Shrinking Factor Dimension: A Reduced-Rank Approach

Online Appendix

A Additional Tables

Table IA.1 Performance of RRA factors: An alternative estimation

This table reports the RMS alphas and total adj-R^2s of RRA K-factor models in explaining four sets of test assets, where the weighting matrix W_2 in (9) is estimated with the principal orthogonal complement thresholding method of Fan, Liao and Mincheva (2013). The basis assets are 202 characteristic portfolios. The sample period is 1974:01–2016:12.

	RMS alpha (%)				Total adj-R^2 (%)			
$K =$	1	3	5	6	1	3	5	6
202 characteristic portfolios	0.23	0.20	0.19	0.18	54.63	61.38	64.83	65.54
48 industry portfolios	0.29	0.27	0.26	0.32	75.86	81.01	83.86	85.59
All stocks	2.51	2.59	2.64	2.91	9.53	12.82	14.21	15.05
All-but-micro stocks	1.74	1.80	1.78	1.85	21.19	27.38	29.74	30.53

Table IA.2 Out-of-sample performances of factor models: PLS and RRA using 202 characteristic portfolios as basis assets

This table reports the out-of-sample root-mean-squared alphas and total adj-R^2s of different factor models for explaining four sets of test assets. We use the first 30-year data to estimate the weights of the PCA, PLS, and RRA factors and the rest 13-year data for out-of-sample evaluation. For each individual asset, we employ a 60-month rolling window approach, requiring at least 24 observations, to calculate the out-of-sample root-mean-squared alphas and total adj-R^2s. As such, the out-of-sample evaluation period is 2006:01–2016:12.

	Root-mean-squared alpha (%)				Total adj-R^2 (%)			
$K =$	1	3	5	6	1	3	5	6
Panel A: 48 industry portfolios								
FF	0.46	0.53	0.57	0.48	53.66	53.72	51.20	51.82
PCA	0.98	0.97	0.85	0.86	30.26	31.73	34.50	32.24
PLS	0.93	0.51	0.43	0.39	33.04	44.11	54.68	54.89
RRA	0.46	0.46	0.34	0.36	54.15	54.16	53.98	56.81
Panel B: 202 characteristic portfolios								
FF	0.29	0.30	0.24	0.22	78.22	85.04	84.73	86.27
PCA	1.05	1.02	0.84	0.86	49.71	49.88	52.50	50.06
PLS	0.98	0.43	0.24	0.23	53.10	66.40	80.50	80.65
RRA	0.29	0.28	0.23	0.23	82.79	85.27	86.85	87.23
Panel C: All stocks								
FF	2.86	2.97	3.07	3.14	6.46	−0.41	−9.02	−16.39
PCA	2.94	2.96	2.95	2.99	4.66	−1.74	−9.83	−15.29
PLS	2.91	2.92	2.95	2.98	5.12	−0.53	−7.48	−12.54
RRA	2.84	2.90	3.03	3.11	8.14	0.75	−9.39	−14.77
Panel D: All-but-micro stocks								
FF	2.01	2.03	2.09	2.05	20.01	15.94	8.20	2.05
PCA	2.15	2.14	2.10	2.18	11.92	7.71	2.27	−2.94
PLS	2.11	1.98	2.05	2.02	13.14	12.57	9.79	5.77
RRA	1.98	1.98	1.97	2.01	22.28	16.48	8.54	5.63

Table IA.3 In-sample performance of RRA factors estimated with a pricing error restriction and using 202 characteristic portfolios as basis assets

This table reports the root-mean-squared alphas and total adj-R^2s of RRA factors in explaining four sets of test assets. The RRA factors are extracted by using the reduced-rank approach and are assumed to have a pricing error restriction as $\alpha_i = \eta\sigma_i$, where σ_i is asset i's volatility. When extracting the RRA factors, the 202 characteristic portfolios are used as basis assets to estimate the weights of factor proxies. The sample period is 1974:01–2016:12.

	Root-mean-squared alpha (%)				Total adj-R^2 (%)			
$K=$	1	3	5	6	1	3	5	6
Panel A: 48 industry portfolios								
$\eta = 0$	0.26	0.32	0.28	0.25	51.73	58.02	60.19	62.23
$\eta = 0.5/12$	0.26	0.28	0.27	0.24	51.58	57.96	60.13	62.13
$\eta = 1/12$	0.35	0.31	0.33	0.31	51.11	57.56	59.85	61.76
$\eta = 1.5/12$	0.46	0.41	0.42	0.42	50.47	56.82	59.26	61.07
Panel B: 202 characteristic portfolios								
$\eta = 0$	0.30	0.22	0.15	0.15	79.80	86.91	88.95	89.43
$\eta = 0.5/12$	0.32	0.25	0.21	0.20	79.65	86.73	88.75	89.24
$\eta = 1/12$	0.42	0.36	0.33	0.32	79.01	86.06	88.07	88.57
$\eta = 1.5/12$	0.54	0.49	0.47	0.46	77.89	84.90	86.89	87.40
Panel C: All stocks								
$\eta = 0$	2.47	2.79	3.06	3.04	11.40	14.40	15.90	16.27
$\eta = 0.5/12$	2.44	2.80	3.08	3.06	11.46	14.41	15.90	16.26
$\eta = 1/12$	2.45	2.81	3.10	3.09	11.46	14.35	15.84	16.19
$\eta = 1.5/12$	2.48	2.84	3.14	3.13	11.34	14.24	15.72	16.08
Panel D: All-but-micro stocks								
$\eta = 0$	1.75	1.94	1.96	1.99	23.47	27.96	29.82	30.58
$\eta = 0.5/12$	1.71	1.94	1.97	2.00	23.45	27.89	29.74	30.49
$\eta = 1/12$	1.70	1.96	2.00	2.02	23.30	27.67	29.56	30.30
$\eta = 1.5/12$	1.73	2.00	2.04	2.06	22.95	27.33	29.26	29.99

Table IA.4 Out-of-sample performance of RRA factors estimated with a pricing error restriction and using 48 industry portfolios as basis assets

This table reports the out-of-sample root-mean-squared alphas and total adj-R^2s of RRA factors in explaining four sets of test assets. The RRA factors are extracted by using the reduced-rank approach and are assumed to have pricing error as $\alpha_i = \eta\sigma_i$, where σ_i is asset i's volatility. When extracting the RRA factors, the 48 industry portfolios are used as basis assets to estimate the weights of factor proxies. We use the first 30-year data to estimate the weights of the RRA factors and the rest 13-year data for out-of-sample evaluation. For each individual asset, we employ a 60-month rolling window approach, requiring at least 24 observations, to calculate the out-of-sample root-mean-squared alphas and total adj-R^2s. As such, the out-of-sample evaluation period is 2006:01–2016:12.

	Root-mean-squared alpha (%)				Total adj-R^2 (%)			
$K=$	1	3	5	6	1	3	5	6
Panel A: 48 industry portfolios								
$\eta = 0$	0.47	0.35	0.31	0.34	55.24	55.56	57.13	55.70
$\eta = 0.5/12$	0.46	0.36	0.31	0.35	54.93	55.38	56.86	55.73
$\eta = 1/12$	0.46	0.37	0.32	0.38	52.96	53.51	55.09	54.58
$\eta = 1.5/12$	0.46	0.38	0.34	0.44	49.52	50.12	52.07	52.42
Panel B: 202 characteristic portfolios								
$\eta = 0$	0.29	0.24	0.23	0.26	80.54	80.81	82.93	83.83
$\eta = 0.5/12$	0.29	0.24	0.23	0.31	79.41	79.46	80.89	83.01
$\eta = 1/12$	0.29	0.25	0.25	0.38	75.95	75.93	76.84	80.58
$\eta = 1.5/12$	0.30	0.27	0.28	0.47	70.55	70.65	71.26	76.90
Panel C: All stocks								
$\eta = 0$	2.83	2.85	2.90	2.96	7.32	1.24	−7.84	−13.08
$\eta = 0.5/12$	2.83	2.85	2.88	2.96	7.27	1.21	−7.94	−13.08
$\eta = 1/12$	2.82	2.85	2.87	2.96	6.90	0.82	−8.36	−13.33
$\eta = 1.5/12$	2.82	2.85	2.87	2.96	6.21	0.10	−9.03	−13.78
Panel D: All-but-micro stocks								
$\eta = 0$	2.00	1.97	2.01	2.04	21.43	17.12	10.86	6.85
$\eta = 0.5/12$	1.99	1.96	2.00	2.03	21.16	16.78	10.48	6.78
$\eta = 1/12$	1.98	1.95	2.00	2.03	20.17	15.68	9.44	6.17
$\eta = 1.5/12$	1.98	1.95	2.00	2.04	18.50	13.92	7.87	5.10

Table IA.5 Out-of-sample performance of RRA factors estimated with a pricing error restriction and using 202 characteristic portfolios as basis assets

This table reports the out-of-sample root-mean-squared alphas and total adj-R^2s of RRA factors in explaining four sets of test assets. The RRA factors are extracted by using the reduced-rank approach and are assume to have a pricing error restriction as $\alpha_i = \eta\sigma_i$, where σ_i is asset i's volatility. When extracting the RRA factors, the 202 characteristic portfolios are used as basis assets to estimate the weights of factor proxies. We use the first 30-year data to estimate the weights of the RRA factors and the rest 13-year data for out-of-sample evaluation. For each individual asset, we employ a 60-month rolling window approach, requiring at least 24 observations, to calculate the out-of-sample root-mean-squared alphas and total adj-R^2s. As such, the out-of-sample evaluation period is 2006:01–2016:12.

	Root-mean-squared alpha (%)				Total adj-R^2 (%)			
$K=$	1	3	5	6	1	3	5	6
Panel A: 48 industry portfolios								
$\eta = 0$	0.46	0.46	0.38	0.36	54.29	53.77	52.69	56.02
$\eta = 0.5/12$	0.46	0.46	0.38	0.36	54.39	53.65	52.63	55.44
$\eta = 1/12$	0.46	0.45	0.37	0.36	53.26	52.37	51.44	54.14
$\eta = 1.5/12$	0.46	0.45	0.37	0.36	51.08	50.04	49.19	52.08
Panel B: 202 characteristic portfolios								
$\eta = 0$	0.29	0.27	0.23	0.23	82.70	85.21	86.51	87.00
$\eta = 0.5/12$	0.29	0.27	0.23	0.23	82.29	84.49	85.89	86.42
$\eta = 1/12$	0.29	0.27	0.23	0.23	80.02	82.18	83.58	84.74
$\eta = 1.5/12$	0.30	0.28	0.23	0.23	76.20	78.45	79.63	81.94
Panel C: All stocks								
$\eta = 0$	2.84	2.90	3.02	3.09	8.05	0.75	−10.32	−15.09
$\eta = 0.5/12$	2.84	2.90	3.01	3.08	8.08	0.80	−10.26	−15.12
$\eta = 1/12$	2.83	2.90	3.00	3.07	7.83	0.62	−10.39	−15.29
$\eta = 1.5/12$	2.83	2.90	3.00	3.07	7.31	0.24	−10.73	−15.62
Panel D: All-but-micro stocks								
$\eta = 0$	1.99	1.99	1.99	2.03	22.22	16.38	7.06	4.97
$\eta = 0.5/12$	1.98	1.98	1.99	2.03	22.15	16.32	7.02	4.76
$\eta = 1/12$	1.98	1.98	1.99	2.02	21.49	15.75	6.52	4.22
$\eta = 1.5/12$	1.98	1.98	1.99	2.03	20.32	14.74	5.57	3.34

Table IA.6 In-sample performance of factor models estimated by pre-specifying FF five factors and using 202 characteristic portfolios as basis assets

This table reports the root-mean-squared alphas and total adj-R^2s of different factor models in explaining four sets of test assets. FF5 refers to the FF five-factor model, and FF5+PCA, FF5+PLS, and FF5+RRA refer to K-factor models that include FF5 and $(K-5)$ PCA, PLS, and RRA factors, respectively. PCA factors are extracted from the factor proxies excluding the FF five factors; PLS and RRA refer to factors estimated with the 202 characteristic portfolios as basis assets. The sample period is 1974:01–2016:12.

	Root-mean-squared alpha (%)					Total adj-R^2 (%)				
$K=$	5	6	7	8	10	5	6	7	8	10
Panel A: 48 industry portfolios										
FF5	0.34	–	–	–	–	57.57	–	–	–	–
FF5+PCA	–	0.31	0.31	0.31	0.28	–	58.80	59.23	61.00	61.85
FF5+PLS	–	0.30	0.28	0.27	0.23	–	59.05	61.51	61.76	62.73
FF5+RRA	–	0.29	0.30	0.29	0.27	–	58.75	61.44	62.44	63.85
Panel B: 202 characteristic portfolios										
FF5	0.19	–	–	–	–	86.94	–	–	–	–
FF5+PCA	–	0.15	0.15	0.15	0.14	–	87.52	87.65	87.99	88.55
FF5+PLS	–	0.15	0.14	0.15	0.15	–	87.86	88.48	88.74	89.23
FF5+RRA	–	0.15	0.15	0.15	0.15	–	88.42	89.05	89.64	90.17
Panel C: All stocks										
FF5	3.08	–	–	–	–	14.70	–	–	–	–
FF5+PCA	–	3.22	3.28	3.43	3.61	–	15.26	15.42	15.79	16.24
FF5+PLS	–	3.28	3.33	3.45	3.55	–	15.52	15.99	16.22	16.55
FF5+RRA	–	3.15	3.25	3.19	3.43	–	15.55	15.98	16.46	17.09
Panel D: All-but-micro stocks										
FF5	2.06	–	–	–	–	28.39	–	–	–	–
FF5+PCA	–	2.13	2.16	2.20	2.27	–	29.10	29.42	30.28	31.01
FF5+PLS	–	2.14	2.15	2.18	2.27	–	29.37	30.40	30.78	31.42
FF5+RRA	–	2.10	2.16	2.18	2.26	–	29.43	30.60	31.04	32.20

Table IA.7 Performance of alternative PCA factors

This table reports the root-mean-squared alphas and total adj-R^2s of alternative PCA factors in explaining four sets of test assets, where the factors are directly extracted from 202 characteristic portfolios. BS-PCA and RP-PCA refer to the methods used in Balvers and Stivers (2018) and Lettau and Pelger (2020), respectively. The sample period is 1974:01–2016:12.

	Root-mean-squared alpha (%)				Total adj-R^2 (%)			
$K =$	1	3	5	6	1	3	5	6
Panel A: 48 industry portfolios								
PCA	0.25	0.31	0.27	0.27	52.47	58.46	62.94	65.26
BS-PCA	0.28	0.37	0.30	0.30	52.82	57.82	62.62	65.12
RP-PCA	0.25	0.36	0.29	0.29	52.57	58.10	62.74	65.18
Panel B: 202 characteristic portfolios								
PCA	0.30	0.22	0.15	0.15	80.21	87.63	90.06	90.89
BS-PCA	0.31	0.18	0.16	0.16	79.97	87.37	90.03	90.86
RP-PCA	0.30	0.18	0.15	0.15	80.20	87.49	90.05	90.88
Panel C: All stocks								
PCA	2.46	2.78	2.90	2.95	11.44	14.87	16.67	17.32
BS-PCA	2.49	3.03	3.12	3.18	11.11	14.86	16.68	17.33
RP-PCA	2.47	2.92	3.03	3.09	11.38	14.87	16.68	17.34
Panel D: All-but-micro stocks								
PCA	1.74	1.95	1.99	2.00	23.58	28.29	30.26	31.16
BS-PCA	1.80	2.07	2.11	2.13	23.25	27.61	30.18	31.11
RP-PCA	1.75	2.02	2.06	2.08	23.53	27.86	30.21	31.13

Table IA.8 Performance of LASSO-based factors: robustness

This table reports the root-mean-squared alphas and total adj-R^2s of LASSO-based factor models in explaining four sets of test assets. We follow Feng, Giglio and Xiu (2020) and select factors from 70 factor proxies that best explain the average returns of the 202 characteristic portfolios. CV refers to choosing factors with cross-validation. The sample period is 1974:01–2016:12.

	Root-mean-squared alpha (%)				Total adj-R^2 (%)			
$K =$	3	5	6	CV	3	5	6	CV
48 industry portfolios	0.25	0.32	0.26	0.26	55.63	57.35	58.08	53.43
202 characteristic portfolios	0.23	0.15	0.14	0.30	84.83	86.77	87.02	83.62
All stocks	2.72	3.20	3.25	2.50	13.52	14.97	15.20	12.56
All-but-micro stocks	1.91	2.12	2.14	1.73	26.59	28.06	28.61	24.70

B Definitions of 62 Anomalies as Factor Proxies

Dvp Dividend to price ratio (Litzenberger and Ramaswamy, 1979): Annual total dividends payouts divided by the market value at the end of June

Top Total payouts (Boudoukh, Michaely, Richardson, and Roberts, 2007): Dividends (dvc) on common stock plus repurchases

Nop Net payout yields (Boudoukh, Michaely, Richardson, and Roberts, 2007): Total payouts minus equity issuances

Ssgrow Sustainable growth (Lockwood and Prombutr, 2010): Annual growth in book value of equity

Ebp Enterprise component of book to price (Penman, Richardson, and Tuna, 2007): Book value of net operating asset (net debt plus book equity) to the net operating assets (net debt plus market equity)

Ndp Net debt to price (Penman, Richardson, and Tuna, 2007): Net debt to the market equity

Dur Equity duration (Dechow, Sloan, and Soliman, 2004): Weighted average of the time to each of the respective net cash distributions divided by market equity

Ndf Net debt financing (Bradshaw, Richardson, and Sloan, 2006): Cash proceeds from the issuance of long-term debt (dltis) minus cash payments for long-term debt reductions (dltr), plus the net changes in current debt (dlcch)

Nxf Net external financing (Bradshaw, Richardson, and Sloan, 2006): Sale of common and preferred stocks (sstk) minus cash payments for the repurchases of preferred stocks (prstkc), minus cash payments for dividends (dv)

Cei Composite equity issuance (Daniel and Titman, 2006): Log growth rate in the market equity not attributable to stock returns

Aci Abnormal capital investment (Titman, Wei, and Xie, 2004): Capital expenditure (capx) for the fiscal year divided by the average of last three years of capital expenditure minus one

Noa Net operating asset (Hirshleifer, Hou, Teoh, and Zhang, 2004): Operating assets (at-che) minus operating liabilities (at−dlc−dltt−mib−pstk−ceq)

Pta Percentage total accruals (Richardson, Sloan, Soliman, and Tuna, 2005): Total accruals scaled by the absolute value of net income (ni)

dCoa Change in current operating assets (Richardson, Sloan, Soliman, and Tuna, 2005): Change in current assets (act) minus change in cash and short term investment (che)

dNco Change in net non-current operating assets (Richardson, Sloan, Soliman, and Tuna, 2005): Change in non-current operating assets minus change in non-current liabilities

dNca Change in non-current operating assets (Richardson, Sloan, Soliman, and Tuna, 2005): Change in total asset (at) minus change in current assets (act), minus change in long-term investments (ivao)

dFnl Change in financial liabilities (Richardson, Sloan, Soliman, and Tuna, 2005): Change in short-term investments plus change in long-term investments

Cop Cash-based operating profitability (Ball, Gerakos, Linnainmaa, and Nikolaev, 2015): Total revenue (revt) minus cost of goods sold (cogs), minus selling, general, and administrative expenses (xsga), plus research and development expenditures (xrd), minus change in accounts receivable (rect), minus change in inventory (invt), minus change in prepaid expenses (xpp), plus change in deferred revenue (drc+drlt), plus change in trade accounts payable (ap), and plus change in accrued expenses (xacc), all scaled by book assets (at)

F_g7 F-score (Piotroski, 2000): The sum of nine firm's fundamental signals as either good or bad depending on the signals' implications for future stock prices and profitability

Ol Operating leverage (Novy-Marx, 2011): Operate costs to total assets

Rdm R&D to market (Chan, Lakonishok, and Sougiannis, 2001): R&D expenses (xrd) divided by the market value at the end of December

Adm Advertising expenses-to-market equity (Chan, Lakonishok, and Sougiannis, 2001): Advertising expenses (xad) to market value at the end of December

Bca Brand capital to assets (Belo, Lin, and Vitorino, 2014): Accumulating advertising expensed with the perpetual inventory method

Oca_ia Industry-adjusted Organizational capital to assets (Eisfeldt and Papanikolaou, 2013): Organizational capital to assets with 17 industry adjusted with the perpetual inventory method

Rnaq Quarterly return on net operating assets (Soliman, 2008): Quarterly operating income after depreciation (oiadpq) divided by one-quarter-lagged net operating assets

Pmq Quarterly profit margin (Soliman, 2008): Quarterly operating income after depreciation (oiadpq) divided by quarterly slaes (saleq)

Atoq Quarterly asset turnover (Soliman, 2008): Quarterly sales (saleq) divided by one-quarter-lagged net operating assets

Ctoq Quarterly capital turnover (Haugen and Baker, 1996): Quarterly sales (saleq) divided by one-quarter-lagged total assets (atq)

Glaq Quarterly gross profits to lagged assets (Novy-Marx, 2013): Quarterly total revenue (revtq) minus cost of goods sold (cogsq), divided by one-quarter-lagged total assets (atq)

Oleq Quarterly operating profits to lagged equity (Fama and French, 2015): Quarterly total revenue (revtq) minus cost of goods sold (cogsq), minus selling, general, and administraive expenses (xsgaq), minus interest expenses (xintq), all scaled by one-quarter-lagged book equity

Olaq Quarterly operating profits to lagged assets (Ball, Gerakos, Linnainmaa, and Nikolaev, 2015): Quarterly total revenue (revtq) minus cost of goods sold (cogsq), minus selling, general, and administraive expenses (xsgaq), plus research and development expenditures (xrdq), all scaled by one-quarter-lagged book assets (atq)

Claq Quarterly cash-based operating profits to lagged assets (Ball, Gerakos, Linnainmaa, and Nikolaev, 2015): Quarterly total revenue (revtq) minus cost of goods sold (cogsq), minus selling, general, and administraive expenses (xsgaq), plus research and development expenditures (xrdq), minus change in accounts receivable (rectq), minus change in inventory (invtq), plus change in deferred revenue (drcq+drltq), plus change in trade accounts payable (apq), all scaled by one-quarter-lagged book assets (atq)

Oq Quarterly O-score (Dichev, 1998): Replace annual O-score components as quarterly components

Olq Quarterly operating leverage (Novy-Marx, 2011): Quarterly operating costs (cogsq+xsgaq) divided by assets (atq) for the fiscal quarter ending at least four months ago

Kzq Quarterly Kaplan-Zingales index(Lamont, Polk, and Saaa-Requejo, 2001): Replace annual KZ index components as quarterly components

Acc Working capital accruals (Sloan, 1996): Annual income before extraordinary items (ib) minus operating cash flows (oancf) divided by average total assets (at); if oancf is missing then set to change in act−change in che−change in lct+change in dlc+change in txp−dp

Agr Asset growth (Cooper, Gulen, and Schill, 2008): Annual percent change in total assets (at)

Bm_ia Industry-adjusted book to market (Asness, Porter, and Stevens, 2000): Industry adjusted book-to-market ratio

Cashdebt Cash flow to debt (Ou and Penman, 1989): Earnings before depreciation and extraordinary items (ib+dp) divided by average total liabilities (lt)

Cfp Cash flow to price ratio (Desai, Rajgopal, and Venkatachalam, 2004): Operating cash flows divided by fiscal-year-end market capitalization

Cfp_ia Industry-adjusted cash flow to price ratio (Asness, Porter, and Stevens, 2000): Industry adjusted cfp

Chcsho Change in shares outstanding (Pontiff and Woodgate, 2008): Annual percent change in shares outstanding (csho)

Chinv Change in inventory (Thomas and Zhang, 2002): Change in inventory (inv) scaled by average total assets (at)

Egr Growth in common shareholder equity (Richardson, Sloan, Soliman, and Tuna, 2005): Annual percent change in book value of equity (ceq)

Ep Earnings to price (Basu, 1977): Annual income before extraordinary items (ib) divided by end of fiscal year market cap

gCapx Growth in capital expenditures (Anderson and Garcia-Feijoo, 2006): Percent change in capital expenditures from year $t-2$ to year t

gLtnoa Growth in long term net operating assets (Fairfield, Whisenant, and Yohn, 2003): Growth in long term net operating assets

Hire Employee growth rate (Belo, Lin, and Vitorino, 2014): Percent change in number of employees (emp)

Invest Capital expenditures and inventory (Hou, Xue, and Zhang, 2020): Annual change in gross property, plant, and equipment (ppegt) + annual change in inventories (invt) all scaled by lagged total assets (at)

Lgr Growth in long-term debt (Richardson, Sloan, Soliman, and Tuna, 2005): Annual percent change in total liabilities (lt)

Orgcap Organizational capital (Eisfeldt and Papanikolaou, 2013): Capitalized SG&A expenses

Pchsale_Pchinvt % change in sales−% change in inventory (Abarbanell and Bushee, 1998):Annual percent change in sales (sale) minus annual percent change in inventory (invt)

Pchsaleinv % change sales-to-inventory (Ou and Penman, 1989): Percent change in saleinv

Roic Return on invested capital (Brown and Rowe, 2007): Annual earnings before interest and taxes (ebit) minus non-operating income (nopi) divided by non-cash enterprise value (ceq+lt−che)

Saleinv Sales to inventory (Ou and Penman, 1989): Annual sales divided by total inventory

Salerec Sales to receivables (Ou and Penman, 1989): Annual sales divided by accounts receivable

Sp Sales to price (Barbee Jr., Mukherji, and Raines, 1996): Annual revenue (sale) divided by fiscal-year-end market capitalization

Tb Tax income to book income (Lev and Nissim, 2004): Tax income, calculated from current tax expense divided by maximum federal tax rate, divided by income before extraordinary items

Chtxq Quarterly change in tax expense (Thomas and Zhang, 2011): Percent change in total taxes (txtq) from quarter $t-4$ to t

Ear Earnings announcement return (Kishore, Brandt, Santa-Clara, and Venkatachalam, 2008): Sum of daily returns in three days around earnings announcement. Earnings announcement from Compustat quarterly file (rdq)

Roaq Return on assets (Kishore, Brandt, Santa-Clara, and Venkatachalam, 2008): Income before extraordinary items (ibq) divided by one quarter lagged total assets (atq)

Roeq Return on equity (Hou, Xue, and Zhang, 2015): Earnings before extraordinary items divided by lagged common shareholders' equity