

# Replicating Anomalies

Kewei Hou<sup>1</sup>    Chen Xue<sup>2</sup>    Lu Zhang<sup>3</sup>

<sup>1</sup>The Ohio State University and CAFR

<sup>2</sup>University of Cincinnati

<sup>3</sup>The Ohio State University and NBER

NBER Long-term Asset Management Conference  
May 4, 2018

Most anomalies fail to replicate

Replicate the published anomalies literature with 447 variables, controlling for microcaps via NYSE breakpoints and value-weights

- 286 (64%) with  $t < 1.96$ , 380 (85%) with  $t < 3$
- Replicated anomalies much weaker than originally reported
- Similar replication results in the original samples: 293 (66%) with  $t < 1.96$ , 387 (86.6%) with  $t < 3$

1 Replication Procedures

2 447 Anomalies

3 Replication Results

## 1 Replication Procedures

## 2 447 Anomalies

## 3 Replication Results

Fama and French (2008): Microcaps are 60% of firms but only 3% of market cap, highest equal-weighted returns, largest cross-sectional dispersions in returns and anomaly variables

Many ways of overweighting microcaps:

- NYSE-Amex-NASDAQ breakpoints with equal-weights
- Cross-sectional regressions

Pure replication: To do something again in exactly the same way

**Scientific replication:** Different sample, different population, and perhaps similar but not identical model

- “[A]ppears much more suited in type to our methods of research and, indeed, comprises most of what economists view as replication (p. 716, our emphasis)”

See also the May 2017 issue of American Economic Review

1 Replication Procedures

2 447 Anomalies

3 Replication Results



Category	Number
Momentum	57
Value-versus-growth	68
Investment	38
Profitability	79
Intangibles	103
Trading frictions	102

Panel A: **Momentum** (57)

---

Sue1, Sue6, Sue12	<b>Earnings surprise</b> (1-, 6-, 12-month), Foster, Olsen, and Shevlin (1984)
Abr1, Abr6, Abr12	Cumulative abnormal stock returns around earnings announcements (1-, 6-, 12-month), Chan, Jegadeesh, and Lakonishok (1996)
Re1, Re6, Re12	Revisions in analysts' earnings forecasts (1-, 6-, 12-month), Chan, Jegadeesh, and Lakonishok (1996)
$R^6_1$ , $R^6_6$ , $R^6_{12}$	<b>Price momentum</b> (6-month prior returns, 1-, 6-, 12-month), Jegadeesh and Titman (1993)
$R^{11}_1$ , $R^{11}_6$ , $R^{11}_{12}$	Price momentum (11-month prior returns, 1-, 6-, 12-month), Fama and French (1996)
Im1, Im6, Im12	<b>Industry momentum</b> (1-, 6-, 12-month), Moskowitz and Grinblatt (1999)
Rs1, Rs6, Rs12	Revenue surprise (1-, 6-, 12-month), Jegadeesh and Livnat (2006)
Tes1, Tes6, Tes12	Tax expense surprise (1-, 6-, 12-month), Thomas and Zhang (2011)
dEf1, dEf6, dEf12	Analysts' forecast change (1-, 6-, 12-month), Hawkins, Chamberlin, and Daniel (1984)
Nei1, Nei6, Nei12	# consecutive quarters with earnings increases (1-, 6-, 12-month), Barth, Elliott, and Finn (1999)

52w1, 52w6, 52w12	<b>52-week high</b> (1-, 6-, and 12-month), George and Hwang (2004)
$\epsilon^{11}1, \epsilon^{11}6, \epsilon^{11}12$	11-month residual momentum (1-, 6-, 12-month), Blitz, Huij, and Martens (2011)
$\epsilon^61, \epsilon^66, \epsilon^612$	6-month residual momentum (1-, 6-, 12-month), Blitz, Huij, and Martens (2011)
Sm1, Sm6, Sm12	<b>Segment momentum</b> (1-, 6-, 12-month), Cohen and Lou (2012)
llr1, llr6, llr12	Industry lead-lag effect in prior returns (1-, 6-, 12-month), Hou (2007)
lle1, lle6, lle12	Industry lead-lag effect in earnings surprises (1-, 6-, 12-month), Hou (2007)
Cm1, Cm6, Cm12	<b>Customer momentum</b> (1-, 6-, 12-month), Cohen and Frazzini (2008)
Sim1, Sim6, Sim12	Supplier industries momentum (1-, 6-, 12-month), Menzly and Ozbas (2010)
Cim1, Cim6, Cim12	Customer industries momentum (1-, 6-, 12-month), Menzly and Ozbas (2010)

## Panel B: Value-versus-growth (68)

Bm	Book-to-market equity, Rosenberg, Reid, and Lanstein (1985)
Bmj	Book-to-June-end market equity, Asness and Frazzini (2013)
Bm <sup>q1</sup> , Bm <sup>q6</sup> , Bm <sup>q12</sup>	Book-to-current market equity (1-, 6-, 12-month), Asness and Frazzini (2013)
Dm	Debt-to-market, Bhandari (1988)
Dm <sup>q1</sup> , Dm <sup>q6</sup> , Dm <sup>q12</sup>	Debt-to-market (1-, 6-, 12-month)
Am	Assets-to-market, Fama and French (1992)
Am <sup>q1</sup> , Am <sup>q6</sup> , Am <sup>q12</sup>	Assets-to-market (1-, 6-, 12-month)
Rev1, Rev6, Rev12	Reversal (1-, 6-, 12-month), De Bondt and Thaler (1985)
Ep	Earnings-to-price, Basu (1983)
Ep <sup>q1</sup> , Ep <sup>q6</sup> , Ep <sup>q12</sup>	Earnings-to-price (1-, 6-, 12-month)
Efp1, Efp6, Efp12	Analysts' earnings forecasts-to-price (1-, 6-, 12-month), Elgers, Lo, and Pfeiffer (2001)
Cp	Cash flow-to-price, Lakonishok, Shleifer, and Vishny (1994)
Cp <sup>q1</sup> , Cp <sup>q6</sup> , Cp <sup>q12</sup>	Cash flow-to-price (1-, 6-, 12-month)
Dp	Dividend yield, Litzenberger and Ramaswamy (1979)
Dp <sup>q1</sup> , Dp <sup>q6</sup> , Dp <sup>q12</sup>	Dividend yield (1-, 6-, 12-month)

Op	Payout yield, Boudoukh, Michaely, Richardson, and Roberts (2007)
Op <sup>q</sup> 1, Op <sup>q</sup> 6, Op <sup>q</sup> 12	Payout yield (1-, 6-, 12-month)
Nop	<b>Net payout yield</b> , Boudoukh, Michaely, Richardson, and Roberts (2007)
Nop <sup>q</sup> 1, Nop <sup>q</sup> 6, Nop <sup>q</sup> 12	Net payout yield (1-, 6-, 12-month)
Sr	<b>Five-year sales growth rank</b> , Lakonishok, Shleifer, and Vishny (1994)
Sg	Annual sales growth, Lakonishok, Shleifer, and Vishny (1994)
Em	<b>Enterprise multiple</b> , Loughran and Wellman (2011)
Em <sup>q</sup> 1, Em <sup>q</sup> 6, Em <sup>q</sup> 12	Enterprise multiple (1-, 6-, 12-month)
Sp	Sales-to-price, Barbee, Mukherji, and Raines (1996)
Sp <sup>q</sup> 1, Sp <sup>q</sup> 6, Sp <sup>q</sup> 12	Sales-to-price (1-, 6-, 12-month)
Ocp	<b>Operating cash flow-to-price</b> , Desai, Rajgopal, and Venkatachalam (2004)
Ocp <sup>q</sup> 1, Ocp <sup>q</sup> 6, Ocp <sup>q</sup> 12	Operating cash flow-to-price (1-, 6-, 12-month)

Ir	Intangible return, Daniel and Titman (2006)
Vhp	<b>Intrinsic value-to-market</b> , Frankel and Lee (1998)
Vfp	<b>Analysts-based intrinsic value-to-market</b> , Frankel and Lee (1998)
Ebp	Enterprise book-to-price, Penman, Richardson, and Tuna (2007)
Ebp <sup>q1</sup> , Ebp <sup>q6</sup> , Ebp <sup>q12</sup>	Enterprise book-to-price (1-, 6-, 12-month)
Ndp	Net debt-to-price, Penman, Richardson, and Tuna (2007)
Ndp <sup>q1</sup> , Ndp <sup>q6</sup> , Ndp <sup>q12</sup>	Net debt-to-price (1-, 6-, 12-month)
Dur	<b>Equity duration</b> , Dechow, Sloan, and Soliman (2004)
Ltg1, Ltg6, Ltg12	Long-term analysts' growth forecasts, La Porta (1996)

## Panel C: Investment (38)

Aci	Abnormal corporate investment, Titman, Wei, and Xie (2004)
I/A	Investment-to-assets, Cooper, Gulen, and Schill (2008)
Ia <sup>q1</sup> , Ia <sup>q6</sup> , Ia <sup>q12</sup>	Investment-to-assets (1-, 6-, 12-month)
dPia	Changes in PPE and inventory/assets, Lyandres, Sun, and Zhang (2008)
Noa	Net operating assets, Hirshleifer, Hou, Teoh, and Zhang (2004)
dNoa	Changes in net operating assets, Hou, Xue, and Zhang (2015)
dLno	Change in long-term net operating assets, Fairfield, Whisenant, and Yohn (2003)
Ig	Investment growth, Xing (2008)
2Ig	Two-year investment growth, Anderson and Garcia-Feijoo (2006)
3Ig	Three-year investment growth, Anderson and Garcia-Feijoo (2006)
Nsi	Net stock issues, Pontiff and Woodgate (2008)
dli	% change in investment – % change in industry investment, Abarbanell and Bushee (1998)
Cei	Composite equity issuance, Daniel and Titman (2006)
Cdi	Composite debt issuance, Lyandres, Sun, and Zhang (2008)
Ivg	Inventory growth, Belo and Lin (2011)

Ivc	Inventory changes, Thomas and Zhang (2002)
Oa	Operating accruals, Sloan (1996)
Ta	Total accruals, Richardson, Sloan, Soliman, and Tuna (RSST, 2005)
dWc	Change in net non-cash working capital, RSST (2005)
dCoa	Change in current operating assets, RSST (2005)
dCol	Change in current operating liabilities, RSST (2005)
dNco	Change in net non-current operating assets, RSST (2005)
dNca	Change in non-current operating assets, RSST (2005)
dNcl	Change in non-current operating liabilities, RSST (2005)
dFin	Change in net financial assets, RSST (2005)
dSti	Change in short-term investments, RSST (2005)
dLti	Change in long-term investments, RSST (2005)
dFnL	Change in financial liabilities, RSST (2005)
dBe	Change in common equity, RSST (2005)
Dac	Discretionary accruals, Xie (2001)
Poa, Pta, Pda	Percent operating, total, discretionary accruals, Hafzalla, Lundholm, and Van Winkle (2011)
Nxf, Nef, Ndf	Net external, equity, debt financing, Bradshaw, Richardson, and Sloan (2006)



## Panel D: Profitability (78)

Roe1, Roe6, Roe12	Return on equity (1-, 6-, 12-month), Hou, Xue, and Zhang (2015)
dRoe1, dRoe6, dRoe12	4-quarter Change in Roe (1-, 6-, 12-month)
Roal, Roa6, Roa12	Return on assets (1-, 6-, 12-month), Balakrishnan, Bartov, and Faurel (2010)
dRoa1, dRoa6, dRoa12	4-quarter Change in Roa (1-, 6-, 12-month)
Rna	Return on net operating assets, Soliman (2008)
Pm	Profit margin, Soliman (2008)
Ato	Asset turnover, Soliman (2008)
Cto	Capital turnover, Haugen and Baker (1996)
Rna <sup>q</sup> 1, Rna <sup>q</sup> 6, Rna <sup>q</sup> 12	Return on net operating assets (1-, 6-, 12-month)
Pm <sup>q</sup> 1, Pm <sup>q</sup> 6, Pm <sup>q</sup> 12	Profit margin (1-, 6-, 12-month)
Ato <sup>q</sup> 1, Ato <sup>q</sup> 6, Ato <sup>q</sup> 12	Asset turnover (1-, 6-, 12-month)
Cto <sup>q</sup> 1, Cto <sup>q</sup> 6, Cto <sup>q</sup> 12	Capital turnover (1-, 6-, 12-month)
Gpa	Gross profits-to-assets, Novy-Marx (2013)
Gla	Gross profits-to-lagged assets

Gla <sup>q</sup> 1, Gla <sup>q</sup> 6, Gla <sup>q</sup> 12	Gross profits-to-lagged assets (1-, 6-, 12-month)
Ope	<b>Operating profits-to-equity</b> , Fama and French (2015)
Ole	Operating profits-to-lagged equity
Ole <sup>q</sup> 1, Ole <sup>q</sup> 6, Ole <sup>q</sup> 12	Operating profits-to-lagged equity (1-, 6-, 12-month)
Opa	<b>Operating profits-to-assets</b> , Ball, Gerakos, Linnainmaa, and Nikolaev (2015)
Ola	Operating profits-to-lagged assets
Ola <sup>q</sup> 1, Ola <sup>q</sup> 6, Ola <sup>q</sup> 12	Operating profits-to-lagged assets (1-, 6-, 12-month)
Cop	<b>Cash-based operating profitability</b> , Ball, Gerakos, Linnainmaa, and Nikolaev (2015b)
Cl	Cash-based operating profits-to-lagged assets
Cl <sup>q</sup> 1, Cl <sup>q</sup> 6, Cl <sup>q</sup> 12	Cash-based operating profits-to-lagged assets (1-, 6-, 12-month)
F	<b>Fundamental (F) score</b> , Piotroski (2000)
F <sup>q</sup> 1, F <sup>q</sup> 6, F <sup>q</sup> 12	Quarterly F-score (1-, 6-, 12-month)
Fp1, Fp6, Fp12	<b>Failure probability</b> (1-, 6-, 12-month), Campbell, Hilscher, and Szilagyi (2008)
O	<b>O-score</b> , Dichev (1998)
O <sup>q</sup> 1, O <sup>q</sup> 6, O <sup>q</sup> 12	Quarterly O-score (1-, 6-, 12-month)

Z	Z-score, Dichev (1998)
Z <sup>q</sup> 1, Z <sup>q</sup> 6, Z <sup>q</sup> 12	Quarterly Z-score (1-, 6-, 12-month)
G	Growth score, Mohanram (2005)
Cr1, Cr6, Cr12	Credit ratings (1-, 6-, 12-month), Avramov, Chordia, Jostova, and Philipov (2009)
Tbi	Taxable income-to-book income, Green, Hand, and Zhang (2013)
Tbi <sup>q</sup> 1, Tbi <sup>q</sup> 6, Tbi <sup>q</sup> 12	Quarterly taxable income-to-book income (1-, 6-, 12-month)
Bl	Book leverage, Fama and French (1992)
Bl <sup>q</sup> 1, Bl <sup>q</sup> 6, Bl <sup>q</sup> 12	Quarterly book leverage (1-, 6-, 12-month)
Sg <sup>q</sup> 1, Sg <sup>q</sup> 6, Sg <sup>q</sup> 12	Quarterly sales growth (1-, 6-, 12-month)

## Panel E: Intangibles (103)

---

Oca	Organizational capital-to-assets, Eisfeldt and Papanikolaou (2013)
loca	Industry-adjusted organizational capital-to-assets, Eisfeldt and Papanikolaou (2013)
Adm	Advertising expense-to-market, Chan, Lakonishok, and Sougiannis (2001)
gAd	Growth in advertising expense, Lou (2014)
Rdm	R&D-to-market, Chan, Lakonishok, and Sougiannis (2001)
Rdm <sup>q1</sup> , Rdm <sup>q6</sup> , Rdm <sup>q12</sup>	Quarterly R&D-to-market (1-, 6-, 12-month)
Rds	R&D-to-sales, Chan, Lakonishok, and Sougiannis (2001)
Rds <sup>q1</sup> , Rds <sup>q6</sup> , Rds <sup>q12</sup>	Quarterly R&D-to-sales (1-, 6-, 12-month)
Ol	Operating leverage, Novy-Marx (2011)
Ol <sup>q1</sup> , Ol <sup>q6</sup> , Ol <sup>q12</sup>	Quarterly operating leverage (1-, 6-, 12-month)
Hn	Hiring rate, Belo, Lin, and Bazdresch (2014)
Rca	R&D capital-to-assets, Li (2011)
Bca	Brand capital-to-assets, Belo, Lin, and Vitorino (2014)
Aop	Analysts optimism, Frankel and Lee (1998)

# 447 Anomalies

## Six categories of anomalies

Pafe	Predicted analysts forecast error, Frankel and Lee (1998)
Parc	Patent-to-R&D capital, Hirshleifer, Hsu, and Li (2013)
Crđ	Citations-to-R&D expense, Hirshleifer, Hsu, and Li (2013)
Hs	Industry concentration (sales), Hou and Robinson (2006)
Ha	Industry concentration (total assets), Hou and Robinson (2006)
He	Industry concentration (book equity), Hou and Robinson (2006)
Age1, Age6, Age12	Firm age (1-, 6-, 12-month), Jiang, Lee, and Zhang (2005)
D1	Price delay based on $R^2$ , Hou and Moskowitz (2005)
D2	Price delay based on slopes, Hou and Moskowitz (2005)
D3	Price delay based on slopes adjusted for standard errors, Hou and Moskowitz (2005)
dSi	% change in sales – % change in inventory, Abarbanell and Bushee (1998)
dSa	% change in sales – % change in accounts receivable, Abarbanell and Bushee (1998)
dGs	% change in gross margin – % change in sales, Abarbanell and Bushee (1998)

# 447 Anomalies

## Six categories of anomalies

dSs	% change in sales – % change in SG&A, Abarbanell and Bushee (1998)
Etr	<b>Effective tax rate</b> , Abarbanell and Bushee (1998)
Lfe	Labor force efficiency, Abarbanell and Bushee (1998)
Ana1, Ana6, Ana12	<b>Analysts coverage</b> (1-, 6-, 12-month), Elgers, Lo, and Pfeiffer (2001)
Tan	Tangibility of assets, Hahn and Lee (2009)
Tan <sup>q</sup> 1, Tan <sup>q</sup> 6, Tan <sup>q</sup> 12	Quarterly tangibility (1-, 6-, 12-month)
Rer	Real estate ratio, Tuzel (2010)
Kz	<b>The Kaplan-Zingales index</b> , Lamont, Polk, and Saa-Requejo (2001)
Kz <sup>q</sup> 1, Kz <sup>q</sup> 6, Kz <sup>q</sup> 12	Quarterly Kaplan-Zingales index (1-, 6-, 12-month)
Ww	<b>The Whited-Wu (2006) index</b>
Ww <sup>q</sup> 1, Ww <sup>q</sup> 6, Ww <sup>q</sup> 12	Quarterly Whited-Wu index (1-, 6-, 12-month)
Sdd	Secured debt-to-total debt, Valta (2016)
Cdd	Convertible debt-to-total debt, Valta (2016)
Vcf1, Vcf6, Vcf12	Cash flow volatility (1-, 6-, 12-month), Huang (2009)
Cta1, Cta6, Cta12	Cash-to-assets (1-, 6-, 12-month), Palazzo (2012)

# 447 Anomalies

## Six categories of anomalies

Gind	Corporate governance, Gompers, Ishii, and Metrick (2003)
Acq, Acq <sup>q</sup> 1, Acq <sup>q</sup> 6, Acq <sup>q</sup> 12	Accrual quality (1-, 6-, 12-month) Francis, Lafond, Olsson, and Schipper (2005)
Eper	Earnings persistence, Francis, Lafond, Olsson, and Schipper (2004)
Eprd	Earnings predictability, Francis, Lafond, Olsson, and Schipper (2004)
Esm	Earnings smoothness, Francis, Lafond, Olsson, and Schipper (2004)
Evr	Value relevance of earnings, Francis, Lafond, Olsson, and Schipper (2004)
Etl	Earnings timeliness, Francis, Lafond, Olsson, and Schipper (2004)
Ecs	Earnings conservatism, Francis, Lafond, Olsson, and Schipper (2004)
Frm	Pension funding rate (scaled by market equity), Franzoni and Martin (2006)
Fra	Pension funding rate (scaled by assets), Franzoni and Martin (2006)

Ala	Asset liquidity (scaled by book assets), Ortiz-Molina and Phillips (2014)
Alm	Asset liquidity (scaled by market assets), Ortiz-Molina and Phillips (2014)
Ala <sup>q</sup> 1, Ala <sup>q</sup> 6, Ala <sup>q</sup> 12	Asset liquidity (book assets) (1-, 6-, 12-month)
Alm <sup>q</sup> 1, Alm <sup>q</sup> 6, Alm <sup>q</sup> 12	Asset liquidity (market assets) (1-, 6-, 12-month)
Dis1, Dis6, Dis12	<b>Dispersion of analysts' earnings forecasts</b> (1-, 6-, 12-month) Diether, Malloy, and Scherbina (2002)
Dlg1, Dlg6, Dlg12	Dispersion in analyst long-term growth forecasts (1-, 6-, 12-month) Anderson, Ghysels, and Juergens (2005)
Dls1, Dls6, Dls12	Disparity between long- and short-term earnings growth forecasts (1-, 6-, 12-month), Da and Warachka (2011)
Ob	Order backlog, Rajgopal, Shevlin, and Venkatachalam (2003)



$R_a^1$	12-month-lagged return, Heston and Sadka (2008)
$R_n^1$	Year 1-lagged return, nonannual, Heston and Sadka (2008)
$R_a^{[2,5]}$	Years 2–5 lagged returns, annual, Heston and Sadka (2008)
$R_n^{[2,5]}$	Years 2–5 lagged returns, nonannual, Heston and Sadka (2008)
$R_a^{[6,10]}$	Years 6–10 lagged returns, annual, Heston and Sadka (2008)
$R_n^{[6,10]}$	Years 6–10 lagged returns, nonannual, Heston and Sadka (2008)
$R_a^{[11,15]}$	Years 11–15 lagged returns, annual, Heston and Sadka (2008)
$R_n^{[11,15]}$	Years 11–15 lagged returns, nonannual, Heston and Sadka (2008)
$R_a^{[16,20]}$	Years 16–20 lagged returns, annual, Heston and Sadka (2008)
$R_n^{[16,20]}$	Years 16–20 lagged returns, nonannual, Heston and Sadka (2008)

## Panel F: Trading frictions (102)

Me	Market equity, Banz (1981)
lv	Idiosyncratic volatility, Ali, Hwang, and Trombley (2003)
lvff1, lvff6, lvff12	<b>Idiosyncratic volatility per the 3-factor model</b> (1-, 6-, 12-month), Ang, Hodrick, Xing, and Zhang (2006)
lvc1, lvc6, lvc12	Idiosyncratic volatility per the CAPM (1-, 6-, 12-month)
lvq1, lvq6, lvq12	Idiosyncratic volatility per the $q$ -factor model (1-, 6-, 12-month)
Tv1, Tv6, Tv12	<b>Total volatility</b> (1-, 6-, 12-month), Ang, Hodrick, Xing, and Zhang (2006)
Sv1, Sv6, Sv12	<b>Systematic volatility</b> (1-, 6-, 12-month), Ang, Hodrick, Xing, and Zhang (2006)
$\beta_1, \beta_6, \beta_{12}$	Market beta (1-, 6-, 12-month), Fama and MacBeth (1973)
$\beta^{FP}1, \beta^{FP}6, \beta^{FP}12$	<b>The Frazzini-Pedersen (2014) beta</b> (1-, 6-, 12-month)
$\beta^D1, \beta^D6, \beta^D12$	The Dimson (1979) beta (1-, 6-, 12-month)
Srev	<b>Short-term reversal</b> , Jegadeesh (1990)
Tur1, Tur6, Tur12	<b>Share turnover</b> (1-, 6-, 12-month), Datar, Naik, and Radcliffe (1998)

# 447 Anomalies

## Six categories of anomalies

Cvt1, Cvt6, Cvt12	Coefficient of variation for share turnover (1-, 6-, 12-month), Chordia, Subrahmanyam, and Anshuman (2001)
Dtv1, Dtv6, Dtv12	<b>Dollar trading volume</b> (1-, 6-, 12-month), Brennan, Chordia, and Subrahmanyam (1998)
Cvd1, Cvd6, Cvd12	Coefficient of variation for dollar trading volume (1-, 6-, 12-month), Chordia, Subrahmanyam, and Anshuman (2001)
Pps1, Pps6, Pps12	<b>Share price</b> (1-, 6-, 12-month), Miller and Scholes (1982)
Ami1, Ami6, Ami12	Absolute return-to-volume (1-, 6-, 12-month), Amihud (2002)
Lm <sup>1</sup> 1, Lm <sup>1</sup> 6, Lm <sup>1</sup> 12	<b>Prior 1-month turnover-adjusted number of zero daily trading volume</b> (1-, 6-, 12-month), Liu (2006)
Lm <sup>6</sup> 1, Lm <sup>6</sup> 6, Lm <sup>6</sup> 12	Prior 6-month turnover-adjusted number of zero daily trading volume (1-, 6-, 12-month), Liu (2006)
Lm <sup>12</sup> 1, Lm <sup>12</sup> 6, Lm <sup>12</sup> 12	Prior 12-month turnover-adjusted number of zero daily trading volume (1-, 6-, 12-month), Liu (2006)
Mdr1, Mdr6, Mdr12	<b>Maximum daily return</b> (1-, 6-, 12-month), Bali, Cakici, and Whitelaw (2011)
Ts1, Ts6, Ts12	<b>Total skewness</b> (1-, 6-, 12-month), Bali, Engle, and Murray (2015)
Isc1, Isc6, Isc12	Idiosyncratic skewness per the CAPM (1-, 6-, 12-month)

Isff1, Isff6, Isff12	Idiosyncratic skewness per the 3-factor model (1-, 6-, 12-month)
Isq1, Isq6, Isq12	Idiosyncratic skewness per the $q$ -factor model (1-, 6-, 12-month)
Cs1, Cs6, Cs12	Coskewness (1-, 6-, 12-month), Harvey and Siddique (2000)
$\beta^{-1}$ , $\beta^{-6}$ , $\beta^{-12}$	Downside beta (1-, 6-, 12-month), Ang, Chen, and Xing (2006)
Tail1, Tail6, Tail12	<b>Tail risk</b> (1-, 6-, 12-month), Kelly and Jiang (2014)
$\beta^{\text{ret}1}$ , $\beta^{\text{ret}6}$ , $\beta^{\text{ret}12}$	Liquidity beta (return-return) (1-, 6-, 12-month), Acharya and Pedersen (2005)
$\beta^{\text{lcc}1}$ , $\beta^{\text{lcc}6}$ , $\beta^{\text{lcc}12}$	<b>Liquidity beta (illiquidity-illiquidity)</b> (1-, 6-, 12-month), Acharya and Pedersen (2005)
$\beta^{\text{lrc}1}$ , $\beta^{\text{lrc}6}$ , $\beta^{\text{lrc}12}$	Liquidity beta (return-illiquidity) (1-, 6-, 12-month), Acharya and Pedersen (2005)
$\beta^{\text{lcr}1}$ , $\beta^{\text{lcr}6}$ , $\beta^{\text{lcr}12}$	Liquidity beta (illiquidity-return) (1-, 6-, 12-month), Acharya and Pedersen (2005)
$\beta^{\text{net}1}$ , $\beta^{\text{net}6}$ , $\beta^{\text{net}12}$	<b>Net liquidity beta</b> (1-, 6-, 12-month), Acharya and Pedersen (2005)
Shl1, Shl6, Shl12	<b>The high-low bid-ask spread estimator</b> (1-, 6-, 12-month), Corwin and Schultz (2012)
Sba1, Sba6, Sba12	Bid-ask spread (1-, 6-, 12-month), Hou and Loh (2015)
$\beta^{\text{Lev}1}$ , $\beta^{\text{Lev}6}$ , $\beta^{\text{Lev}12}$	<b>Leverage beta</b> (1-, 6-, 12-month), Adrian, Etula, and Muir (2014)

1 Replication Procedures

2 447 Anomalies

3 Replication Results

Despite our low  $t$ -cutoff of 1.96, 286 anomalies (64%) cannot be replicated, 380 (85%) with  $t < 3$

Anomalies that cannot be replicated across categories:

	Number	%
Momentum	20	35%
Value-versus-growth	37	54%
Investment	11	29%
Profitability	46	58%
Intangibles	77	75%
Trading frictions	95	93%

Anomalies existed, but traded away once publicized?

In the original samples, 293 anomalies (66%) cannot be replicated ( $t < 1.96$ ), 387 (86.6%) with  $t < 3$

	Number	%
Momentum	24	42%
Value-versus-growth	44	65%
Investment	13	34%
Profitability	38	48%
Intangibles	81	79%
Trading frictions	93	91%

NYSE-Amex-NASDAQ breakpoints and equal-weights:  
How equal-weighting “inflates” anomalies?

181 (40%) not replicated ( $t < 1.96$ ), 241 (54%) with  $t < 3$

	Number	%
Momentum	9	16%
Value-versus-growth	14	21%
Investment	1	3%
Profitability	36	46%
Intangibles	59	57%
Trading frictions	62	61%

The inflation rate on the average absolute return spread is 42%, ranging from 27% for momentum and 56% for trading frictions



	Sue6	Sue12	Re12	$R^{11}12$	Rs6	Rs12	Tes1	Tes6	Tes12	Nei12
$m$	0.19	0.11	0.28	0.43	0.14	0.06	0.26	0.28	0.18	0.14
$t_m$	1.65	1.00	1.47	1.92	1.01	0.44	1.56	1.90	1.34	1.36
	52w1	52w12	$\epsilon^61$	Sm6	Sm12	lle6	lle12	Cm6	Sim6	Sim12
$m$	0.14	0.45	0.20	0.09	0.14	0.27	0.11	0.18	0.12	0.15
$t_m$	0.43	1.88	1.20	0.88	1.87	1.79	0.84	1.83	1.11	1.80

Chan, Jegadeesh, and Lakonishok (1996): Buy-and-hold Sue return of 1.13% with equal-weights

Thomas and Zhang (2011): Buy-and-hold Tes return of 1.3% with NYSE-Amex-NASDAQ breakpoints and equal-weights

	Dp <sup>q1</sup>	Dp <sup>q6</sup>	Dp <sup>q12</sup>	Op	Op <sup>q1</sup>	Op <sup>q6</sup>	Op <sup>q12</sup>	Nop <sup>q1</sup>	Nop <sup>q6</sup>	Nop <sup>q12</sup>	Sr	Sg
<i>m</i>	0.26	0.19	0.20	0.37	0.10	0.10	0.17	0.22	0.25	0.31	-0.20	-0.01
<i>t<sub>m</sub></i>	1.02	0.76	0.85	1.70	0.42	0.52	0.87	0.91	1.14	1.48	-1.08	-0.08
	Ocp <sup>q12</sup>	Ebp <sup>q1</sup>	Ebp <sup>q6</sup>	Ebp <sup>q12</sup>	Ndp	Ndp <sup>q1</sup>	Ndp <sup>q6</sup>	Ndp <sup>q12</sup>	Ltg1	Ltg6	Ltg12	Ocp <sup>q6</sup>
<i>m</i>	0.41	0.27	0.26	0.35	0.31	0.17	0.18	0.27	-0.03	-0.04	-0.01	0.51
<i>t<sub>m</sub></i>	1.71	1.00	1.01	1.44	1.62	0.71	0.77	1.22	-0.09	-0.10	-0.02	1.89

Lakonishok, Shleifer, and Vishny (1994): -0.61% for Sr with NYSE-Amex breakpoints and equal-weights (no NASDAQ)

Penman, Richardson, and Tuna (2007): 0.73% for Ndp with NYSE-Amex-NASDAQ breakpoints and equal-weights

	la <sup>q1</sup>	3lg	Cdi	Ta	dCol	dNcl	dSti	dLti	dBe	Nxf	Nef
<i>m</i>	-0.32	-0.21	-0.00	-0.23	-0.11	-0.11	0.15	-0.22	-0.31	-0.27	-0.17
<i>t<sub>m</sub></i>	-1.72	-1.46	-0.01	-1.63	-0.76	-0.95	0.98	-1.44	-1.89	-1.44	-0.86

Richardson, Sloan, Soliman, and Tuna (2005): -1.11%  
(size-adjusted) for Ta with NYSE-Amex-NASDAQ breakpoints and equal-weights

Bradshaw, Richardson, and Sloan (2006): -1.29% (size-adjusted)  
for Nxf and -0.93% for Nef with NYSE-Amex-NASDAQ  
breakpoints and equal-weights

	Pm <sup>q6</sup>	Pm <sup>q12</sup>	Gla	Ope	Ole	Ole <sup>q12</sup>	Opa	Ola	F	Fp	Fp <sup>q1</sup>	Fp <sup>q12</sup>
<i>m</i>	0.17	0.18	0.16	0.25	0.07	0.35	0.37	0.20	0.29	-0.38	-0.48	-0.36
<i>t<sub>m</sub></i>	0.82	0.89	1.04	1.20	0.37	1.78	1.87	1.07	1.06	-1.28	-1.43	-1.25
	O	O <sup>q1</sup>	O <sup>q6</sup>	O <sup>q12</sup>	Z	Z <sup>q1</sup>	Z <sup>q6</sup>	Z <sup>q12</sup>	G	Cr1	Cr6	Cr12
<i>m</i>	-0.06	-0.36	-0.21	-0.14	-0.00	0.01	-0.03	-0.09	0.27	0.04	0.01	0.01
<i>t<sub>m</sub></i>	-0.30	-1.57	-0.96	-0.64	-0.02	0.06	-0.15	-0.46	1.35	0.12	0.02	0.03

Campbell, Hilscher, and Szilagyi (2008): Fp -0.81% in the 1981–2003 sample with NYSE-Amex-NASDAQ breakpoints

Dichev (1998): -1.17% for the highest-10%-minus-lowest-70% O portfolio with NYSE-Amex-NASDAQ breakpoints and equal-weights

# Results

Intangibles, 77 out of 103 (75%) not replicated

	Variable	Authors	Original estimates	Our estimates	Original methods
Dis	Dispersion of analysts forecasts	Diether, Malloy, Scherbina (2002)	-0.79% (-2.88)	-0.24% (-0.89)	All breakpoints, equal-weights, \$5 price screen
Gind	Corporate governance	Gompers, Ishii, Metrick (2003)	-0.71% (-2.73)	0.02% (0.06)	Carhart alpha
Acq	Accruals quality	Francis, LaFond, Olsson, Schipper (2005)		-0.07% (-0.36)	E/P as cost of equity

Trading frictions, 95 out of 102 (93%) not replicated, the low volatility anomaly

	lv	lvff1	lvff6	lvff12	lvc1	lvc6	lvc12	lvq1
$m$	-0.22	-0.51	-0.33	-0.18	-0.48	-0.32	-0.20	-0.48
$t_m$	-0.66	-1.62	-1.11	-0.62	-1.48	-1.07	-0.69	-1.53
	lvq6	lvq12	Tv1	Tv6	Tv12	Sv1	Sv6	Sv12
$m$	-0.30	-0.19	-0.40	-0.25	-0.20	-0.53	-0.19	-0.16
$t_m$	-1.05	-0.68	-1.16	-0.77	-0.62	-2.47	-1.36	-1.43

15 out of 16 idiosyncratic, total, and systematic volatility measures are insignificant with NYSE breakpoints, similar with equal-weights

Ang, Hodrick, Xing, and Zhang (2006):  $-1.06\%$ ,  $-0.97\%$ ,  $-1.04\%$  ( $t = -3.1, -2.86, -3.9$ ) for lvff1, Tv1, and Sv1, respectively, with NYSE-Amex-NASDAQ breakpoints

# Results

Traditional liquidity measures decimated:  
43 out of 46 (93%) not replicated, 100% with  $t$ -cutoff = 3

	Tur1	Tur6	Tur12	Cvt1	Cvt6	Cvt12	Dtv1	Dtv6	Dtv12	Cvd1	Cvd6	Cvd12
$m$	-0.15	-0.14	-0.10	0.13	0.11	0.17	-0.27	-0.37	-0.42	0.10	0.12	0.18
$t_m$	-0.57	-0.53	-0.38	0.87	0.73	1.26	-1.45	-1.99	-2.28	0.65	0.85	1.25
	Pps1	Pps6	Pps12	Ami1	Ami6	Ami12	Lm <sup>1</sup> 1	Lm <sup>1</sup> 6	Lm <sup>1</sup> 12	Lm <sup>6</sup> 1	Lm <sup>6</sup> 6	Lm <sup>6</sup> 12
$m$	-0.02	0.04	-0.04	0.28	0.37	0.42	-0.07	0.21	0.20	0.38	0.35	0.30
$t_m$	-0.06	0.15	-0.14	1.31	1.73	1.99	-0.33	0.95	0.93	1.82	1.67	1.40
	Lm <sup>12</sup> 1	Lm <sup>12</sup> 6	Lm <sup>12</sup> 12	$\beta^{\text{ret}}1$	$\beta^{\text{ret}}6$	$\beta^{\text{ret}}12$	$\beta^{\text{lcc}}1$	$\beta^{\text{lcc}}6$	$\beta^{\text{lcc}}12$	$\beta^{\text{lrc}}1$	$\beta^{\text{lrc}}6$	$\beta^{\text{lrc}}12$
$m$	0.38	0.33	0.24	0.04	0.01	0.19	0.34	0.31	0.31	0.05	0.02	0.05
$t_m$	1.78	1.57	1.13	0.12	0.03	1.13	1.54	1.45	1.49	0.17	0.07	0.17
	$\beta^{\text{lcr}}1$	$\beta^{\text{lcr}}6$	$\beta^{\text{lcr}}12$	$\beta^{\text{net}}1$	$\beta^{\text{net}}6$	$\beta^{\text{net}}12$	Srev	$\beta^{\text{lev}}1$	$\beta^{\text{lev}}6$	$\beta^{\text{lev}}12$		
$m$	0.06	-0.02	-0.05	0.14	0.15	0.10	-0.26	0.43	0.30	0.25		
$t_m$	0.46	-0.17	-0.49	0.41	0.47	0.32	-1.31	1.78	1.31	1.15		

## Why does the existing frictions literature report different results?

Cross-sectional regressions:

- Datar, Naik, and Radcliffe (1998, share turnover)
- Chordia, Subrahmanyam, and Anshuman (2001, dollar trading volume and its coefficient of variation)
- Amihud (2002, absolute return-to-volume)
- Acharya and Pedersen (2005, liquidity betas)

Jegadeesh (1990): NYSE-Amex-NASDAQ breakpoints and equal-weights,  $-1.99\%$  ( $t = -12.55$ )

Liu (2006): NYSE breakpoints and equal-weights, from  $0.18\%$  ( $t = 0.93$ ) to  $0.85\%$  ( $t = 4.4$ ), 8 out of 9 measures significant



# Results

Replicated anomalies: Magnitudes much lower than originally reported

	Anomaly	Original authors	Original estimates	Our estimates	Original methods
Abr6	Abnormal returns around earnings announcements	Chan, Jegadeesh, Lakonishok (1996)	0.98%	0.30% (3.24)	Buy-and-hold, equal-weights
R <sup>6</sup> 6	Prior 6-month returns, 6-month holding period	Jegadeesh, Titman (1993)	1.10% (3.61)	0.82% (3.49)	NYSE-Amex breakpoints, equal-weights
Cm1	Customer momentum, 1-month holding period	Cohen, Frazzini (2008)	1.58% (3.79)	0.79% (3.74)	All breakpoints, value-weights, \$5 price screen

Replicated anomalies: Magnitudes much lower than originally reported

	Anomaly	Original authors	Original estimates	Our estimates	Original methods
Cp	Cash flow-to-price	Lakonishok, Shleifer, Vishny (1994)	0.83%	0.49% (2.47)	NYSE-Amex breakpoints, equal-weights
I/A	Investment-to-assets	Cooper, Gulen, Schill (2008)	-1.05% (-5.04)	-0.46% (-2.92)	All breakpoints, value-weights
			-1.73% (-8.45)		All breakpoints, equal-weights
Oa	Operating accruals	Sloan (1996)	-0.87% (-4.71)	-0.27% (-2.13)	NYSE-Amex breakpoints, equal-weights, size-adjusted

Replicate the published anomalies literature with 447 variables, controlling for microcaps via NYSE breakpoints and value-weights

- 286 (64%) with  $t < 1.96$ , 380 (85%) with  $t < 3$
- Replicated anomalies much weaker than originally reported
- Similar replication results in the original samples: 293 (66%) with  $t < 1.96$ , 387 (86.6%) with  $t < 3$

Capital markets are more efficient than previously recognized