Project A: Market Data, Volatility, and Indices

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Q1.

(a) Through Bloomberg, the team obtained S&P 500 data ranging from March 4, 1957 to September 16, 2018, because the index began tracking 500 companies at that time.

- Prior to March 4, 1957, the data still shows up, but it was only tracking 90 stocks.
- The article "Market Swings Are Becoming New Standard" uses the data set starting from 1962. This might be derived from the fact that S&P index were computed after September 1962. However, since the Bloomberg data displays data before 1962 and since S&P 500 began in 1957, the team decided to use data from 1957.

(b) The team conducted the data integrity check from March 4, 1957 to September 16, 2018. Below are five data integrity checks that the team has made.

- **[Negative Value]** The team has checked that there is no negative value.
- **[Open = High = Low = Close]** The high price and the low price of the S&P 500 were same from March 4, 1957 to April 20, 1982. Also, the high and low price of the S&P 500 is same at Jun 12, 1989. The team assumed that the data were not collected properly, since there must be at least one trade among 500 stocks.
- **[Missing Data]** There are some missing values. The trading market was closed for the weekends (Saturday & Sunday) and holidays (ex. Christmas, New Year's). Also, there were special occasions such as 9/11/2001 that closed the market for a week (9/11-9/15).
- **[Overnight Trade** or **Open_t - Close_{t-1}]** In most of the cases (approx. 75%), the open price of the day changed from the close price of previous day within ±5% range, while approx. 25% remains unchanged. One day (5/28/1962) sticks out by changing at the rate of -6.7%. This might be due to "Kennedy Slide of 1962" (event that stock market declined during Presidential term of Kennedy)
- **[Low > High]** The team has check that there is no low value higher than high value.

(c)

- **[Method]** Since the high and low are the same before April 20, 1982, the team estimated the probabilities after April 20, 1982.
- **[Result]**
  - ✓ $\text{Prob}(p_{high} = p_{open}) = 1078/9{,}181 = 11.7\%$
  - ✓ $\text{Prob}(p_{high} = p_{close}) = 606/9{,}181 = 6.6\%$
  - ✓ $\text{Prob}(p_{low} = p_{open}) = 1350/9{,}181 = 14.7\%$
  - ✓ $\text{Prob}(p_{low} = p_{close}) = 182/9{,}181 = 2.0\%$
- **[Assumption]** If the data follow the random walk hypothesis, then its log returns are normally distributed and are mutually independent
- **[Random Walk Hypothesis]** According to the probability result we got before, we cannot conclude whether these data follow random walk hypothesis or not, because we cannot test the data if returns are normally distributed or mutually independent.

(d) Below chart is the rank of H_t. 15 out of 20 occurred during the period 9/1/2008-8/30/2011. It implies that major stock prices fluctuated during the financial crisis. Additionally, October 19, 1987 was the Black Monday, when stock markets crashed globally.

#	Dates	PX_OPEN	PX_HIGH	PX_LOW	PX_LAST	H_t
1	10/19/1987	282.7	282.7	224.83	224.84	25.7%
2	10/20/1987	225.06	245.62	216.46	236.83	13.5%
3	11/13/2008	853.13	913.01	818.69	911.29	11.5%
4	10/10/2008	902.31	936.36	839.8	899.22	11.5%
5	10/28/2008	848.92	940.51	845.27	940.51	11.3%
6	10/9/2008	988.42	1005.25	909.19	909.92	10.6%
7	10/13/2008	912.75	1006.93	912.75	1003.35	10.3%
8	10/15/2008	994.6	994.6	903.99	907.84	10.0%
9	11/20/2008	805.87	820.52	747.78	752.44	9.7%
10	5/6/2010	1164.38	1167.58	1065.79	1128.15	9.6%
11	10/21/1987	236.83	259.26	236.83	258.38	9.5%
12	10/16/2008	909.53	947.71	865.83	946.43	9.5%
13	9/29/2008	1209.07	1209.07	1106.39	1106.39	9.3%
14	10/26/1987	248.2	248.22	227.26	227.67	9.2%
15	12/1/2008	888.61	888.61	815.69	816.21	8.9%
16	10/6/2008	1097.56	1097.56	1007.97	1056.89	8.9%
17	7/24/2002	797.71	844.32	775.68	843.42	8.8%
18	10/22/2008	951.67	951.67	875.81	896.78	8.7%
19	11/21/2008	755.84	801.2	741.02	800.03	8.1%
20	11/24/2008	801.2	865.6	801.2	851.81	8.0%

(*Highlighted dates represent the period between 9/1/2008-8/30/2011)

(e) Below table is the 20 positive overnight returns during the period 1/1/1980-8/30/2011. The table implies that during 1980 – 1982 had the highest overnight returns.

#	Dates	PX_OPEN	PX_HIGH	PX_LOW	PX_LAST	$R_{overnight,t}$
1	3/22/1982	112.77	112.77	112.77	112.77	2.0%
2	2/24/1982	113.47	113.47	113.47	113.47	1.8%
3	1/28/1982	118.92	118.92	118.92	118.92	3.3%
4	11/2/1981	124.2	124.2	124.2	124.2	1.9%
5	10/30/1981	121.89	121.89	121.89	121.89	2.4%
6	10/2/1981	119.36	119.36	119.36	119.36	1.9%
7	9/28/1981	115.53	115.53	115.53	115.53	2.4%
8	3/25/1981	137.11	137.11	137.11	137.11	1.8%
9	3/12/1981	133.19	133.19	133.19	133.19	2.5%
10	11/12/1980	134.59	134.59	134.59	134.59	2.5%
11	11/5/1980	131.33	131.33	131.33	131.33	1.8%

12	10/6/1980	131.73	131.73	131.73	131.73	1.9%
13	9/3/1980	126.12	126.12	126.12	126.12	1.9%
14	7/14/1980	120.01	120.01	120.01	120.01	1.8%
15	6/4/1980	112.61	112.61	112.61	112.61	1.9%
16	4/22/1980	103.43	103.43	103.43	103.43	3.6%
17	4/9/1980	103.11	103.11	103.11	103.11	1.9%
18	3/28/1980	100.68	100.68	100.68	100.68	2.5%
19	3/18/1980	104.1	104.1	104.1	104.1	1.8%
20	1/8/1980	108.95	108.95	108.95	108.95	2.0%

Below table is the 20 negative overnight returns during the period 1/1/1980-8/30/2011. The table implies that during 1980 – 1982 had the lowest overnight returns.

#	Dates	PX_OPEN	PX_HIGH	PX_LOW	PX_LAST	$R_{overnight,t}$
1	9/25/1986	231.83	236.28	230.67	231.83	-1.9%
2	2/8/1982	114.63	114.63	114.63	114.63	-2.2%
3	2/1/1982	117.78	117.78	117.78	117.78	-2.2%
4	1/11/1982	116.78	116.78	116.78	116.78	-2.3%
5	1/5/1982	120.05	120.05	120.05	120.05	-2.2%
6	9/25/1981	112.77	112.77	112.77	112.77	-1.9%
7	8/24/1981	125.5	125.5	125.5	125.5	-2.9%
8	2/2/1981	126.91	126.91	126.91	126.91	-2.0%
9	1/20/1981	131.65	131.65	131.65	131.65	-2.0%
10	1/7/1981	135.08	135.08	135.08	135.08	-2.2%
11	12/8/1980	130.61	130.61	130.61	130.61	-2.6%
12	12/1/1980	137.21	137.21	137.21	137.21	-2.4%
13	11/6/1980	128.91	128.91	128.91	128.91	-1.8%
14	9/29/1980	123.54	123.54	123.54	123.54	-2.2%
15	8/18/1980	123.39	123.39	123.39	123.39	-1.9%
16	4/7/1980	100.19	100.19	100.19	100.19	-1.9%
17	3/24/1980	99.28	99.28	99.28	99.28	-3.0%
18	3/17/1980	102.26	102.26	102.26	102.26	-3.0%
19	3/6/1980	108.65	108.65	108.65	108.65	-2.2%
20	1/2/1980	105.76	105.76	105.76	105.76	-2.0%

(f) Below table evaluates highest jumps. It is sorted by highest in absolute value. It occurred twice during the 9/1/2008-8/30/2011.

#	Dates	PX_OPEN	PX_HIGH	PX_LOW	PX_LAST	r_t	σ_t	j_t	$\lvert j_t \rvert$
1	10/19/1987	282.7	282.7	224.83	224.84	(0.23)	0.01	(17.70)	17.70
2	5/28/1962	55.5	55.5	55.5	55.5	(0.07)	0.01	(9.29)	9.29
3	10/13/1989	355.41	355.53	332.81	333.62	(0.06)	0.01	(9.29)	9.29

4	2/5/2018	2741.06	2763.39	2638.17	2648.94	(0.04)	0.01	(7.87)	7.87
5	2/27/2007	1449.25	1449.25	1389.42	1399.04	(0.04)	0.00	(7.63)	7.63
6	10/27/1997	941.64	941.64	876.73	876.99	(0.07)	0.01	(6.79)	6.79
7	11/26/1963	72.38	72.38	72.38	72.38	0.04	0.01	6.41	6.41
8	8/8/2011	1198.48	1198.48	1119.28	1119.46	(0.07)	0.01	(6.13)	6.13
9	6/24/2016	2103.81	2103.81	2032.57	2037.41	(0.04)	0.01	(5.95)	5.95
10	8/17/1982	105.4	109.33	104.32	109.04	0.05	0.01	5.92	5.92
11	8/31/1998	1027.14	1033.47	957.28	957.28	(0.07)	0.01	(5.82)	5.82
12	11/22/1963	69.61	69.61	69.61	69.61	(0.03)	0.00	(5.77)	5.77
13	2/4/1994	480.68	481.02	469.28	469.81	(0.02)	0.00	(5.74)	5.74
14	9/11/1986	247.06	247.06	234.67	235.18	(0.05)	0.01	(5.30)	5.30
15	2/16/1993	444.53	444.53	433.47	433.91	(0.02)	0.00	(5.27)	5.27
16	11/1/1978	96.85	96.85	96.85	96.85	0.04	0.01	5.25	5.25
17	11/24/1958	51.33	51.33	51.33	51.33	(0.03)	0.01	(5.13)	5.13
18	8/4/2011	1260.23	1260.23	1199.54	1200.07	(0.05)	0.01	(5.13)	5.13
19	8/16/1971	98.76	98.76	98.76	98.76	0.03	0.01	5.01	5.01
20	11/15/1991	397.15	397.16	382.62	382.62	(0.04)	0.01	(5.01)	5.01

(*Highlighted dates represent the period between 9/1/2008-8/30/2011)

Q2. According to the data extracted from Bloomberg and Yahoo, we can get the dataset as below:

Data source	Open Price	High Price	Low Price	Close Price
Bloomberg	122	126.97	122	126.97
Yahoo	122	125.97	122	125.97
Difference	**0**	**1**	**0**	**1**

Comparing two data sources, there existed 1-point difference in high price and close price.

Although 1-point difference seems not significant, however, if we consider lots of financial products including ETF, derivatives (eg. options, futures, stock SWAP… etc.) were linked to S&P500, the price discrepancy that may result to model pricing mistakes. For example, the price discrepancy may lead to the discrepancy intrinsic value of call option base on different information sources. Considering the leverage effect of derivative products and magnificent trading volume in the market, we can assume that the impact of price discrepancy may result chaos to the financial market and the impact can be economically significant.

We can compare the third-party quotes to these two information sources to make sure which one is more reliable. According to the NYSE official site historical data, we can find the dataset below:

Data source	Open Price	High Price	Low Price	Close Price
NYSE	122	125.97	122	125.97

The dataset is exactly the same with Yahoo. Since we believe the NYSE source is authoritative, so we can conclude that the Yahoo data is more reliable than Bloomberg.

Q3.

(a) On March 6 2015, Dow Jones Industry Average (DJIA) index is 17856.78, and we already know the old divisor the price-weighted Index is 0.130216081. In addition, Apple was added to the index and AT&T was removed from the index. According to this information, we can summary them below:

Indicator or stock name	Index or price on 3/6/2015
DJIA Index	17,856.78
Old divisor	0.130216081
Apple	126.6
AT&T	33.48

And we can get the new divisor formula as:

$$\text{New divisor} = \frac{DJIA\ Index * Old\ divisor - AT\&T\ Price + Apple\ Price}{DJIA\ Index}$$

So the new divisor equals to $\frac{17,856.78*0130216081-33.48+\quad .6}{17,856.78} = 0.1354309$

(b) We can calculate the AT&T weight in original index by steps below:

Step 1. $\frac{34.48}{0.130216} = 257.11$

Step 2. $\frac{257.2107}{17856.78} = 1.44\%$

(c) Before removing the AT&T, the weight of other 29 companies is 100% - 1.3844% = 98.56% ; After removing AT&T and add Apple into the index, the weight of the other 29 companies would be:

$$1-(\frac{126.6/0.1354309}{17856.78}) = 94.77\%$$

(d) According to the data extract from the Yahoo Finance, we can get the historical price of Amazon and Berkshire Hathaway below:

Stock Name	Stock price on 03/06/2015
Amazon	380.09
Berkshire Hathaway (Class A)	218,810.99

If we add Amazon instead of Apple, new divisor would equal to:

$$\frac{17,856.78*0130216081-3\ .48+38\ .09}{17,856.78} = 0.15$$

If we add Berkshire Hathaway instead of Apple, new divisor would equal to:

$$\frac{17,856.78*0130216081-3\ .48+380.09}{17,856.78} = 12.38$$

(e) Since the index number must remain the same after stock split, the stock split event (which causes lower stock price) will result a drop in divisor value. Therefore, the team assumes that, even though the replacement of Apple would make the divisor increase, VISA's stock split by 1:4 would partly ease the increasing effect of the divisor.