.77	11695.63	11695.63	3.01E+09
31/08/2020	11718.81	11829.84	11697.42	11775.46	11775.46	3.61E+09
01/09/2020	11850.96	11945.72	11794.78	11939.67	11939.67	3.51E+09
02/09/2020	12047.26	12074.06	11836.18	12056.44	12056.44	3.98E+09
03/09/2020	11861.9	11894.4	11361.36	11458.1	11458.1	4.47E+09
04/09/2020	11396.24	11531.18	10875.87	11313.13	11313.13	4.28E+09
08/09/2020	10900.7	11131.5	10837.2	10847.69	10847.69	3.91E+09
09/09/2020	11064.76	11217.69	10970.45	11141.56	11141.56	3.55E+09
10/09/2020	11235.53	11299.53	10875.02	10919.59	10919.59	3.84E+09
11/09/2020	11010.07	11033.04	10728.03	10853.55	10853.55	3.63E+09
14/09/2020	11010.14	11118.29	10982.26	11056.65	11056.65	3.74E+09
15/09/2020	11193.96	11244.46	11127.98	11190.32	11190.32	3.79E+09
16/09/2020	11222.08	11245.42	11046.43	11050.47	11050.47	3.68E+09
17/09/2020	10796.05	10974.45	10783.81	10910.28	10910.28	3.74E+09
18/09/2020	10973.45	10977.68	10639.95	10793.28	10793.28	5.76E+09
21/09/2020	10610.14	10782.74	10519.49	10778.8	10778.8	3.9E+09
22/09/2020	10873.3	10979.65	10737.52	10963.64	10963.64	3.52E+09
23/09/2020	10950.82	10962.03	10612.91	10632.99	10632.99	4.1E+09

NASDAQ_Raw_Data

2. Calculating Growth and Volatility:

One new variable will be added to the BTC dataset: Growth, and two new variables will be added to the MSTR and NASDAQ datasets: Growth and Volatility. All other variables (except Date/Time) will be removed post calculation. The units for Growth and Volatility variables are percentages.

BTC:

To calculate the growth of the price of BTC from 11/08/2020, the current average price minus the average price at 11/08/2020 is divided by average price at 11/08/2020 multiplied by 100.

```
=((B3-$B$2)/$B$2)*100
```

MSTR and NASDAQ:

To calculate the growth of the price of MSTR and NASDAQ from 11/08/2020, the current close minus 11/08/2020 close is divided by 11/08/2020 close and multiplied by 100.

```
=((E3-$E$2)/$E$2)*100
```

Volatility is calculated by current close minus current open divided by current open and multiplied by 100.

```
=((E2-B2)/B2)*100
```

The datasets are then merged into a new workbook using get data from Text/CSV. The data is then moved to a new sheet named “Combined_Data” where the last pre-processing step will occur.

3. Current state of the dataset:

	A	B	C	D	E	F	G	H	I
1	Date	BTC Growth			Date	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility
2	11/08/2020	0			11/08/2020	0	-5.000356187	0	-1.460703775
3	12/08/2020	1.605144324			12/08/2020	1.593886883	1.496066464	2.127642986	1.23293463
4	13/08/2020	3.342543022			13/08/2020	1.56423828	-1.068743532	2.408272442	0.141832303
5	14/08/2020	3.350970653			14/08/2020	8.703392458	6.54702102	2.193113612	-0.207751503
6	15/08/2020	4.162916582			17/08/2020	6.63503378	-2.817376624	3.217248828	0.419375815
7	16/08/2020	4.4502282			18/08/2020	6.116094641	-0.900029758	3.969458061	0.358882259
8	17/08/2020	8.102757557			19/08/2020	5.026317036	-1.199526475	3.372398311	-0.609372001
9	18/08/2020	5.267011813			20/08/2020	6.857439446	1.686066314	4.471278164	1.518959339
10	19/08/2020	3.021291346			21/08/2020	7.554305787	0.470919687	4.905761988	0.473950014
11	20/08/2020	4.168270739			24/08/2020	10.1490126	1.419796587	5.53565211	-0.607291045
12	21/08/2020	1.159123896			25/08/2020	8.948037727	-1.170134523	6.340172611	0.84641433
13	22/08/2020	2.542386629			26/08/2020	8.28082073	-1.762170516	8.181897079	1.28891505
14	23/08/2020	2.395977421			27/08/2020	8.621843788	-0.549784829	7.813535845	-0.537727293
15	24/08/2020	3.324636116			28/08/2020	8.89613766	-0.406811295	8.465406487	0.05431994
16	25/08/2020	-0.300103907			31/08/2020	7.079845111	-1.914975618	9.20575157	0.483414204
17	26/08/2020	0.696985084			01/09/2020	10.32693906	2.627413372	10.72863663	0.748546618
18	27/08/2020	-0.684392046			02/09/2020	11.20172074	1.037311685	11.81156769	0.076205379

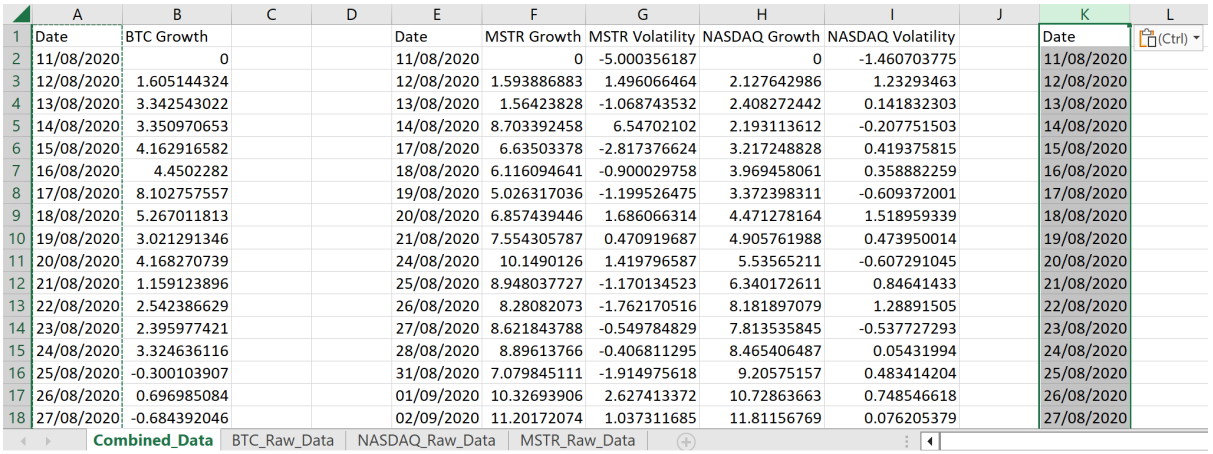
Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

	A	B	C	D	E
1	Date	BTC Growth			Date
2	11/08/2020	0			11/08/2020
3	12/08/2020	1.605144324			12/08/2020
4	13/08/2020	3.342543022			13/08/2020
5	14/08/2020	3.350970653			14/08/2020
6	15/08/2020	4.162916582			17/08/2020
7	16/08/2020	4.4502282			18/08/2020
8	17/08/2020	8.102757557			19/08/2020
9	18/08/2020	5.267011813			20/08/2020
10	19/08/2020	3.021291346			21/08/2020
11	20/08/2020	4.168270739			24/08/2020

The data needs to be processed before running the calculations and visualisations in SPSS. This is due to the fact that BTC trades 24/7, whereas MSTR and NASDAQ only trade on non-holiday weekdays. This causes the MSTR and NASDAQ Date variable to have missing values and be misaligned with BTC’s Date variable values, starting at the cells highlighted red. Creating visualisations from this data would lead to inaccurate representations.

4. Processing steps to solve the misaligned values:

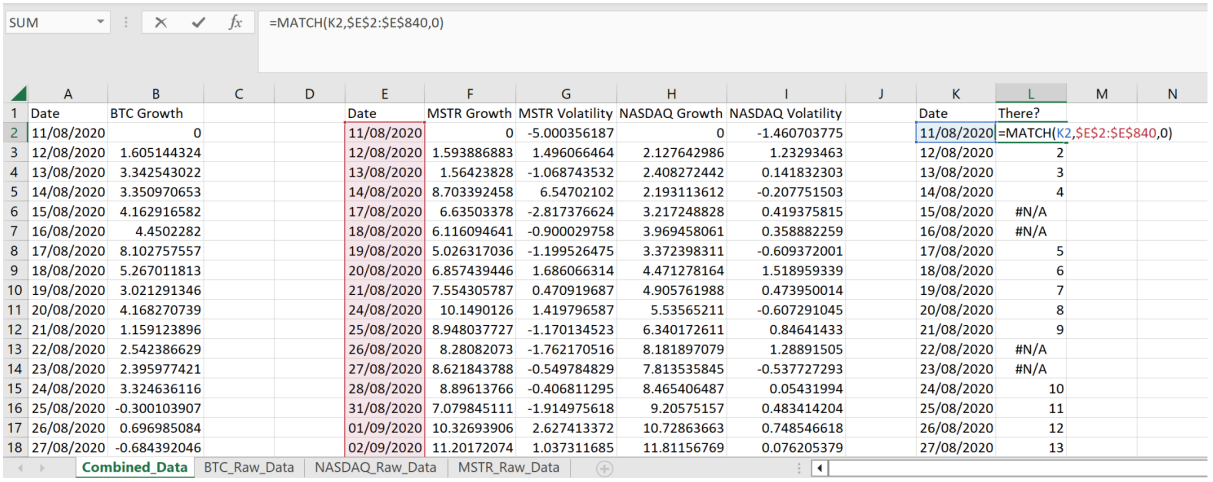
I. Add a new column (K) for Date in ascending order (copy and paste BTC Date variable values)



	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	BTC Growth			Date	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility		Date	(Ctrl)
2	11/08/2020	0			11/08/2020	0	-5.000356187	0	-1.460703775		11/08/2020	
3	12/08/2020	1.605144324			12/08/2020	1.593886883	1.496066464	2.127642986	1.23293463		12/08/2020	
4	13/08/2020	3.342543022			13/08/2020	1.56423828	-1.068743532	2.408272442	0.141832303		13/08/2020	
5	14/08/2020	3.350970653			14/08/2020	8.703392458	6.54702102	2.193113612	-0.207751503		14/08/2020	
6	15/08/2020	4.162916582			17/08/2020	6.63503378	-2.817376624	3.217248828	0.419375815		15/08/2020	
7	16/08/2020	4.4502282			18/08/2020	6.116094641	-0.900029758	3.969458061	0.358882259		16/08/2020	
8	17/08/2020	8.102757557			19/08/2020	5.026317036	-1.199526475	3.372398311	-0.609372001		17/08/2020	
9	18/08/2020	5.267011813			20/08/2020	6.857439446	1.686066314	4.471278164	1.518959339		18/08/2020	
10	19/08/2020	3.021291346			21/08/2020	7.554305787	0.470919687	4.905761988	0.473950014		19/08/2020	
11	20/08/2020	4.168270739			24/08/2020	10.1490126	1.419796587	5.53565211	-0.607291045		20/08/2020	
12	21/08/2020	1.159123896			25/08/2020	8.948037727	-1.170134523	6.340172611	0.84641433		21/08/2020	
13	22/08/2020	2.542386629			26/08/2020	8.28082073	-1.762170516	8.181897079	1.28891505		22/08/2020	
14	23/08/2020	2.395977421			27/08/2020	8.621843788	-0.549784829	7.813535845	-0.537727293		23/08/2020	
15	24/08/2020	3.324636116			28/08/2020	8.89613766	-0.406811295	8.465406487	0.05431994		24/08/2020	
16	25/08/2020	-0.300103907			31/08/2020	7.079845111	-1.914975618	9.20575157	0.483414204		25/08/2020	
17	26/08/2020	0.696985084			01/09/2020	10.32693906	2.627413372	10.72863663	0.748546618		26/08/2020	
18	27/08/2020	-0.684392046			02/09/2020	11.20172074	1.037311685	11.81156769	0.076205379		27/08/2020	

Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

II. Insert match formula in another column (L): =MATCH(K2,$E$2:$E$840,0), where K2 equals the first Date cell in step 1, $E$2:$E$840 is the column that has missing dates, and 0 means exact match. This looks up the value in each cell of column K in the lookup range E2-840, returning a number (in ascending order for each observation) if found, and #N/A if not.

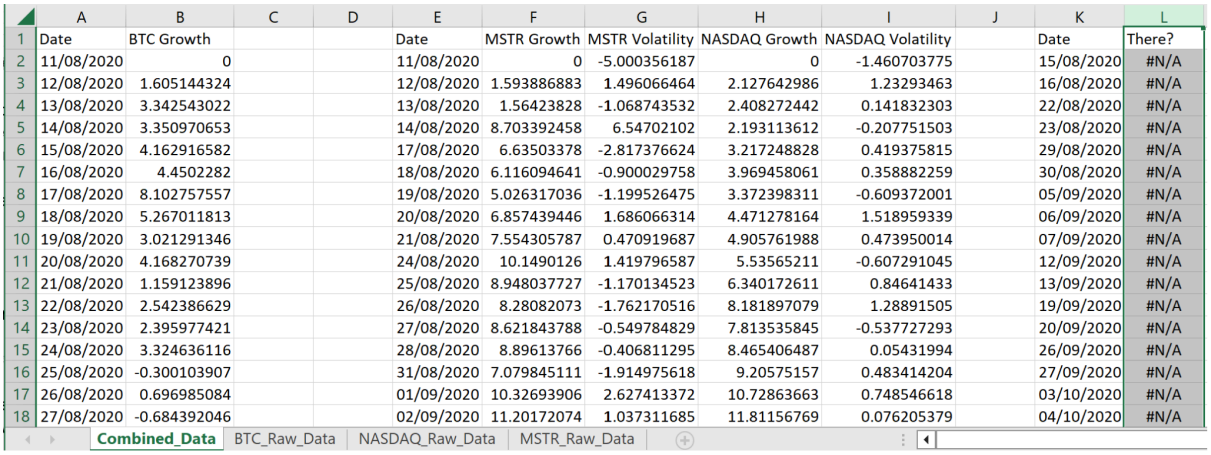


SUM | =MATCH(K2,$E$2:$E$840,0)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Date	BTC Growth			Date	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility		Date	There?		
2	11/08/2020	0			11/08/2020	0	-5.000356187	0	-1.460703775		11/08/2020	=MATCH(K2,$E$2:$E$840,0)		
3	12/08/2020	1.605144324			12/08/2020	1.593886883	1.496066464	2.127642986	1.23293463		12/08/2020	2		
4	13/08/2020	3.342543022			13/08/2020	1.56423828	-1.068743532	2.408272442	0.141832303		13/08/2020	3		
5	14/08/2020	3.350970653			14/08/2020	8.703392458	6.54702102	2.193113612	-0.207751503		14/08/2020	4		
6	15/08/2020	4.162916582			17/08/2020	6.63503378	-2.817376624	3.217248828	0.419375815		15/08/2020	#N/A		
7	16/08/2020	4.4502282			18/08/2020	6.116094641	-0.900029758	3.969458061	0.358882259		16/08/2020	#N/A		
8	17/08/2020	8.102757557			19/08/2020	5.026317036	-1.199526475	3.372398311	-0.609372001		17/08/2020	5		
9	18/08/2020	5.267011813			20/08/2020	6.857439446	1.686066314	4.471278164	1.518959339		18/08/2020	6		
10	19/08/2020	3.021291346			21/08/2020	7.554305787	0.470919687	4.905761988	0.473950014		19/08/2020	7		
11	20/08/2020	4.168270739			24/08/2020	10.1490126	1.419796587	5.53565211	-0.607291045		20/08/2020	8		
12	21/08/2020	1.159123896			25/08/2020	8.948037727	-1.170134523	6.340172611	0.84641433		21/08/2020	9		
13	22/08/2020	2.542386629			26/08/2020	8.28082073	-1.762170516	8.181897079	1.28891505		22/08/2020	#N/A		
14	23/08/2020	2.395977421			27/08/2020	8.621843788	-0.549784829	7.813535845	-0.537727293		23/08/2020	#N/A		
15	24/08/2020	3.324636116			28/08/2020	8.89613766	-0.406811295	8.465406487	0.05431994		24/08/2020	10		
16	25/08/2020	-0.300103907			31/08/2020	7.079845111	-1.914975618	9.20575157	0.483414204		25/08/2020	11		
17	26/08/2020	0.696985084			01/09/2020	10.32693906	2.627413372	10.72863663	0.748546618		26/08/2020	12		
18	27/08/2020	-0.684392046			02/09/2020	11.20172074	1.037311685	11.81156769	0.076205379		27/08/2020	13		

Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

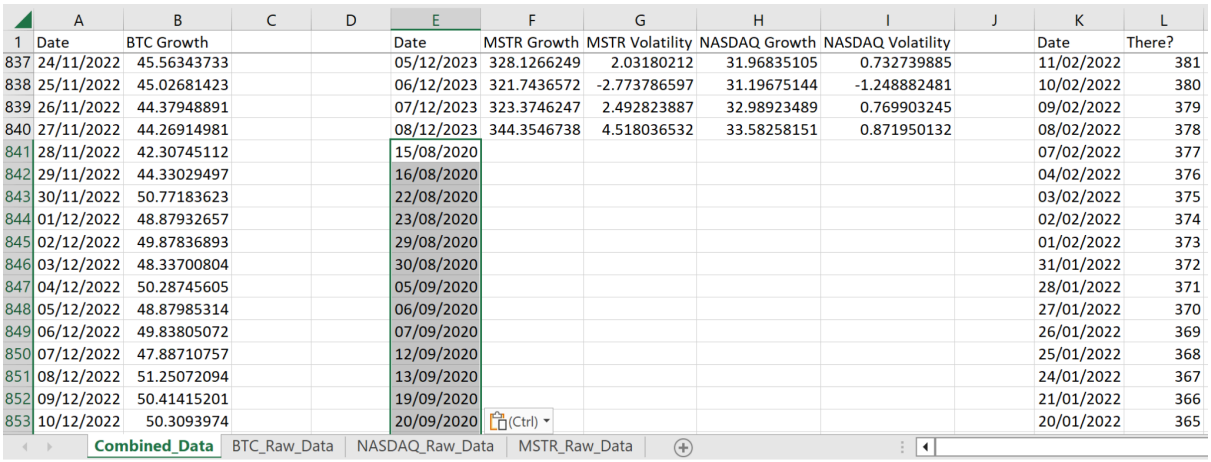
III. Select column L and sort from Z-A expanding the selection to column K. This puts all of the cells with #N/A at the top of column L and the corresponding missing dates in column K.



	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	BTC Growth			Date	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility		Date	There?
2	11/08/2020	0			11/08/2020	0	-5.000356187	0	-1.460703775		15/08/2020	#N/A
3	12/08/2020	1.605144324			12/08/2020	1.593886883	1.496066464	2.127642986	1.23293463		16/08/2020	#N/A
4	13/08/2020	3.342543022			13/08/2020	1.56423828	-1.068743532	2.408272442	0.141832303		22/08/2020	#N/A
5	14/08/2020	3.350970653			14/08/2020	8.703392458	6.54702102	2.193113612	-0.207751503		23/08/2020	#N/A
6	15/08/2020	4.162916582			17/08/2020	6.63503378	-2.817376624	3.217248828	0.419375815		29/08/2020	#N/A
7	16/08/2020	4.4502282			18/08/2020	6.116094641	-0.900029758	3.969458061	0.358882259		30/08/2020	#N/A
8	17/08/2020	8.102757557			19/08/2020	5.026317036	-1.199526475	3.372398311	-0.609372001		05/09/2020	#N/A
9	18/08/2020	5.267011813			20/08/2020	6.857439446	1.686066314	4.471278164	1.518959339		06/09/2020	#N/A
10	19/08/2020	3.021291346			21/08/2020	7.554305787	0.470919687	4.905761988	0.473950014		07/09/2020	#N/A
11	20/08/2020	4.168270739			24/08/2020	10.1490126	1.419796587	5.53565211	-0.607291045		12/09/2020	#N/A
12	21/08/2020	1.159123896			25/08/2020	8.948037727	-1.170134523	6.340172611	0.84641433		13/09/2020	#N/A
13	22/08/2020	2.542386629			26/08/2020	8.28082073	-1.762170516	8.181897079	1.28891505		19/09/2020	#N/A
14	23/08/2020	2.395977421			27/08/2020	8.621843788	-0.549784829	7.813535845	-0.537727293		20/09/2020	#N/A
15	24/08/2020	3.324636116			28/08/2020	8.89613766	-0.406811295	8.465406487	0.05431994		26/09/2020	#N/A
16	25/08/2020	-0.300103907			31/08/2020	7.079845111	-1.914975618	9.20575157	0.483414204		27/09/2020	#N/A
17	26/08/2020	0.696985084			01/09/2020	10.32693906	2.627413372	10.72863663	0.748546618		03/10/2020	#N/A
18	27/08/2020	-0.684392046			02/09/2020	11.20172074	1.037311685	11.81156769	0.076205379		04/10/2020	#N/A

Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

IV. Copy the missing dates denoted by #N/A and paste them at the end of the MSTR and NASDAQ Date variable (Column E).

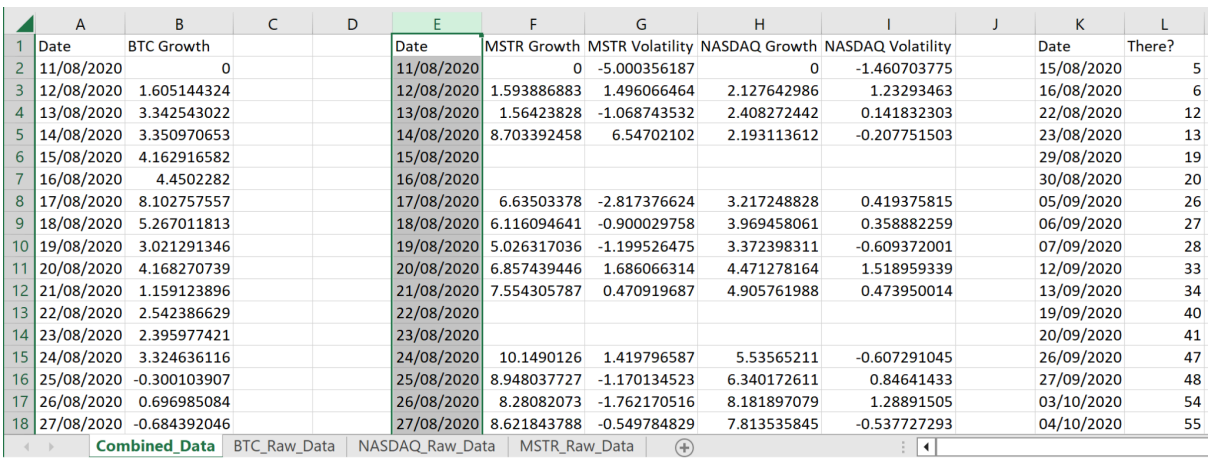


	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	BTC Growth			Date	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility		Date	There?
837	24/11/2022	45.56343733			05/12/2023	328.1266249	2.03180212	31.96835105	0.732739885		11/02/2022	381
838	25/11/2022	45.02681423			06/12/2023	321.7436572	-2.773786597	31.19675144	-1.248882481		10/02/2022	380
839	26/11/2022	44.37948891			07/12/2023	323.3746247	2.492823887	32.98923489	0.769903245		09/02/2022	379
840	27/11/2022	44.26914981			08/12/2023	344.3546738	4.518036532	33.58258151	0.871950132		08/02/2022	378
841	28/11/2022	42.30745112			15/08/2020						07/02/2022	377
842	29/11/2022	44.33029497			16/08/2020						04/02/2022	376
843	30/11/2022	50.77183623			22/08/2020						03/02/2022	375
844	01/12/2022	48.87932657			23/08/2020						02/02/2022	374
845	02/12/2022	49.87836893			29/08/2020						01/02/2022	373
846	03/12/2022	48.33700804			30/08/2020						31/01/2022	372
847	04/12/2022	50.28745605			05/09/2020						28/01/2022	371
848	05/12/2022	48.87985314			06/09/2020						27/01/2022	370
849	06/12/2022	49.83805072			07/09/2020						26/01/2022	369
850	07/12/2022	47.88710757			12/09/2020						25/01/2022	368
851	08/12/2022	51.25072094			13/09/2020						24/01/2022	367
852	09/12/2022	50.41415201			19/09/2020						21/01/2022	366
853	10/12/2022	50.3093974			20/09/2020						20/01/2022	365

(Ctrl)

Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

V. Sort the MSTR and NASDAQ date variable in ascending order and expand the selection to columns F to I.



	A	B	C	D	E	F	G	H	I	J	K	L
1	Date	BTC Growth			Date	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility		Date	There?
2	11/08/2020	0			11/08/2020	0	-5.000356187	0	-1.460703775		15/08/2020	5
3	12/08/2020	1.605144324			12/08/2020	1.593886883	1.496066464	2.127642986	1.23293463		16/08/2020	6
4	13/08/2020	3.342543022			13/08/2020	1.56423828	-1.068743532	2.408272442	0.141832303		22/08/2020	12
5	14/08/2020	3.350970653			14/08/2020	8.703392458	6.54702102	2.193113612	-0.207751503		23/08/2020	13
6	15/08/2020	4.162916582			15/08/2020						29/08/2020	19
7	16/08/2020	4.4502282			16/08/2020						30/08/2020	20
8	17/08/2020	8.102757557			17/08/2020	6.63503378	-2.817376624	3.217248828	0.419375815		05/09/2020	26
9	18/08/2020	5.267011813			18/08/2020	6.116094641	-0.900029758	3.969458061	0.358882259		06/09/2020	27
10	19/08/2020	3.021291346			19/08/2020	5.026317036	-1.199526475	3.372398311	-0.609372001		07/09/2020	28
11	20/08/2020	4.168270739			20/08/2020	6.857439446	1.686066314	4.471278164	1.518959339		12/09/2020	33
12	21/08/2020	1.159123896			21/08/2020	7.554305787	0.470919687	4.905761988	0.473950014		13/09/2020	34
13	22/08/2020	2.542386629			22/08/2020						19/09/2020	40
14	23/08/2020	2.395977421			23/08/2020						20/09/2020	41
15	24/08/2020	3.324636116			24/08/2020	10.1490126	1.419796587	5.53565211	-0.607291045		26/09/2020	47
16	25/08/2020	-0.300103907			25/08/2020	8.948037727	-1.170134523	6.340172611	0.84641433		27/09/2020	48
17	26/08/2020	0.696985084			26/08/2020	8.28082073	-1.762170516	8.181897079	1.28891505		03/10/2020	54
18	27/08/2020	-0.684392046			27/08/2020	8.621843788	-0.549784829	7.813535845	-0.537727293		04/10/2020	55

Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

5. Transformed dataset:

This now correctly matches MSTR and NASDAQ variables with the BTC Date variable and so the duplicate Date variable and “There?” column has been removed. The data has gone through the necessary pre-processing steps and can be imported into SPSS, ready to handle the missing values. The image below illustrates the transformed dataset.

	A	B	C	D	E	F	G	H	I
1	Date	BTC Growth	MSTR Growth	MSTR Volatility	NASDAQ Growth	NASDAQ Volatility			
2	11/08/2020	0	0	-5.000356187	0	-1.460703775			
3	12/08/2020	1.605144324	1.593886883	1.496066464	2.127642986	1.23293463			
4	13/08/2020	3.342543022	1.56423828	-1.068743532	2.408272442	0.141832303			
5	14/08/2020	3.350970653	8.703392458	6.54702102	2.193113612	-0.207751503			
6	15/08/2020	4.162916582							
7	16/08/2020	4.4502282							
8	17/08/2020	8.102757557	6.63503378	-2.817376624	3.217248828	0.419375815			
9	18/08/2020	5.267011813	6.116094641	-0.900029758	3.969458061	0.358882259			
10	19/08/2020	3.021291346	5.026317036	-1.199526475	3.372398311	-0.609372001			
11	20/08/2020	4.168270739	6.857439446	1.686066314	4.471278164	1.518959339			
12	21/08/2020	1.159123896	7.554305787	0.470919687	4.905761988	0.473950014			
13	22/08/2020	2.542386629							
14	23/08/2020	2.395977421							
15	24/08/2020	3.324636116	10.1490126	1.419796587	5.53565211	-0.607291045			
16	25/08/2020	-0.300103907	8.948037727	-1.170134523	6.340172611	0.84641433			
17	26/08/2020	0.696985084	8.28082073	-1.762170516	8.181897079	1.28891505			
18	27/08/2020	-0.684392046	8.621843788	-0.549784829	7.813535845	-0.537727293			

Combined_Data | BTC_Raw_Data | NASDAQ_Raw_Data | MSTR_Raw_Data

Note that the growth variables start at zero, this is because they represent the growth from 11/08/2020 (current observation) and thus equals zero percent. The individual data sheets were subsequently removed.

Data cleaning in SPSS:

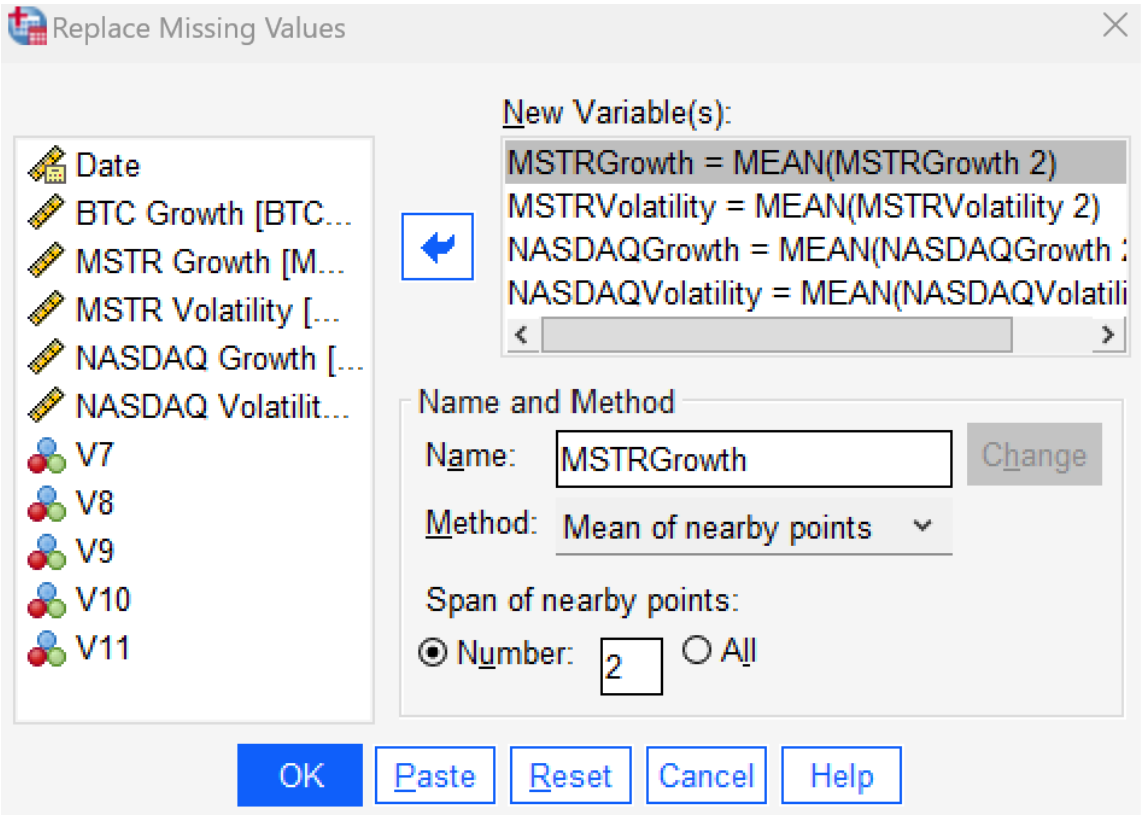
1. **Missing values:**

MSTR and NASDAQ missing values:

The variables associated with MSTR and NASDAQ have a clear missing values pattern representing the weekends and holidays in which the stocks are not available for trade, thus no data has been collected.

2. **Dealing with the missing values:**

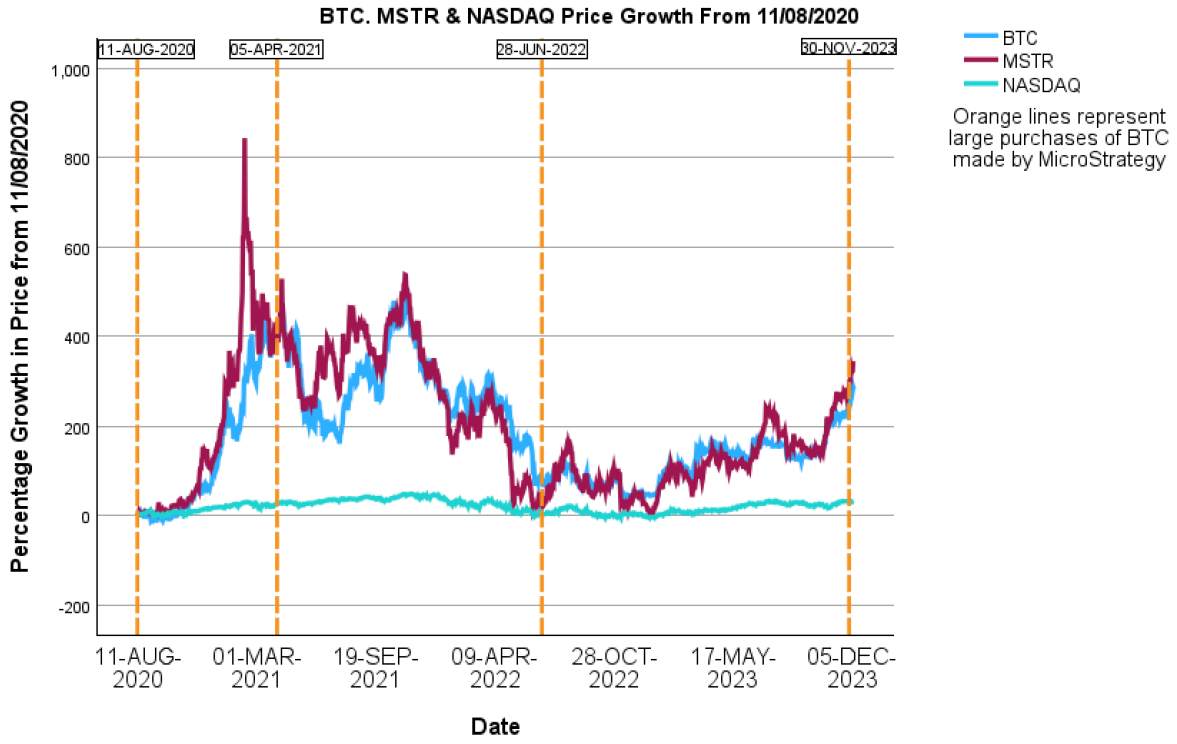
To deal with the missing values for each variable the missing values will be replaced with the average of the nearby values.



Each variable with missing values has been added to the replace missing values handler. The method used is 'Mean of nearby points' specifying the span of nearby points is 2. The span of nearby points is the number of valid values above and below the missing value used to compute the mean (IBM, 2021). A relatively low span of 2 has been chosen in order to capture the trend of nearby data points, providing more insightful visualisations. However, the values in the final observation 1216 for variables MSTRGrowth, MSTRVolatility, NASDAQGrowth and NASDAQVolatility are still missing due to the span being too large (as several of the final values were missing), this is manually replaced by the mean of the four preceding observations. All pre-processing steps in Excel and SPSS have been completed, allowing the business analytics model to be created.

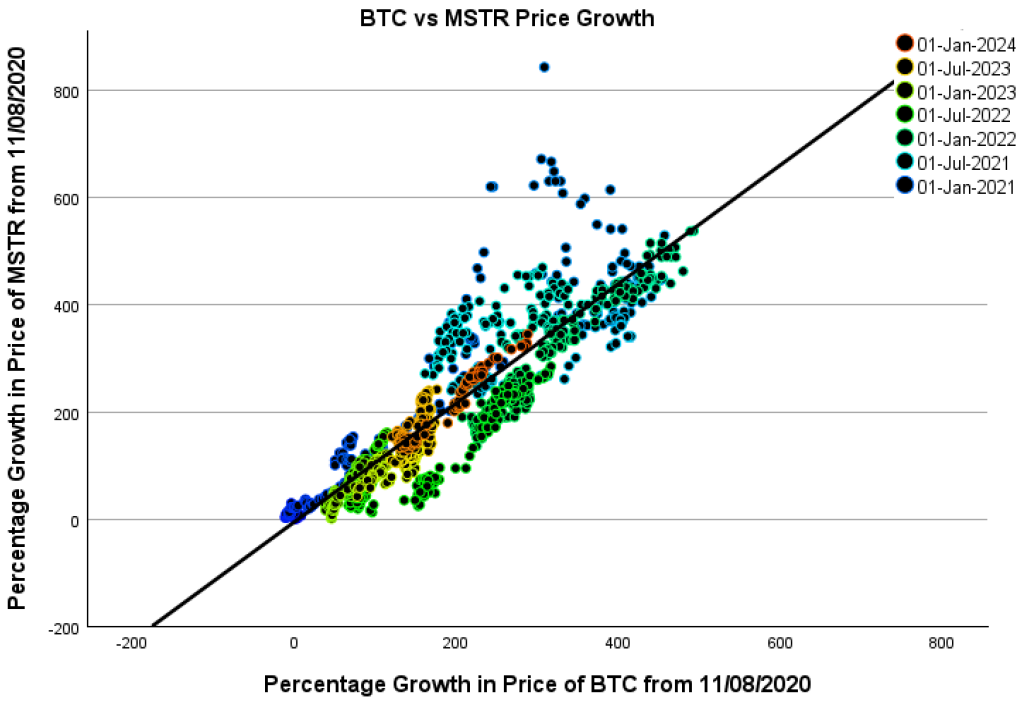
Model outputs:

1. Multi-line graph



The multi-line graph shows the percentage growth in price of variables BTC, MSTR and NASDAQ from 11/08/2020 to 09/12/2023, with reference lines showing when MicroStrategy made large purchases of Bitcoin. The key takeaways from this visualisation include; the price growth of MSTR is significantly higher and more volatile than NASDAQ shown by the extreme fluctuations in the plotted lines, and visually, MSTR closely mirrors the price growth of BTC, suggesting that they are likely correlated.

2. Scatter plot



The scatter plot shows the price growth of MSTR and the price growth of BTC from 11/08/2020, coloured by date. It is clear that the data points follow a positive correlation as shown by the fitted trend line. Another interesting part of the visualisation is that both variables experienced high growth between 01-Jan-2021 and 01-Jan-2022. This is likely due to the fact that Bitcoin experienced a large price increase, with the price rising from $34,000 in January 2021 to an all-time-high of $65,000 in November 2021 (Statista, 2023).

3. Correlations

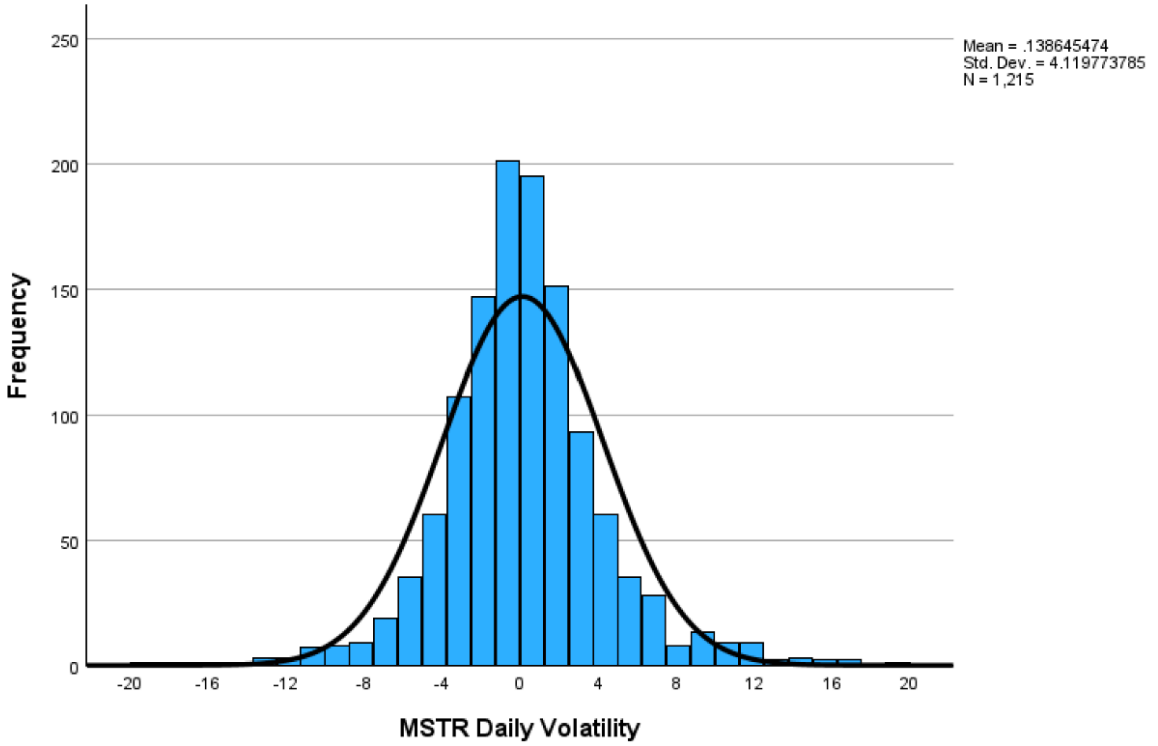
Correlations

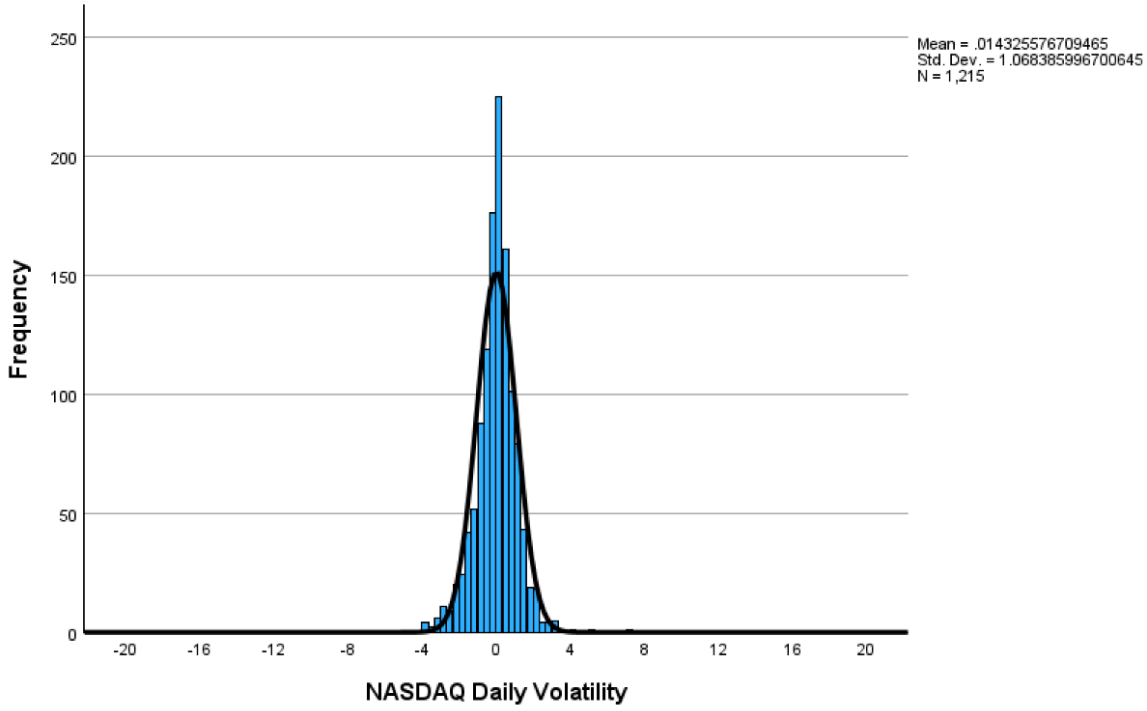
		BTC Growth	MEAN (MSTRGrowth, 2)
BTC Growth	Pearson Correlation	1	.900**
	Sig. (2-tailed)		<.001
	N	1216	1215
MEAN(MSTRGrowth,2)	Pearson Correlation	.900**	1
	Sig. (2-tailed)	<.001	
	N	1215	1215

**. Correlation is significant at the 0.01 level (2-tailed).

The table above illustrates a correlation matrix between BTC growth and MSTR growth. The Pearson Correlation Coefficient (r) is 0.900**, the two asterisks represent that the correlation between the variables is very strong. The associated p-value is less than 0.001, meaning that we can empirically conclude that there is a strong positive relationship between BTC price growth and MSTR price growth at the 1% confidence level. Furthermore the Coefficient of Determination (r^2) is 0.81, meaning that the model explains 81% of the variance observed in the dependent variable (MSTR price growth). However, it is important to note that correlation does not equal causation, this limitation is considered later in the report.

4. Histograms

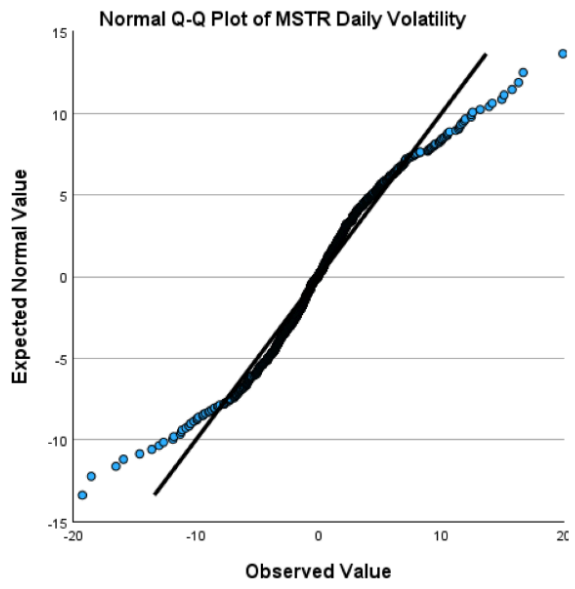


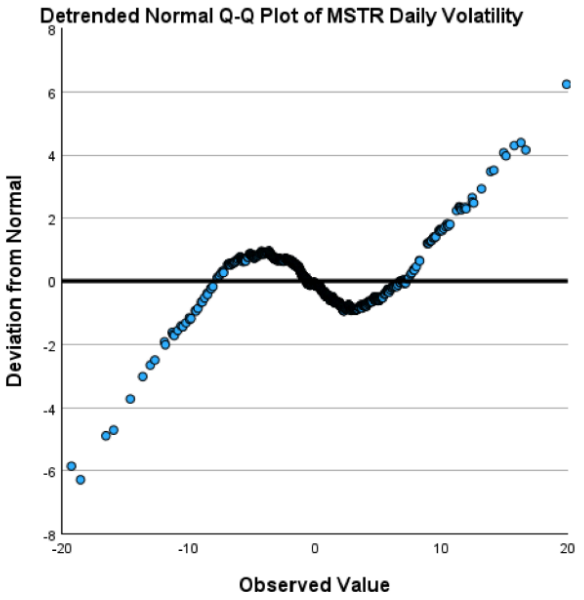


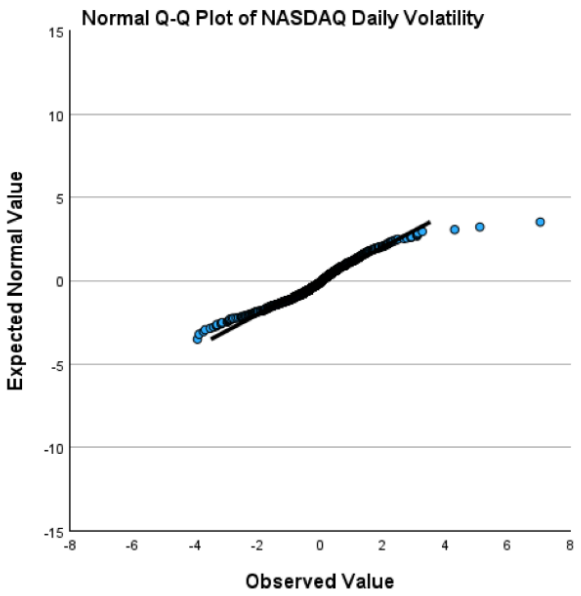
The histograms above plot the frequency of the daily volatility values (%) of MSTR and NASDAQ. The same minimum, maximum and scale has been used for the x-axis to provide a better visualisation of the disparity in volatility. The normal distribution curve of MSTR is much wider than NASDAQ, ranging from -12 to 12, whereas NASDAQ ranges from -4 to 4.

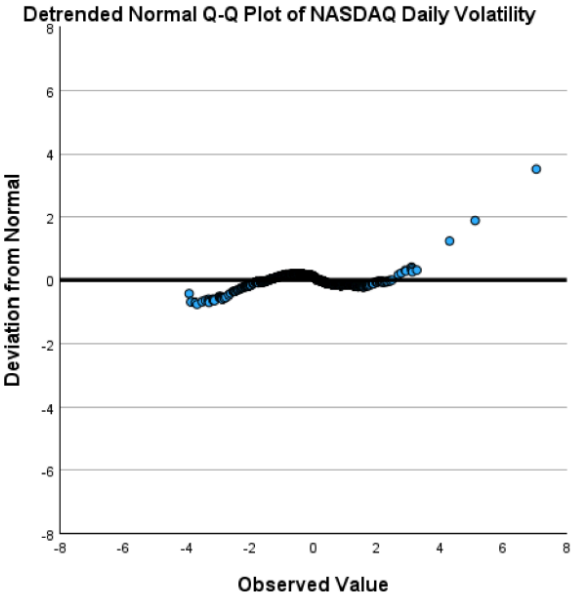
This suggests that MSTR is significantly more volatile than traditional stocks as represented by NASDAQ. This is further understood using the mean and standard deviation. MSTR has a mean of 0.139, whereas NASDAQ has a significantly lower mean of 0.014. The standard deviation of MSTR is 4.12 and NASDAQ 1.09. This suggests that on average the volatility of MSTR is much higher than the volatility of NASDAQ, with larger deviations from the mean. Furthering the notion that MSTR does not follow traditional stock price behaviour, visually and quantitatively.

5. Normal and Detrended Normal Q-Q Plots









The Q-Q plot provides further visualisation of MSTR and NASDAQ daily volatility plotted against a perfectly normal distribution. From the detrended Q-Q plot, it is clear to see that the plot of MSTR volatility has a much more significant deviation from the perfect normal distribution compared to NASDAQ volatility. Furthermore, it is observed that MSTR volatility has heavy tails, suggesting that it is a leptokurtic distribution (highly dispersed), exhibiting non-normality (Brooks, 2018). NASDAQ volatility has much lighter tails and is less disbursed, exhibiting higher normality. This suggests that there is a higher density of data located at the extremes of MSTR volatility values, further supporting the notion that MSTR experiences significantly higher daily volatility compared to NASDAQ.

Limitation:

Although the model concluded that the strength of the correlation between the price growth of BTC and MSTR is 0.900 and the visualisations provide a case for a correlated relationship, it is important to note that correlation does not equal causation. The observed association does not necessarily indicate a direct cause-and-effect relationship, and other external factors or coincidences could contribute to the observed patterns, which is highly likely in complex trading markets. This is important for stakeholders to consider when using the model, in order to not be misled by false assumptions.

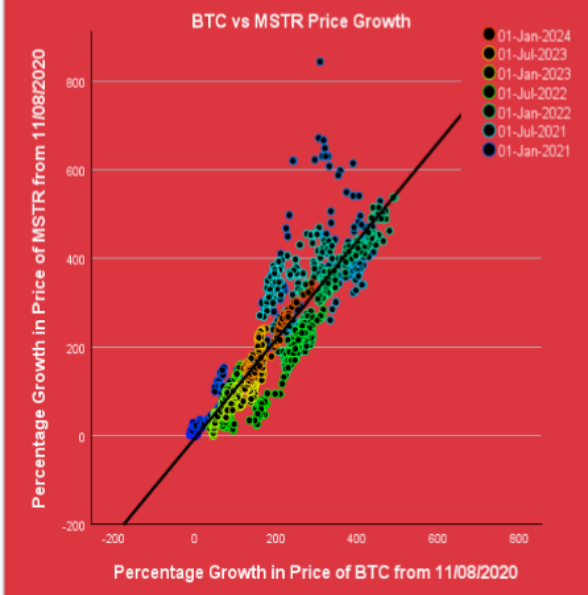
Conclusion:

The SPSS model analysis demonstrates a strong positive relationship between the price growth of Bitcoin and MicroStrategy, evidenced visually by the line graph and scatter plot, and empirically concluded using the Correlation Coefficient of 0.900. The model, supported by the histogram and Q-Q plot visualisations, emphasises MicroStrategy' heightened volatility compared to NASDAQ, indicating a leptokurtic distribution and departure from traditional stock price behaviour for MicroStrategy. The model suggests that Bitcoins price movements do have an impact on MicroStrategy stock price. The likely reason for this is due to the fact that MicroStrategy almost acts as a Bitcoin holding company, as they hold such a large portion of Bitcoin’s supply, consequently affecting their investment performance and net asset value, which is reflected by fluctuations in their stock price. In summary, the model has been successful in completing all objectives and provides insightful visualisations on the relationship between Bitcoin, MicroStrategy and NASDAQ, enabling stakeholders to make more informed financial decisions, with the limitations of the model considered. This is critically useful, considering the run up to the fourth halving of Bitcoin in April 2024, which in the past has triggered significant price growth (Binance, no date). The model is suitable to present to a client with no further adjustments required as the pre-processing steps have thoroughly addressed all issues with missing values and misalignment. The application is reusable and can be generalised to any other similar data as the model has direct objectives, statistical measurements and clear pre-processing steps, allowing the model's logic and framework to easily be applied to other assets that the business owns.

Data story:

MicroStrategy®

Is Not A Software Company.



MicroStrategy has made large purchases of Bitcoin (₿) since August 2020, to such an extent that they own 1 in 120 ₿. Having such a large holding of ₿ has made the stock price move in symphony with ₿'s price, as illustrated by the line graph where MSTR price growth mirrors that of BTC. The Correlation Coefficient associated with the scatter plot is 0.9, suggesting a high strength positive relationship. Leading up to the fourth halving of ₿ in April 2024, we may see explosive growth in the stock price of MicroStrategy regardless of their performance as a software company.

Data sources:
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Yahoo! Finance (2023) *MicroStrategy Incorporated* (MSTR). Available at: https://finance.yahoo.com/quote/MSTR/history?p=MSTR (Accessed: 10/12/2023).
Yahoo! Finance (2023) NASDAQ *Composite* (^IXIC). Available at: https://finance.yahoo.com/quote/%5EIXIC/history?p=%5EIXIC (Accessed: 10/12/2023).

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Binance (no date) *When Is the Next Bitcoin Halving in 2024?* Available at: https://www.binance.com/en-GB/events/bitcoin-halving (Accessed: 15/12/2023).

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Yahoo! Finance (2023) *NASDAQ Composite (^IXIC).* Available at: https://finance.yahoo.com/quote/%5EIXIC/history?p=%5EIXIC (Accessed: 10/12/2023).