Misvaluing Innovation

Cohen. L., Diether. K., Malloy. C.

The Review of Financial Studies, 2013.

Background

- The research and development (R&D), while crucially important for the firm value, are uncertain and difficult to decipher how they will ultimately impact firm value.
- Since the late 1980s, virtually all of the increases in total R&D spending have come from the private sector. R&D investment has increasingly become a market-driven activity.

Existing Literatures

- Firms with high ratios of R&D relative to market equity earn high subsequent return (Chan et al., 2001; Lev and Sougiannis, 1996). And large increases in R&D expenditures predict positive future abnormal returns (Eberhart et al., 2004)
- Some researchers argue that investors may overestimate the benefits from R&D or simply ignore the fact that many R&D investments are not profitable (Jensen (1993)).
- Growth stock underperformance is concentrated in stocks with significant “intangible” information, while market overreaction to intangible information that fails to interpret (Daniel and Titman 2006)

R&D Abilities

- The notion of “Ability” is meant to capture simply how good a firm is at turning R&D expenditures into something the firm values.
- Ability is computed for each firm every year using five (j=1...5) time-series regressions of sales growth on past R&D. Ability is computed as the average of the five slope coefficients:

$$log\left(\frac{Sales_{it}}{Sales_{it-1}}\right) = \gamma_0 + \gamma_j \log\left(1 + R\&D_{it-j}\right) + \epsilon_{it}$$

- In estimating a firm's ability, for every firm in each year we use eight years of past data for each firm-level regression, we require a minimum of six (75%) nonmissing R&D observations and that over half the R&D observations are positive

Data

- We draw monthly stock returns, shares outstanding, and volume capitalization from CRSP and accounting variables from Compustat.
- We combine these items with firm-level patent data drawn from the NBER's U.S. Patent Citations Data File, segment-level product data from the Compustat, Segment Data File, earnings' guidance data from First Call and CEO founder data from Fahlenbrach's (2009) hand-collected data and the Corporate Data Library
- We draw international stock return data from Datastream and accounting data from Worldscope

Data

- We include all NYSE, AMEX, and NASDAQ stocks (with CRSP shares codes 10 to 12 and a non-missing R&D estimate in a given year) from July 1978 to December 2009 with lagged share prices above five dollars into these portfolios and rebalance the portfolios yearly.
- All the breakpoints of these portfolios are computed before applying the lagged price filter.

Diagnostics of R&D Abilities

- If we are truly capturing a meaningful measure of a firm's ability at research and development, we might expect to see some level of persistence in this measure.

Panel A: Ability Summary Statistics

	Mean	Median	St. Dev
Ability	3.26	3.29	11.11
$log(1 + R\&D)$	0.18	0.17	0.07
$log(sales_t/sales_{t-1})$	0.07	0.07	0.28

Panel B: Mean Annual Persistence in Ability

$Prob(Quintile = i)$, $year = t$ if $Quintile = i$, $year = t - lag$

	Ability Quintiles				
Lag	Low	2	3	4	High
1	0.66	0.50	0.51	0.49	0.70
2	0.48	0.37	0.40	0.36	0.55
3	0.38	0.32	0.35	0.29	0.46
4	0.30	0.30	0.32	0.26	0.39
5	0.26	0.28	0.30	0.24	0.36

Portfolio returns

- In this section we examine average returns on portfolios formed using information about both a firm's ability and its level of R&D.

	Low Ability			High Ability			
	$R\&D_{low}$	$R\&D_{mid}$	$R\&D_{high}$	$R\&D_{low}$	$R\&D_{mid}$	$R\&D_{high}$	Spread
Panel A: Equal-Weight Portfolios							
Excess Returns							
Mean	0.81	0.75	0.62	0.80	0.83	1.35	0.73
T-stat	3.04	2.61	1.48	3.00	2.81	2.76	2.61
Size-B/M-Mom Adjusted Returns							
Mean	-0.07	-0.04	-0.10	-0.03	0.08	0.79	0.89
T-stat	-0.86	-0.43	-0.50	-0.42	0.90	2.84	3.32
Size-B/M Adjusted Returns							
Mean	0.02	0.08	-0.04	0.04	0.15	0.88	0.92
T-stat	0.27	0.94	-0.18	0.57	1.79	2.84	3.33
Industry Adjusted Returns							
Mean	0.15	0.12	-0.03	0.18	0.22	0.81	0.84
T-stat	1.35	1.05	-0.16	1.58	2.17	2.97	3.03
Three Factor Model α							
α	0.04	0.02	-0.02	0.02	0.14	0.72	0.74
T-stat	0.38	0.21	-0.09	0.20	1.45	2.52	2.59
Four Factor Model α							
α	0.10	0.10	0.14	0.12	0.25	0.90	0.76
T-stat	0.88	0.90	0.75	1.18	2.51	3.11	2.59

Portfolio returns

- In this section we examine average returns on portfolios formed using information about both a firm's ability and its level of R&D.

	Panel B: Value-Weight Portfolios						
	Low Ability			High Ability			
	$R\&D_{low}$	$R\&D_{mid}$	$R\&D_{high}$	$R\&D_{low}$	$R\&D_{mid}$	$R\&D_{high}$	Spread
	Excess Returns						
Mean	0.73	0.60	0.32	0.56	0.72	1.22	0.90
T-stat	2.79	2.18	0.81	2.18	2.25	2.61	2.30
	Size-B/M-Mom Adjusted Returns						
Mean	0.16	-0.05	-0.20	-0.06	0.21	0.72	0.92
T-stat	1.52	-0.40	-0.91	-0.63	1.67	2.30	2.64
	Size-B/M Adjusted Returns						
Mean	0.11	-0.02	-0.10	0.02	0.16	0.68	0.78
T-stat	0.84	-0.13	-0.41	0.16	1.06	1.99	2.10
	Industry Adjusted Returns						
Mean	0.16	0.01	-0.32	0.04	0.17	0.63	0.95
T-stat	1.43	0.07	-1.48	0.42	1.52	2.02	2.61
	Three Factor Model α						
α	0.19	-0.04	-0.16	-0.01	0.12	0.89	1.05
T-stat	1.36	-0.26	-0.62	-0.04	0.87	2.64	2.64
	Four Factor Model α						
α	0.14	0.06	-0.15	0.01	0.19	0.78	0.93
T-stat	0.95	0.35	-0.56	0.09	1.33	2.27	2.30

Additional characteristics

- The four-factor loadings in Panel C suggest that the GoodR&D portfolio loads negatively on value and momentum and positively on size, meaning that the stocks in this portfolio are typically large growth stocks with poor past returns.

Panel C: Equal Weight Portfolios Four Factor Loadings							
	Low Ability			High Ability			
	$R\&D_{low}$	2	$R\&D_{high}$	$R\&D_{low}$	$R\&D_{mid}$	$R\&D_{high}$	Spread
b	0.99	1.00	1.11	0.99	1.01	1.18	0.06
t(b)	38.52	40.16	24.86	40.82	43.82	17.25	0.93
s	0.42	0.57	0.89	0.40	0.59	0.91	0.01
t(s)	11.95	16.88	14.63	11.92	18.61	9.75	0.15
h	0.43	0.23	-0.37	0.42	0.09	-0.51	-0.13
t(h)	11.30	6.25	-5.58	11.65	2.48	-4.98	-1.30
u	-0.06	-0.08	-0.17	-0.10	-0.11	-0.18	-0.02
t(y)	-2.46	-3.41	-4.18	-4.81	-5.16	-3.03	-0.29
# Stocks	84	69	25	114	60	10	

Additional characteristics

- In addition, the High Ability-High R&D portfolio contains an average of only 10 stocks per month, the percentage of market capitalization (0.71% of the stock market's annual value on average) is larger than that of the "small value" portfolio (0.50% of the stock market's annual value on average) that is featured prominently in the literature.

Panel C: Equal Weight Portfolios Four Factor Loadings							
	Low Ability			High Ability			
	$R\&D_{low}$	2	$R\&D_{high}$	$R\&D_{low}$	$R\&D_{mid}$	$R\&D_{high}$	Spread
b	0.99	1.00	1.11	0.99	1.01	1.18	0.06
t(b)	38.52	40.16	24.86	40.82	43.82	17.25	0.93
s	0.42	0.57	0.89	0.40	0.59	0.91	0.01
t(s)	11.95	16.88	14.63	11.92	18.61	9.75	0.15
h	0.43	0.23	-0.37	0.42	0.09	-0.51	-0.13
t(h)	11.30	6.25	-5.58	11.65	2.48	-4.98	-1.30
u	-0.06	-0.08	-0.17	-0.10	-0.11	-0.18	-0.02
t(y)	-2.46	-3.41	-4.18	-4.81	-5.16	-3.03	-0.29
# Stocks	84	69	25	114	60	10	

Additional characteristics

- In Table IV we demonstrate that simple sorts on R&D or Ability alone yield no pattern in average returns.

	Panel A: *R&D* Portfolios						
	$R\&D_{zero}$	$R\&D_{low}$	2	3	4	$R\&D_{high}$	$High - Zero$
				Equal-Weight: Excess Returns			
Mean	0.63	0.70	0.67	0.83	0.79	0.29	-0.33
T-stat	2.11	2.56	2.36	2.35	1.82	0.58	-0.90
				Equal-Weight: Size-B/M-Mom adjusted returns			
Mean	-0.18	-0.11	-0.07	0.15	0.24	-0.09	0.09
T-stat	-1.63	-1.56	-1.03	1.71	1.66	-0.41	0.31
				Value-Weight: Excess Returns			
Mean	0.72	0.59	0.51	0.61	0.64	0.47	-0.25
T-stat	2.41	2.47	1.92	2.16	1.97	1.01	-0.62
				Value-Weight: Size-B/M-Mom adjusted returns			
Mean	0.13	0.02	-0.04	0.15	0.10	0.15	0.01
T-stat	1.00	0.27	-0.55	2.14	1.04	0.72	0.05
				Number of Stocks			
Mean	278	308	296	278	268	198	

Additional characteristics

- In Table IV we demonstrate that simple sorts on R&D or Ability alone yield no pattern in average returns.

	Panel B: Value-Weight *Ability* Portfolios					
	$Ability_{low}$	2	3	4	$Ability_{high}$	$High - Low$
			Equal-Weight: Excess Returns			
Mean	0.77	0.77	0.81	0.86	0.83	0.07
T-stat	2.77	2.39	2.25	2.76	3.02	1.09
			Equal-Weight: Size-B/M-Mom adjusted returns			
Mean	-0.06	0.09	0.17	0.13	0.03	0.09
T-stat	-0.87	1.03	1.39	1.56	0.60	1.50
			Value-Weight: Excess Returns			
Mean	0.63	0.58	0.62	0.59	0.58	-0.04
T-stat	2.59	2.11	2.13	2.12	2.22	-0.34
			Value-Weight: Size-B/M-Mom adjusted returns			
Mean	0.06	0.06	0.05	0.12	0.04	-0.03
T-stat	0.99	0.70	0.50	1.49	0.52	-0.31
			Number of Stocks			
Mean	188	170	155	174	194	

Cross-sectional regressions

- We employ monthly Fama and Macbeth (1973) regressions to further assess the predictive power of our ability classification.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$R\&D_{high} * ability_{high}$	0.627	0.649	0.758	0.785				
	(2.41)	(2.46)	(2.86)	(3.04)				
$R\&D_{high} * ability_{low}$		-0.140	-0.214	-0.208				
		(-0.77)	(-1.17)	(-1.15)				
$\log(1 + R\&D) * ability_{high}$					5.433	5.786	9.547	
					(2.14)	(2.25)	(3.62)	
$\log(1 + R\&D) * ability_{low}$						0.881	0.809	-0.038
						(0.52)	(0.50)	(-32.00)
$ability_{high}$	-0.048	-0.103	-0.055	-0.016	-0.142	-0.213	-0.267	0.027
	(-0.83)	(-1.44)	(-0.95)	(-0.27)	(-1.48)	(-1.83)	(-2.92)	(51.02)
$ability_{low}$		-0.143	-0.101	-0.070		0.881	0.809	-0.038
		(-1.90)	(-1.62)	(-1.11)		(0.52)	(0.50)	(-32.00)
$R\&D_{high}$	0.109	0.093	0.134	0.094				
	(0.64)	(0.56)	(1.13)	(0.82)				
$R\&D_{low}$			-0.170	-0.176				
			(-2.38)	(-2.50)				
$R\&D_{zero}$			-0.861	-1.040				
			(-2.39)	(-2.85)				
$\log(1 + R\&D)$					0.803	0.479	1.267	0.012
					(0.91)	(0.53)	(1.39)	(11.49)
$\log(ME)$	-0.028	-0.026	-0.041	-0.049	-0.026	-0.025	-0.035	0.000
	(-0.73)	(-0.69)	(-1.19)	(-1.38)	(-0.69)	(-0.66)	(-1.01)	(15.76)
$\log(B/M)$	0.247	0.257	0.220	0.277	0.258	0.263	0.230	-0.001
	(3.55)	(3.75)	(3.58)	(4.85)	(3.62)	(3.83)	(3.74)	(-12.85)
$r_{-12,2}$	0.775	0.766	0.788	0.749	0.811	0.796	0.803	0.000
	(3.59)	(3.57)	(4.02)	(3.93)	(3.63)	(3.62)	(4.06)	(0.64)
r_{-1}			-3.771	-4.046			-3.810	0.000
			(-8.42)	(-9.24)			(-8.40)	(1.47)
$turnover$			-0.308	-0.320			-0.318	0.001
			(-1.71)	(-1.85)			(-1.79)	(12.92)
σ			-0.123	-0.114			-0.111	0.001
			(-1.87)	(-1.79)			(-1.65)	(13.28)
Industry Fixed Effects				Yes				Yes
Number of Months	354	354	354	354	354	354	354	354
Total Observations	290272	290272	283031	283031	290272	290272	283031	283031

Cross-sectional regressions

- Controlling for Other R&D-Related Effects.
  - Large increases in R&D expenditures predict positive future abnormal returns (Eberhart et al., 2004)
    - Large increase: $raw\ \Delta R\&D_t > 5\%, R\&D_t/assets_{t-1} > 5\%, and\ \Delta(R\&D_t/assets_{t-1}) > 5\%$
  - The BM effect is largely driven by overreaction to intangible information (Daniel and Titman, 2005)
    - $bm_t = bm_{t-\tau} + r^B(t-\tau, t) - r(t-\tau, t)$
    - $bm_t \equiv \log\left(\frac{\mathrm{BE}_t}{\mathrm{ME}_t}\right) = \log\left(\frac{B_t}{P_t}\right) = \underbrace{\log\left(\frac{B_{t-\tau}}{P_{t-\tau}}\right)}_{\equiv bm_{t-\tau}} + \log\left(\frac{B_t}{B_{t-\tau}}\right) - \log\left(\frac{P_t}{P_{t-\tau}}\right)$
  - Innovative efficiency is positively related to future returns (Hirshleifer et al., 2010)
    - Patents/R&D is patents to lagged raw R&D

Cross-sectional regressions

- Out of Sample Tests: International Evidence and Pre-1980 U.S.

	ALL: UK, JPN,Ger		UK	JPN	Ger	Early U.S.: 74-80	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$R\&D_{high} * ability_{high}$	0.510	0.501	0.923	0.416	-0.138	0.572	0.661
	(2.32)	(2.24)	(1.37)	(1.69)	(-0.20)	(1.04)	(1.18)
$R\&D_{high} * ability_{low}$		-0.158	-0.139	0.043	-0.477		0.103
		(-0.84)	(-0.25)	(0.19)	(-0.60)		(0.15)
$ability_{high}$	-0.045	-0.064	-0.085	-0.099	0.634	-0.029	-0.077
	(-0.70)	(-0.85)	(-0.47)	(-1.18)	(2.03)	(-0.16)	(-0.37)
$ability_{low}$		-0.099	0.111	-0.187	0.379		-0.100
		(-1.18)	(0.63)	(-1.97)	(1.11)		(-0.50)
$R\&D_{high}$	0.199	0.145	0.339	0.045	0.468	0.073	0.029
	(1.94)	(1.39)	(1.39)	(0.43)	(1.13)	(0.32)	(0.12)
$R\&D_{low}$		-0.156	0.113	-0.247	-0.342		0.192
		(-1.48)	(0.63)	(-2.04)	(-1.14)		(0.87)
$R\&D_{zero}$		-0.230	-0.199	-0.331	-0.686		0.162
		(-0.73)	(-0.52)	(-0.84)	(-0.86)		(0.22)
$\log(ME)$	0.016	0.012	0.004	0.002	-0.086	-0.214	-0.215
	(0.34)	(0.27)	(0.07)	(0.03)	(-1.17)	(-2.13)	(-2.16)
$\log(B/M)$	0.251	0.265	0.203	0.318	0.028	0.535	0.512
	(3.09)	(3.31)	(1.70)	(2.80)	(0.14)	(1.91)	(1.81)
$r_{-12,2}$	0.001	0.001	0.008	-0.007	0.010	0.892	0.895
	(0.30)	(0.24)	(2.07)	(-1.52)	(1.40)	(1.51)	(1.53)
r_{-1}	-0.048	-0.048	-0.026	-0.064	-0.004	-8.207	-8.139
	(-5.77)	(-5.80)	(-2.37)	(-6.41)	(-0.22)	(-5.84)	(-5.94)
Country Fixed Effects	Yes	Yes					
Number of Months	186	186	186	186	126	73	73
Total Observations	185697	185697	33543	132019	17992	23601	23601

Cross-sectional regressions

- Controlling for Other R&D-Related Effects.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$R\&D_{high} * ability_{high}$	0.615	0.721	0.603	0.741	0.676	0.780	0.629	0.747
	(2.31)	(2.71)	(2.30)	(2.80)	(2.49)	(2.87)	(2.38)	(2.81)
$R\&D_{high} * ability_{low}$	-0.147	-0.213	-0.198	-0.231	-0.125	-0.217	-0.152	-0.222
	(-0.81)	(-1.16)	(-1.09)	(-1.26)	(-0.68)	(-1.17)	(-0.84)	(-1.22)
$ability_{high}$	-0.093	-0.053	-0.036	-0.023	-0.111	-0.058	-0.092	-0.054
	(-1.33)	(-0.91)	(-0.55)	(-0.39)	(-1.56)	(-1.00)	(-1.29)	(-0.93)
$ability_{low}$	-0.134	-0.100	-0.083	-0.069	-0.146	-0.098	-0.135	-0.093
	(-1.84)	(-1.60)	(-1.23)	(-1.12)	(-1.95)	(-1.56)	(-1.80)	(-1.49)
$R\&D_{high}$	0.047	0.093	-0.058	-0.005	0.067	0.105	0.089	0.139
	(0.30)	(0.79)	(-0.42)	(-0.04)	(0.40)	(0.89)	(0.54)	(1.17)
$R\&D_{low}$		-0.153		-0.077		-0.181		-0.142
		(-2.21)		(-1.18)		(-2.55)		(-1.98)
$R\&D_{zero}$		-0.838		-0.770		-1.082		-0.968
		(-2.33)		(-2.15)		(-3.01)		(-2.66)
$\log(ME)$	-0.026	-0.041	-0.025	-0.042	-0.036	-0.046	-0.050	-0.060
	(-0.68)	(-1.18)	(-0.65)	(-1.20)	(-0.95)	(-1.30)	(-1.31)	(-1.75)
$\log(B/M)$	0.263	0.226	0.269	0.226			0.245	0.210
	(3.86)	(3.68)	(4.07)	(3.71)			(3.58)	(3.43)
$r_{-12,2}$	0.771	0.791	0.756	0.784	0.714	0.706	0.785	0.805
	(3.59)	(4.03)	(3.55)	(4.01)	(3.27)	(3.55)	(3.66)	(4.10)
$\Delta R\&D^{large}_{t-1}$	0.192	0.205						
	(1.72)	(2.01)						
$\Delta R\&D^{large}_{t-5,t-1}$			0.302	0.344				
			(2.75)	(3.89)				
$\log(B/M)_{t-5}$					0.092	0.091		
					(1.55)	(1.65)		
r_{book}					0.014	-0.002		
					(0.25)	(-0.03)		
$r_{intangible}$					-0.221	-0.189		
					(-2.72)	(-2.52)		
$\frac{Patents}{R\&D}_{high}$							-0.069	-0.062
							(-0.66)	(-0.56)
$\frac{Patents}{R\&D}_{low}$							-0.333	-0.322
							(-3.65)	(-3.86)
Other Controls		Yes		Yes		Yes		Yes
Number of Months	354	354	354	354	354	354	354	354
Total Observations	290272	283031	290272	283031	284098	277350	290272	283031

Non-Regression Ability Measure

- Our final robustness check utilizes a different, non-parametric method for classifying R&D Ability, we employ simple cross-sectional sorts of scaled measures of output per unit of R&D.
- We use both profit/lagged R&D and sales/lagged R&D as measures. lagged R&D represents an average of the last 1-5 years of R&D, to be flexible to the lead time of turning R&D into sales (and profit)
- Non-parametric approach is meant to address any potential concerns that our regression framework may introduce into how the Ability coefficients are determined.

Mechanism

- A. Real Outcomes. Firms that we classify as high ability firms may simply anticipate higher sales growth in the future, and hence may ramp up R&D and other firm-level activities in advance of sales growth.
  - We explore whether R&D spending by high ability firms leads to tangible outcomes.
- B. Heterogeneity in Information Provision by Firms. If firm opacity is impacting whether investors are able to decipher firm ability, then more open firms should have less of the return predictability that we document.
  - We test if the returns are lower for high ability firms who provide more earnings guidance relative to high ability firms who provide less earnings guidance.

Mechanism

- C. Founder Effects. Some firms (e.g., Apple) may have had the benefit of a unique “founder effect,” which could persist for many years but then diminish after the founder leaves.
  - We test this idea directly by comparing non-founder-led firms to founder-led firms.
- D. Variation in Financial Constraints. Financially constrained firms will likely only be able to increase R&D when they have exceptionally good R&D projects to invest in.
  - We compare a financially constrained firm and a unconstrained firm, we may expect a stronger signal from the R&D spending of the financially constrained firm.

Mechanism

- E. Ramping up all firm operations. Our interaction measure simply picks up firms that are: i.) good at predicting their future growth (through Ability high), ii.) ramping up all firm operations
  - We look at large increases in capital expenditures (CAPEX high) and large increases in total operating expenditures (OPEX high) by these firms

Mechanism A

	Panel A: R&D lagged one period							
	Patent Stock	Cite Stock	Patent Flow	Cite Flow	Patent Stock	Cite Stock	Patent Flow	Cite Flow
$\log(1+R\&D)ability_{high}$	11.96	16.70	9.07	14.87	9.18	12.61	6.99	11.31
	(7.2)	(6.8)	(7.1)	(6.8)	(6.6)	(6.1)	(6.3)	(6.2)
$ability_{high}$	-0.63	-0.95	-0.45	-0.75	-0.52	-0.78	-0.37	-0.60
	(-19.8)	(-19.7)	(-13.4)	(-11.2)	(-18.2)	(-17.9)	(-12.1)	(-10.8)
$\log(1+R\&D)$	2.21	3.10	1.94	3.16	1.92	2.68	1.81	2.90
	(3.0)	(3.0)	(3.1)	(3.0)	(3.1)	(3.0)	(3.2)	(3.1)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects					Yes	Yes	Yes	Yes
$\overline{R}^2$	0.42	0.31	0.28	0.17	0.46	0.35	0.31	0.19
Number of Years	27	27	27	27	27	27	27	27
Total Observations	27464	27464	27464	27464	27464	27464	27464	27464

	Panel B: Average R&D from $t-5$ to $t-1$							
	Patent Stock	Cite Stock	Patent Flow	Cite Flow	Patent Stock	Cite Stock	Patent Flow	Cite Flow
$\log(1+R\&D)_{-5,1}ability_{high}$	16.51	22.69	12.41	20.30	12.33	16.43	9.45	15.15
	(9.2)	(9.5)	(10.4)	(9.8)	(8.6)	(8.5)	(9.6)	(9.6)
$ability_{high}$	-0.69	-1.05	-0.50	-0.83	-0.55	-0.83	-0.39	-0.65
	(-28.1)	(-24.6)	(-16.6)	(-13.2)	(-22.7)	(-19.0)	(-15.0)	(-12.9)
$\log(1+R\&D)_{-5,-1}$	1.94	2.62	1.62	2.63	1.78	2.42	1.55	2.52
	(3.1)	(2.9)	(3.0)	(2.9)	(3.2)	(3.1)	(3.2)	(3.1)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects					Yes	Yes	Yes	Yes
$\overline{R}^2$	0.45	0.34	0.32	0.20	0.48	0.37	0.35	0.22
Number of Years	27	27	27	27	27	27	27	27
Total Observations	28625	28625	28625	28625	28625	28625	28625	28625

Mechanism A

	(1)	(2)	(3)	(4)	(5)	(6)
$\log(1+R\&D)*ability_{high}$	4.414	4.628	3.458			
	(2.73)	(2.67)	(2.36)			
$\log(1+R\&D)_{-5,-1}*ability_{high}$				0.515	0.455	0.436
				(7.54)	(6.01)	(3.17)
$ability_{high}$	-0.367	-0.466	-0.313	-0.048	-0.053	-0.048
	(-2.86)	(-3.29)	(-1.54)	(-3.49)	(-3.36)	(-2.51)
$\log(1+R\&D)$	-0.058	-0.021	-0.177			
	(-0.87)	(-0.26)	(-1.81)			
$\log(1+R\&D)_{-5,-1}$				-0.011	-0.013	-0.029
				(-1.20)	(-1.44)	(-3.04)
$\overline{products}_{-5,-1}$	1.281	1.261	1.250	1.022	1.010	1.001
	(47.90)	(46.42)	(45.94)	(107.45)	(95.76)	(96.35)
$\log(ME)$		0.152	0.163		0.012	0.013
		(6.63)	(6.68)		(5.86)	(5.83)
$\log(B/M)$		0.137	0.214		0.005	0.011
		(2.17)	(2.98)		(1.01)	(2.05)
$\log(1+leverage)$		0.291	0.307		0.028	0.032
		(2.85)	(2.75)		(2.27)	(2.17)
$\log(instown)$		0.599	0.754		0.074	0.098
		(2.03)	(2.41)		(1.66)	(1.92)
$\log(age)$		-0.256	-0.202		-0.022	-0.019
		(-3.35)	(-3.46)		(-5.13)	(-6.42)
Industry Fixed Effects			Yes			Yes
$\overline{R}^2$	0.87	0.87	0.87	0.81	0.82	0.82
Number of Years	9	9	9	9	9	9
Total Observations	6078	5992	5992	6185	6098	6098

Mechanism BCD

Panel A: Pooled regressions: Opacity Interaction ($guidance$)

	$R\&D_{high}ability_{high}$	$R\&D_{high}ability_{high}guidance_{high}$	Controls
Estimate	1.553	-1.161	Yes
T-stat	(3.52)	(-1.53)	

Panel B: Pooled regressions: Founder Interaction

	$R\&D_{high}ability_{high}$	$R\&D_{high}ability_{high}founder$	Controls
Estimate	0.640	1.534	Yes
T-stat	(1.38)	(1.61)	

Panel C: Pooled Regressions: Financial Constraint Interaction (KZ_x)

	$R\&D_{high}ability_{high}$	$R\&D_{high}ability_{high}KZ_{mid}$	$R\&D_{high}ability_{high}KZ_{most}$	Controls
Estimate	0.450	0.692	1.415	Yes
T-stat	(1.31)	(1.20)	(1.62)	

Panel D: Pooled Regressions: Financial Constraint Interaction ($Cash$)

	$R\&D_{high}ability_{high}$	$R\&D_{high}ability_{high}cash_{mid}$	$R\&D_{high}ability_{high}cash_{low}$	Controls
Estimate	0.732	0.013	0.427	Yes
T-stat	(1.91)	(0.02)	(0.52)	

Panel E: F-M Regression of returns on Ability and CAPX

	$CAPX_{high}ability_{high}$	$ability_{high}$	$CAPX_{high}$	Controls
Estimate	-0.127	-0.109	-0.051	Yes
T-stat	(-1.05)	(-1.44)	(-0.61)	

Panel F: F-M Regression of returns on Ability and OPEX

	$OPEX_{high}ability_{high}$	$ability_{high}$	$OPEX_{high}$	Controls
Estimate	-0.070	-0.131	-0.269	Yes
T-stat	(-0.35)	(-1.87)	(-2.12)	

Conclusion

- In this paper we demonstrate that firm-level innovation is predictable, persistent, and simple to compute, but the stock market ignores the implications of publicly available information when setting prices.
- In particular, R&D spending by high ability firms leads to increased numbers of patents, patent citations, and new product innovations by these firms in the future.
- We find that a long-short portfolio strategy that takes advantage of the information in past track records yields abnormal returns of 11 percent per annum.

Consideration

- Form a new indicate variable for choosing funds.
- Find other “good ability” variables for return.