A Knockoff filter approach to asset allocation *

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This paper investigates using the Knockoff filter of Barber and Candés (2019) as a novel to optimise long-only equity portfolios by controlling false discoveries and cross-sectional dependence among US equities. Three conventional strategies of value investing, growth investing, and investing in companies by largest market capitalisation are considered as benchmark strategies. Using the Fama–French–Carhart factor analysis, this paper quantifies the benefits of the Knockoff regression in generating excess returns alpha and mitigating factor-related risks embedded in common investment strategies.

*All errors are mine.

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1 Baseline

The benchmark in this section is CRSP value-weighted market index. Large caps are defined as top 100 assets by the largest market capitalisation as of 31st December of the year prior to the investment period. Growth stocks are defined as assets with highest EPS/Price ratio. Value stocks are defined as assets with highest BPS/Price ratio. All portfolios are equal weight.

1.1 Top 100 by market capitalisation

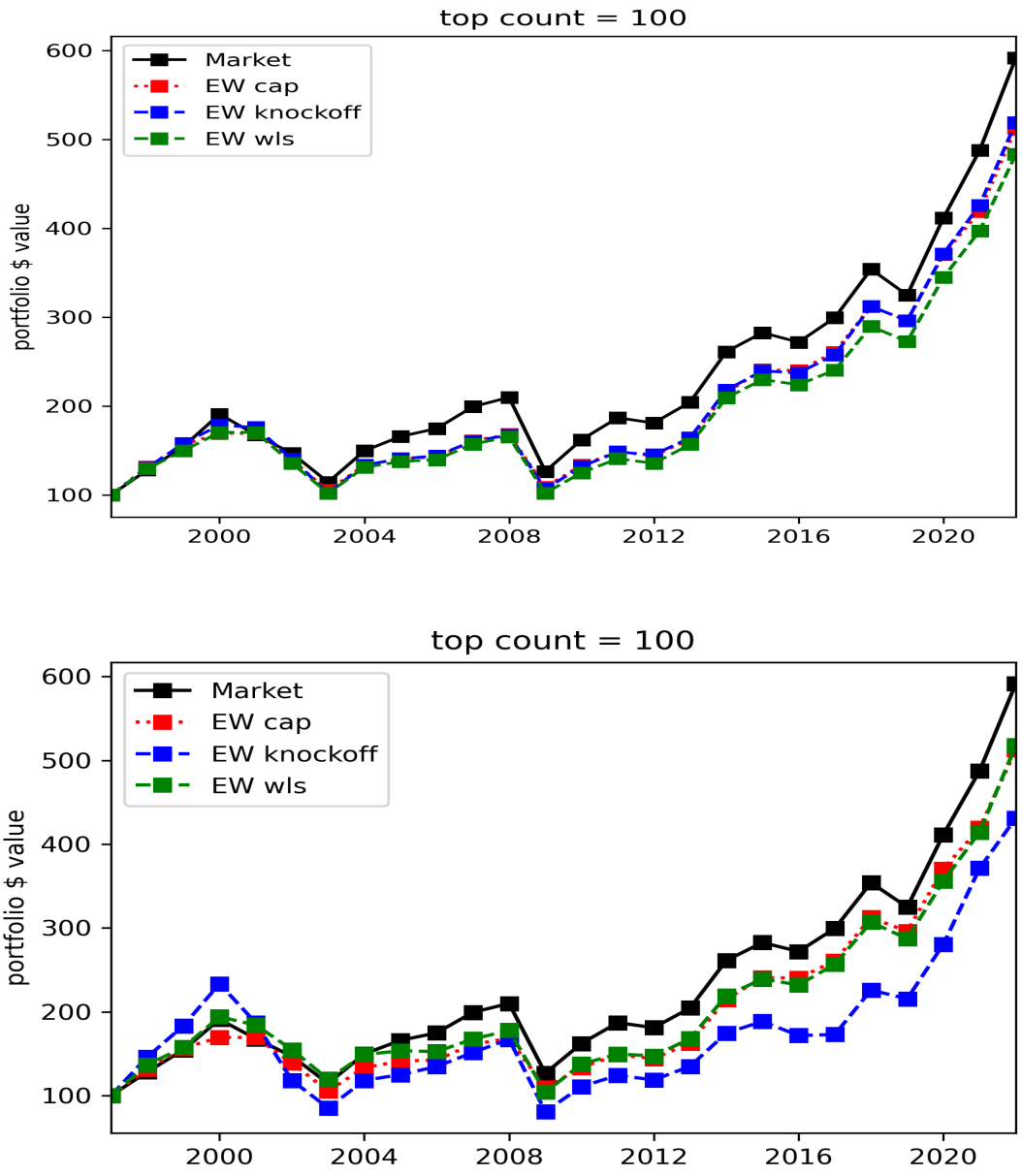

Figure 1: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Cap top 100

Dep. Variable:	cap ret	**R-squared:**	0.956
Model:	OLS	**Adj. R-squared:**	0.955
Method:	Least Squares	**F-statistic:**	1600.
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.44e-198
Time:	20:07:50	**Log-Likelihood:**	971.92
No. Observations:	300	**AIC:**	-1934.
Df Residuals:	295	**BIC:**	-1915.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0013	0.001	-2.249	0.025	-0.002	-0.000
mktrf	0.9468	0.013	71.225	0.000	0.921	0.973
smb	-0.1985	0.018	-11.309	0.000	-0.233	-0.164
hml	0.0935	0.018	5.292	0.000	0.059	0.128
umd	-0.0970	0.012	-8.196	0.000	-0.120	-0.074

Omnibus:	26.236	**Durbin-Watson:**	2.006
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	107.206
Skew:	0.109	**Prob(JB):**	5.25e-24
Kurtosis:	5.920	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.952
Model:	OLS	**Adj. R-squared:**	0.951
Method:	Least Squares	**F-statistic:**	1454.
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	9.95e-193
Time:	20:07:50	**Log-Likelihood:**	940.76
No. Observations:	300	**AIC:**	-1872.
Df Residuals:	295	**BIC:**	-1853.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0013	0.001	-2.090	0.037	-0.003	-7.66e-05
mktrf	0.9828	0.015	66.637	0.000	0.954	1.012
smb	-0.1787	0.019	-9.175	0.000	-0.217	-0.140
hml	0.0513	0.020	2.617	0.009	0.013	0.090
umd	-0.1372	0.013	-10.447	0.000	-0.163	-0.111

Omnibus:	35.950	**Durbin-Watson:**	2.121
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	203.173
Skew:	0.188	**Prob(JB):**	7.61e-45
Kurtosis:	7.014	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.950
Model:	OLS	**Adj. R-squared:**	0.950
Method:	Least Squares	**F-statistic:**	1410.
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	7.64e-191
Time:	20:07:50	**Log-Likelihood:**	938.73
No. Observations:	300	**AIC:**	-1867.
Df Residuals:	295	**BIC:**	-1849.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0013	0.001	-2.008	0.046	-0.003	-2.49e-05
mktrf	0.9793	0.015	65.955	0.000	0.950	1.009
smb	-0.1861	0.020	-9.492	0.000	-0.225	-0.148
hml	0.0434	0.020	2.199	0.029	0.005	0.082
umd	-0.1280	0.013	-9.686	0.000	-0.154	-0.102

Omnibus:	20.813	**Durbin-Watson:**	1.975
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	61.982
Skew:	0.175	**Prob(JB):**	3.47e-14
Kurtosis:	5.199	**Cond. No.**	34.5

Notes:

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

1.2 Top 100 large cap value stocks

The considered minimum market capitalisation is $50 billions.

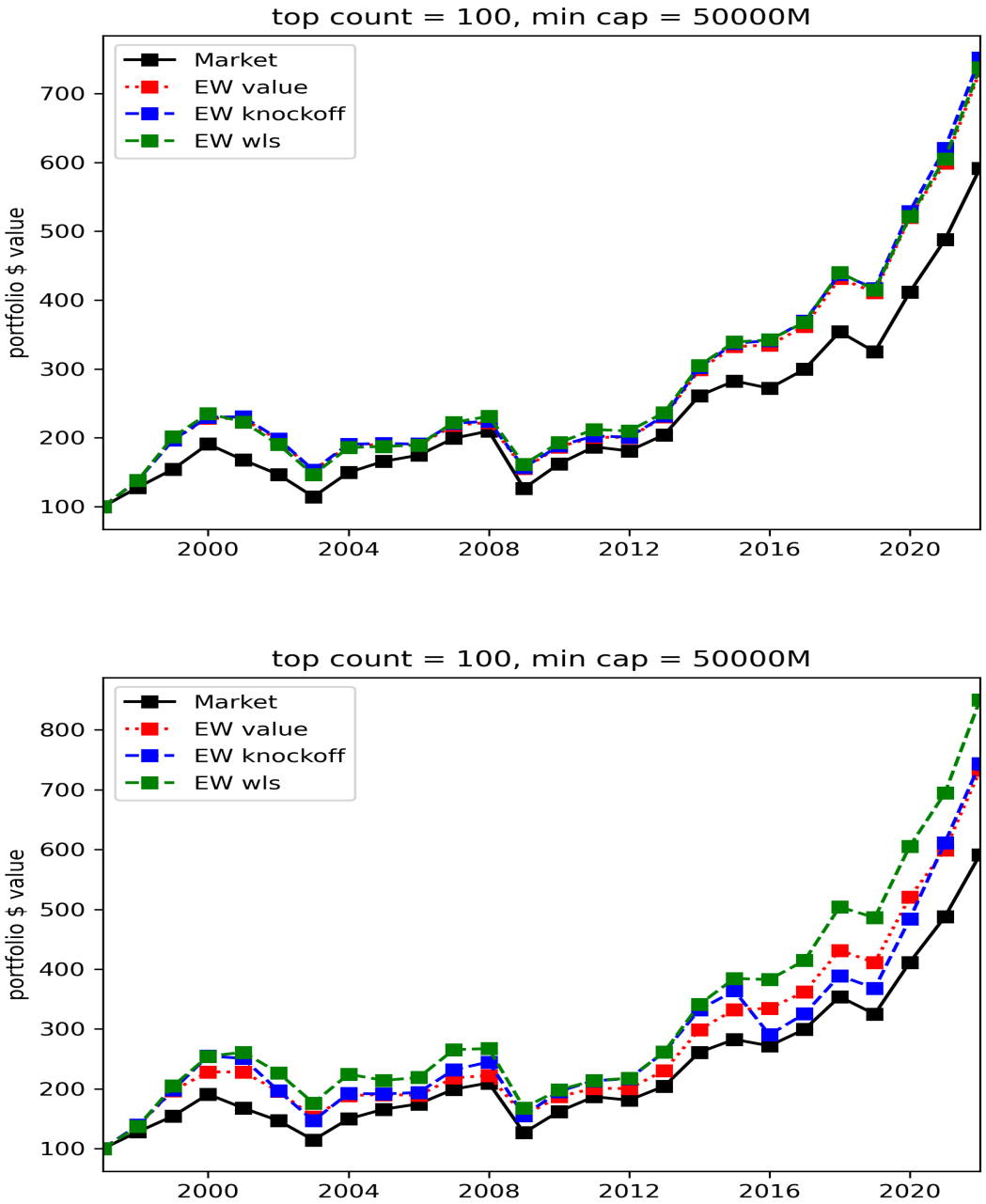

Figure 2: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Value top 100

Dep. Variable:	value ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	488.0
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.10e-128
Time:	21:54:10	**Log-Likelihood:**	800.16
No. Observations:	300	**AIC:**	-1590.
Df Residuals:	295	**BIC:**	-1572.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.755	0.451	-0.003	0.001
mktrf	0.9332	0.024	39.598	0.000	0.887	0.980
smb	-0.3014	0.031	-9.685	0.000	-0.363	-0.240
hml	0.0321	0.031	1.025	0.306	-0.030	0.094
umd	-0.0936	0.021	-4.463	0.000	-0.135	-0.052

Omnibus:	215.321	**Durbin-Watson:**	1.776
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	7486.304
Skew:	-2.409	**Prob(JB):**	0.00
Kurtosis:	26.994	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.875
Model:	OLS	**Adj. R-squared:**	0.874
Method:	Least Squares	**F-statistic:**	518.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	4.83e-132
Time:	21:54:10	**Log-Likelihood:**	794.60
No. Observations:	300	**AIC:**	-1579.
Df Residuals:	295	**BIC:**	-1561.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0010	0.001	-1.004	0.316	-0.003	0.001
mktrf	0.9708	0.024	40.436	0.000	0.924	1.018
smb	-0.2661	0.032	-8.395	0.000	-0.328	-0.204
hml	-0.0156	0.032	-0.490	0.624	-0.078	0.047
umd	-0.1145	0.021	-5.358	0.000	-0.157	-0.072

Omnibus:	248.304	**Durbin-Watson:**	1.767
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	10872.964
Skew:	-2.929	**Prob(JB):**	0.00
Kurtosis:	31.905	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.868
Method:	Least Squares	**F-statistic:**	491.1
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	4.98e-129
Time:	21:54:10	**Log-Likelihood:**	795.66
No. Observations:	300	**AIC:**	-1581.
Df Residuals:	295	**BIC:**	-1563.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.778	0.437	-0.003	0.001
mktrf	0.9507	0.024	39.739	0.000	0.904	0.998
smb	-0.2927	0.032	-9.265	0.000	-0.355	-0.231
hml	0.0276	0.032	0.867	0.387	-0.035	0.090
umd	-0.0944	0.021	-4.433	0.000	-0.136	-0.052

Omnibus:	201.914	**Durbin-Watson:**	1.796
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	6672.322
Skew:	-2.195	**Prob(JB):**	0.00
Kurtosis:	25.683	**Cond. No.**	34.5

Notes:

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

1.3 Top 100 large cap growth stocks

The considered minimum market capitalisation is $50 billions.

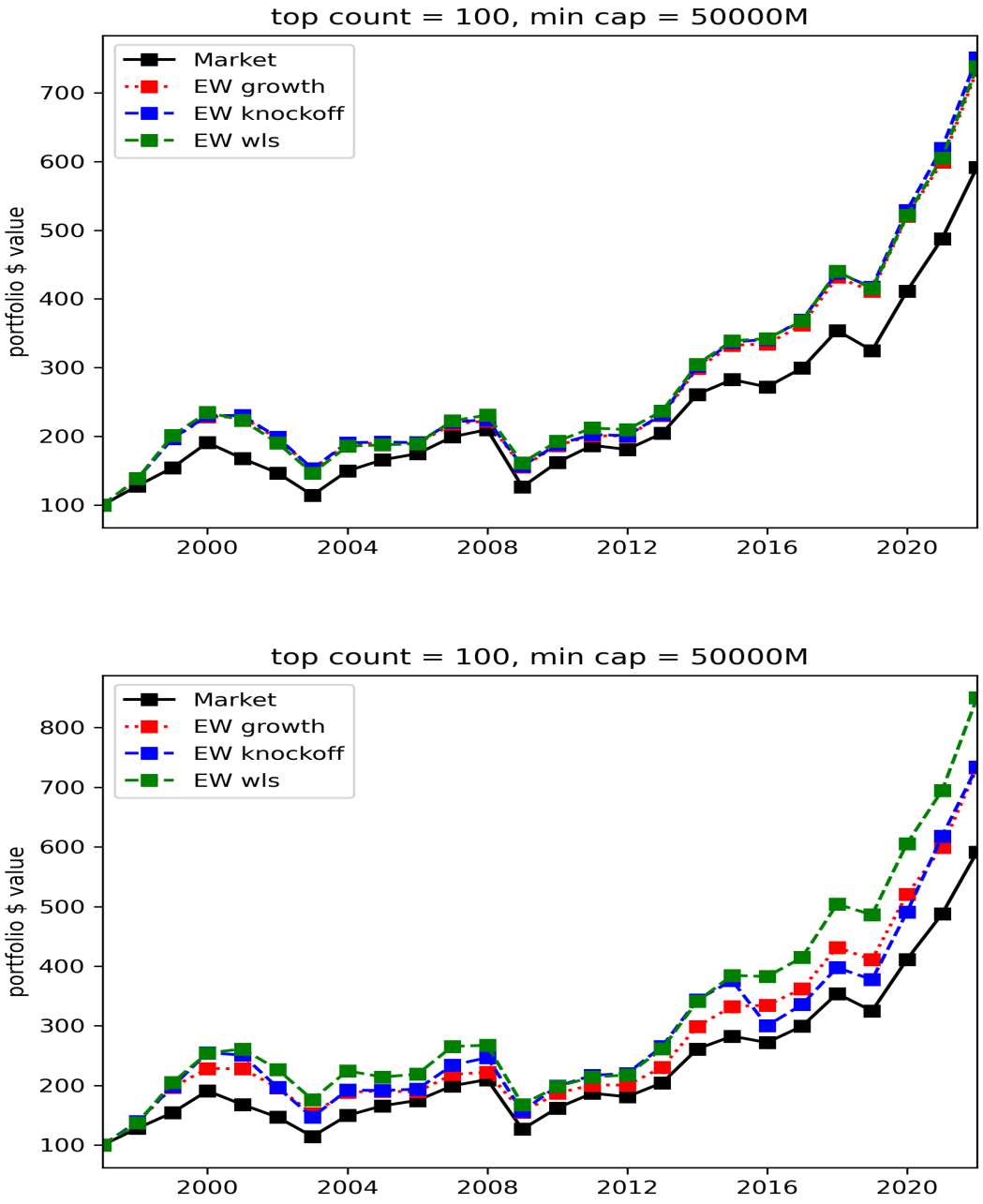

Figure 3: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Growth top 100

Dep. Variable:	growth ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	488.0
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.10e-128
Time:	22:03:25	**Log-Likelihood:**	800.16
No. Observations:	300	**AIC:**	-1590.
Df Residuals:	295	**BIC:**	-1572.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.755	0.451	-0.003	0.001
mktrf	0.9332	0.024	39.598	0.000	0.887	0.980
smb	-0.3014	0.031	-9.685	0.000	-0.363	-0.240
hml	0.0321	0.031	1.025	0.306	-0.030	0.094
umd	-0.0936	0.021	-4.463	0.000	-0.135	-0.052

Omnibus:	215.321	**Durbin-Watson:**	1.776
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	7486.304
Skew:	-2.409	**Prob(JB):**	0.00
Kurtosis:	26.994	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.875
Model:	OLS	**Adj. R-squared:**	0.874
Method:	Least Squares	**F-statistic:**	518.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	4.83e-132
Time:	22:03:25	**Log-Likelihood:**	794.60
No. Observations:	300	**AIC:**	-1579.
Df Residuals:	295	**BIC:**	-1561.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0010	0.001	-1.004	0.316	-0.003	0.001
mktrf	0.9708	0.024	40.436	0.000	0.924	1.018
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umd	-0.1145	0.021	-5.358	0.000	-0.157	-0.072

Omnibus:	248.304	**Durbin-Watson:**	1.767
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	10872.964
Skew:	-2.929	**Prob(JB):**	0.00
Kurtosis:	31.905	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.870
Model:	OLS	**Adj. R-squared:**	0.868
Method:	Least Squares	**F-statistic:**	492.1
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.87e-129
Time:	22:03:25	**Log-Likelihood:**	795.78
No. Observations:	300	**AIC:**	-1582.
Df Residuals:	295	**BIC:**	-1563.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.785	0.433	-0.003	0.001
mktrf	0.9513	0.024	39.782	0.000	0.904	0.998
smb	-0.2923	0.032	-9.257	0.000	-0.354	-0.230
hml	0.0284	0.032	0.895	0.372	-0.034	0.091
umd	-0.0942	0.021	-4.426	0.000	-0.136	-0.052

Omnibus:	201.983	**Durbin-Watson:**	1.796
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	6687.077
Skew:	-2.196	**Prob(JB):**	0.00
Kurtosis:	25.709	**Cond. No.**	34.5

Notes:

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

1.4 Top 100 medium cap value stocks

The considered minimum market capitalisation is $500 millions.

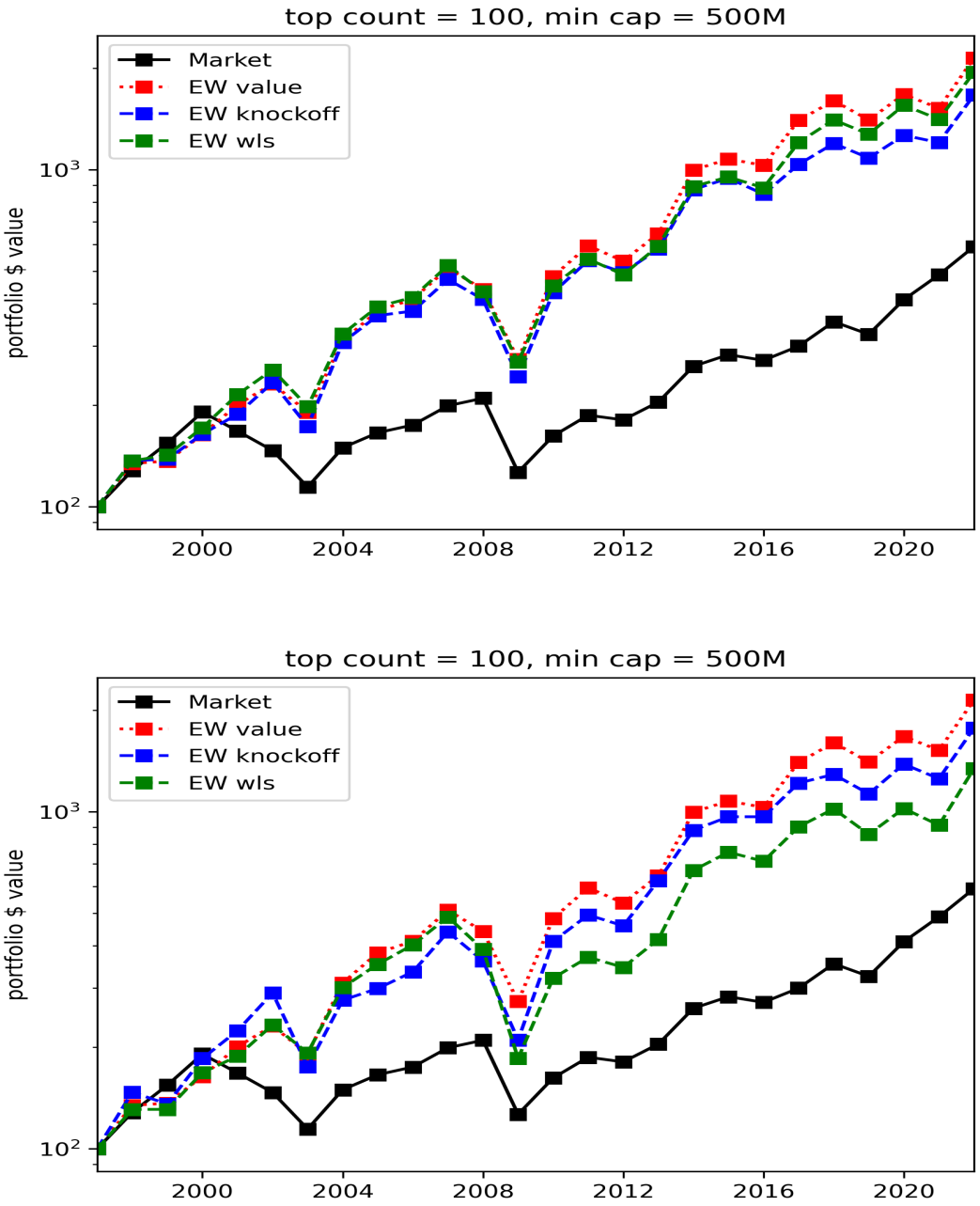

Figure 4: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Value top 100

Dep. Variable:	value ret	**R-squared:**	0.910
Model:	OLS	**Adj. R-squared:**	0.908
Method:	Least Squares	**F-statistic:**	742.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.41e-152
Time:	21:23:28	**Log-Likelihood:**	723.46
No. Observations:	300	**AIC:**	-1437.
Df Residuals:	295	**BIC:**	-1418.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0037	0.001	2.893	0.004	0.001	0.006
mktrf	1.1092	0.030	36.448	0.000	1.049	1.169
smb	0.4343	0.040	10.807	0.000	0.355	0.513
hml	0.9116	0.040	22.540	0.000	0.832	0.991
umd	-0.3233	0.027	-11.934	0.000	-0.377	-0.270

Omnibus:	148.267	**Durbin-Watson:**	2.088
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	1459.733
Skew:	1.771	**Prob(JB):**	0.00
Kurtosis:	13.210	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.906
Model:	OLS	**Adj. R-squared:**	0.905
Method:	Least Squares	**F-statistic:**	711.7
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.90e-150
Time:	21:23:28	**Log-Likelihood:**	716.60
No. Observations:	300	**AIC:**	-1423.
Df Residuals:	295	**BIC:**	-1405.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0033	0.001	2.517	0.012	0.001	0.006
mktrf	1.1227	0.031	36.059	0.000	1.061	1.184
smb	0.4125	0.041	10.033	0.000	0.332	0.493
hml	0.8489	0.041	20.516	0.000	0.767	0.930
umd	-0.3448	0.028	-12.442	0.000	-0.399	-0.290

Omnibus:	93.655	**Durbin-Watson:**	2.010
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	480.943
Skew:	1.182	**Prob(JB):**	3.67e-105
Kurtosis:	8.735	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.912
Model:	OLS	**Adj. R-squared:**	0.911
Method:	Least Squares	**F-statistic:**	765.5
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	2.25e-154
Time:	21:23:28	**Log-Likelihood:**	727.69
No. Observations:	300	**AIC:**	-1445.
Df Residuals:	295	**BIC:**	-1427.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0028	0.001	2.225	0.027	0.000	0.005
mktrf	1.1396	0.030	37.980	0.000	1.081	1.199
smb	0.3716	0.040	9.378	0.000	0.294	0.450
hml	0.7520	0.040	18.859	0.000	0.674	0.830
umd	-0.3732	0.027	-13.974	0.000	-0.426	-0.321

Omnibus:	55.631	**Durbin-Watson:**	1.889
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	124.084
Skew:	0.917	**Prob(JB):**	1.14e-27
Kurtosis:	5.562	**Cond. No.**	34.5

Notes:

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

1.5 Top 100 medium cap growth stocks

The considered minimum market capitalisation is $500 millions.

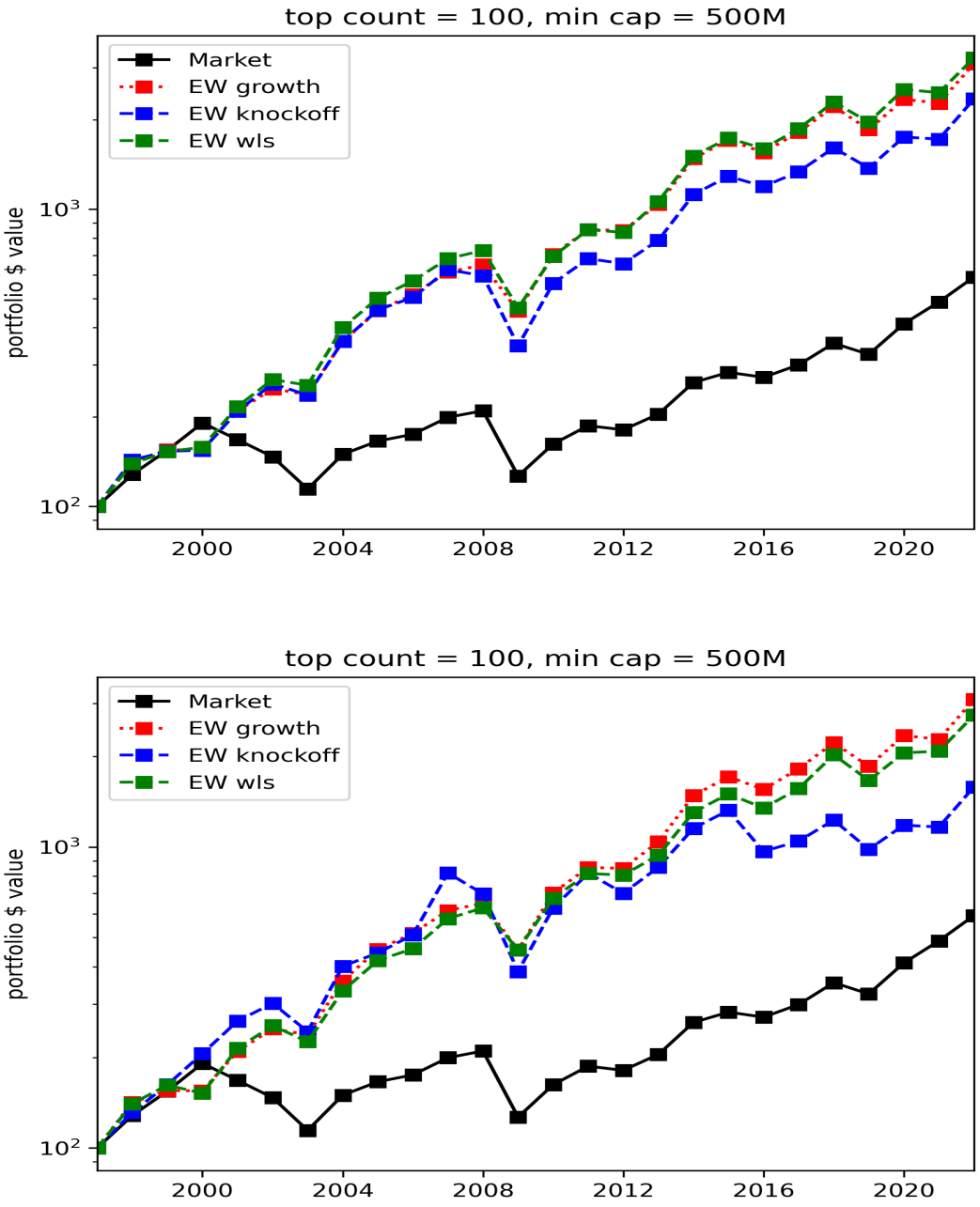

Figure 5: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Growth top 100

Dep. Variable:	growth ret	**R-squared:**	0.852
Model:	OLS	**Adj. R-squared:**	0.850
Method:	Least Squares	**F-statistic:**	423.8
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	6.56e-121
Time:	21:46:22	**Log-Likelihood:**	706.31
No. Observations:	300	**AIC:**	-1403.
Df Residuals:	295	**BIC:**	-1384.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0045	0.001	3.274	0.001	0.002	0.007
mktrf	0.9925	0.032	30.801	0.000	0.929	1.056
smb	0.2622	0.043	6.163	0.000	0.178	0.346
hml	0.6883	0.043	16.073	0.000	0.604	0.773
umd	-0.1599	0.029	-5.575	0.000	-0.216	-0.103

Omnibus:	27.593	**Durbin-Watson:**	2.068
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	94.179
Skew:	0.280	**Prob(JB):**	3.54e-21
Kurtosis:	5.687	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.850
Model:	OLS	**Adj. R-squared:**	0.848
Method:	Least Squares	**F-statistic:**	417.9
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.75e-120
Time:	21:46:22	**Log-Likelihood:**	704.86
No. Observations:	300	**AIC:**	-1400.
Df Residuals:	295	**BIC:**	-1381.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0042	0.001	3.077	0.002	0.002	0.007
mktrf	1.0084	0.032	31.144	0.000	0.945	1.072
smb	0.2207	0.043	5.163	0.000	0.137	0.305
hml	0.6353	0.043	14.765	0.000	0.551	0.720
umd	-0.1685	0.029	-5.848	0.000	-0.225	-0.112

Omnibus:	20.204	**Durbin-Watson:**	1.976
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	46.479
Skew:	0.296	**Prob(JB):**	8.07e-11
Kurtosis:	4.835	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.859
Model:	OLS	**Adj. R-squared:**	0.857
Method:	Least Squares	**F-statistic:**	448.6
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	5.06e-124
Time:	21:46:22	**Log-Likelihood:**	709.17
No. Observations:	300	**AIC:**	-1408.
Df Residuals:	295	**BIC:**	-1390.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0032	0.001	2.337	0.020	0.001	0.006
mktrf	1.0395	0.032	32.568	0.000	0.977	1.102
smb	0.2058	0.042	4.884	0.000	0.123	0.289
hml	0.6102	0.042	14.386	0.000	0.527	0.694
umd	-0.1795	0.028	-6.317	0.000	-0.235	-0.124

Omnibus:	42.800	**Durbin-Watson:**	1.995
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	137.260
Skew:	0.586	**Prob(JB):**	1.56e-30
Kurtosis:	6.099	**Cond. No.**	34.5

Notes:

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

1.6 Top 100 small cap value stocks

The considered minimum market capitalisation is $5 millions.

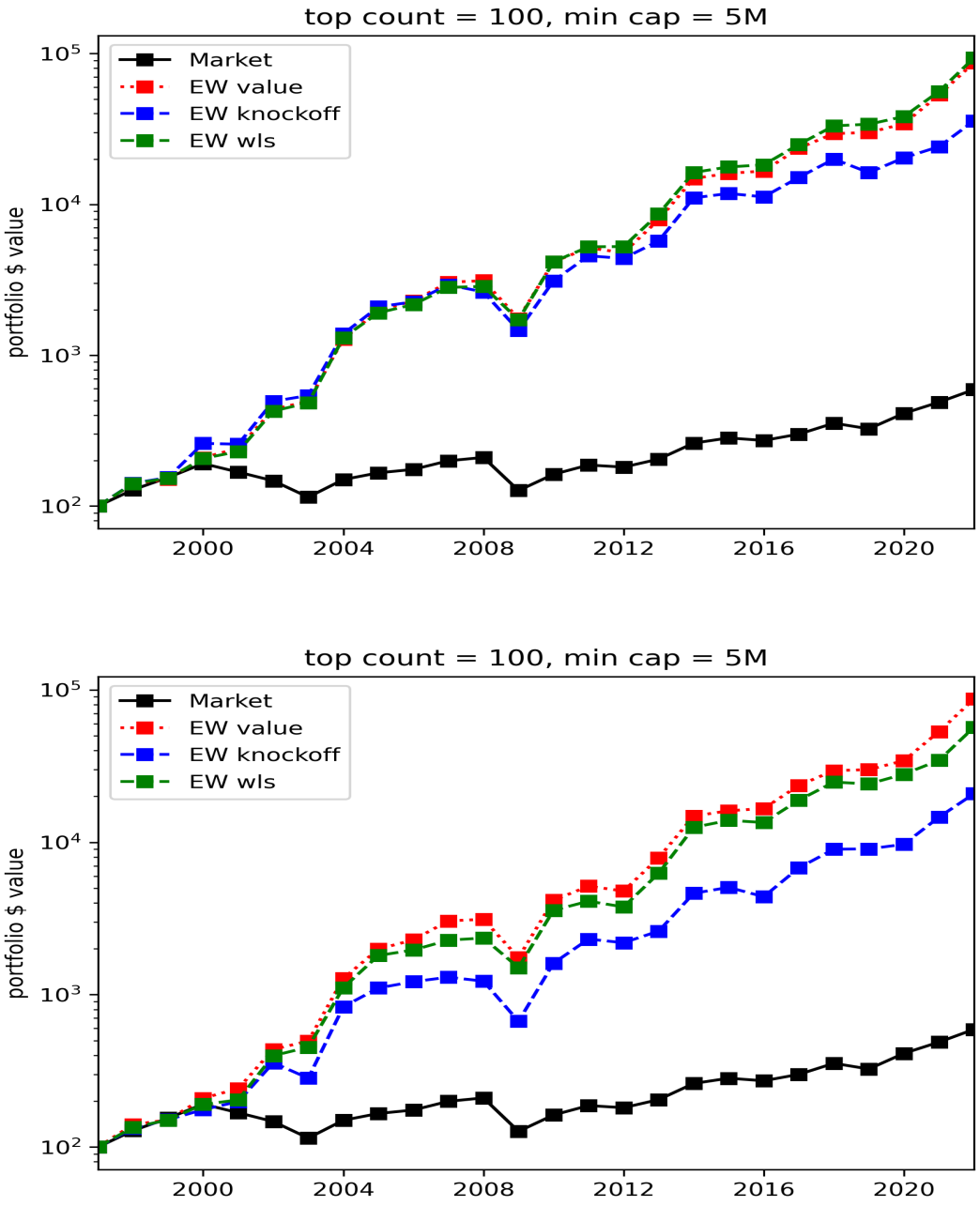

Figure 6: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Value top 100

Dep. Variable:	value ret	**R-squared:**	0.299
Model:	OLS	**Adj. R-squared:**	0.289
Method:	Least Squares	**F-statistic:**	31.40
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	8.58e-22
Time:	20:35:15	**Log-Likelihood:**	263.90
No. Observations:	300	**AIC:**	-517.8
Df Residuals:	295	**BIC:**	-499.3
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.1273	0.006	-21.291	0.000	-0.139	-0.116
mktrf	0.7427	0.141	5.275	0.000	0.466	1.020
smb	0.9495	0.186	5.107	0.000	0.584	1.315
hml	0.4958	0.187	2.650	0.008	0.128	0.864
umd	-0.5551	0.125	-4.429	0.000	-0.802	-0.308

Omnibus:	10.257	**Durbin-Watson:**	0.686
Prob(Omnibus):	0.006	**Jarque-Bera (JB):**	10.330
Skew:	-0.423	**Prob(JB):**	0.00571
Kurtosis:	3.335	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.331
Model:	OLS	**Adj. R-squared:**	0.322
Method:	Least Squares	**F-statistic:**	36.46
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	9.18e-25
Time:	20:35:15	**Log-Likelihood:**	271.43
No. Observations:	300	**AIC:**	-532.9
Df Residuals:	295	**BIC:**	-514.4
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.1075	0.006	-18.447	0.000	-0.119	-0.096
mktrf	0.7199	0.137	5.243	0.000	0.450	0.990
smb	1.0059	0.181	5.548	0.000	0.649	1.363
hml	0.5367	0.182	2.941	0.004	0.178	0.896
umd	-0.6357	0.122	-5.201	0.000	-0.876	-0.395

Omnibus:	19.598	**Durbin-Watson:**	0.861
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	21.571
Skew:	-0.613	**Prob(JB):**	2.07e-05
Kurtosis:	3.472	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.448
Model:	OLS	**Adj. R-squared:**	0.441
Method:	Least Squares	**F-statistic:**	59.92
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	5.40e-37
Time:	20:35:15	**Log-Likelihood:**	350.83
No. Observations:	300	**AIC:**	-691.7
Df Residuals:	295	**BIC:**	-673.1
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0400	0.004	-8.931	0.000	-0.049	-0.031
mktrf	0.9747	0.105	9.249	0.000	0.767	1.182
smb	0.8342	0.139	5.995	0.000	0.560	1.108
hml	0.3397	0.140	2.426	0.016	0.064	0.615
umd	-0.4495	0.094	-4.792	0.000	-0.634	-0.265

Omnibus:	33.451	**Durbin-Watson:**	1.075
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	41.605
Skew:	-0.833	**Prob(JB):**	9.24e-10
Kurtosis:	3.741	**Cond. No.**	34.5

Notes:

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

1.7 Top 100 small cap growth stocks

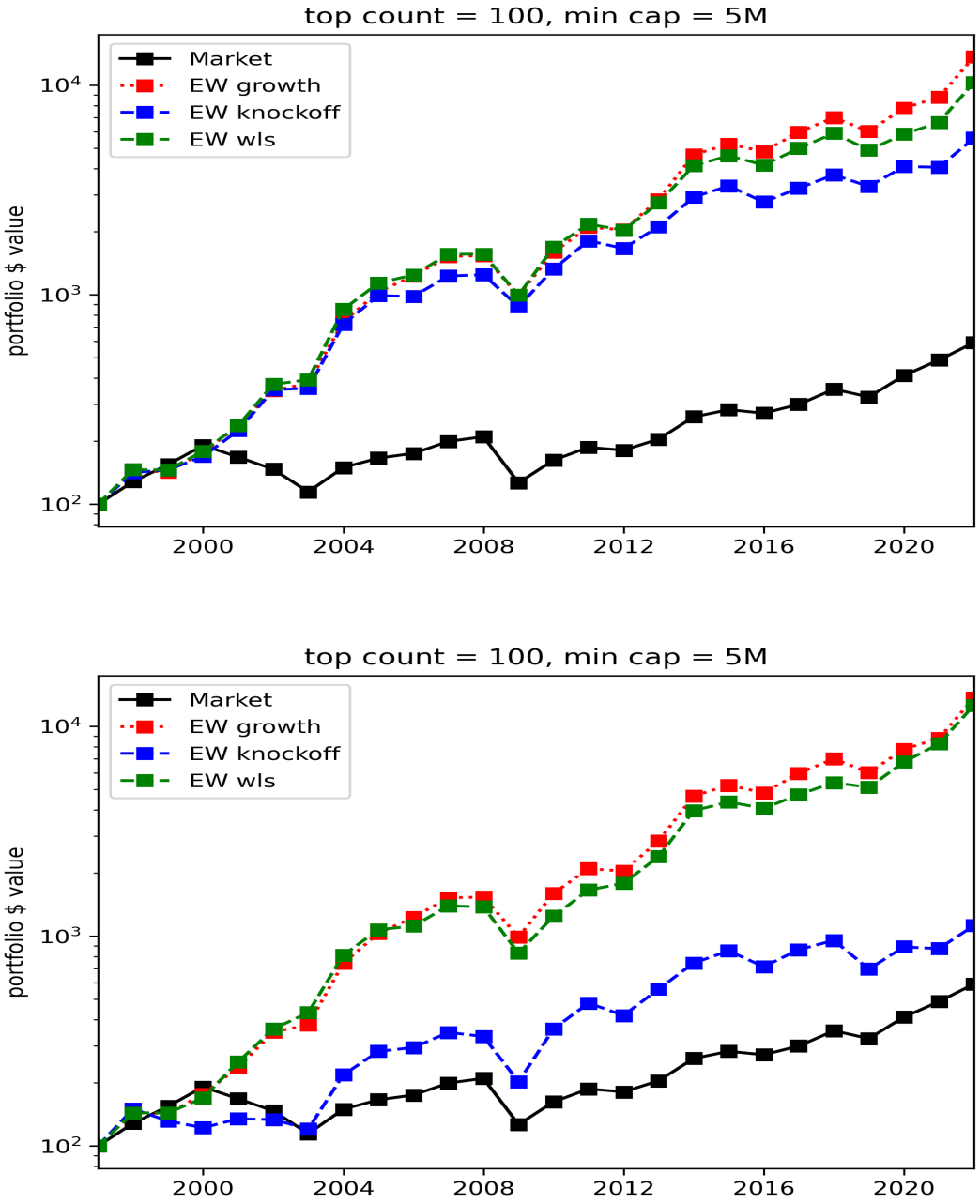

Figure 7: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Growth top 100

Dep. Variable:	growth ret	**R-squared:**	0.471
Model:	OLS	**Adj. R-squared:**	0.464
Method:	Least Squares	**F-statistic:**	65.63
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.18e-39
Time:	21:01:57	**Log-Likelihood:**	401.33
No. Observations:	300	**AIC:**	-792.7
Df Residuals:	295	**BIC:**	-774.1
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0576	0.004	-15.225	0.000	-0.065	-0.050
mktrf	1.0409	0.089	11.689	0.000	0.866	1.216
smb	0.5654	0.118	4.808	0.000	0.334	0.797
hml	0.5287	0.118	4.467	0.000	0.296	0.762
umd	-0.1872	0.079	-2.361	0.019	-0.343	-0.031

Omnibus:	68.442	**Durbin-Watson:**	0.776
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	125.283
Skew:	-1.227	**Prob(JB):**	6.24e-28
Kurtosis:	5.001	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.500
Model:	OLS	**Adj. R-squared:**	0.493
Method:	Least Squares	**F-statistic:**	73.71
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.07e-43
Time:	21:01:57	**Log-Likelihood:**	425.08
No. Observations:	300	**AIC:**	-840.2
Df Residuals:	295	**BIC:**	-821.6
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0496	0.003	-14.196	0.000	-0.056	-0.043
mktrf	1.0652	0.082	12.947	0.000	0.903	1.227
smb	0.5035	0.109	4.634	0.000	0.290	0.717
hml	0.5258	0.109	4.809	0.000	0.311	0.741
umd	-0.1309	0.073	-1.787	0.075	-0.275	0.013

Omnibus:	66.670	**Durbin-Watson:**	0.938
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	123.055
Skew:	-1.189	**Prob(JB):**	1.90e-27
Kurtosis:	5.046	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.626
Model:	OLS	**Adj. R-squared:**	0.621
Method:	Least Squares	**F-statistic:**	123.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.02e-61
Time:	21:01:57	**Log-Likelihood:**	506.98
No. Observations:	300	**AIC:**	-1004.
Df Residuals:	295	**BIC:**	-985.4
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0174	0.003	-6.562	0.000	-0.023	-0.012
mktrf	0.9909	0.063	15.824	0.000	0.868	1.114
smb	0.6029	0.083	7.291	0.000	0.440	0.766
hml	0.4426	0.083	5.318	0.000	0.279	0.606
umd	-0.1828	0.056	-3.279	0.001	-0.293	-0.073

Omnibus:	101.889	**Durbin-Watson:**	1.119
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	330.022
Skew:	-1.490	**Prob(JB):**	2.17e-72
Kurtosis:	7.186	**Cond. No.**	34.5

Notes:

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

2 Changing the count

Large caps are defined as top 50 assets by the largest market capitalisation as of 31st December of the year prior to the investment period. Growth stocks are defined as assets with highest EPS/Price ratio. Value stocks are defined as assets with highest BPS/Price ratio. All portfolios are equal weight.

2.1 Top 50 by market capitalisation

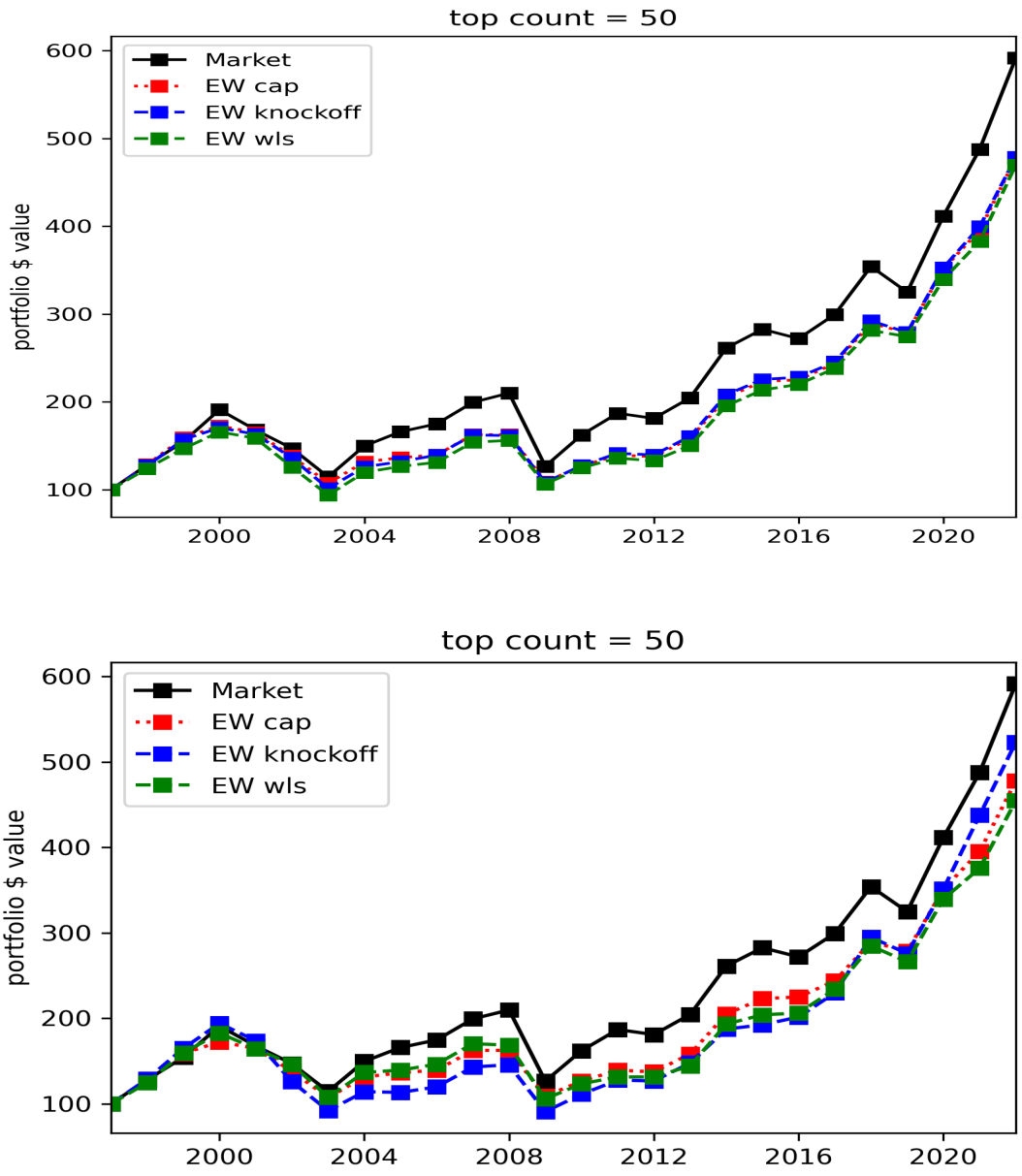

Figure 8: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Cap top 50

Dep. Variable:	cap ret	**R-squared:**	0.939
Model:	OLS	**Adj. R-squared:**	0.938
Method:	Least Squares	**F-statistic:**	1129.
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	2.13e-177
Time:	18:20:49	**Log-Likelihood:**	928.16
No. Observations:	300	**AIC:**	-1846.
Df Residuals:	295	**BIC:**	-1828.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0017	0.001	-2.594	0.010	-0.003	-0.000
mktrf	0.9374	0.015	60.942	0.000	0.907	0.968
smb	-0.2480	0.020	-12.209	0.000	-0.288	-0.208
hml	0.0372	0.020	1.819	0.070	-0.003	0.077
umd	-0.0678	0.014	-4.955	0.000	-0.095	-0.041

Omnibus:	35.177	**Durbin-Watson:**	2.385
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	198.286
Skew:	0.162	**Prob(JB):**	8.76e-44
Kurtosis:	6.970	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.928
Model:	OLS	**Adj. R-squared:**	0.927
Method:	Least Squares	**F-statistic:**	945.6
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	8.06e-167
Time:	18:20:49	**Log-Likelihood:**	887.82
No. Observations:	300	**AIC:**	-1766.
Df Residuals:	295	**BIC:**	-1747.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0021	0.001	-2.772	0.006	-0.004	-0.001
mktrf	0.9738	0.018	55.347	0.000	0.939	1.008
smb	-0.2406	0.023	-10.355	0.000	-0.286	-0.195
hml	0.0140	0.023	0.600	0.549	-0.032	0.060
umd	-0.0857	0.016	-5.469	0.000	-0.116	-0.055

Omnibus:	73.826	**Durbin-Watson:**	2.123
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	543.292
Skew:	-0.768	**Prob(JB):**	1.06e-118
Kurtosis:	9.411	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.932
Model:	OLS	**Adj. R-squared:**	0.931
Method:	Least Squares	**F-statistic:**	1012.
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	6.92e-171
Time:	18:20:49	**Log-Likelihood:**	903.50
No. Observations:	300	**AIC:**	-1797.
Df Residuals:	295	**BIC:**	-1778.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0018	0.001	-2.471	0.014	-0.003	-0.000
mktrf	0.9553	0.017	57.209	0.000	0.922	0.988
smb	-0.2375	0.022	-10.773	0.000	-0.281	-0.194
hml	0.0160	0.022	0.721	0.471	-0.028	0.060
umd	-0.0863	0.015	-5.809	0.000	-0.116	-0.057

Omnibus:	33.132	**Durbin-Watson:**	2.313
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	171.824
Skew:	0.162	**Prob(JB):**	4.89e-38
Kurtosis:	6.693	**Cond. No.**	34.5

Notes:

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

2.2 Top 50 large cap value stocks

The considered minimum market capitalisation is $50 billions.

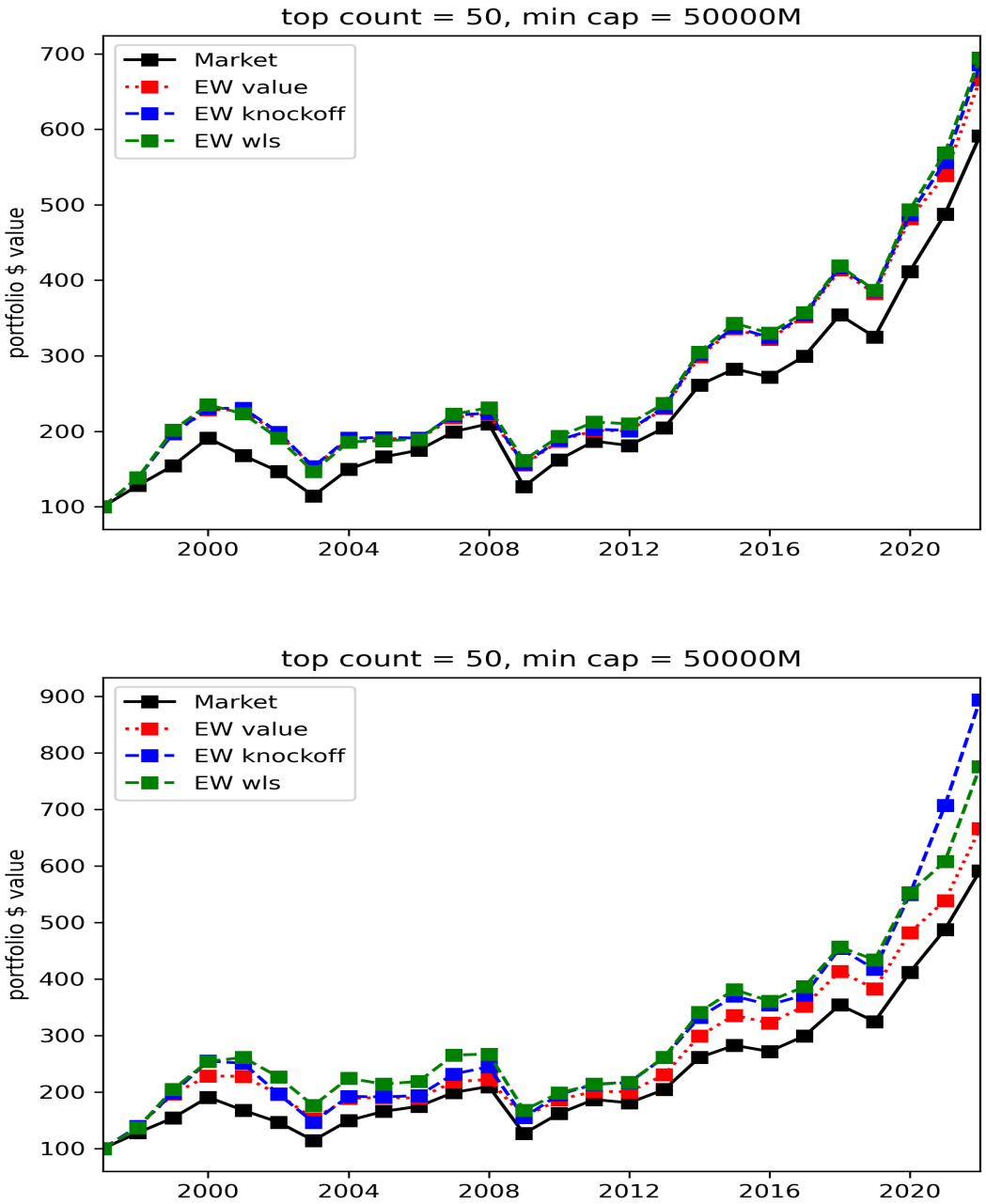

Figure 9: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Value top 50

Dep. Variable:	value ret	**R-squared:**	0.866
Model:	OLS	**Adj. R-squared:**	0.864
Method:	Least Squares	**F-statistic:**	474.6
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.89e-127
Time:	19:31:39	**Log-Likelihood:**	792.74
No. Observations:	300	**AIC:**	-1575.
Df Residuals:	295	**BIC:**	-1557.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0011	0.001	-1.119	0.264	-0.003	0.001
mktrf	0.9395	0.024	38.891	0.000	0.892	0.987
smb	-0.2821	0.032	-8.844	0.000	-0.345	-0.219
hml	0.0785	0.032	2.445	0.015	0.015	0.142
umd	-0.0986	0.022	-4.584	0.000	-0.141	-0.056

Omnibus:	196.956	**Durbin-Watson:**	1.762
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	5638.915
Skew:	-2.164	**Prob(JB):**	0.00
Kurtosis:	23.794	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.870
Model:	OLS	**Adj. R-squared:**	0.868
Method:	Least Squares	**F-statistic:**	494.5
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	2.06e-129
Time:	19:31:39	**Log-Likelihood:**	785.90
No. Observations:	300	**AIC:**	-1562.
Df Residuals:	295	**BIC:**	-1543.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0013	0.001	-1.219	0.224	-0.003	0.001
mktrf	0.9745	0.025	39.431	0.000	0.926	1.023
smb	-0.2511	0.033	-7.694	0.000	-0.315	-0.187
hml	0.0203	0.033	0.619	0.536	-0.044	0.085
umd	-0.1168	0.022	-5.308	0.000	-0.160	-0.073

Omnibus:	228.559	**Durbin-Watson:**	1.789
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	8068.066
Skew:	-2.642	**Prob(JB):**	0.00
Kurtosis:	27.850	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.866
Model:	OLS	**Adj. R-squared:**	0.865
Method:	Least Squares	**F-statistic:**	478.4
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.41e-127
Time:	19:31:39	**Log-Likelihood:**	790.55
No. Observations:	300	**AIC:**	-1571.
Df Residuals:	295	**BIC:**	-1553.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0011	0.001	-1.088	0.278	-0.003	0.001
mktrf	0.9518	0.024	39.117	0.000	0.904	1.000
smb	-0.2850	0.032	-8.870	0.000	-0.348	-0.222
hml	0.0655	0.032	2.027	0.044	0.002	0.129
umd	-0.0975	0.022	-4.503	0.000	-0.140	-0.055

Omnibus:	188.852	**Durbin-Watson:**	1.788
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	5455.867
Skew:	-2.025	**Prob(JB):**	0.00
Kurtosis:	23.495	**Cond. No.**	34.5

Notes:

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

2.3 Top 50 large cap growth stocks

The considered minimum market capitalisation is $50 billions.

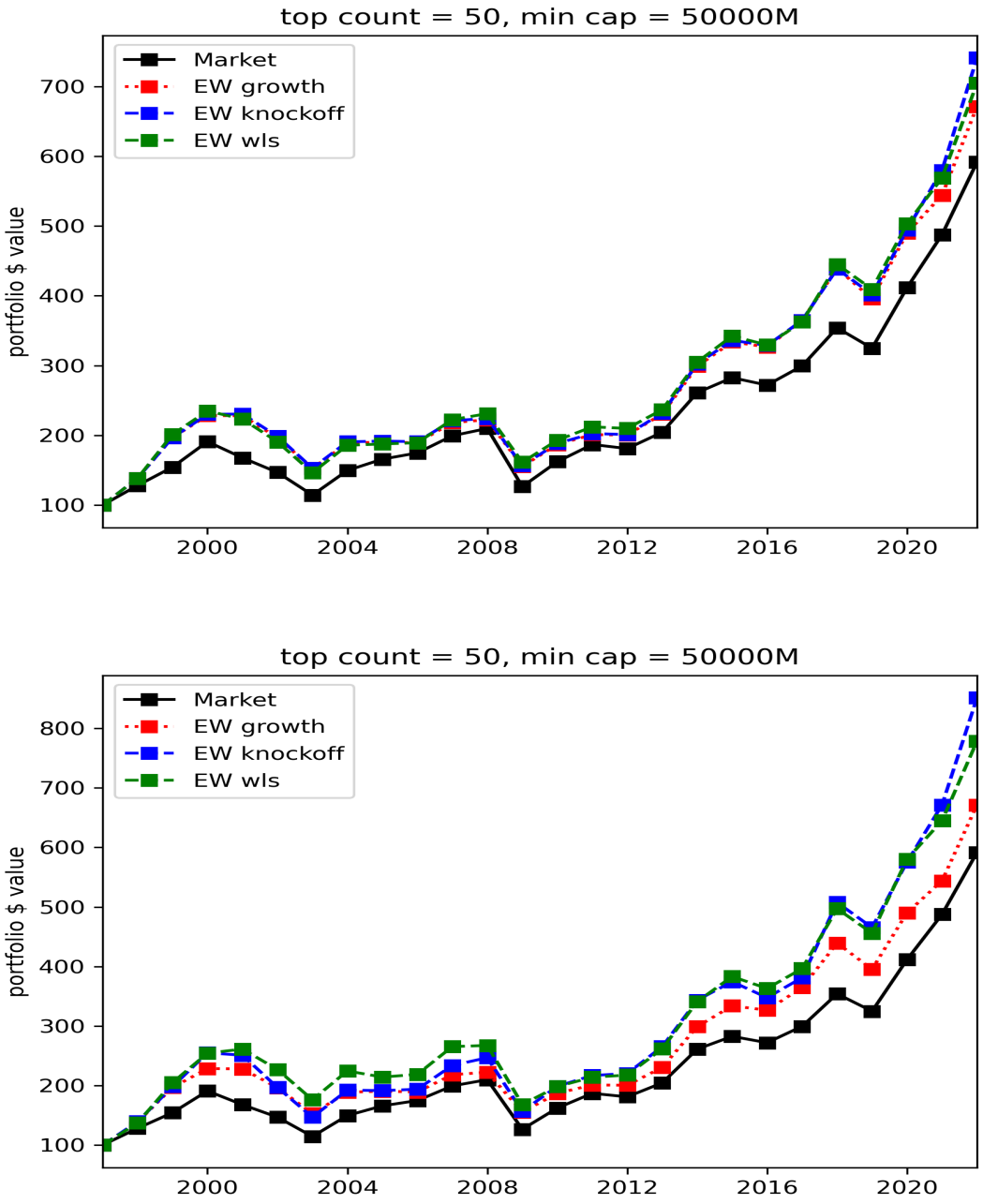

Figure 10: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Growth top 50

Dep. Variable:	growth ret	**R-squared:**	0.866
Model:	OLS	**Adj. R-squared:**	0.864
Method:	Least Squares	**F-statistic:**	475.0
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.49e-127
Time:	19:40:23	**Log-Likelihood:**	792.82
No. Observations:	300	**AIC:**	-1576.
Df Residuals:	295	**BIC:**	-1557.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0011	0.001	-1.055	0.292	-0.003	0.001
mktrf	0.9383	0.024	38.854	0.000	0.891	0.986
smb	-0.2870	0.032	-9.001	0.000	-0.350	-0.224
hml	0.0768	0.032	2.393	0.017	0.014	0.140
umd	-0.1013	0.021	-4.712	0.000	-0.144	-0.059

Omnibus:	195.578	**Durbin-Watson:**	1.784
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	5694.802
Skew:	-2.135	**Prob(JB):**	0.00
Kurtosis:	23.913	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.871
Model:	OLS	**Adj. R-squared:**	0.870
Method:	Least Squares	**F-statistic:**	499.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	6.01e-130
Time:	19:40:23	**Log-Likelihood:**	786.12
No. Observations:	300	**AIC:**	-1562.
Df Residuals:	295	**BIC:**	-1544.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0012	0.001	-1.163	0.246	-0.003	0.001
mktrf	0.9769	0.025	39.561	0.000	0.928	1.026
smb	-0.2562	0.033	-7.858	0.000	-0.320	-0.192
hml	0.0203	0.033	0.619	0.537	-0.044	0.085
umd	-0.1204	0.022	-5.479	0.000	-0.164	-0.077

Omnibus:	228.183	**Durbin-Watson:**	1.785
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	8174.966
Skew:	-2.629	**Prob(JB):**	0.00
Kurtosis:	28.027	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.868
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	486.5
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.66e-128
Time:	19:40:23	**Log-Likelihood:**	791.80
No. Observations:	300	**AIC:**	-1574.
Df Residuals:	295	**BIC:**	-1555.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.824	0.411	-0.003	0.001
mktrf	0.9556	0.024	39.437	0.000	0.908	1.003
smb	-0.2889	0.032	-9.030	0.000	-0.352	-0.226
hml	0.0552	0.032	1.714	0.088	-0.008	0.119
umd	-0.0992	0.022	-4.597	0.000	-0.142	-0.057

Omnibus:	192.296	**Durbin-Watson:**	1.812
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	5805.844
Skew:	-2.066	**Prob(JB):**	0.00
Kurtosis:	24.152	**Cond. No.**	34.5

Notes:

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

2.4 Top 50 medium cap value stocks

The considered minimum market capitalisation is $500 millions.

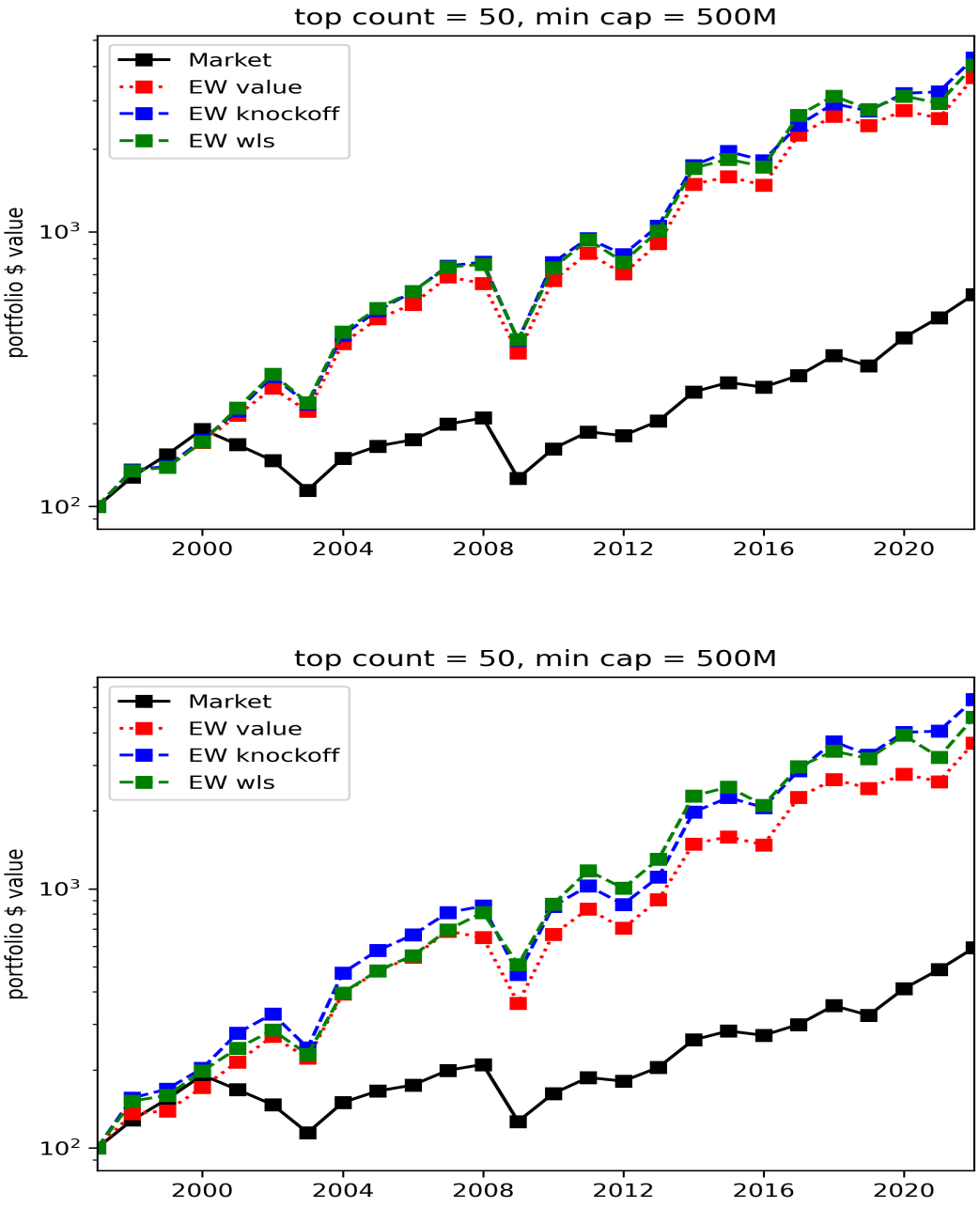

Figure 11: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Value top 50

Dep. Variable:	value ret	**R-squared:**	0.856
Model:	OLS	**Adj. R-squared:**	0.854
Method:	Least Squares	**F-statistic:**	438.9
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	7.95e-123
Time:	19:06:24	**Log-Likelihood:**	607.80
No. Observations:	300	**AIC:**	-1206.
Df Residuals:	295	**BIC:**	-1187.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0060	0.002	3.145	0.002	0.002	0.010
mktrf	1.2046	0.045	26.921	0.000	1.117	1.293
smb	0.4662	0.059	7.890	0.000	0.350	0.582
hml	1.0009	0.059	16.831	0.000	0.884	1.118
umd	-0.4469	0.040	-11.219	0.000	-0.525	-0.368

Omnibus:	217.837	**Durbin-Watson:**	1.999
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	4956.045
Skew:	2.622	**Prob(JB):**	0.00
Kurtosis:	22.209	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.854
Model:	OLS	**Adj. R-squared:**	0.852
Method:	Least Squares	**F-statistic:**	431.1
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	7.54e-122
Time:	19:06:24	**Log-Likelihood:**	608.17
No. Observations:	300	**AIC:**	-1206.
Df Residuals:	295	**BIC:**	-1188.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0062	0.002	3.286	0.001	0.003	0.010
mktrf	1.1900	0.045	26.627	0.000	1.102	1.278
smb	0.4378	0.059	7.420	0.000	0.322	0.554
hml	0.9867	0.059	16.614	0.000	0.870	1.104
umd	-0.4537	0.040	-11.404	0.000	-0.532	-0.375

Omnibus:	83.852	**Durbin-Watson:**	2.008
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	347.529
Skew:	1.114	**Prob(JB):**	3.43e-76
Kurtosis:	7.779	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.853
Model:	OLS	**Adj. R-squared:**	0.851
Method:	Least Squares	**F-statistic:**	428.7
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.54e-121
Time:	19:06:24	**Log-Likelihood:**	616.18
No. Observations:	300	**AIC:**	-1222.
Df Residuals:	295	**BIC:**	-1204.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0065	0.002	3.532	0.000	0.003	0.010
mktrf	1.1785	0.044	27.084	0.000	1.093	1.264
smb	0.4264	0.057	7.421	0.000	0.313	0.539
hml	0.8994	0.058	15.552	0.000	0.786	1.013
umd	-0.4373	0.039	-11.291	0.000	-0.514	-0.361

Omnibus:	139.523	**Durbin-Watson:**	1.916
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	1314.030
Skew:	1.650	**Prob(JB):**	4.59e-286
Kurtosis:	12.707	**Cond. No.**	34.5

Notes:

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

2.5 Top 50 medium cap growth stocks

The considered minimum market capitalisation is $500 millions.

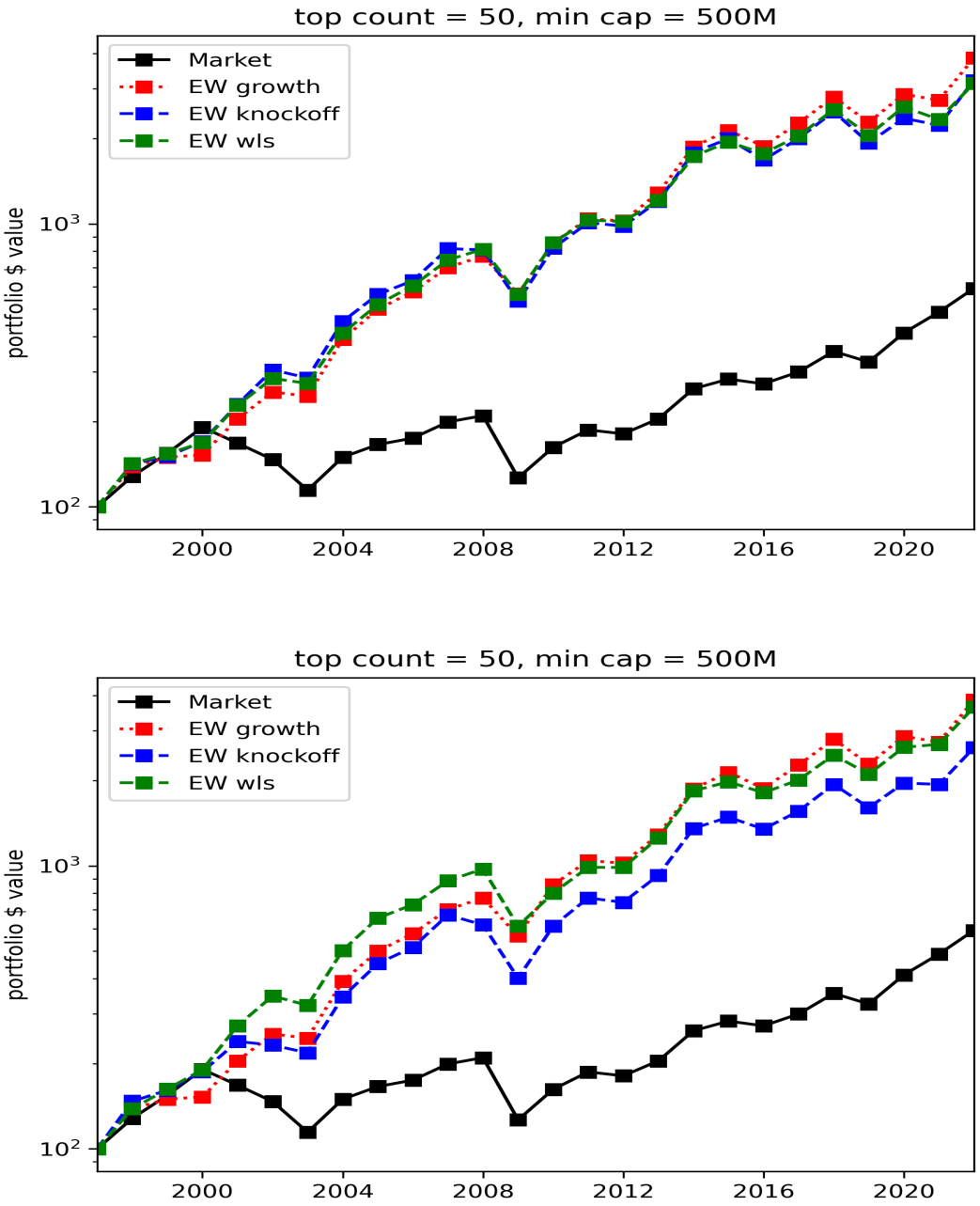

Figure 12: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Growth top 50

Dep. Variable:	growth ret	**R-squared:**	0.815
Model:	OLS	**Adj. R-squared:**	0.813
Method:	Least Squares	**F-statistic:**	325.5
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	7.81e-107
Time:	19:19:53	**Log-Likelihood:**	662.53
No. Observations:	300	**AIC:**	-1315.
Df Residuals:	295	**BIC:**	-1297.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0049	0.002	3.107	0.002	0.002	0.008
mktrf	1.0015	0.037	26.860	0.000	0.928	1.075
smb	0.2837	0.049	5.762	0.000	0.187	0.381
hml	0.6907	0.050	13.940	0.000	0.593	0.788
umd	-0.1668	0.033	-5.026	0.000	-0.232	-0.101

Omnibus:	29.089	**Durbin-Watson:**	2.014
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	85.290
Skew:	0.381	**Prob(JB):**	3.02e-19
Kurtosis:	5.499	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.811
Model:	OLS	**Adj. R-squared:**	0.809
Method:	Least Squares	**F-statistic:**	317.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.64e-105
Time:	19:19:53	**Log-Likelihood:**	653.02
No. Observations:	300	**AIC:**	-1296.
Df Residuals:	295	**BIC:**	-1278.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0043	0.002	2.625	0.009	0.001	0.008
mktrf	1.0234	0.038	26.591	0.000	0.948	1.099
smb	0.2359	0.051	4.642	0.000	0.136	0.336
hml	0.6762	0.051	13.221	0.000	0.576	0.777
umd	-0.1962	0.034	-5.727	0.000	-0.264	-0.129

Omnibus:	50.944	**Durbin-Watson:**	2.053
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	199.114
Skew:	0.645	**Prob(JB):**	5.79e-44
Kurtosis:	6.777	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.834
Model:	OLS	**Adj. R-squared:**	0.831
Method:	Least Squares	**F-statistic:**	369.3
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	1.70e-113
Time:	19:19:53	**Log-Likelihood:**	667.31
No. Observations:	300	**AIC:**	-1325.
Df Residuals:	295	**BIC:**	-1306.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0040	0.002	2.589	0.010	0.001	0.007
mktrf	1.0688	0.037	29.126	0.000	0.997	1.141
smb	0.2662	0.048	5.495	0.000	0.171	0.362
hml	0.6554	0.049	13.440	0.000	0.559	0.751
umd	-0.1865	0.033	-5.711	0.000	-0.251	-0.122

Omnibus:	18.162	**Durbin-Watson:**	2.001
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	40.473
Skew:	0.262	**Prob(JB):**	1.63e-09
Kurtosis:	4.721	**Cond. No.**	34.5

Notes:

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

2.6 Top 50 small cap value stocks

The considered minimum market capitalisation is $5 millions.

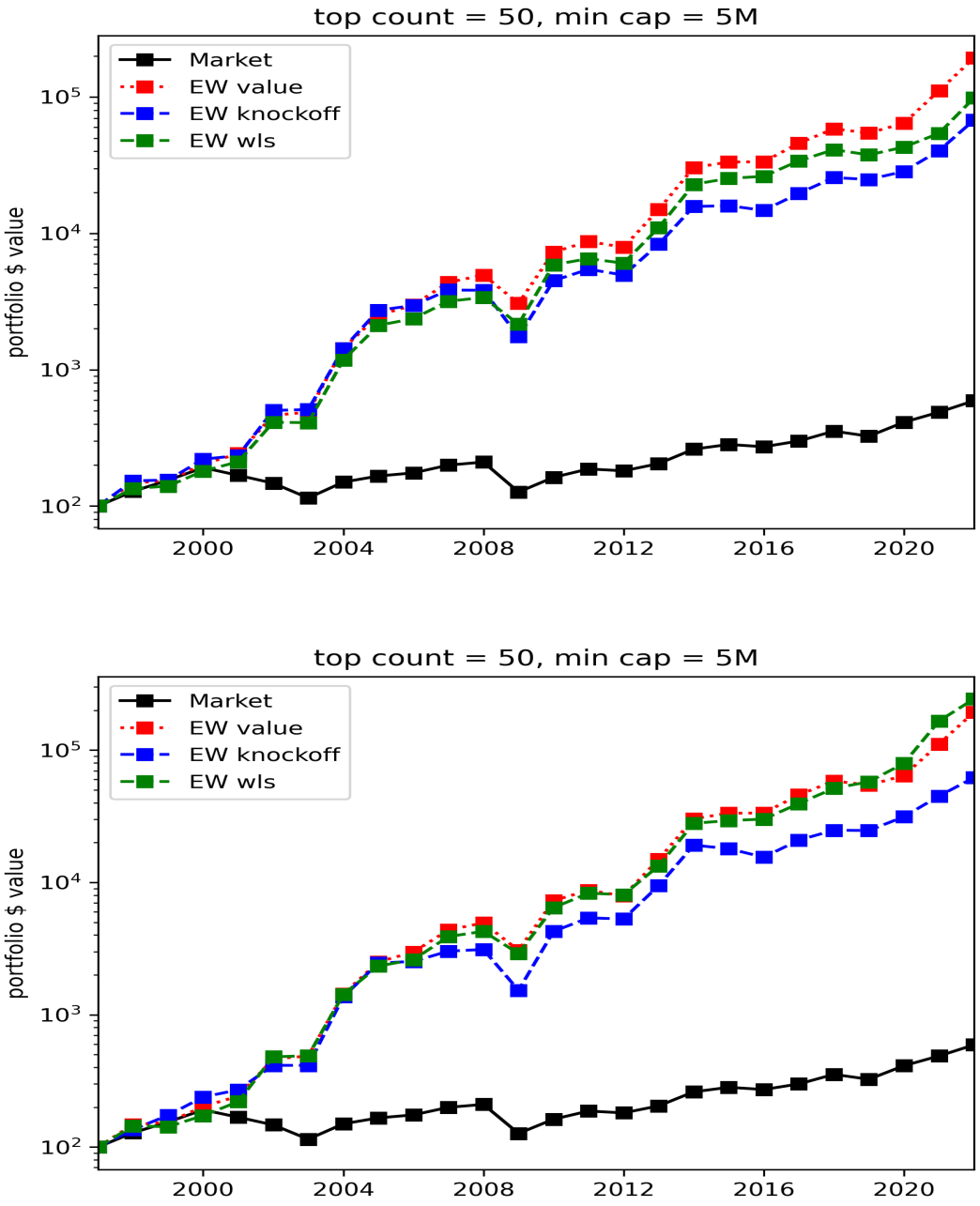

Figure 13: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Value top 50

Dep. Variable:	value ret	**R-squared:**	0.244
Model:	OLS	**Adj. R-squared:**	0.234
Method:	Least Squares	**F-statistic:**	23.80
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	4.46e-17
Time:	18:37:49	**Log-Likelihood:**	216.08
No. Observations:	300	**AIC:**	-422.2
Df Residuals:	295	**BIC:**	-403.6
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.1162	0.007	-16.580	0.000	-0.130	-0.102
mktrf	0.8381	0.165	5.075	0.000	0.513	1.163
smb	1.0053	0.218	4.610	0.000	0.576	1.434
hml	0.5200	0.219	2.369	0.018	0.088	0.952
umd	-0.4541	0.147	-3.089	0.002	-0.743	-0.165

Omnibus:	17.827	**Durbin-Watson:**	0.958
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	42.769
Skew:	0.216	**Prob(JB):**	5.16e-10
Kurtosis:	4.798	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.252
Model:	OLS	**Adj. R-squared:**	0.242
Method:	Least Squares	**F-statistic:**	24.82
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	9.97e-18
Time:	18:37:49	**Log-Likelihood:**	211.42
No. Observations:	300	**AIC:**	-412.8
Df Residuals:	295	**BIC:**	-394.3
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.1001	0.007	-14.051	0.000	-0.114	-0.086
mktrf	0.7424	0.168	4.427	0.000	0.412	1.073
smb	1.1290	0.221	5.098	0.000	0.693	1.565
hml	0.7076	0.223	3.175	0.002	0.269	1.146
umd	-0.5126	0.149	-3.433	0.001	-0.806	-0.219

Omnibus:	13.162	**Durbin-Watson:**	1.050
Prob(Omnibus):	0.001	**Jarque-Bera (JB):**	25.593
Skew:	-0.191	**Prob(JB):**	2.77e-06
Kurtosis:	4.379	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.384
Model:	OLS	**Adj. R-squared:**	0.376
Method:	Least Squares	**F-statistic:**	46.00
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	5.12e-30
Time:	18:37:49	**Log-Likelihood:**	264.64
No. Observations:	300	**AIC:**	-519.3
Df Residuals:	295	**BIC:**	-500.8
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0349	0.006	-5.851	0.000	-0.047	-0.023
mktrf	1.1826	0.140	8.420	0.000	0.906	1.459
smb	0.9776	0.185	5.271	0.000	0.613	1.343
hml	0.7407	0.187	3.968	0.000	0.373	1.108
umd	-0.3873	0.125	-3.098	0.002	-0.633	-0.141

Omnibus:	13.285	**Durbin-Watson:**	1.545
Prob(Omnibus):	0.001	**Jarque-Bera (JB):**	31.209
Skew:	0.001	**Prob(JB):**	1.67e-07
Kurtosis:	4.580	**Cond. No.**	34.5

Notes:

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

2.7 Top 50 small cap growth stocks

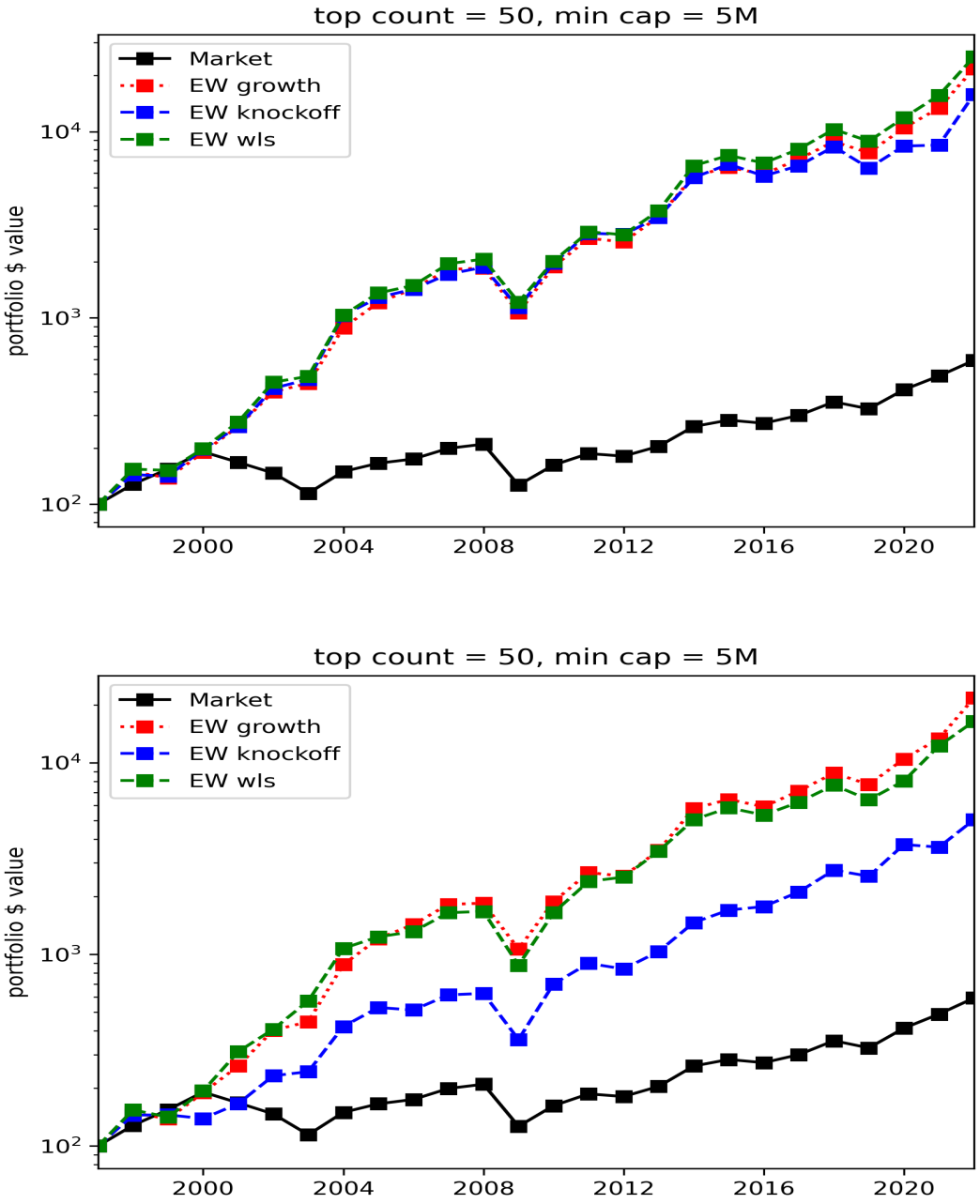

Figure 14: Top panel: daily excess returns, bottom panel: weekly excess returns

EW Growth top 50

Dep. Variable:	growth ret	**R-squared:**	0.395
Model:	OLS	**Adj. R-squared:**	0.387
Method:	Least Squares	**F-statistic:**	48.25
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.39e-31
Time:	18:53:59	**Log-Likelihood:**	335.01
No. Observations:	300	**AIC:**	-660.0
Df Residuals:	295	**BIC:**	-641.5
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0612	0.005	-12.973	0.000	-0.070	-0.052
mktrf	1.1378	0.111	10.242	0.000	0.919	1.356
smb	0.6089	0.147	4.151	0.000	0.320	0.898
hml	0.5679	0.148	3.847	0.000	0.277	0.858
umd	-0.1542	0.099	-1.560	0.120	-0.349	0.040

Omnibus:	74.816	**Durbin-Watson:**	0.876
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	151.902
Skew:	-1.276	**Prob(JB):**	1.03e-33
Kurtosis:	5.375	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.432
Model:	OLS	**Adj. R-squared:**	0.424
Method:	Least Squares	**F-statistic:**	56.10
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	3.74e-35
Time:	18:53:59	**Log-Likelihood:**	348.87
No. Observations:	300	**AIC:**	-687.7
Df Residuals:	295	**BIC:**	-669.2
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0449	0.005	-9.961	0.000	-0.054	-0.036
mktrf	1.1508	0.106	10.849	0.000	0.942	1.360
smb	0.7646	0.140	5.459	0.000	0.489	1.040
hml	0.7174	0.141	5.089	0.000	0.440	0.995
umd	-0.0470	0.094	-0.498	0.619	-0.233	0.139

Omnibus:	83.200	**Durbin-Watson:**	1.117
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	179.870
Skew:	-1.386	**Prob(JB):**	8.74e-40
Kurtosis:	5.589	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.493
Model:	OLS	**Adj. R-squared:**	0.487
Method:	Least Squares	**F-statistic:**	71.83
Date:	Sun, 18 Sep 2022	**Prob (F-statistic):**	2.03e-42
Time:	18:53:59	**Log-Likelihood:**	411.15
No. Observations:	300	**AIC:**	-812.3
Df Residuals:	295	**BIC:**	-793.8
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0218	0.004	-5.962	0.000	-0.029	-0.015
mktrf	1.0991	0.086	12.753	0.000	0.930	1.269
smb	0.5335	0.114	4.688	0.000	0.310	0.758
hml	0.5055	0.115	4.413	0.000	0.280	0.731
umd	-0.1428	0.077	-1.861	0.064	-0.294	0.008

Omnibus:	111.755	**Durbin-Watson:**	1.077
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	403.174
Skew:	-1.601	**Prob(JB):**	2.83e-88
Kurtosis:	7.691	**Cond. No.**	34.5

Notes:

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

3 Changing the benchmark

The benchmark in this section is S&P 500 index. Large caps are defined as top 50/100 assets by the largest market capitalisation as of 31st December of the year prior to the investment period. Growth stocks are defined as assets with highest EPS/Price ratio. Value stocks are defined as assets with highest BPS/Price ratio. All portfolios are equal weight.

3.1 Top 50/100 by market capitalisation

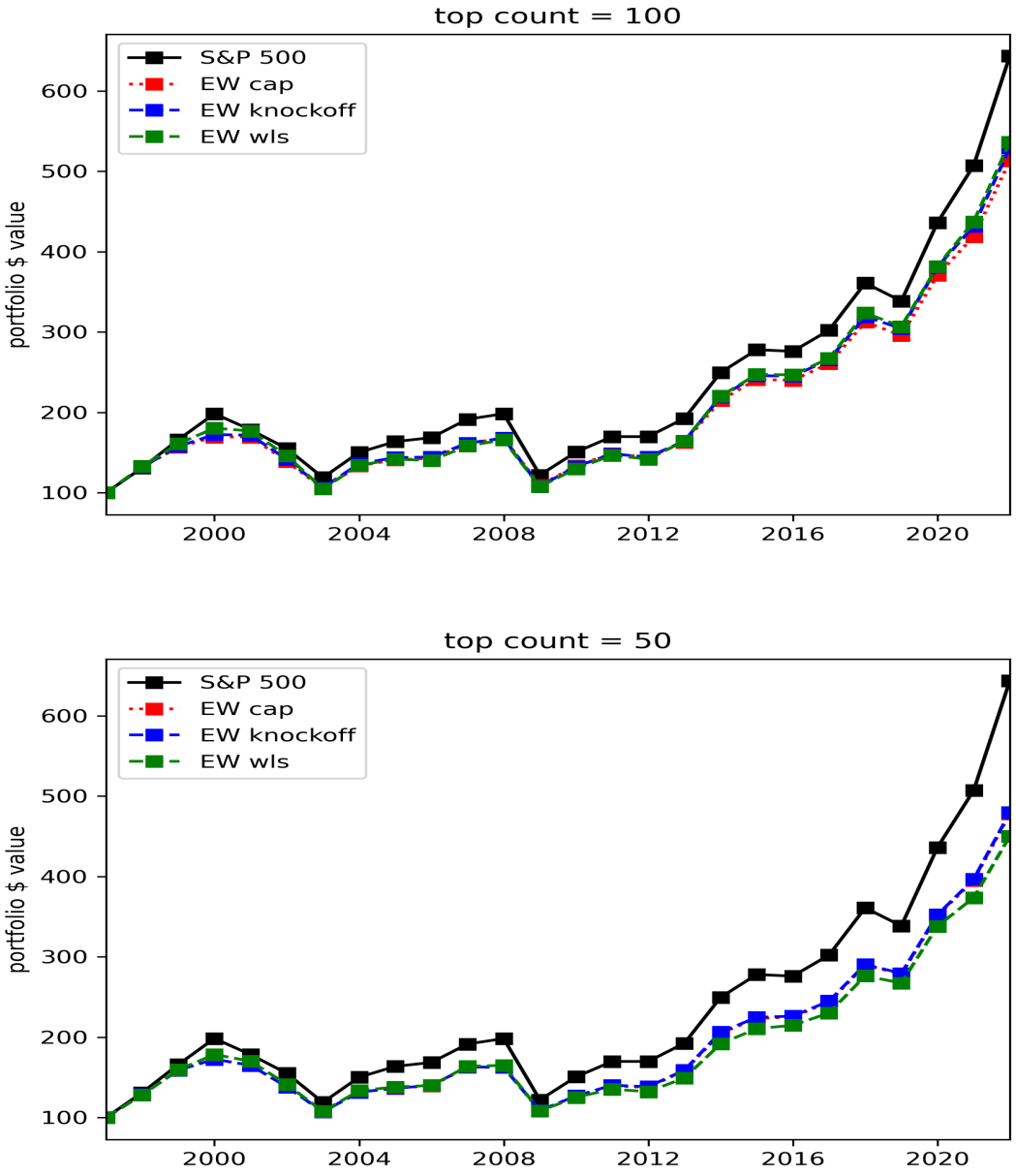

Figure 15: Top panel: top 100, bottom panel: top 50

EW Cap top 100

Dep. Variable:	cap ret	**R-squared:**	0.956
Model:	OLS	**Adj. R-squared:**	0.955
Method:	Least Squares	**F-statistic:**	1600.
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.44e-198
Time:	00:07:19	**Log-Likelihood:**	971.92
No. Observations:	300	**AIC:**	-1934.
Df Residuals:	295	**BIC:**	-1915.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0013	0.001	-2.249	0.025	-0.002	-0.000
mktrf	0.9468	0.013	71.225	0.000	0.921	0.973
smb	-0.1985	0.018	-11.309	0.000	-0.233	-0.164
hml	0.0935	0.018	5.292	0.000	0.059	0.128
umd	-0.0970	0.012	-8.196	0.000	-0.120	-0.074

Omnibus:	26.236	**Durbin-Watson:**	2.006
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	107.206
Skew:	0.109	**Prob(JB):**	5.25e-24
Kurtosis:	5.920	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.949
Model:	OLS	**Adj. R-squared:**	0.948
Method:	Least Squares	**F-statistic:**	1372.
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	3.24e-189
Time:	00:07:19	**Log-Likelihood:**	937.72
No. Observations:	300	**AIC:**	-1865.
Df Residuals:	295	**BIC:**	-1847.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0011	0.001	-1.775	0.077	-0.002	0.000
mktrf	0.9705	0.015	65.142	0.000	0.941	1.000
smb	-0.2056	0.020	-10.449	0.000	-0.244	-0.167
hml	0.0645	0.020	3.258	0.001	0.026	0.103
umd	-0.1265	0.013	-9.541	0.000	-0.153	-0.100

Omnibus:	24.999	**Durbin-Watson:**	2.059
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	100.937
Skew:	0.033	**Prob(JB):**	1.21e-22
Kurtosis:	5.841	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.954
Model:	OLS	**Adj. R-squared:**	0.954
Method:	Least Squares	**F-statistic:**	1540.
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	3.22e-196
Time:	00:07:19	**Log-Likelihood:**	962.99
No. Observations:	300	**AIC:**	-1916.
Df Residuals:	295	**BIC:**	-1897.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0012	0.001	-2.017	0.045	-0.002	-2.83e-05
mktrf	0.9568	0.014	69.862	0.000	0.930	0.984
smb	-0.1960	0.018	-10.841	0.000	-0.232	-0.160
hml	0.0815	0.018	4.479	0.000	0.046	0.117
umd	-0.0987	0.012	-8.098	0.000	-0.123	-0.075

Omnibus:	23.903	**Durbin-Watson:**	2.029
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	88.460
Skew:	0.107	**Prob(JB):**	6.18e-20
Kurtosis:	5.652	**Cond. No.**	34.5

Notes:

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

3.2 Top 50/100 large cap value stocks

The considered minimum market capitalisation is $50 billions.

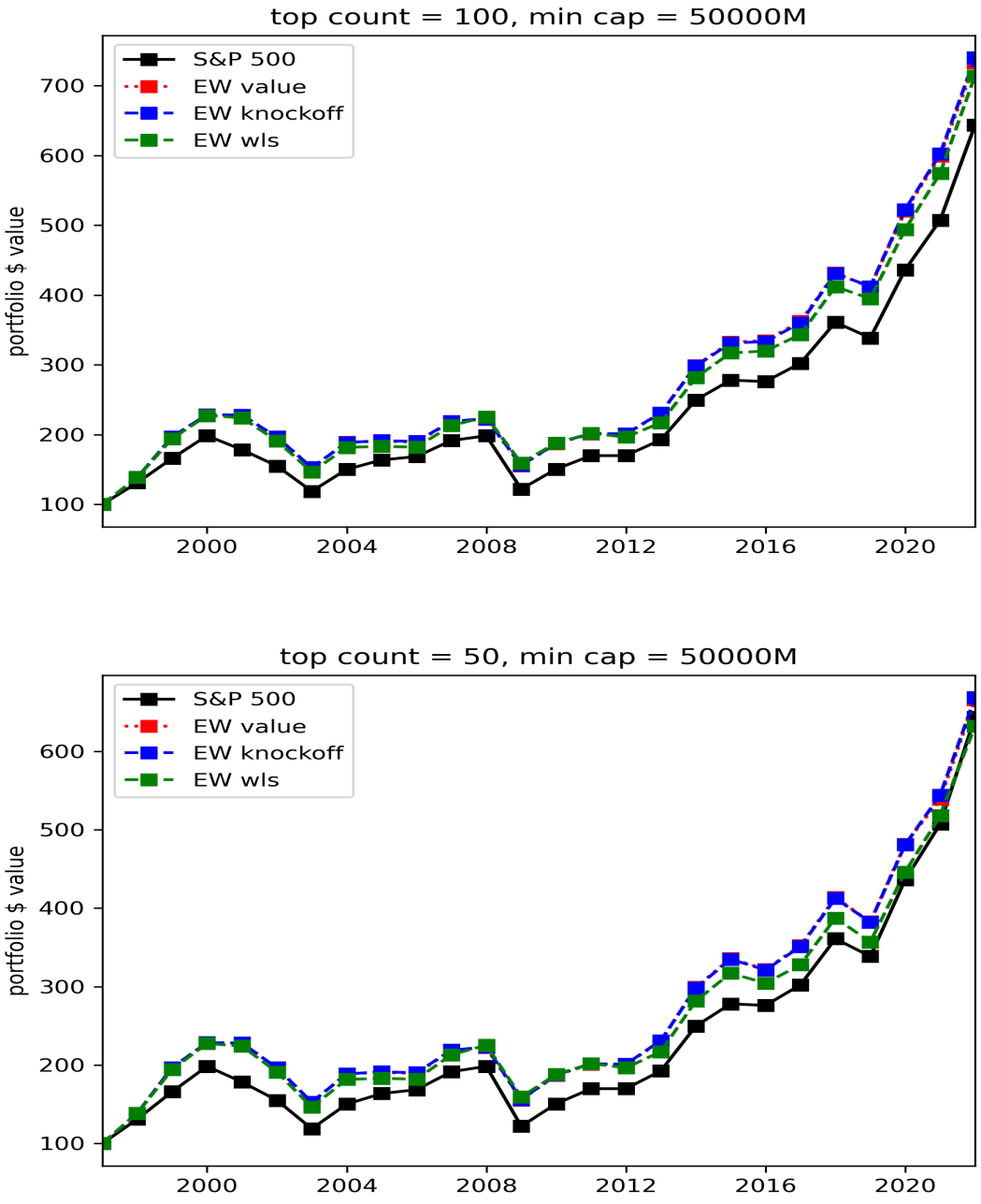

Figure 16: Top panel: top 100, bottom panel: top 50

EW Value top 100

Dep. Variable:	value ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	488.0
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.10e-128
Time:	01:50:06	**Log-Likelihood:**	800.16
No. Observations:	300	**AIC:**	-1590.
Df Residuals:	295	**BIC:**	-1572.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.755	0.451	-0.003	0.001
mktrf	0.9332	0.024	39.598	0.000	0.887	0.980
smb	-0.3014	0.031	-9.685	0.000	-0.363	-0.240
hml	0.0321	0.031	1.025	0.306	-0.030	0.094
umd	-0.0936	0.021	-4.463	0.000	-0.135	-0.052

Omnibus:	215.321	**Durbin-Watson:**	1.776
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	7486.304
Skew:	-2.409	**Prob(JB):**	0.00
Kurtosis:	26.994	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.914
Model:	OLS	**Adj. R-squared:**	0.913
Method:	Least Squares	**F-statistic:**	788.6
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	4.12e-156
Time:	01:50:06	**Log-Likelihood:**	869.50
No. Observations:	300	**AIC:**	-1729.
Df Residuals:	295	**BIC:**	-1710.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	1.881e-05	0.001	0.024	0.981	-0.002	0.002
mktrf	0.9391	0.019	50.210	0.000	0.902	0.976
smb	-0.3072	0.025	-12.441	0.000	-0.356	-0.259
hml	0.0310	0.025	1.246	0.214	-0.018	0.080
umd	-0.0991	0.017	-5.951	0.000	-0.132	-0.066

Omnibus:	63.239	**Durbin-Watson:**	2.135
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	231.261
Skew:	0.854	**Prob(JB):**	6.06e-51
Kurtosis:	6.948	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	487.4
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.31e-128
Time:	01:50:06	**Log-Likelihood:**	799.94
No. Observations:	300	**AIC:**	-1590.
Df Residuals:	295	**BIC:**	-1571.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0007	0.001	-0.748	0.455	-0.003	0.001
mktrf	0.9343	0.024	39.618	0.000	0.888	0.981
smb	-0.2991	0.031	-9.606	0.000	-0.360	-0.238
hml	0.0340	0.031	1.086	0.279	-0.028	0.096
umd	-0.0913	0.021	-4.351	0.000	-0.133	-0.050

Omnibus:	213.958	**Durbin-Watson:**	1.787
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	7436.748
Skew:	-2.385	**Prob(JB):**	0.00
Kurtosis:	26.920	**Cond. No.**	34.5

Notes:

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

3.3 Top 50/100 large cap growth stocks

The considered minimum market capitalisation is $50 billions.

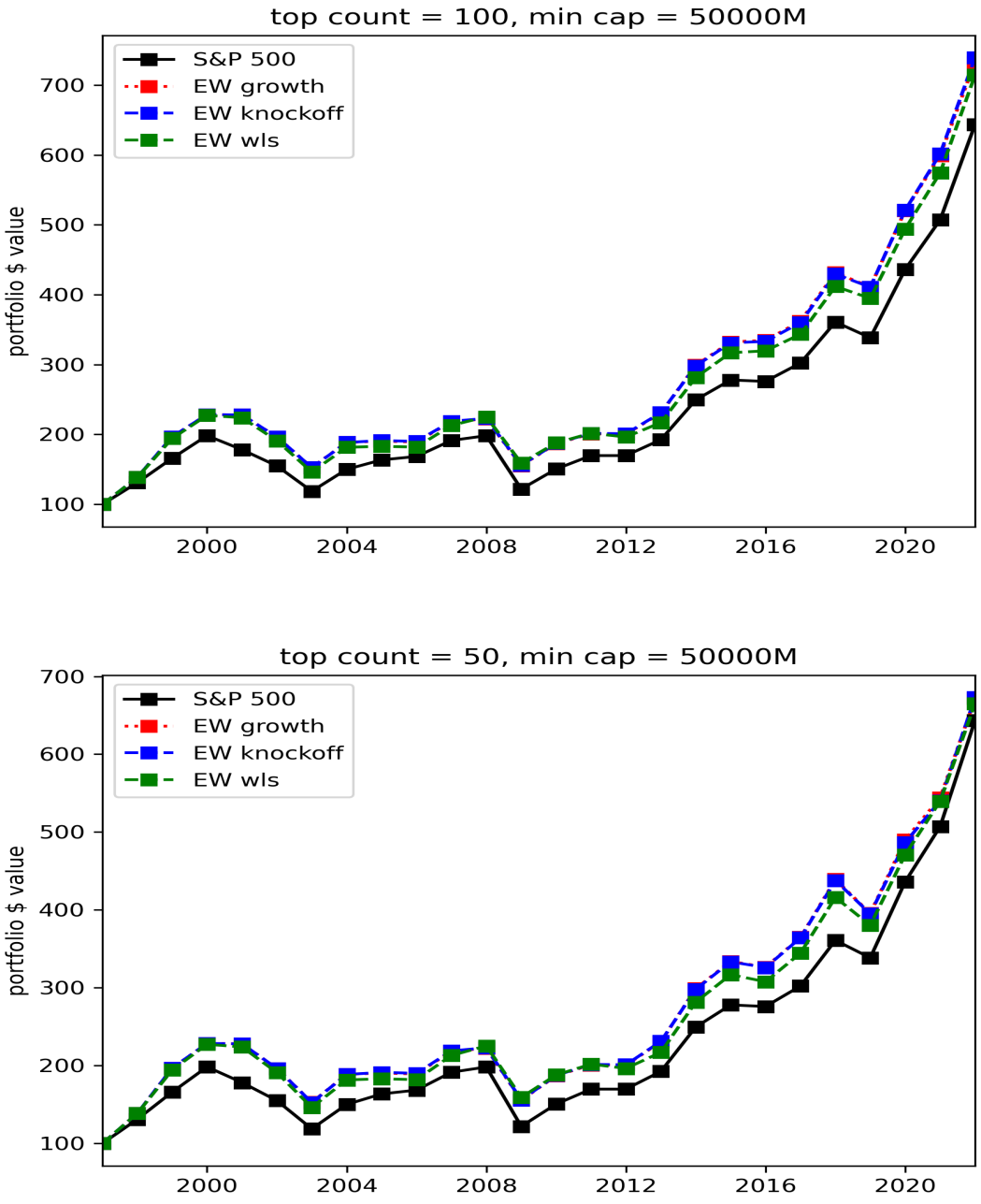

Figure 17: Top panel: top 100, bottom panel: top 50

EW Growth top 100

Dep. Variable:	growth ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	488.0
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.10e-128
Time:	01:57:40	**Log-Likelihood:**	800.16
No. Observations:	300	**AIC:**	-1590.
Df Residuals:	295	**BIC:**	-1572.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.755	0.451	-0.003	0.001
mktrf	0.9332	0.024	39.598	0.000	0.887	0.980
smb	-0.3014	0.031	-9.685	0.000	-0.363	-0.240
hml	0.0321	0.031	1.025	0.306	-0.030	0.094
umd	-0.0936	0.021	-4.463	0.000	-0.135	-0.052

Omnibus:	215.321	**Durbin-Watson:**	1.776
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	7486.304
Skew:	-2.409	**Prob(JB):**	0.00
Kurtosis:	26.994	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.914
Model:	OLS	**Adj. R-squared:**	0.913
Method:	Least Squares	**F-statistic:**	788.6
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	4.12e-156
Time:	01:57:40	**Log-Likelihood:**	869.50
No. Observations:	300	**AIC:**	-1729.
Df Residuals:	295	**BIC:**	-1710.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	1.881e-05	0.001	0.024	0.981	-0.002	0.002
mktrf	0.9391	0.019	50.210	0.000	0.902	0.976
smb	-0.3072	0.025	-12.441	0.000	-0.356	-0.259
hml	0.0310	0.025	1.246	0.214	-0.018	0.080
umd	-0.0991	0.017	-5.951	0.000	-0.132	-0.066

Omnibus:	63.239	**Durbin-Watson:**	2.135
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	231.261
Skew:	0.854	**Prob(JB):**	6.06e-51
Kurtosis:	6.948	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.869
Model:	OLS	**Adj. R-squared:**	0.867
Method:	Least Squares	**F-statistic:**	487.6
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.25e-128
Time:	01:57:40	**Log-Likelihood:**	799.69
No. Observations:	300	**AIC:**	-1589.
Df Residuals:	295	**BIC:**	-1571.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0008	0.001	-0.756	0.450	-0.003	0.001
mktrf	0.9351	0.024	39.618	0.000	0.889	0.982
smb	-0.2975	0.031	-9.547	0.000	-0.359	-0.236
hml	0.0355	0.031	1.132	0.259	-0.026	0.097
umd	-0.0917	0.021	-4.362	0.000	-0.133	-0.050

Omnibus:	213.207	**Durbin-Watson:**	1.791
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	7360.833
Skew:	-2.374	**Prob(JB):**	0.00
Kurtosis:	26.797	**Cond. No.**	34.5

Notes:

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

3.4 Top 50/100 medium cap value stocks

The considered minimum market capitalisation is $500 millions.

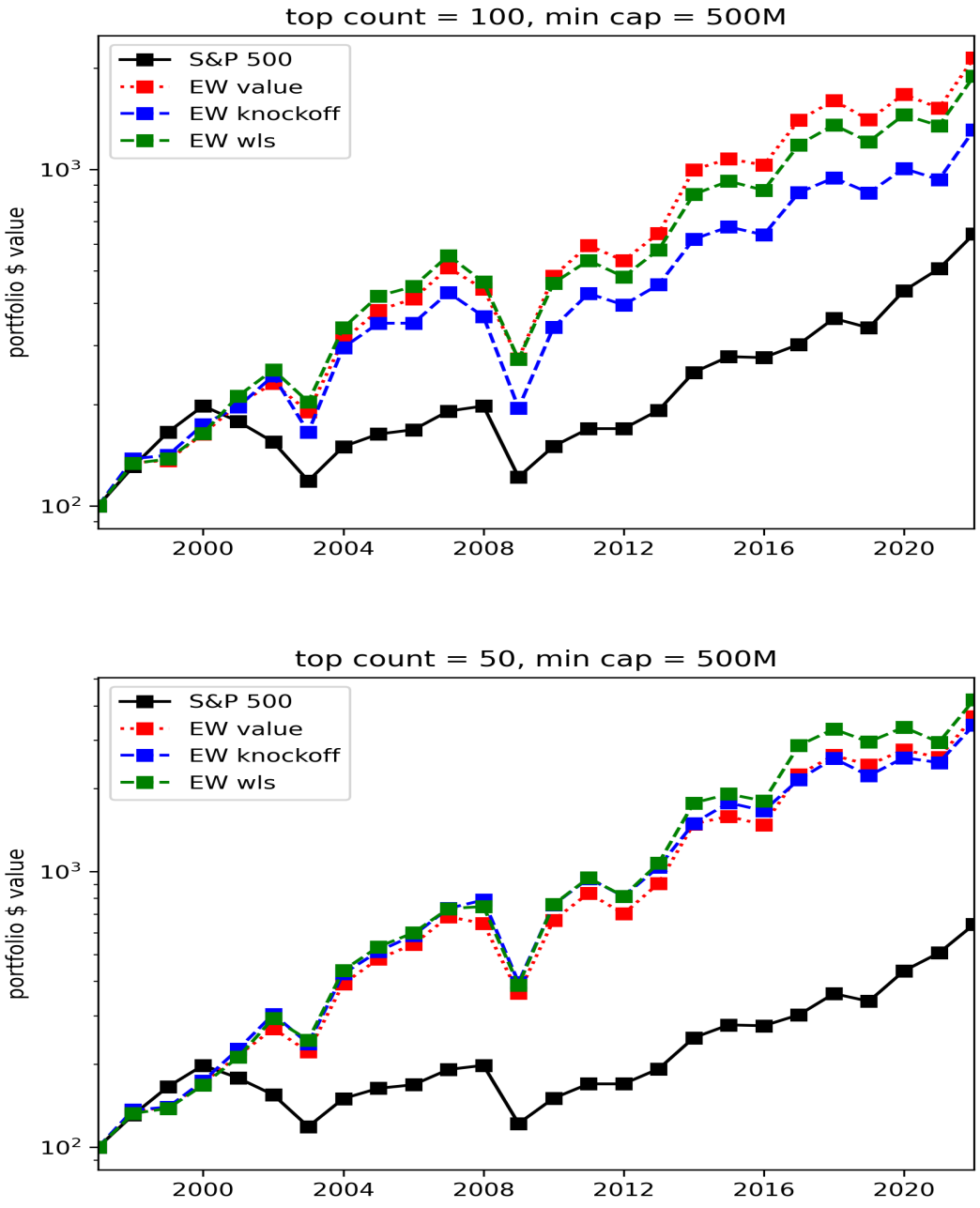

Figure 18: Top panel: top 100, bottom panel: top 50

EW Value top 100

Dep. Variable:	value ret	**R-squared:**	0.910
Model:	OLS	**Adj. R-squared:**	0.908
Method:	Least Squares	**F-statistic:**	742.3
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.41e-152
Time:	01:19:37	**Log-Likelihood:**	723.46
No. Observations:	300	**AIC:**	-1437.
Df Residuals:	295	**BIC:**	-1418.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0037	0.001	2.893	0.004	0.001	0.006
mktrf	1.1092	0.030	36.448	0.000	1.049	1.169
smb	0.4343	0.040	10.807	0.000	0.355	0.513
hml	0.9116	0.040	22.540	0.000	0.832	0.991
umd	-0.3233	0.027	-11.934	0.000	-0.377	-0.270

Omnibus:	148.267	**Durbin-Watson:**	2.088
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	1459.733
Skew:	1.771	**Prob(JB):**	0.00
Kurtosis:	13.210	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.906
Model:	OLS	**Adj. R-squared:**	0.905
Method:	Least Squares	**F-statistic:**	711.6
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	4.02e-150
Time:	01:19:37	**Log-Likelihood:**	717.47
No. Observations:	300	**AIC:**	-1425.
Df Residuals:	295	**BIC:**	-1406.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0034	0.001	2.611	0.009	0.001	0.006
mktrf	1.1162	0.031	35.956	0.000	1.055	1.177
smb	0.4146	0.041	10.114	0.000	0.334	0.495
hml	0.8693	0.041	21.071	0.000	0.788	0.951
umd	-0.3368	0.028	-12.188	0.000	-0.391	-0.282

Omnibus:	92.701	**Durbin-Watson:**	1.940
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	497.976
Skew:	1.152	**Prob(JB):**	7.34e-109
Kurtosis:	8.876	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.897
Model:	OLS	**Adj. R-squared:**	0.896
Method:	Least Squares	**F-statistic:**	642.0
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	3.50e-144
Time:	01:19:37	**Log-Likelihood:**	705.72
No. Observations:	300	**AIC:**	-1401.
Df Residuals:	295	**BIC:**	-1383.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0023	0.001	1.678	0.094	-0.000	0.005
mktrf	1.1315	0.032	35.046	0.000	1.068	1.195
smb	0.3123	0.043	7.325	0.000	0.228	0.396
hml	0.7576	0.043	17.658	0.000	0.673	0.842
umd	-0.3665	0.029	-12.751	0.000	-0.423	-0.310

Omnibus:	72.704	**Durbin-Watson:**	1.883
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	284.159
Skew:	0.971	**Prob(JB):**	1.98e-62
Kurtosis:	7.355	**Cond. No.**	34.5

Notes:

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

3.5 Top 50/100 medium cap growth stocks

The considered minimum market capitalisation is $500 millions.

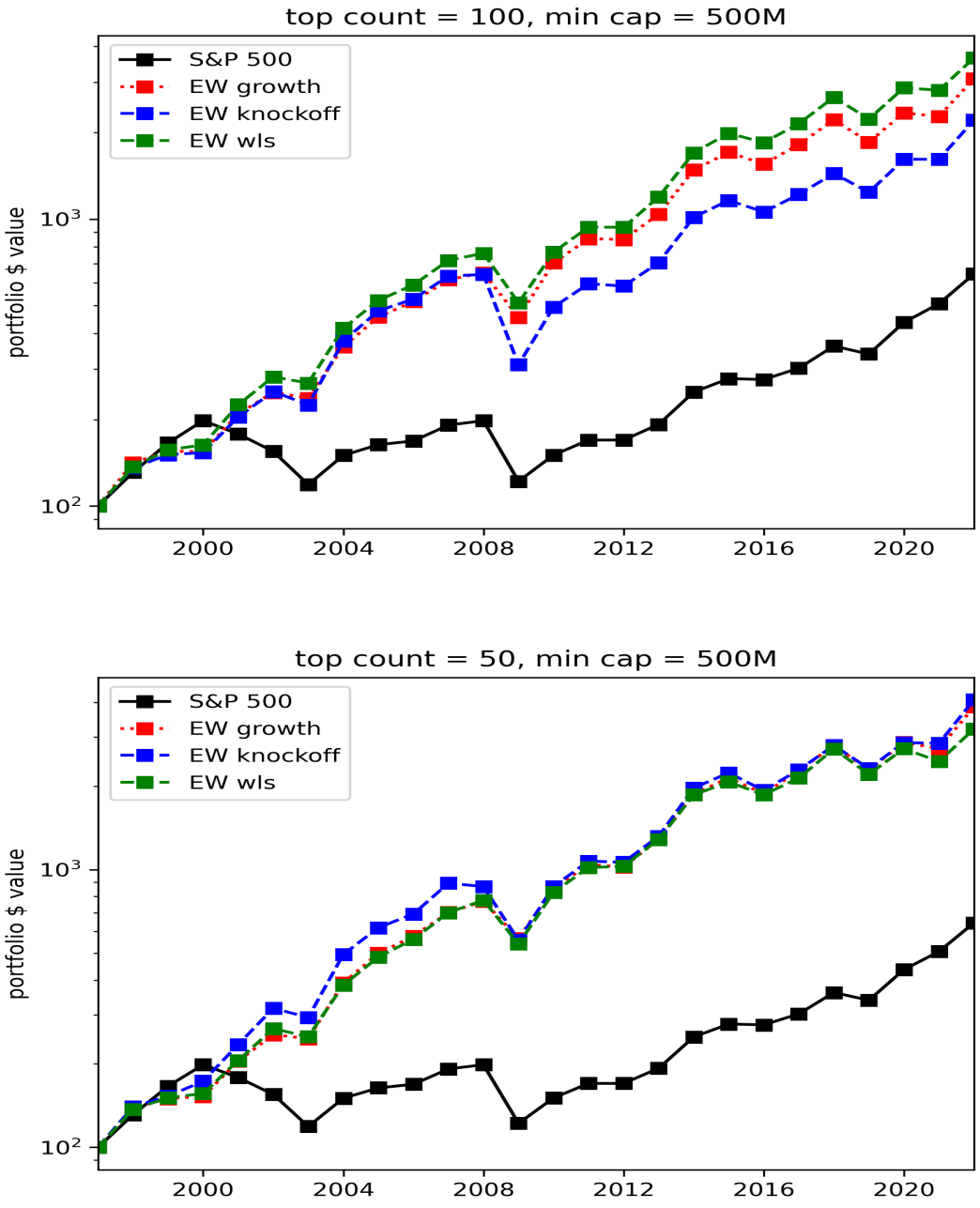

Figure 19: Top panel: top 100, bottom panel: top 50

EW Growth top 100

Dep. Variable:	growth ret	**R-squared:**	0.852
Model:	OLS	**Adj. R-squared:**	0.850
Method:	Least Squares	**F-statistic:**	423.8
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	6.56e-121
Time:	01:42:13	**Log-Likelihood:**	706.31
No. Observations:	300	**AIC:**	-1403.
Df Residuals:	295	**BIC:**	-1384.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0045	0.001	3.274	0.001	0.002	0.007
mktrf	0.9925	0.032	30.801	0.000	0.929	1.056
smb	0.2622	0.043	6.163	0.000	0.178	0.346
hml	0.6883	0.043	16.073	0.000	0.604	0.773
umd	-0.1599	0.029	-5.575	0.000	-0.216	-0.103

Omnibus:	27.593	**Durbin-Watson:**	2.068
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	94.179
Skew:	0.280	**Prob(JB):**	3.54e-21
Kurtosis:	5.687	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.845
Model:	OLS	**Adj. R-squared:**	0.843
Method:	Least Squares	**F-statistic:**	403.5
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	3.01e-118
Time:	01:42:13	**Log-Likelihood:**	702.67
No. Observations:	300	**AIC:**	-1395.
Df Residuals:	295	**BIC:**	-1377.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0048	0.001	3.437	0.001	0.002	0.007
mktrf	0.9920	0.033	30.417	0.000	0.928	1.056
smb	0.2285	0.043	5.306	0.000	0.144	0.313
hml	0.6225	0.043	14.363	0.000	0.537	0.708
umd	-0.1754	0.029	-6.042	0.000	-0.233	-0.118

Omnibus:	24.370	**Durbin-Watson:**	2.032
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	55.648
Skew:	0.387	**Prob(JB):**	8.25e-13
Kurtosis:	4.963	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.859
Model:	OLS	**Adj. R-squared:**	0.857
Method:	Least Squares	**F-statistic:**	448.3
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	5.52e-124
Time:	01:42:13	**Log-Likelihood:**	712.39
No. Observations:	300	**AIC:**	-1415.
Df Residuals:	295	**BIC:**	-1396.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	0.0032	0.001	2.354	0.019	0.001	0.006
mktrf	1.0198	0.032	32.299	0.000	0.958	1.082
smb	0.1945	0.042	4.665	0.000	0.112	0.277
hml	0.6175	0.042	14.715	0.000	0.535	0.700
umd	-0.1871	0.028	-6.657	0.000	-0.242	-0.132

Omnibus:	22.449	**Durbin-Watson:**	1.982
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	78.332
Skew:	0.100	**Prob(JB):**	9.78e-18
Kurtosis:	5.495	**Cond. No.**	34.5

Notes:

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

3.6 Top 50/100 small cap value stocks

The considered minimum market capitalisation is $5 millions.

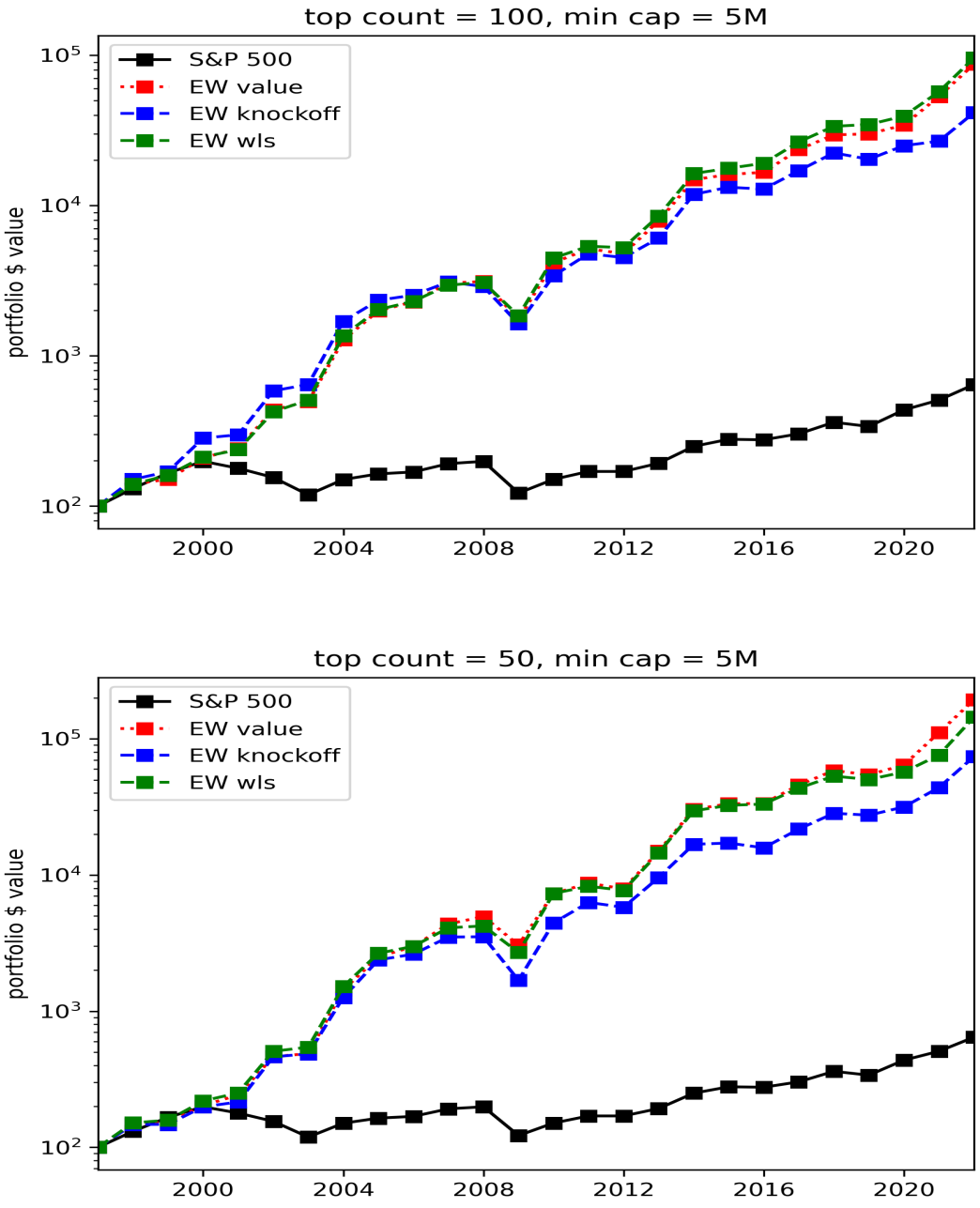

Figure 20: Top panel: top 100, bottom panel: top 50

EW Value top 100

Dep. Variable:	value ret	**R-squared:**	0.299
Model:	OLS	**Adj. R-squared:**	0.289
Method:	Least Squares	**F-statistic:**	31.40
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	8.58e-22
Time:	00:32:31	**Log-Likelihood:**	263.90
No. Observations:	300	**AIC:**	-517.8
Df Residuals:	295	**BIC:**	-499.3
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.1273	0.006	-21.291	0.000	-0.139	-0.116
mktrf	0.7427	0.141	5.275	0.000	0.466	1.020
smb	0.9495	0.186	5.107	0.000	0.584	1.315
hml	0.4958	0.187	2.650	0.008	0.128	0.864
umd	-0.5551	0.125	-4.429	0.000	-0.802	-0.308

Omnibus:	10.257	**Durbin-Watson:**	0.686
Prob(Omnibus):	0.006	**Jarque-Bera (JB):**	10.330
Skew:	-0.423	**Prob(JB):**	0.00571
Kurtosis:	3.335	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.309
Model:	OLS	**Adj. R-squared:**	0.300
Method:	Least Squares	**F-statistic:**	33.02
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	9.29e-23
Time:	00:32:31	**Log-Likelihood:**	256.78
No. Observations:	300	**AIC:**	-503.6
Df Residuals:	295	**BIC:**	-485.0
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.1120	0.006	-18.297	0.000	-0.124	-0.100
mktrf	0.7212	0.144	5.002	0.000	0.437	1.005
smb	0.9495	0.190	4.987	0.000	0.575	1.324
hml	0.5377	0.192	2.806	0.005	0.161	0.915
umd	-0.6603	0.128	-5.145	0.000	-0.913	-0.408

Omnibus:	20.935	**Durbin-Watson:**	0.808
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	23.459
Skew:	-0.626	**Prob(JB):**	8.05e-06
Kurtosis:	3.555	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.415
Model:	OLS	**Adj. R-squared:**	0.407
Method:	Least Squares	**F-statistic:**	52.36
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	2.68e-33
Time:	00:32:31	**Log-Likelihood:**	326.44
No. Observations:	300	**AIC:**	-642.9
Df Residuals:	295	**BIC:**	-624.4
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0335	0.005	-6.902	0.000	-0.043	-0.024
mktrf	0.9253	0.114	8.095	0.000	0.700	1.150
smb	0.9073	0.151	6.012	0.000	0.610	1.204
hml	0.3364	0.152	2.214	0.028	0.037	0.635
umd	-0.5010	0.102	-4.923	0.000	-0.701	-0.301

Omnibus:	41.444	**Durbin-Watson:**	1.134
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	82.624
Skew:	-0.733	**Prob(JB):**	1.14e-18
Kurtosis:	5.113	**Cond. No.**	34.5

Notes:

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

3.7 Top 50/100 small cap growth stocks

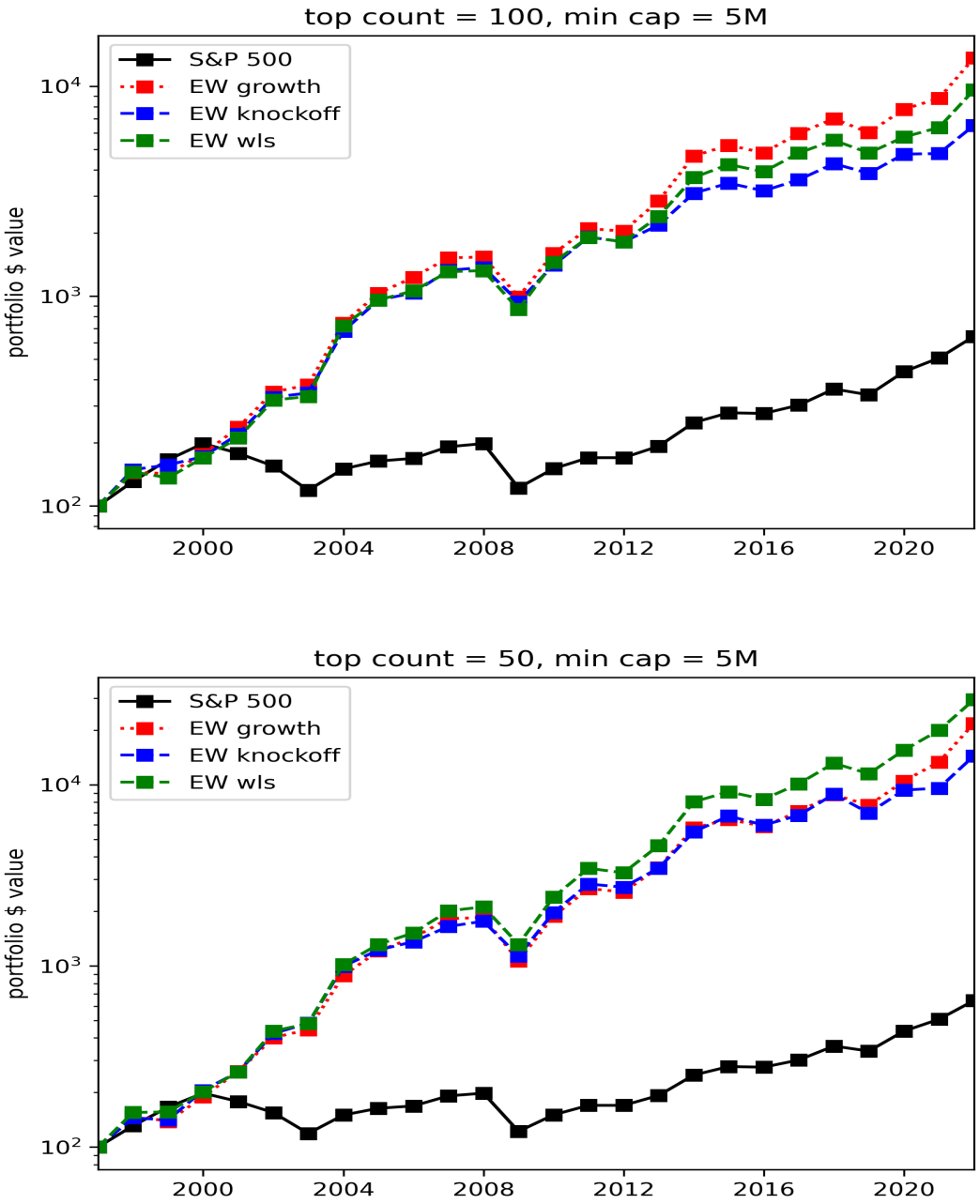

Figure 21: Top panel: top 100, bottom panel: top 50

EW Growth top 100

Dep. Variable:	growth ret	**R-squared:**	0.471
Model:	OLS	**Adj. R-squared:**	0.464
Method:	Least Squares	**F-statistic:**	65.63
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.18e-39
Time:	00:58:14	**Log-Likelihood:**	401.33
No. Observations:	300	**AIC:**	-792.7
Df Residuals:	295	**BIC:**	-774.1
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0576	0.004	-15.225	0.000	-0.065	-0.050
mktrf	1.0409	0.089	11.689	0.000	0.866	1.216
smb	0.5654	0.118	4.808	0.000	0.334	0.797
hml	0.5287	0.118	4.467	0.000	0.296	0.762
umd	-0.1872	0.079	-2.361	0.019	-0.343	-0.031

Omnibus:	68.442	**Durbin-Watson:**	0.776
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	125.283
Skew:	-1.227	**Prob(JB):**	6.24e-28
Kurtosis:	5.001	**Cond. No.**	34.5

Notes:

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

EW WLS selected

Dep. Variable:	wls ret	**R-squared:**	0.485
Model:	OLS	**Adj. R-squared:**	0.478
Method:	Least Squares	**F-statistic:**	69.51
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	2.13e-41
Time:	00:58:14	**Log-Likelihood:**	414.24
No. Observations:	300	**AIC:**	-818.5
Df Residuals:	295	**BIC:**	-800.0
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0527	0.004	-14.565	0.000	-0.060	-0.046
mktrf	1.1272	0.085	13.214	0.000	0.959	1.295
smb	0.4151	0.113	3.685	0.000	0.193	0.637
hml	0.4240	0.113	3.740	0.000	0.201	0.647
umd	-0.1133	0.076	-1.492	0.137	-0.263	0.036

Omnibus:	77.186	**Durbin-Watson:**	0.915
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	162.201
Skew:	-1.297	**Prob(JB):**	6.00e-36
Kurtosis:	5.499	**Cond. No.**	34.5

Notes:

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

EW Knockoff selected

Dep. Variable:	knockoff ret	**R-squared:**	0.689
Model:	OLS	**Adj. R-squared:**	0.685
Method:	Least Squares	**F-statistic:**	163.4
Date:	Mon, 19 Sep 2022	**Prob (F-statistic):**	1.54e-73
Time:	00:58:14	**Log-Likelihood:**	546.35
No. Observations:	300	**AIC:**	-1083.
Df Residuals:	295	**BIC:**	-1064.
Df Model:	4		
Covariance Type:	nonrobust		

	coef	**std err**	**t**	**P> |t|**	**[0.025**	**0.975]**
const	-0.0067	0.002	-2.867	0.004	-0.011	-0.002
mktrf	1.0442	0.055	19.013	0.000	0.936	1.152
smb	0.5068	0.073	6.989	0.000	0.364	0.650
hml	0.3815	0.073	5.227	0.000	0.238	0.525
umd	-0.1880	0.049	-3.847	0.000	-0.284	-0.092

Omnibus:	67.257	**Durbin-Watson:**	1.255
Prob(Omnibus):	0.000	**Jarque-Bera (JB):**	148.000
Skew:	-1.108	**Prob(JB):**	7.28e-33
Kurtosis:	5.632	**Cond. No.**	34.5

Notes:

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