TIØ4317 Empirical and Quantitative Methods in Finance **Exercise 4**
24.02.2025 **Scribe: Adrian Fagerland**

1. Are all variables stationary?

ADF Test Statistics for All Variables:

	Portfolio	Market	Size	Value	Momentum
ADF Test Statistic	-13.10	-14.43	-16.92	-15.65	-6.59
p-value	0.00	0.00	0.00	0.00	0.00
Lags Used	0.00	1.00	0.00	0.00	13.00
Observations	362.00	361.00	362.00	362.00	349.00

Portfolio: Stationary (p-value: 0.0000)

Market: Stationary (p-value: 0.0000)

Size: Stationary (p-value: 0.0000)

Value: Stationary (p-value: 0.0000)

Momentum: Stationary (p-value: 0.0000)

2. Estimated multiple linear regression model

Dep. Variable:	Portfolio	**R-squared:**	0.602
Model:	OLS	**Adj. R-squared:**	0.598
Method:	Least Squares	**F-statistic:**	135.5
Date:	Mon, 24 Feb 2025	**Prob (F-statistic):**	2.27e-70
Time:	16:09:51	**Log-Likelihood:**	711.38
No. Observations:	363	**AIC:**	-1413.
Df Residuals:	358	**BIC:**	-1393.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
Intercept	0.0054	0.002	2.835	0.005	0.002	0.009
Market	0.6697	0.039	17.118	0.000	0.593	0.747
Size	0.8334	0.054	15.567	0.000	0.728	0.939
Value	0.1042	0.056	1.872	0.062	-0.005	0.214
Momentum	0.0952	0.051	1.878	0.061	-0.005	0.195

Omnibus:	50.614	**Durbin-Watson:**	1.585
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	158.396
Skew:	0.605	**Prob(JB):**	4.03e-35
Kurtosis:	6.002	**Cond. No.**	36.4

Notes:
[1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

TODO answer: Is the model significant? Can you draw a conclusion on the significance of the explanatory variables?

Interpreting the coefficient of the market

Market Coefficient: 0.6697

A 1% increase in market return is associated with a 0.6697% change in portfolio return.

Portfolio Market Size Value Momentum dates 1980-10-01 0.017922 0.048999 -0.001831 -0.073336 0.047642 1980-11-01 -0.007557 -0.002069 0.006468 -0.016982 -0.002769 1980-12-01 -0.022945 -0.054350 0.002906 -0.002302 0.005941 1981-01-01 0.030309 -0.015931 0.019980 0.004472 -0.004155 1981-02-01 0.033886 0.048528 -0.008174 0.021949 -0.014549 <class 'pandas.core.frame.DataFrame'> DatetimeIndex: 363 entries, 1980-10-01 to 2010-12-01 Data columns (total 5 columns): Column Non-Null Count Dtype — —— ————— —— 0 Portfolio 363 non-null float64 1 Market 363 non-null float64 2 Size 363 non-null float64 3 Value 363 non-null float64 4 Momentum 363 non-null float64 dtypes: float64(5) memory usage: 17.0 KB None Portfolio Market Size Value Momentum count 363.000000 363.000000 363.000000 363.000000 363.000000 mean 0.010881 0.005143 0.001119 0.003804 0.007652 std 0.054137 0.046702 0.033930 0.037405 0.041660 min -0.183606 -0.270575 -0.118289 -0.204204 -0.273742 255075max 0.272537 0.132756 0.185370 0.209493 0.140642 Augmented Dickey-Fuller Test: Portfolio ADF Test Statistic -1.310474e+01 p-value 1.681558e-24 Lags Used 0.000000e+00 Number of Observations Used 3.620000e+02 Critical Value (1Critical Value (5Critical Value (10Strong evidence against the null hypothesis (Ho), reject the null hypothesis. Data is stationary. Augmented Dickey-Fuller Test: Market ADF Test Statistic -1.442904e+01 p-value 7.685244e-27 Lags Used 1.000000e+00 Number of Observations Used 3.610000e+02 Critical Value (1Critical Value (5Critical Value (10Strong evidence against the null hypothesis (Ho), reject the null hypothesis. Data is stationary. Augmented Dickey-Fuller Test: Size ADF Test Statistic -1.692299e+01 p-value 9.907584e-30 Lags Used 0.000000e+00 Number of Observations Used 3.620000e+02 Critical Value (1Critical Value (5Critical Value (10Strong evidence against the null hypothesis (Ho), reject the null hypothesis. Data is stationary. Augmented Dickey-Fuller Test: Value ADF Test Statistic -1.564669e+01 p-value 1.615256e-28 Lags Used 0.000000e+00 Number of Observations Used 3.620000e+02 Critical Value (1Critical Value

(5Critical Value (10Strong evidence against the null hypothesis (Ho), reject the null hypothesis. Data is stationary. Augmented Dickey-Fuller Test: Momentum ADF Test Statistic -6.594037e+00 p-value 6.997950e-09 Lags Used 1.300000e+01 Number of Observations Used 3.490000e+02 Critical Value (1Critical Value (5Critical Value (10Strong evidence against the null hypothesis (Ho), reject the null hypothesis. Data is stationary. OLS Regression Results

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Dep. Variable: Portfolio R-squared: 0.602 Model: OLS Adj. R-squared: 0.598 Method: Least Squares F-statistic: 135.5 Date: Mon, 24 Feb 2025 Prob (F-statistic): 2.27e-70 Time: 10:15:57 Log-Likelihood: 711.38 No. Observations: 363 AIC: -1413. Df Residuals: 358 BIC: -1393. Df Model: 4 Covariance Type: nonrobust ==========

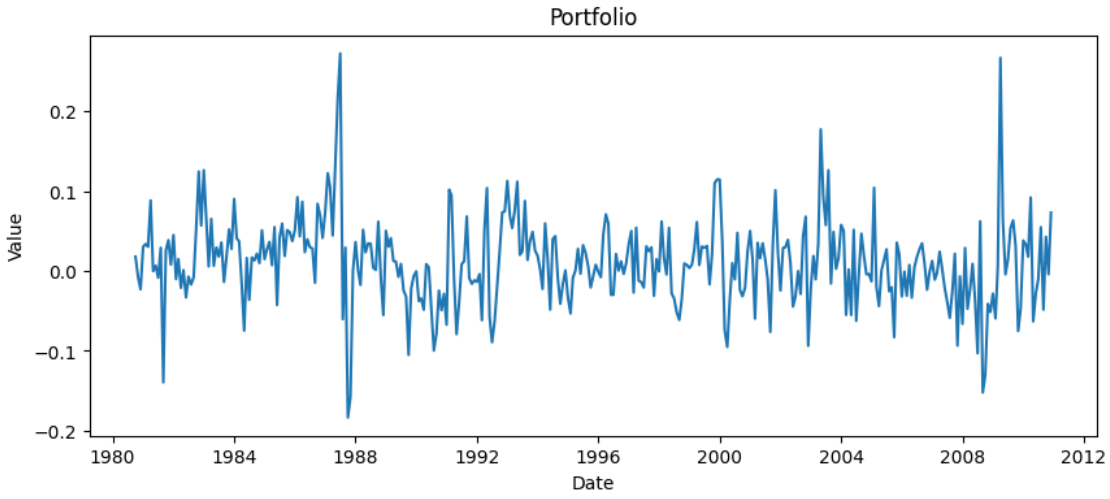
coef std err t P>|t| [0.025 0.975] ----------

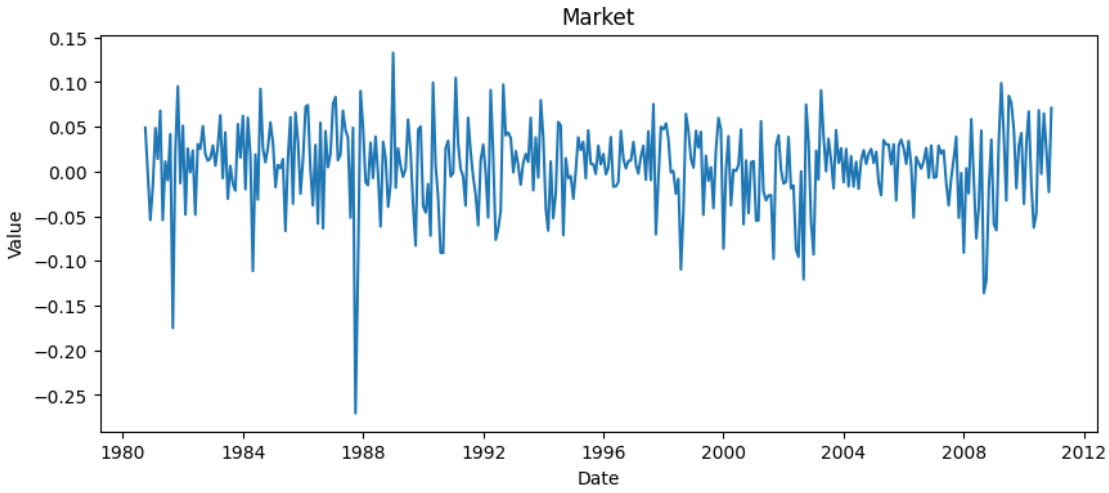
Intercept 0.0054 0.002 2.835 0.005 0.002 0.009 Market 0.6697 0.039 17.118 0.000 0.593 0.747 Size 0.8334 0.054 15.567 0.000 0.728 0.939 Value 0.1042 0.056 1.872 0.062 -0.005 0.214 Momentum 0.0952 0.051 1.878 0.061 -0.005 0.195 ==========

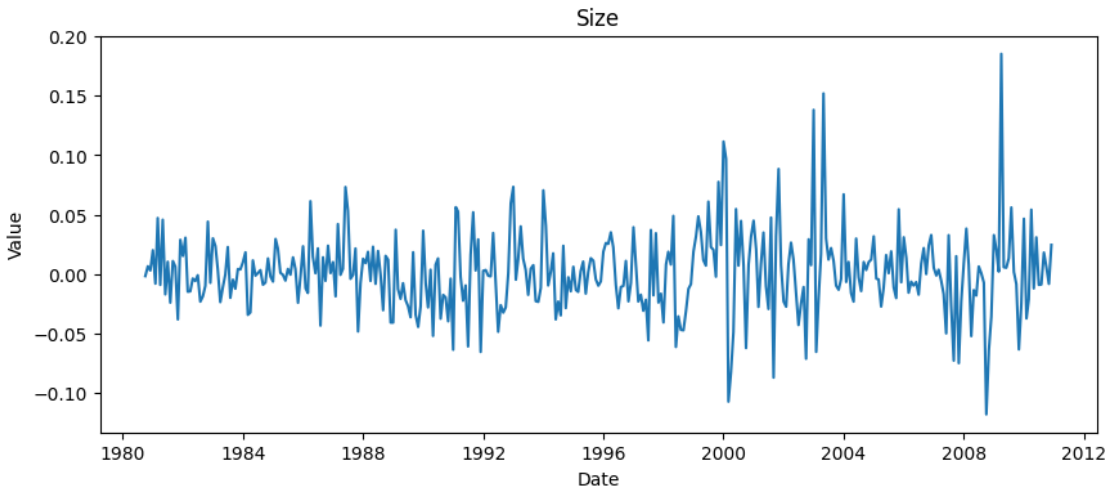
Omnibus: 50.614 Durbin-Watson: 1.585 Prob(Omnibus): 0.000 Jarque-Bera (JB): 158.396 Skew: 0.605 Prob(JB): 4.03e-35 Kurtosis: 6.002 Cond. No. 36.4 ==========

Notes: [1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Market Coefficient: 0.6697 A 1




Market
0.15
0.10
0.05
0.00
−0.05
−0.10
−0.15
−0.20
−0.25
Value
1980
1984
1988
1992
1996
2000
2004
2008
2012
Date


Size
0.20
0.15
0.10
0.05
0.00
−0.05
−0.10
Value
1980
1984
1988
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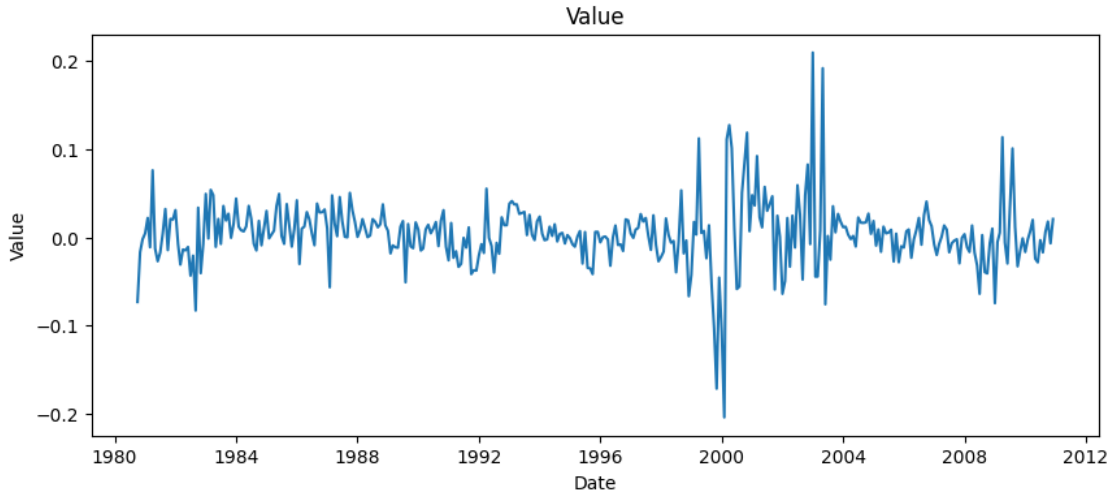
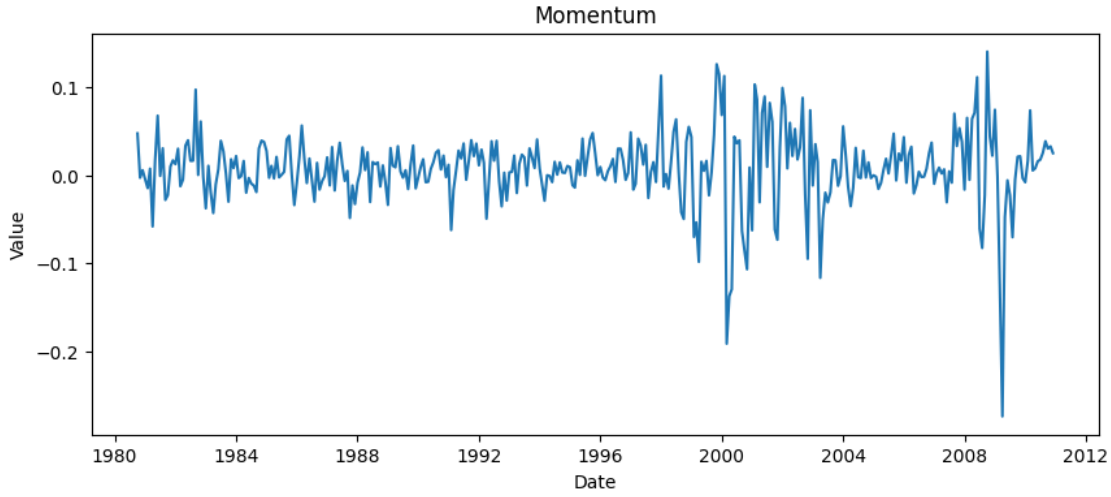
2004
2008
2012
Date





Chow Test for Breakpoint at 1993-01-01 00:00:00: Chow Statistic: 7.2059 P-value: 0.0000 Significant break detected at 1993-01-01 00:00:00 OLS Regression Results ==========
Dep. Variable: Portfolio R-squared: 0.639 Model: OLS Adj. R-squared: 0.630 Method: Least Squares F-statistic: 69.47 Date: Mon, 24 Feb 2025 Prob (F-statistic): 1.03e-72 Time: 10:15:57 Log-Likelihood: 729.02 No. Observations: 363 AIC: -1438. Df Residuals: 353 BIC: -1399. Df Model: 9 Covariance Type: nonrobust ==========
coef std err t P>|t| [0.025 0.975] ----------
———- Intercept 0.0079 0.003 2.646 0.009 0.002 0.014 Market 0.8065 0.051 15.688 0.000 0.705

0.908 Size 1.2198 0.107 11.353 0.000 1.008 1.431 Value 0.2753 0.119 2.307 0.022 0.041 0.510 Momentum 0.1509 0.122 1.236 0.217 -0.089 0.391 $\text{Break}_{D}ummy - 0.0041 0.004 - 1.070 0.285 - 0.012 0.003 Market_{B}reak - 0.2642 0.076 - 3.481 0.001 - 0.413 - 0.115 Size_{B}reak - 0.4900 0.123 - 3.994 0.000 - 0.731 - 0.249 Value_{B}reak - 0.2427 0.134 - 1.818 0.070 - 0.505 0.020 Momentum_{B}reak - 0.1118 0.133 - 0.838 0.402 - 0.374 0.151$ ==========
$Omnibus$: 29.965 $Durbin - Watson$: 1.737 $Prob(Omnibus)$: 0.000 $Jarque - Bera(JB)$: 61.465 $Skew$: 0.456 $Prob(JB)$: 4.50$e{-14}$ $Kurtosis$: 4.798 $Cond.No.$ 146. ==========

Notes: [1] Standard Errors assume that the covariance matrix of the errors is correctly specified.

Durbin-Watson Statistic: 1.7368

Breusch-Godfrey Test: LM Statistic: 17.4535 P-value (LM): 0.1333 F Statistic: 1.4353 P-value (F): 0.1478

Breusch-Pagan Test: LM Statistic: 26.4762 P-value (LM): 0.0017 F Statistic: 3.0858 P-value (F): 0.0014 OLS Regression Results ==========
Dep. Variable: Portfolio R-squared: 0.639 Model: OLS Adj. R-squared: 0.630 Method: Least Squares F-statistic: 48.46 Date: Mon, 24 Feb 2025 Prob (F-statistic): 1.82e-56 Time: 10:15:57 Log-Likelihood: 729.02 No. Observations: 363 AIC: -1438. Df Residuals: 353 BIC: -1399. Df Model: 9 Covariance Type: HAC ==========
coef std err z P>|z| [0.025 0.975] ----------
——- Intercept 0.0079 0.004 1.848 0.065 -0.000 0.016 Market 0.8065 0.060 13.467 0.000 0.689 0.924 Size 1.2198 0.174 7.007 0.000 0.879 1.561 Value 0.2753 0.092 3.004 0.003 0.096 0.455 Momentum 0.1509 0.133 1.134 0.257 -0.110 0.412 $\text{Break}_{D}ummy - 0.0041 0.005 - 0.745 0.456 - 0.015 0.007 Market_{B}reak - 0.2642 0.098 - 2.691 0.007 - 0.457 - 0.072 Size_{B}reak - 0.4900 0.194 - 2.524 0.012 - 0.870 - 0.110 Value_{B}reak - 0.2427 0.122 - 1.987 0.047 - 0.482 - 0.003 Momentum_{B}reak - 0.1118 0.149 - 0.750 0.453 - 0.404 0.180$ ==========
$Omnibus$: 29.965 $Durbin - Watson$: 1.737 $Prob(Omnibus)$: 0.000 $Jarque - Bera(JB)$: 61.465 $Skew$: 0.456 $Prob(JB)$: 4.50$e{-14}$ $Kurtosis$: 4.798 $Cond.No.$ 146. ==========

Notes: [1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 12 lags and without small sample correction OLS Regression Results ==========
Dep. Variable: Portfolio R-squared: 0.633 Model: OLS Adj. R-squared: 0.628 Method: Least Squares F-statistic: 84.85 Date: Mon, 24 Feb 2025 Prob (F-statistic): 1.41e-58 Time: 10:15:57 Log-Likelihood: 725.97 No. Observations: 363 AIC: -1440. Df Residuals: 357 BIC: -1417. Df Model: 5 Covariance Type: HAC ==========
coef std err z P>|z| [0.025 0.975] ----------
—- Intercept 0.0102 0.004 2.528 0.011 0.002 0.018 Market 0.8014 0.059 13.523 0.000 0.685 0.918 Size 1.2616 0.192 6.556 0.000 0.884 1.639 $\text{Break}_{D}ummy - 0.0059 0.005 - 1.142 0.253 - 0.016 0.004 Market_{B}reak - 0.2668 0.097 - 2.750 0.006 - 0.457 - 0.077 Size_{B}reak - 0.5363 0.209 - 2.564 0.010 - 0.946 - 0.126$ ==========
$Omnibus$: 27.260 $Durbin - Watson$: 1.695 $Prob(Omnibus)$: 0.000 $Jarque - Bera(JB)$: 55.728 $Skew$: 0.414 $Prob(JB)$: 7.92$e{-13}$ $Kurtosis$: 4.732 $Cond.No.$ 108. ==========

Notes: [1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 12 lags and without small sample correction OLS Regression Results ==========
Dep. Variable: Portfolio R-squared: 0.332 Model: OLS Adj. R-squared: 0.326 Method: Least Squares F-statistic: 47.11 Date: Mon, 24 Feb 2025 Prob (F-statistic): 1.07e-25 Time: 10:15:57 Log-Likelihood: 617.21 No. Observations: 363 AIC: -1226. Df Residuals: 359 BIC: -1211. Df Model: 3 Covariance Type: HAC ==========
coef std err z P>|z| [0.025 0.975] ——————————————————————————
—— Intercept 0.0099 0.006 1.596 0.111 -0.002 0.022 Market 0.7144 0.072 9.967 0.000 0.574 0.855 $\text{Break}_{D}ummy - 0.00410.008 - 0.5410.589 - 0.0190.011Market_{B}reak - 0.11290.131 - 0.8640.387 - 0.3690.143$ ==========
$Omnibus : 86.844Durbin - Watson : 1.404Prob(Omnibus) : 0.000Jarque - Bera(JB) : 282.017Skew : 1.054Prob(JB) : 5.76e{-}62Kurtosis : 6.769Cond.No.57.9$ ==========

Notes: [1] Standard Errors are heteroscedasticity and autocorrelation robust (HAC) using 12 lags and without small sample correction