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Paper presentation

Topic: Firm innovation and capital markets

Paper: Innovative efficiency and stock returns

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Three parts

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Structure of the paper

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Part 1. Literature review

Existing studies examine the effect of innovative input or output separately on operating performance, market valuation, and stock returns.

- **Input side studies (R&D)**

Expensing or capitalization of R&D contains valuation-relevant information.

R&D intensity predicts higher level and volatility of future operating performance and stock returns.

Growth in R&D predicts future stock returns.

Distinguish between risk versus mispricing as explanations for R&D-related abnormal returns.

- **Output side studies (Patents)**

Patents and citations also contain valuation-relevant information.

Part 1. Literature review

Measuring innovative efficiency inherently requires exploiting the information in innovative input and output taken together.

- **Patents-based IE measure: Patents/RDC**

Patents-based IE measure VS Patents-to-book equity ratio in Deng, Lev, and Narin (1999)

- **Citations-based IE measure: Citations/RD**

Citations-based IE measure VS Measure in Gu (2005)

Citations-based IE measure VS Citation intensity measure in Deng, Lev, and Narin (1999)

Part 2. Empirical analysis

Data: Compustat, Center for Research in Security Prices (CRSP), the National Bureau of Economic Research (NBER) patent database.

Sample period: 1981 to 2006

Patents/RDC:

$$Patents_{i,t}/\left(R\&D_{i,t-2}+0.8*R\&D_{i,t-3}+0.6*R\&D_{i,t-4}+0.4*R\&D_{i,t-5}+0.2*R\&D_{i,t-6}\right), \quad (1)$$

Citations/RD:

$$\frac{Citations}{RD}=\frac{\sum_{j=1}^{5}\sum_{k=1}^{N_{t-j}} C_{ik}^{t-j}}{\left(R\&D_{i,t-3}+R\&D_{i,t-4}+R\&D_{i,t-5}+R\&D_{i,t-6}+R\&D_{i,t-7}\right)}, \quad (2)$$

Part 2. Empirical analysis

4.1 Operating performance and innovative efficiency

$$OP_{i,t+1} = \alpha_0 + \alpha_1 \ln(1+IE_{i,t}) + \alpha_2 \ln\left(1+\frac{AD_{i,t}}{ME_{i,t}}\right) + \alpha_3 \ln\left(1+\frac{CapEx_{i,t}}{ME_{i,t}}\right) + \alpha_4 OP_{i,t} + \alpha_5 \Delta OP_{i,t} + \sum_{j=1}^{48} \gamma_j Industry_j \quad (3)$$

$$OP_{i,t+1} = \alpha_0 + \alpha_1 \ln(1+IE_{i,t}) + \alpha_2 \ln\left(1+\frac{AD_{i,t}}{ME_{i,t}}\right) + \alpha_3 \ln\left(1+\frac{CapEx_{i,t}}{ME_{i,t}}\right) + \alpha_4 OP_{i,t} + \alpha_5 \Delta OP_{i,t} + \alpha_6 \ln\left(1+\frac{RD_{i,t}}{ME_{i,t}}\right) + \alpha_7 RDG_{i,t} + \alpha_8 \ln\left(1+\frac{PAT_{i,t}}{ME_{i,t}}\right) + \alpha_9 \Delta APC_{i,t} + \sum_{j=1}^{48} \gamma_j Industry_{j,} \quad (4)$$

	Panel A: *IE = Patents/RDC*				Panel B: *IE = Citations/RD*			
Explanatory variable	*ROA*	*ROA*	*CF*	*CF*	*ROA*	*ROA*	*CF*	*CF*
$\ln(1+IE)$	0.52	0.45	0.43	0.49	0.56	0.43	0.41	0.31
	(4.96)	(2.68)	(5.44)	(3.71)	(4.98)	(3.50)	(4.68)	(3.49)
$\ln(1+RD/ME)$		0.74		0.87		0.66		0.77
		(4.31)		(3.89)		(3.75)		(3.30)
RDG		0.15		1.20		0.21		1.28
		(0.29)		(3.05)		(0.42)		(3.25)
$\ln(1+PAT/ME)$		0.02		−2.28		0.15		−0.37
		(0.08)		(−1.18)		(1.11)		(−0.25)
ΔAPC		0.16		0.21		0.13		0.20
		(1.82)		(2.84)		(1.51)		(2.71)
$\ln(1+AD/ME)$	0.41	0.34	0.59	0.51	0.43	0.35	0.60	0.51
	(4.35)	(3.78)	(5.50)	(5.65)	(4.57)	(3.94)	(5.70)	(5.78)
$\ln(1+CapEx/ME)$	2.44	2.35	2.43	2.38	2.44	2.34	2.42	2.35
	(6.99)	(7.36)	(5.79)	(6.28)	(6.98)	(7.22)	(5.76)	(6.11)
Current *ROA*	83.53	83.13			83.43	83.06		
	(31.22)	(31.33)			(31.19)	(31.24)		
ΔROA	−11.58	−11.44			−11.56	−11.41		
	(−10.66)	(−10.42)			(−10.57)	(−10.36)		

Part 2. Empirical analysis

4.2 Market valuation and innovative efficiency

$$\ln(MTB_{i,t}) = \alpha_0 + \alpha_1 \ln(1+IE_{i,t}) + \alpha_2 \ln(1+IE_{i,t-1}) + \alpha_3 RDG_{i,t} + \alpha_4 \ln\left(1+\frac{PAT_{i,t}}{ME_{i,t}}\right) + \alpha_5 \Delta APC_{i,t} + \alpha_6 \frac{RD_{i,t}}{BE_{i,t}} + \alpha_7 \frac{1}{BE_{i,t}} + \alpha_8 \frac{E^B_{i,t}(1-\tau_{i,t}) - r_t BE_{i,t-1}}{BE_{i,t}} + \alpha_9 \frac{\tau_{i,t} RD_{i,t}}{BE_{i,t}} + \alpha_{10} \ln\left(1+\frac{AD_{i,t}}{ME_{i,t}}\right) + \alpha_{11} \ln\left(1+\frac{CapEx_{i,t}}{ME_{i,t}}\right) + \sum_{j=1}^{48} \gamma_j Industry_j, \quad (5)$$

Explanatory variable	Panel A: *IE=Patents/RDC*				Panel B: *IE=Citations/RD*			
$\ln(1+IE_{i,t})$	1.95	1.90	6.35	1.99	2.69	2.90	4.82	3.91
	(5.57)	(4.65)	(11.25)	(4.97)	(5.77)	(6.70)	(7.40)	(8.52)
$\ln(1+IE_{i,t-1})$		0.92		4.52		0.41		1.48
		(2.74)		(10.93)		(1.91)		(2.97)
$RDG_{i,t}$			−17.05	−11.86			−16.62	−11.72
			(−8.99)	(−6.32)			(−8.89)	(−6.31)
$\ln(1+PAT_{i,t}/ME_{i,t})$			−8.98	−7.04			−6.94	−5.66
			(−11.48)	(−18.68)			(−9.20)	(−14.32)
$\Delta APC_{i,t}$			1.30	1.07			0.89	0.83
			(3.79)	(4.31)			(2.71)	(3.43)
$RD_{i,t}/BE_{i,t}$	18.43	18.82	21.76	20.67	18.28	18.68	21.00	20.24
	(29.18)	(28.78)	(30.66)	(30.99)	(29.64)	(29.19)	(10.99)	(31.06)
$1/BE_{i,t}$	25.27	24.69	25.04	24.43	25.42	24.82	25.53	24.66
	(13.57)	(13.54)	(13.63)	(13.45)	(13.76)	(13.67)	(14.43)	(13.75)
Abnormal $earnings_{i,t}$	79.16	75.77	79.78	76.26	79.09	75.73	80.10	76.33
	(28.91)	(29.33)	(28.76)	(29.67)	(28.99)	(29.43)	(28.95)	(29.82)
RD tax $shields_{i,t}$	14.64	14.03	14.77	13.92	14.27	13.68	14.39	13.57
	(7.78)	(7.84)	(8.22)	(8.26)	(7.80)	(7.87)	(8.20)	(8.22)
$\ln(1+AD_{i,t}/ME_{i,t})$	−5.80	−4.58	−5.38	−4.22	−5.74	−4.52	−5.34	−4.18
	(−8.44)	(−7.04)	(−7.49)	(−6.36)	(−8.33)	(−6.89)	(−7.18)	(−6.12)
$\ln(1+CapEx_{i,t}/ME_{i,t})$	−20.94	−17.14	−19.43	−15.89	−20.87	−17.08	−19.76	−15.99
	(−23.19)	(−28.75)	(−22.37)	(−25.74)	(−23.56)	(−29.62)	(−22.91)	(−26.67)
Intercept	−34.43	−36.71	−33.10	−36.04	−34.49	−36.76	−33.04	−36.09
	(−5.90)	(−5.94)	(−5.31)	(−5.81)	(−5.49)	(−5.94)	(−5.31)	(−5.82)
Industry dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	75.51	74.15	76.15	74.10	75.55	73.81	76.09	74.14

Part 2. Empirical analysis

5. Predictability of returns based upon innovative efficiency

5.1. Fama-MacBeth regression results

Explanatory variable	Panel A: *IE=Patents/RDC*		Panel B: *IE=Citations/RD*	
ln(1+*IE*)	0.08	0.04	0.11	0.07
	(4.44)	(1.81)	(5.13)	(2.92)
ln(1+*RD/ME*)		0.13		0.13
		(3.28)		(3.22)
RDG		0.12		0.12
		(1.08)		(1.11)
ln(1+*PAT/ME*)		0.05		0.05
		(1.78)		(2.29)
Quartile (*ΔAPC*)		0.07		0.05
		(2.65)		(1.94)
ln(*Size*)	−0.30	−0.30	−0.30	−0.30
	(−3.06)	(−3.13)	(−3.13)	(−3.14)
ln(*BTM*)	0.39	0.37	0.39	0.37
	(6.76)	(6.32)	(6.73)	(6.34)
Momentum	−0.05	−0.06	−0.05	−0.06
	(−0.48)	(−0.60)	(−0.47)	(−0.60)
ln(1+*AD/ME*)	0.06	0.05	0.06	0.06
	(1.81)	(1.74)	(1.81)	(1.76)
ln(1+*CapEx/ME*)	−0.11	−0.12	−0.11	−0.12
	(−3.09)	(−3.25)	(−3.09)	(−3.25)
ROA	0.15	0.16	0.15	0.15
	(2.96)	(3.20)	(2.93)	(3.16)
AG	−0.26	−0.24	−0.26	−0.24
	(−6.36)	(−5.89)	(−6.32)	(−5.89)
NS	−0.12	−0.14	−0.12	−0.14
	(−2.54)	(−3.26)	(−2.56)	(−3.30)
IO	0.14	0.14	0.14	0.14
	(3.00)	(2.90)	(2.94)	(2.89)
Intercept	1.03	0.99	1.04	1.02
	(2.27)	(2.16)	(2.29)	(2.22)
Industry dummy	Yes	Yes	Yes	Yes
Adjusted R^2	6.55	6.83	6.56	6.83

Part 2. Empirical analysis

5. Predictability of returns based upon innovative efficiency

5.2. Portfolio tests

Excess return (percent)		Carhart four-factor model					Investment-based three-factor model			
IE		α (percent)	*MKT*	*SMB*	*HML*	*MOM*	α (percent)	*MKT*	*INV*	*ROE*
Panel A: *Patents/RDC*										
Low	0.49	−0.19	1.08	0.57	−0.14	−0.05	0.10	1.10	−0.13	−0.37
t	(1.48)	(−2.20)	(45.31)	(16.47)	(−3.22)	(−1.70)	(0.74)	(31.74)	(−1.89)	(−6.74)
Middle	0.86	0.22	1.01	0.49	−0.18	−0.02	0.39	1.07	−0.00	−0.29
t	(2.78)	(2.48)	(43.89)	(10.42)	(−3.67)	(−0.61)	(2.40)	(30.98)	(−0.05)	(−3.80)
High	0.90	0.27	1.04	0.53	−0.21	−0.04	0.50	1.08	−0.04	−0.37
t	(2.79)	(3.08)	(41.96)	(10.79)	(−5.80)	(−1.35)	(3.08)	(31.25)	(−0.63)	(−5.22)
Panel B: *Citations/RD*										
Low	0.59	−0.09	1.05	0.55	−0.13	−0.03	0.17	1.08	−0.07	−0.33
t	(1.86)	(−0.94)	(40.67)	(13.72)	(−2.94)	(−0.95)	(1.15)	(30.00)	(−1.04)	(−5.33)
Middle	0.81	0.14	1.01	0.44	−0.06	−0.03	0.25	1.05	0.08	−0.21
t	(2.78)	(1.65)	(49.27)	(13.02)	(−1.44)	(−1.00)	(1.85)	(31.16)	(1.20)	(−3.60)
High	0.85	0.26	1.04	0.49	−0.26	−0.05	0.49	1.08	−0.11	−0.38
t	(2.65)	(3.07)	(41.67)	(10.34)	(−7.23)	(−1.68)	(3.15)	(33.73)	(−1.69)	(−5.62)

Excess return (percent)	Carhart four-factor model plus UMO						Investment-based three-factor model plus UMO				
IE	α (percent)	*MKT*	*SMB*	*HML*	*MOM*	*UMO*	α (percent)	*MKT*	*INV*	*ROE*	*UMO*

Part 2. Empirical analysis

6. Limited attention, valuation uncertainty, and the strength of return predictability based upon innovative efficiency

	IE = *Patents/RDC*		IE = *Citations/RD*	
	IE only	Augmented	IE only	Augmented
Panel A: Subsamples split by investor attention proxies				
Micro size	0.09	0.09	0.13	0.07
	(3.58)	(2.32)	(4.42)	(2.34)
Small size	0.09	0.08	0.09	0.07
	(3.17)	(1.87)	(2.81)	(1.80)
Big size	0.05	0.01	0.04	0.02
	(2.07)	(0.32)	(1.49)	(0.61)
Low AC	0.09	0.06	0.10	0.08
	(2.64)	(1.62)	(3.07)	(2.21)
High AC	0.06	0.04	0.07	0.05
	(2.61)	(1.53)	(2.72)	(1.65)
Panel B: Subsamples split by valuation uncertainty proxies				
Young age	0.12	0.07	0.14	0.11
	(4.33)	(1.96)	(4.86)	(3.26)
Old age	0.02	−0.00	0.05	0.02
	(0.71)	(−0.63)	(2.10)	(0.91)
High turnover	0.10	0.08	0.10	0.07
	(4.12)	(2.74)	(4.12)	(2.37)
Low turnover	0.03	−0.00	0.09	0.06
	(1.09)	(−0.91)	(3.05)	(1.79)
High IVOL	0.09	0.07	0.14	0.08
	(4.66)	(3.18)	(4.19)	(2.08)
Low IVOL	0.08	0.02	0.05	0.03
	(2.80)	(0.59)	(2.49)	(1.34)

Part 2. Empirical analysis

7. The EMI factor

EMI: Efficient Minus Inefficient based on Patents/RDC (EMI1) and on Citations/RD (EMI2).

The table is about EMI1 as an example, similar results are found for EMI2.

	Portfolio weights												Tangency portfolio		
Portfolio	*MKT*	*SMB*	*HML*	*EMI*	*INV*	*ROE*	*MOM*	*UMO*	*RDG*	*ΔvAPC*	*RDME*	*PAT/ME*	Mean	Standard deviation	Ex post SR
Panel C: Ex post tangency portfolio (EMI is created based on *Patents/RDC*)															
1	1.00												0.68	4.31	0.16
2	1.09	−0.09											0.73	4.65	0.16
3	0.34	0.15	0.51										0.43	1.51	0.29
4	0.20	0.09	0.29	0.42									0.42	1.06	0.39
5	0.18	0.07	0.19	0.32	0.24								0.41	0.97	0.43
6	0.17	0.14	0.18	0.32		0.19							0.48	0.99	0.49
7	0.19	0.06	0.27	0.35			0.13						0.48	1.05	0.46
8	0.26	0.07	0.04	0.26				0.37					0.62	1.16	0.53

Part 3. About plan

The relationship between innovation and stock return.

Innovative efficiency (IE) is a reasonable measure for innovation and worthy of reference.

The main method may be Fama Macbeth cross-sectional regressions and/or DID.

Like this paper, dividing sub-samples according to certain standards.

Thanks for your listening !