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FIN3080 PROJECT 2

INVESTMENT ANALYSIS AND PORTFOLIO MANAGEMENT

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Catalogue

a.

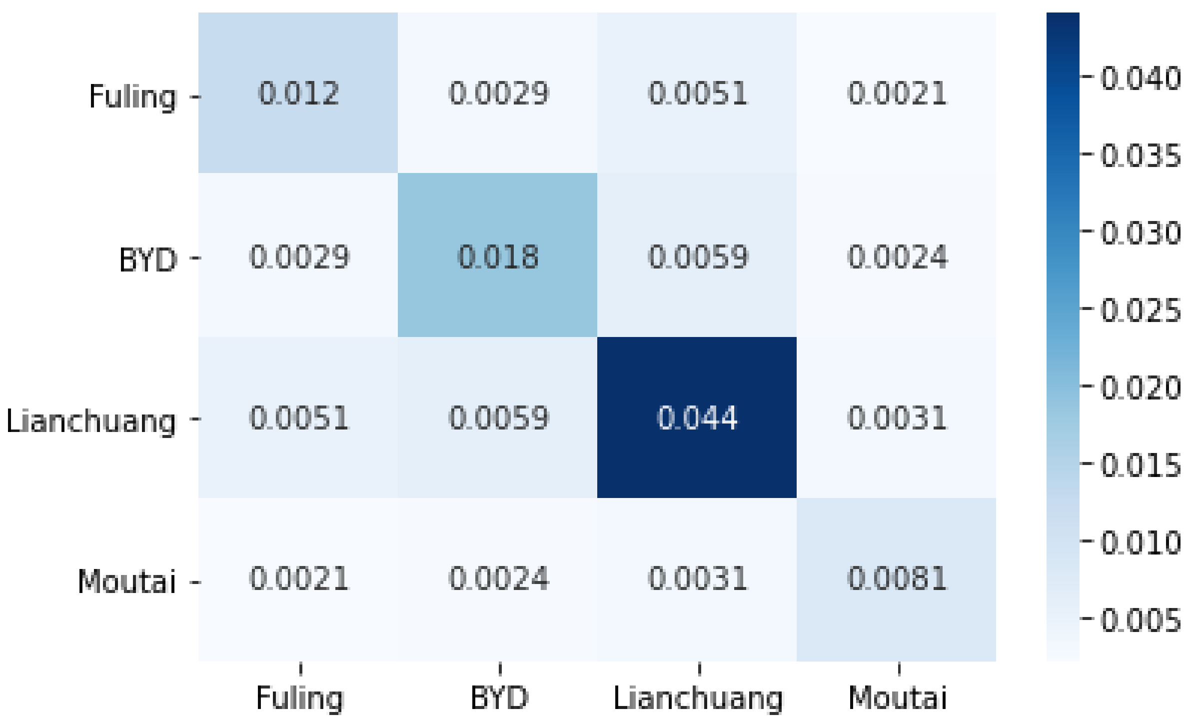
Data

The data comes from CSMAR. It contains monthly return rates of Moutai shares (stock code: 600519), Lianchuang Electronics (stock code: 300343), BYD (stock code: 002594), and Fuling mustard (stock code: 002507) from January 2013 to June 2019. All the return rates consider cash bonuses. There are 78 return rates for each stock. Missing monthly returns are represented by the return of last month.

Mean and Variance

	Stock Code	Mean	Variance
Fuling Mustard	002507	3.54%	0.012
BYD	002594	2.03%	0.018
Lianchuang Electronics	300343	0.06%	0.044
Moutai Shares	600519	2.84%	0.008

Covariance Matrix



b.

Deviation of Equations

Σ represents the covariance matrix.
μ is a vector representing the expected returns.
π represents the portfolio choice.
$1 = (1, \ldots, 1)^T$
Suppose

$$a = 1^T\Sigma^{-1}1 \qquad b = 1^T\Sigma^{-1}\mu \qquad c = \mu^T\Sigma^{-1}\mu$$

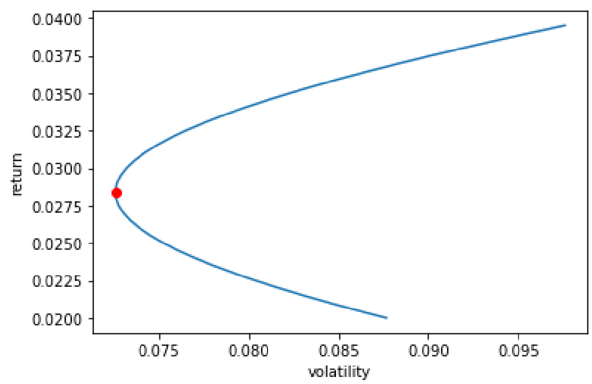
The optimization problem is $\min\frac{1}{2}\pi^T\Sigma\pi$ subject to $\mu^T\pi = \mu_P$ and $1^T\pi = 1$

$$\Rightarrow \sigma_p = \left(\frac{a\mu_P{}^2 - 2b\mu_P + c}{ac - b^2}\right)^{\frac{1}{2}}$$

The corresponding weight of portfolio is

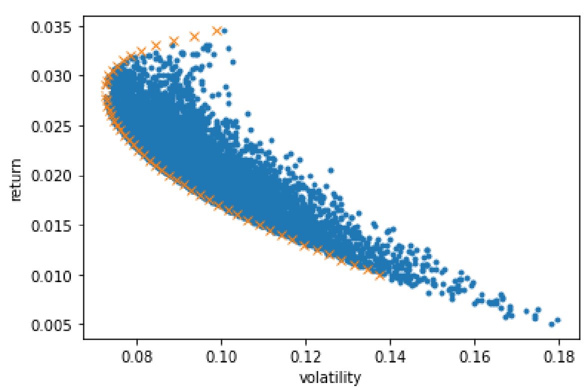
$$\pi = \frac{c - b\mu_P}{ac - b^2}\Sigma^{-1}\mu + \frac{a\mu_P - b}{ac - b^2}\Sigma^{-1}1$$

Taking μ_P as y axis and σ_p as x axis, the minimum-variance frontier is shown below. The line above the red point is the efficient frontier.



Verification

Represent 1000 different weight distributions of portfolio on the graph. The shape matches the equation derived above. Consequently, the derivation is correct.



c.

Weight

The global minimum variance portfolio:

$$\sigma_p = \left(\frac{1}{a}\right)^{\frac{1}{2}} \qquad \mu_P = \frac{b}{a}$$

The optimal weight distribution for the global minimum variance portfolio is

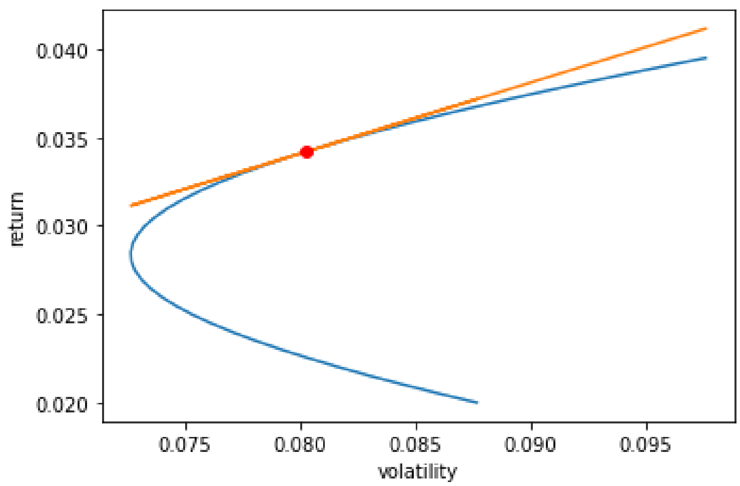
$$w = \frac{\Sigma^{-1}1}{a} = [0.2920 \quad 0.1638 \quad 0.0272 \quad 0.5170]$$

To get the minimum variance, investors can invest 29.20% Fuling Mustard, 16.38% BYD, 2.72% Lianchuang Electronics, and 51.70% Moutai Shares.

d.

Efficient Frontier

The monthly return of the risk-free asset is 0.2%. The efficient frontier of the asset portfolio composed of the above four risk-free assets and national debt is shown below.



Sharp Ratio and Weight

The maximum sharp ratio in all investment portfolios is the slope of the orange line. The corresponding market portfolio is represented by the red point.

$$Sharp\ Ratio = \frac{w^T\mu - r_f}{(w^T\Sigma w)^{\frac{1}{2}}} = 0.4013$$

$$w = \frac{\Sigma^{-1}(\mu - r_f 1)}{1^T\Sigma^{-1}(\mu - r_f 1)} = [0.4798 \quad 0.0877 \quad -0.1127 \quad 0.5452]$$

Since shorting is allowed in the market, weights can be negative. Negative weight means borrow money from other people. This market portfolio is composed of 47.98% Fuling Mustard, 8.77% BYD, -11.27% Lianchuang Electronics, and 54.52% Moutai Shares.

a.

Data

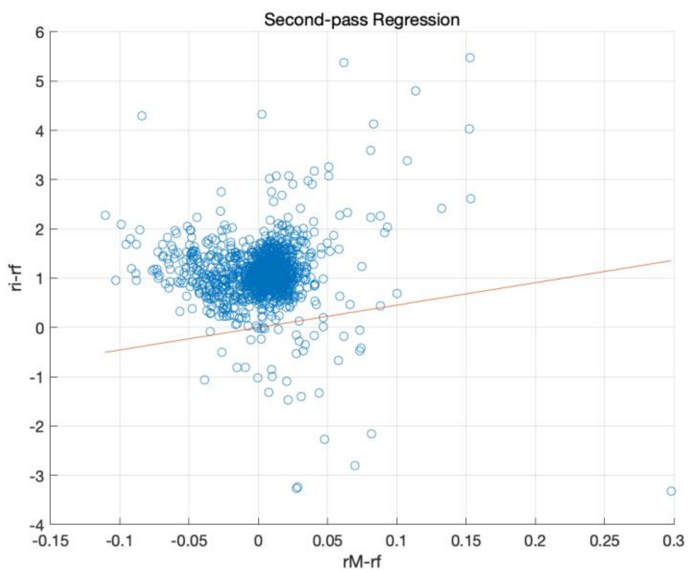
The data comes from CSMAR. It contains risk-free rate, Shanghai stock index, and Shanghai A share from January 2013 to December 2018. Reinvestment and cash bonuses are also taken into consideration.

Data Processing

Firstly, we use the index at the end of each month to calculate the index rate of return and record it as r_M. Then we use the $r_M - r_f$ at each month to get the data. We use Excel to classify individual stocks by month and subtract the risk-free interest rate from the corresponding individual stock yield to get $r_{it} - r_{ft}$. And then put $r_{it} - r_{ft}$ and $r_M - r_f$ into one Excel.

Linear Regression

We use the Matlab to get data from Excel, then regress x and y (The code is attached in "Q2.pdf").



Model Test

Firstly, we can see that $r_{it} - r_{ft}$ is less than 0, which means that the return of risk-free assets is higher than risky asset. Hence, the CAPM is not established for A share Market.
The index on 2013.1 is 2385.422. The index on 2018.12 is 2493.896

```
>> (1+(2493.896-2385.422)/2385.422)^(1/72)

ans =

    1.0006
```

We used the index at the end of December 2018 and the index at the beginning of January 2013 to calculate the average monthly rate of the index and found that it was far less than the risk-free interest rate for any time period. This can prove that the CAPM model is not suitable for the Chinese market.

b.

Breakpoints

We take 10% as breakpoints of the individual stocks, and we have np=10. Calculate the beta coefficient of each individual stock, and put them into a matrix, and finally generate excel. The detail code is shown in “Q2.pdf”.

The outcome is shown on the right. Items with a beta coefficient of 0 in Excel need to be eliminated. Because in the original stock code, these stock codes do not exist, but the algorithm can only add one per circle.

There are a total of 1454 beta coefficients, so it is divided into ten groups and each group has 145 samples. (In order to facilitate data processing, discard the four excess stocks.)

Sort the stocks according to the beta coefficient and use each column vector in the large matrix to represent a portfolio. Here is a part of the matrix.

	A	B	C	D	E	F	G	H	I	J
1	603319	603896	600309	600452	600763	600203	600365	603160	600063	600903
2	603486	600237	600192	600385	600011	600731	600933	600832	600528	603600
3	603085	603288	600882	600897	603773	600962	603556	600716	603810	600559
4	603819	603638	600760	600489	600620	603355	603500	600826	603757	603030
5	603336	603707	603585	600496	601177	600477	603339	600879	603777	601688
6	603223	600429	600664	600368	603899	600667	600149	601789	600783	601600
7	601882	600066	600081	603183	601388	600723	600362	600765	603169	600428
8	603220	600097	600638	603806	600993	600546	600582	600481	600657	600380
9	600087	603278	600079	603101	600787	600052	600790	601163	600173	601519
10	603559	603586	600403	603922	600168	600718	600327	600875	603897	603900
11	603117	600793	600979	600644	603520	601718	603708	600178	603066	600207
12	603778	603717	603518	600539	600483	600058	600199	600639	600343	600353
13	603633	603976	600508	600688	600015	601268	600577	600728	600698	601010
14	603045	601888	603878	600818	603626	601886	600663	600031	603055	600369
15	603090	600703	603233	601666	600661	600308	601369	603012	603081	600665
16	603501	601288	600312	600896	600565	600624	601628	600784	601000	600415
17	603083	603108	603178	603609	600281	601969	600022	600588	601880	600576
18	603028	601139	600455	600604	600630	600176	600221	600796	600895	603601
19	603722	603988	600420	600127	600356	600217	600131	600598	600881	600122
20	603986	600797	600674	600114	600449	600626	600152	600996	600806	601212
21	603032	600660	603617	600961	600078	603963	600720	600075	601881	600855
22	601228	600228	601929	603168	600292	600676	603002	600300	600647	603595

	A	B
1	6.00E+05	0.68456
2	6.00E+05	0
3	6.00E+05	0
4	6.00E+05	0
5	6.00E+05	0.94048
6	6.00E+05	1.0978
7	6.00E+05	0.78411
8	6.00E+05	0.72916
9	6.00E+05	1.1785
10	6.00E+05	0.72836
11	6.00E+05	0.99983
12	6.00E+05	1.0017
13	6.00E+05	1.1278
14	6.00E+05	0
15	6.00E+05	0
16	6.00E+05	1.0052
17	6.00E+05	0.90721
18	6.00E+05	1.1168
19	6.00E+05	1.0664
20	6.00E+05	0.95672
21	6.00E+05	1.3289
22	6.00E+05	1.3319
23	6.00E+05	1.1675
24	6.00E+05	1.015
25	6.00E+05	0
26	6.00E+05	0.34615
27	6.00E+05	1.276
28	6.00E+05	1.1549
29	6.00E+05	0.77503
30	6.00E+05	1.3784
31	6.00E+05	1.7659
32	6.00E+05	1.2511
33	6.00E+05	0
34	6.00E+05	1.1166
35	6.00E+05	0
36	6.00E+05	1.4628

对应股票

T-Statistics

Calculate the beta coefficient of each investment portfolio and calculate the standard error and average of ‘$beta(np) - beta(n1)$’.

```
b1Matrix = 1x10
    0.624060344464574   0.807143369288082   0.924788594874920 ...
```

```
s =
   1.408478321103084
tStat =
   2.610050822167354
```

Conclusion

Hence, we get the table:

outcome variable	1	2	3	4	5	6	7	8	9	10	10-1 t-stat
beta	0.6241	0.8071	0.9248	1.0004	1.0762	1.1553	1.2402	1.3727	1.5897	4.3003	3.6762
standard error											1.4084783
t-statistic											2.6100508
p-value											0.01

Consequently, we have 99% certainty to reject the null hypothesis. Hence, through univariate portfolio sort, the CAPM is not established on A-share Market. If you change the frequency, the result remains the same.

Reason Speculation

- Many stocks are non-tradable stocks, which makes asset pricing difficult.
- China does not have a short-selling mechanism for individual stocks, which makes it impossible to sell stocks and buy risk-free assets for arbitrage.
- Participants in China's financial markets are mostly irrational, causing stock prices to be erroneously pushed up.
- The main purchasers of risk-free assets in China are financial intermediaries, and financial intermediaries are mainly state-owned assets. Other participants are likely to be restricted by policies and unable to participate in arbitrage activities in the national debt market.
- China restricts capital inflows and outflows while restricting foreign investment activities, which has led to misallocation of funds.
- The inability of the index to represent the market leads to index distortion.
- The impact of the trade war in 2018 caused a sharp correction in the stock market.

a.

Data

All data for question (3) Long Short Portfolio comes from Wind. We use circulating market value(流通市值) rather than total market value(总市值) to represent size factor because only the circulating market value participates in market transactions. For the size and short-term reversal factors, we use monthly data. And for volume variance and amihud's liquidity measure factors, we use daily data. For sharp ratio calculation, we use the risk-free rate at 2018.12.31 to represent r_f.

Portfolio Construction

For each factor, we first calculate the factor data for each month and sort the factor data from small to large. We use market-value weighted method to long stocks which correspond to the smallest 20% factor data and short stocks which correspond to the largest 20% factor data. Then we calculate the portfolio return rate in the next month. Keep repeating the above process until end, we get the return rate for each factor at each month from 2010.1 to 2018.12. The return rate data is stored in the attached excel file called 'portfolio return 数据汇总.xlsx'.

Result

	size	volume variance	amihud's liquidity measure	short-term reversal
年化收益率	14.16%	0.41%	-3.15%	3.29%
波动率	7.78%	3.50%	3.21%	4.96%
sharp ratio	1.627586103	0.643325858	-1.448941799	0.361103742
胜率	60.75%	44.34%	42.99%	54.72%
最大回撤率	48.89%	27.44%	29.06%	36.25%

b.

Result

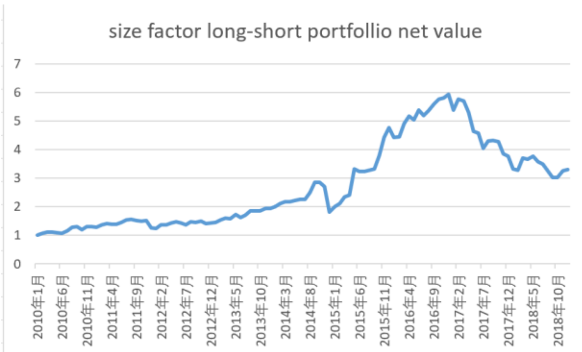
	size	volume variance	amihud's liquidity measure	short-term reversal
多头年化收益率	16.38%	2.87%	1.08%	-2.09%
空头年化收益率	-5.68%	-6.88%	-8.57%	1.01%

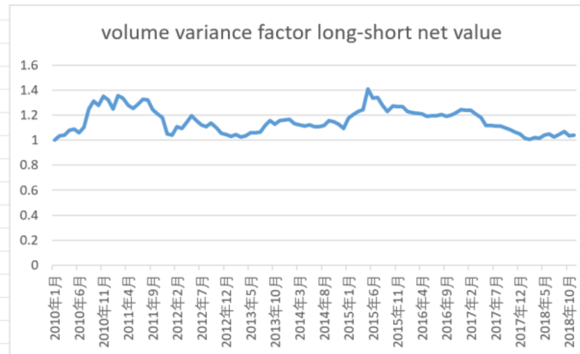
From above picture, the long portfolio of size factor contributes most for corresponding long-short portfolio return.

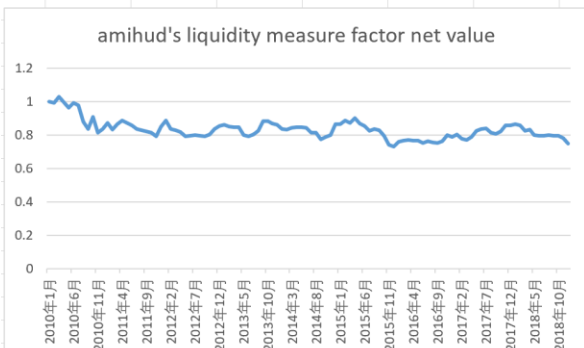
c.

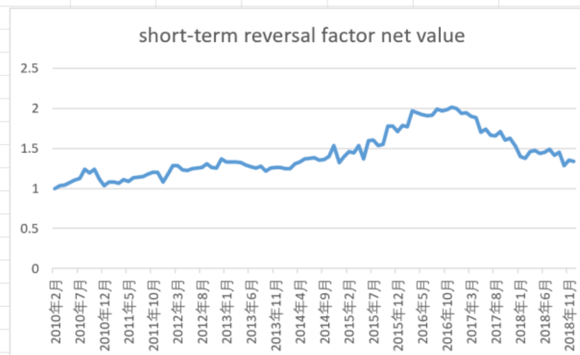
Result

The monthly net value curve corresponding to each factor is as follows:









a.

Data

The data comes from CSMAR. It contains risk-free rate, return rate of Shanghai stock index, return rate of Shanghai A share, total market value of Shanghai A share, and BM from January 2010 to December 2018. The data is processed by the equation,

$$r = r_f + \beta_1(r_m - r_f) + \beta_2(SMB) + \beta_3(HML) + \varepsilon$$

Market Risk Premium Factor

Use 'Shanghai Stock Index Yield - Risk-Free Rate' to get this factor. It is easy to deal with through Excel.

SMB Factor and HML Factor

The first is to divide individual stocks into two groups (Small and Big) according to their market capitalization at the end of January each year. The first 50% are in the Big group, and the last 50% are in the Small group

Then all stocks are individually divided according to the book-to-market value ratio. Divided into three groups (High, Medium, Low), the first 30% is the High group, the middle 40% is the Medium group, and the last 30% is the Low group.

Therefore, from June of the current year to May of the following year, all stocks are divided into these 6 groups (B/L, B/M, B/H, S/L, S/M, S/H). During the period, the grouping will not change, unless there is no transaction data. Then calculate the market value weighted rate of return for the 6 combinations in each trading month to obtain the rate of return of these 6 combinations; finally calculate the SMB factor and HML factor in each trading month, the calculation formula is as follows (Sort once a year)

$$SMB = \frac{(S/L + S/M + S/H)}{3} - \frac{(B/L + B/M + B/H)}{3}$$
$$HML = \frac{(S/H + B/H)}{2} - \frac{(S/L + B/L)}{2}$$

After program processing, we get SMB and HML. A part of Excel as Shown,

time	rm	rf(%)	rm-rf	SMB	HML
2010-01	-0.08784	0.1856	-0.08969	0.051625	-0.01282
2010-02	0.020958	0.1856	0.019102	0.005888	-0.01354
2010-03	0.018732	0.1856	0.016876	-0.014853	-0.02215
2010-04	-0.07671	0.1856	-0.07857	-0.008687	0.044528
2010-05	-0.097	0.1856	-0.09886	-0.022294	-0.08492
2010-06	-0.07476	0.1856	-0.07661	-0.02246	-0.01738
2010-07	0.099705	0.1856	0.097849	-0.021099	-0.01767

So far, the three-factor model has been established.

b.

Use the three-factor model constructed in (4)a to test the excess return (alpha) of each long-short combination in (3) a. The model test result data is stored at one excel file called ‘Q4(2).xlsx’. Based on the Fama-French 3-factor model, we conduct multiple linear regression analysis for four long-short portfolios. And the regression results are as follows:

Summary of Output

Size factor long-short portfolio

Regression Analysis	
Multiple R	0.743170777
R Square	0.552302803
Adjusted R Square	0.539263079
Standard Error	0.052775686
Observation	107

Variance Analysis

	df	SS	MS	F	Significance F
Regression Analysis	3	0.353914107	0.117971369	42.35540538	6.48037E-18
Residual	103	0.286883124	0.002785273		
Total	106	0.640797231			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.00713522	0.005138428	1.388599785	0.167950074	-0.00305564	0.017326079
X Variable 1	0.064601376	0.080314661	0.804353475	0.423045512	-0.09468381	0.223886563
X Variable 2	1.314185289	0.127156934	10.33514449	1.32947E-17	1.061999501	1.566371078
X Variable 3	-0.595143992	0.160510986	-3.707808455	0.000338786	-0.913479676	-0.276808308

Volume variance long-short portfolio

Regression Analysis	
Multiple R	0.559150997
R Square	0.312649837
Adjusted R Square	0.29262993
Standard Error	0.029316865
Observation	107

Variance Analysis

	df	SS	MS	F	Significance F
Regression Analysis	3	0.040267293	0.013422431	15.61694704	1.91657E-08
Residual	103	0.08852629	0.000859479		
Total	106	0.128793583			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.002407943	0.002854394	-0.843591848	0.400852434	-0.00806896	0.003253074
X Variable 1	0.111224704	0.04461475	2.493002973	0.01425981	0.02274187	0.199707537
X Variable 2	0.397961191	0.070635607	5.634002578	1.54023E-07	0.257872125	0.538050258
X Variable 3	-0.196607324	0.089163764	-2.205013716	0.029677105	-0.373442621	-0.019772027

Amuhud's liquidity measure long-short portfolio

Regression Analysis	
Multiple R	0.48579238
R Square	0.235994237
Adjusted R Square	0.213741642
Standard Error	0.028436146
Observation	107

Variance Analysis

	df	SS	MS	F	Significance F
Regression Analysis	3	0.025726663	0.008575554	10.60524564	3.89272E-06
Residual	103	0.083287285	0.000808614		
Total	106	0.109013948			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	-0.003032379	0.002768644	-1.095258	0.275958094	-0.008523332	0.002458573
X Variable 1	0.085183085	0.043274462	1.968437742	0.05170524	-0.000641605	0.171007774
X Variable 2	-0.281640455	0.068513618	-4.110722286	7.94137E-05	-0.417521057	-0.145759854
X Variable 3	0.291561844	0.086485164	3.371235363	0.001054658	0.120038919	0.46308477

Short-term reversal long-short portfolio

Regression Analysis	
Multiple R	0.26211422
R Square	0.068703864
Adjusted R Square	0.041312801
Standard Error	0.048563853
Observation	106

Variance Analysis

	df	SS	MS	F	Significance F
Regression Analysis	3	0.01774679	0.005915597	2.508258427	0.063055627
Residual	102	0.240561679	0.002358448		
Total	105	0.258308469			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%
Intercept	0.002566792	0.004751328	0.540226183	0.590218672	-0.006857444	0.011991027
X Variable 1	0.077005495	0.073938007	1.041487291	0.300111761	-0.069650192	0.223661182
X Variable 2	-0.000654778	0.117009036	-0.005595958	0.995546025	-0.232741645	0.23143209
X Variable 3	-0.368709514	0.147838519	-2.494001676	0.014238025	-0.661946516	-0.075472513

The significance F for size, volume variance, amihud's liquidity measure and short-term reversal these four long-short portfolios are 6.48E-18, 1.92E-08, 3.89E-06 and 0.063056 respectively. So, Fama-French model can explain the excess returns for these four long-short portfolios very well. The Fama-French model is significant for the excess returns of the four long-short portfolios.