

# Financial Econometrics (ECO764A)

## Assignment-2

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## 1 Data

We use monthly data of 50 companies from Japan and NIKKEI 225 STOCK AVERAGE - PRICE INDEX for market index across year 2018-2021 to find coefficient of all the factor model using regression. We have used monthly risk free rate ( $r_f$ ) of Japan as 0.03%

## 2 Capital Asset Pricing Model(CAPM)

**CAPM** is a model that describes the relationship between systematic risk and expected return for assets. It is used throughout finance for pricing risky securities and generating expected returns for assets, given the risk of those assets and cost of capital.

The formula for calculating the expected return of an asset given at risk is as follows:

$$ER_i = R_f + \beta_i(ER_m - R_f)$$

where:

$ER_i$  = expected return of investment

$R_f$  = risk free rate

$\beta_i$  = beta of the environment

$ER_m - R_f$  = market risk premium

The goal of CAPM formula is to evaluate whether a stock is fairly valued when its risk and the time value of money are compared to its expected return.

### 3 Fama-French Three Factor Model

The Fama- French 3-factor model is an asset pricing Model that expands on the capital assets pricing model by adding size risk and value risk factors to the market risk factors.

The Fama-French model aims to describe stock returns through three factors: (1) market risk, (2) the outperformance of small-cap companies relative to large-cap companies, and (3) the outperformance of high book-to-market value companies versus low book-to-market value companies.

The formula for the Fama French Three Factor Model is:

$$R_{it} - R_{ft} = \alpha_{it} + \beta_1(R_{Mt} - R_{ft}) + \beta_2SMB_t + \beta_3HML_t + \epsilon_{it}$$

where:

$R_{it}$  = total return of a stock or portfolio i at time t

$R_{ft}$  = risk free rate of return at time t

$R_{Mt}$  = total market portfolio return at time t

$R_{it} - R_{ft}$  = expected excess return

$R_{Mt} - R_{ft}$  = excess return on the market portfolio (index)

$SMB_t$  = size premium (small minus big)

$HML_t$  = value premium (high minus low)

$\beta_{1,2,3}$  = factor coefficients

### 4 Carhart Four Factor Model

The Carhart Four Factor Model is a popular multifactor model used to price securities. This model is an extension of the Fama and French 3-factor model. This model includes a cross sectional momentum factor that improves the explanatory power of the multifactor model considerably.

The equation for the Carhart Four Factor model is as follows:

$$r_i = r_f + \beta_1 \cdot Mkt + \beta_2 \cdot HML + \beta_3 \cdot SMB + \beta_4 \cdot MOM + \epsilon$$

where:

$Mkt$  = return on the market portfolio

$HML$  = book-to-market factor

$SMB$  = size factor

$MOM$  = momentum factor

## 5 Construction of factors

We can construct SMB, HML and MOM factors following the steps:

1. Calculate the excess returns, i.e.  $R_i - R_f$ .
2. Sort the excess returns on Size (market capitalization) and then on value (ROE).
3. Denote bottom 30 percent, middle (40 percent) and top (30 percent) as Small, Medium and Big when arranged according to their market capitalisation.
4. Denote bottom 30 percent, middle (40 percent) and top (30 percent) as Value, Neutral and Growth when arranged according to their (BM) ratio, which in this case is calculated from return on investments from the data.
5. Winners are calculated by taking the top 30 percent of all the stocks according to the returns on the stocks. The returns are calculated according to the Price Indices of the different stocks.
6. Similarly, losers are calculated by taking the bottom 30 percent of all the stocks according to the returns on the stocks.
7. Use the formula to calculate SMB:

$$SMB = 1/2 * (smallvalue + smallneutral + smallgrowth) - 1/2 * (bigvalue + bigneutral + biggrowth)$$

$$SMB = 1/2 * (S1V1 + S1V2 + S1V3) - 1/2 * (S3V1 + S3V2 + S3V3)$$

8. Use the formula to calculate HML:

$$HML = 1/2 * (smallvalue + bigvalue) - 1/2 * (smallgrowth + biggrowth)$$

$$HML = 1/2 * (S1 * V1 + S3 * V1) - 1/2 * (S1 * V3 + S3 * V3)$$

The HML factor is thus designed to capture the effect of value while being largely free of the influence of size

9. Use the formula to calculate MOM:

$$MOM = 1/2 * (smallwinner + bigwinner) - 1/2 * (smallloser + bigloser)$$

$$MOM = 1/2 * (S1 * W1 + S3 * W1) - 1/2 * (S1 * W2 + S3 * W2)$$

The MOM factor is thus designed to capture the effect of the past performance value while being largely free of the influence of size and book to market ratio.

## 6 Analysis

- Average  $R_{sq}$  for all the regressions is listed below:

CAPM Model: Average  $R_{sq} = 0.40478$

Carhart Model: Average  $R_{sq} = 0.49181$

Three factor Model: Average  $R_{sq} = 0.4787$

While the value of  $R_{sq}$  is not very different, Carhart Model slightly outperforms the other two.

- Intercept alpha is never zero therefore not significant, thus implying that CAPM cannot explain the results very well.
- The results for 3 factor model is not much different from 4 factor CAPM, Hence, to evaluate another factor seems to be an overshoot.
- This shows that MOM factor has less significant impact on the return of individual companies.
- Sharpe ratio of some companies is negative that shows some companies perform poorly than risk free asset in period 2018-21 may be due to corona outbreak
- Sharpe ratio for companies in japan is very low (and sometimes  $< 0$ ) that shows why japanese market is in a steady decline.

Table 1: Sharpe and Treynor ratio

SN	company	sharpe ratio	treynor ratio
1	TOYOTA MOTOR	0.024	0.152
2	SOFTBANK GROUP	0.106	0.876
3	SONY	0.222	1.831
4	NIPPON TELG. & TEL.	-0.002	-0.015
5	FAST RETAILING	0.126	1.01
6	CHUGAI PHARM.	0.311	3.296
7	RECRUIT HOLDINGS	0.239	2.199
8	KDDI	-0.068	-0.949
9	SHIN	0.23	1.484
10	MITSUBISHI UFJ FINL.GP.	0.026	0.155
11	DAIICHI SANKYO	0.303	5.172
12	SOFTBANK	0.075	-19.724
13	DAIKIN INDUSTRIES	0.221	1.352
14	TOKYO ELECTRON	0.26	2.576
15	FANUC	0.134	0.883
16	HONDA MOTOR	-0.006	-0.035
17	M3	0.204	3.86
18	TAKEDA PHARMACEUTICAL	-0.087	-0.772
19	DENSO	0.093	0.549
20	HITACHI	0.127	0.777
21	ITOCHU	0.137	0.866
22	SUMITOMO MITSUI FINL.GP.	0.032	0.186
23	JAPAN TOBACCO	-0.28	-2.671
24	MITSUBISHI	0.082	0.544
25	JAPAN POST HOLDINGS	-0.095	-0.676
26	CENTRAL JAPAN RAILWAY	-0.166	-1.379
27	KAO	0.033	0.573
28	MITSUBISHI ELECTRIC	0.068	0.396
29	MIZUHO FINL.GP.	-0.006	-0.035
30	PANASONIC	0.088	0.532
31	SEVEN & I HDG.	-0.049	-0.488
32	TOKIO MARINE HOLDINGS	0.093	0.58
33	AEON	0.241	1.763
34	ASTELLAS PHARMA	-0.011	-0.094
35	CANON	-0.093	-0.639
36	FUJIFILM HOLDINGS	0.102	0.886
37	FUJITSU	0.2	1.433
38	KOMATSU	0.118	0.718
39	mitsui	0.094	0.626
40	NISSAN MOTOR	-0.017	-0.127
41	TERUMO	0.139	1.213
42	Z HOLDINGS	0.109	1.176
43	BRIDGESTONE	-0.011	-0.078
44	EAST JAPAN RAILWAY	-0.139	-1.232
45	KUBOTA	0.084	0.585
46	NEXON	0.188	3.198
47	OLYMPUS	0.164	1.485
48	OTSUKA HOLDINGS	0.05	0.456
49	SHISEIDO	0.21	3.817
50	EISAI	0.021	0.23

Table 2: CAPM Model

SN	company	$\alpha$	$\beta_{F-r_f}$
1	TOYOTA MOTOR	-1.033	1.137
2	SOFTBANK GROUP	-0.314	1.698
3	SONY	0.828	1.075
4	NIPPON TELG. & TEL.	-0.619	0.576
5	FAST RETAILING	-0.076	1.509
6	CHUGAI PHARM.	1.675	0.749
7	RECRUIT HOLDINGS	1.087	0.955
8	KDDI	-0.829	0.412
9	SHIN	0.529	1.248
10	MITSUBISHI UFJ FINL.GP.	-1.583	1.747
11	DAIICHI SANKYO	2.246	0.546
12	SOFTBANK	0.314	-0.015
13	DAIKIN INDUSTRIES	0.35	1.202
14	TOKYO ELECTRON	1.735	1.145
15	FANUC	-0.241	1.359
16	HONDA MOTOR	-1.504	1.373
17	M3	1.769	0.632
18	TAKEDA PHARMACEUTICAL	-1.663	0.907
19	DENSO	-0.705	1.377
20	HITACHI	-0.441	1.555
21	ITOCHU	-0.233	1.2
22	SUMITOMO MITSUI FINL.GP.	-1.478	1.69
23	JAPAN TOBACCO	-1.927	0.517
24	MITSUBISHI	-0.624	1.208
25	JAPAN POST HOLDINGS	-1.655	0.953
26	CENTRAL JAPAN RAILWAY	-2.229	0.913
27	KAO	-0.169	0.347
28	MITSUBISHI ELECTRIC	-0.969	1.457
29	MIZUHO FINL.GP.	-1.604	1.464
30	PANASONIC	-0.922	1.745
31	SEVEN & I HDG.	-1.039	0.671
32	TOKIO MARINE HOLDINGS	-0.638	1.328
33	AEON	0.656	0.934
34	ASTELLAS PHARMA	-0.883	0.765
35	CANON	-1.599	0.941
36	FUJIFILM HOLDINGS	-0.12	0.686
37	FUJITSU	0.508	1.365
38	KOMATSU	-0.536	1.563
39	MITSUMI	-0.562	1.292
40	NISSAN MOTOR	-2.003	1.687
41	TERUMO	0.12	0.793
42	Z HOLDINGS	0.11	0.958
43	BRIDGESTONE	-1.137	0.998
44	EAST JAPAN RAILWAY	-1.891	0.825
45	KUBOTA	-0.624	1.312
46	NEXON	1.213	0.568
47	OLYMPUS	0.442	1.043
48	OTSUKA HOLDINGS	-0.52	0.86
49	SHISEIDO	1.372	0.498
50	EISAI	-0.846	1.018

Table 3: Three Factor Model

SN	company	$\alpha$	$\beta_{F-r_f}$	$\beta_{HML}$	$\beta_{SMB}$
1	TOYOTA MOTOR	-0.317	0.673	0.458	0.643
2	SOFTBANK GROUP	-0.28	1.874	-0.453	-0.179
3	SONY	-0.564	1.262	0.82	-0.494
4	NIPPON TELG. & TEL.	-0.951	0.642	0.144	-0.141
5	FAST RETAILING	0.676	1.078	0.348	0.616
6	CHUGAI PHARM.	0.412	1.105	0.299	-0.645
7	RECRUIT HOLDINGS	0.936	1.428	-0.995	-0.532
8	KDDI	-1.604	0.665	0.103	-0.432
9	SHIN	0.599	1.032	0.455	0.244
10	MITSUBISHI UFJ FINL.GP.	-0.243	0.82	0.997	1.264
11	DAIICHI SANKYO	1.992	0.324	0.763	0.181
12	SOFTBANK	0.344	-0.026	-0.002	0.018
13	DAIKIN INDUSTRIES	0.043	1.222	0.233	-0.086
14	TOKYO ELECTRON	0.948	1.654	-0.502	-0.706
15	FANUC	0.489	1.21	-0.309	0.312
16	HONDA MOTOR	-0.514	0.924	0.172	0.685
17	M3	-0.781	1.866	-0.631	-1.847
18	TAKEDA PHARMACEUTICAL	-1.478	0.725	0.269	0.232
19	DENSO	0.016	1.047	0.134	0.503
20	HITACHI	1.104	0.959	0.018	0.958
21	ITOCHU	0.563	0.869	0.066	0.519
22	SUMITOMO MITSUI FINL.GP.	-0.234	0.939	0.664	1.058
23	JAPAN TOBACCO	-1.996	0.533	0.024	-0.032
24	MITSUBISHI	0.635	0.791	-0.149	0.709
25	JAPAN POST HOLDINGS	-0.69	0.222	0.869	0.977
26	CENTRAL JAPAN RAILWAY	-1.637	0.672	0.037	0.381
27	KAO	-0.331	0.41	-0.002	-0.101
28	MITSUBISHI ELECTRIC	0.044	1.03	0.101	0.667
29	MIZUHO FINL.GP.	-0.386	0.833	0.4	0.926
30	PANASONIC	-0.59	1.201	0.998	0.645
31	SEVEN & I HDG.	-0.979	0.558	0.214	0.131
32	TOKIO MARINE HOLDINGS	0.459	0.539	0.889	1.067
33	AEON	0.372	0.939	0.245	-0.066
34	ASTELLAS PHARMA	-1.116	0.884	-0.072	-0.176
35	CANON	-0.793	0.526	0.26	0.61
36	FUJIFILM HOLDINGS	0.318	0.49	0.072	0.301
37	FUJITSU	0.583	1.28	0.134	0.105
38	KOMATSU	0.593	1.061	0.172	0.771
39	mitsui	1.207	0.687	-0.164	1.016
40	NISSAN MOTOR	0.198	0.981	-0.316	1.215
41	TERUMO	-0.678	1.033	0.154	-0.423
42	Z HOLDINGS	-1.012	1.657	-0.652	-0.978
43	BRIDGESTONE	-0.603	0.58	0.515	0.556
44	EAST JAPAN RAILWAY	-1.152	0.446	0.234	0.558
45	KUBOTA	0.325	0.802	0.355	0.741
46	NEXON	0.346	0.873	0.061	-0.507
47	OLYMPUS	0.583	1.125	-0.325	-0.057
48	OTSUKA HOLDINGS	-1.261	1.091	0.121	-0.403
49	SHISEIDO	1.283	0.67	-0.331	-0.201
50	EISAI	-1.666	1.197	0.319	-0.363

Table 4: Four Factor Model

SN	company	$\alpha$	$\beta_{F-r_f}$	$\beta_{HML}$	$\beta_{SMB}$	$\beta_{MOM}$
1	TOYOTA MOTOR	-0.291	0.667	0.495	0.641	-0.033
2	SOFTBANK GROUP	-0.169	1.849	-0.294	-0.187	-0.14
3	SONY	-0.795	1.315	0.489	-0.477	0.292
4	NIPPON TELG. TEL.	-0.635	0.57	0.597	-0.164	-0.4
5	FAST RETAILING	0.7	1.072	0.382	0.614	-0.03
6	CHUGAI PHARM.	0.66	1.049	0.654	-0.663	-0.314
7	RECRUIT HOLDINGS	0.811	1.457	-1.174	-0.523	0.159
8	KDDI	-1.389	0.616	0.411	-0.448	-0.272
9	SHIN	0.372	1.084	0.13	0.261	0.287
10	MITSUBISHI UFJ FINL.GP.	-0.501	0.879	0.627	1.284	0.327
11	DAIICHI SANKYO	2.066	0.307	0.869	0.175	-0.094
12	SOFTBANK	0.276	-0.01	-0.099	0.023	0.086
13	DAIKIN INDUSTRIES	0.005	1.23	0.178	-0.083	0.049
14	TOKYO ELECTRON	0.773	1.694	-0.753	-0.693	0.221
15	FANUC	0.193	1.278	-0.733	0.335	0.375
16	HONDA MOTOR	-0.657	0.957	-0.034	0.696	0.182
17	M3	-0.573	1.819	-0.333	-1.863	-0.263
18	TAKEDA PHARMACEUTICAL	-1.346	0.694	0.458	0.222	-0.167
19	DENSO	-0.036	1.059	0.058	0.507	0.067
20	HITACHI	0.962	0.991	-0.186	0.969	0.18
21	ITOCHU	0.673	0.844	0.224	0.511	-0.139
22	SUMITOMO MITSUI FINL.GP.	-0.382	0.972	0.452	1.069	0.186
23	JAPAN TOBACCO	-1.939	0.52	0.105	-0.036	-0.072
24	MITSUBISHI	0.469	0.829	-0.388	0.721	0.211
25	JAPAN POST HOLDINGS	-0.778	0.242	0.743	0.984	0.111
26	CENTRAL JAPAN RAILWAY	-1.39	0.616	0.391	0.362	-0.312
27	KAO	-0.226	0.386	0.149	-0.108	-0.133
28	MITSUBISHI ELECTRIC	-0.047	1.05	-0.029	0.674	0.114
29	MIZUHO FINL.GP.	-0.448	0.847	0.311	0.93	0.079
30	PANASONIC	-0.778	1.244	0.728	0.659	0.238
31	SEVEN I HDG.	-0.928	0.547	0.286	0.128	-0.064
32	TOKIO MARINE HOLDINGS	0.477	0.535	0.915	1.066	-0.023
33	AEON	0.454	0.92	0.364	-0.073	-0.105
34	ASTELLAS PHARMA	-0.874	0.828	0.275	-0.194	-0.307
35	CANON	-0.847	0.538	0.182	0.614	0.068
36	FUJIFILM HOLDINGS	0.409	0.469	0.204	0.294	-0.116
37	FUJITSU	0.49	1.302	0.0	0.112	0.118
38	KOMATSU	0.191	1.153	-0.404	0.801	0.509
39	mitsui	1.171	0.695	-0.216	1.018	0.045
40	NISSAN MOTOR	0.104	1.002	-0.451	1.222	0.119
41	TERUMO	-0.524	0.997	0.376	-0.435	-0.196
42	Z HOLDINGS	-0.923	1.637	-0.524	-0.985	-0.113
43	BRIDGESTONE	-0.558	0.57	0.579	0.552	-0.057
44	EAST JAPAN RAILWAY	-1.041	0.42	0.394	0.55	-0.141
45	KUBOTA	0.325	0.802	0.355	0.741	0.0
46	NEXON	0.336	0.875	0.048	-0.506	0.012
47	OLYMPUS	0.77	1.082	-0.057	-0.071	-0.236
48	OTSUKA HOLDINGS	-1.147	1.065	0.284	-0.411	-0.144
49	SHISEIDO	1.044	0.724	-0.673	-0.183	0.302
50	EISAI	-1.309	1.116	0.832	-0.39	-0.452