Short- and Long-Run Uncertainty

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Horizons of Uncertainty

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Even Longer:

▶ Will the next US Congress move to enact comprehensive immigration, welfare or tax reform?

Much, much longer:

▶ Will humanity succesfully colonize Mars (without mistakenly abandoning Matt Damon there)?

Research Questions

1. How can we measure aggregate and firm-level uncertainty at varying horizons?

2. How do firms respond to short vs. long-run uncertainty?
   - Empirical evidence
   - Model evidence

3. What drives short- versus long-run uncertainty?

Preview of Findings

1. **Measure uncertainty by horizon with option-implied volatility**

   ▸ Implied volatility curves
   ▸ Short- (30-day) and medium-run (6-month) implied vol. "sufficient statistics"

2. **Firms respond to both short- and long-run uncertainty**

   ▸ **Less adjustable, longer-lived assets** (e.g. capital) linked relatively more to **long-run** uncertainty
   ▸ **Shorter-lived, more adjustable investments** (e.g. hiring) linked relatively more to **short-run** uncertainty

3. **Uncertainty linked to:**

   ▸ Economic policy uncertainty (long)
   ▸ Oil price volatility (short)
   ▸ Currency volatility, CEO-churn (both short and long)

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Related Literature

Uncertainty and the macro-economy Schwert (1989), Fernández-Villaverde et al (2009), Bachmann (2010), Fernández-Villaverde and Rubio-Ramírez (2010), Baker et al (2012), Scotti (2013), Jurado et al (2013), Fernández-Villaverde et al (2013),

Uncertainty at the micro level Campbell et al (2001), Kehrig (2011), Bloom et al (2012), Vavra (2013), Meghir and Pistaferri (2004), Storesletten et al (2004), Heathcote, Perri, and Violante (2010), Guvenen et al (forthcoming),

Real Options Theory and Investment Under Uncertainty: Bernanke (1983), Brennan and Schwartz (1985), McDonald and Siegel (1986), Dixit and Pindyck (1994), Ramey and Shapiro (2001), Cooper and Haltiwanger (2006), Bloom(2009), Bloom et al (2007) Schaal (2010) Valleta and Bengali (2013), Mecikovsky and Meier (2015)

Empirical Work: Leahy and Whited (1996), Guiso and Parigi (1999), Stein and Stone (2012), Gulen and Ion (2013), Senga (2015)

OUTLINE

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OPTION IMPLIED VOLATILITY

Run option-pricing model (e.g. Black-Scholes) "in reverse"

▶ Infer volatility of underlying asset price from observed option prices

For a horizon of $T \in \{30, 60, 91, 182, 365...\}$ days:

$$\text{ImplVolT}_{it} = \mathbb{E}_t \left(\frac{1}{T} \int_t^{t+T} \sigma_i(s) \mathrm{d}s \right)$$

$\sigma_i(s) =$ volatility of underlying i on date t

Short-/Long-run Uncertainty: implied volatility by expiration horizon

MARKET IMPLIED VOLATILITY CURVE: VIX

Notes: Average VIX for the indicated month by horizon. Source: Goldman Sachs.

FIRM IMPLIED VOLATILITY CURVES
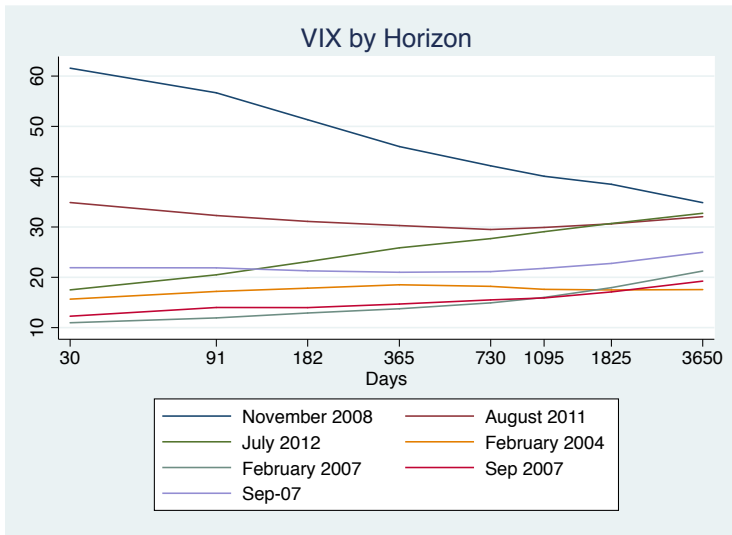
GPS (Gap, Inc.) Implied Volatility July
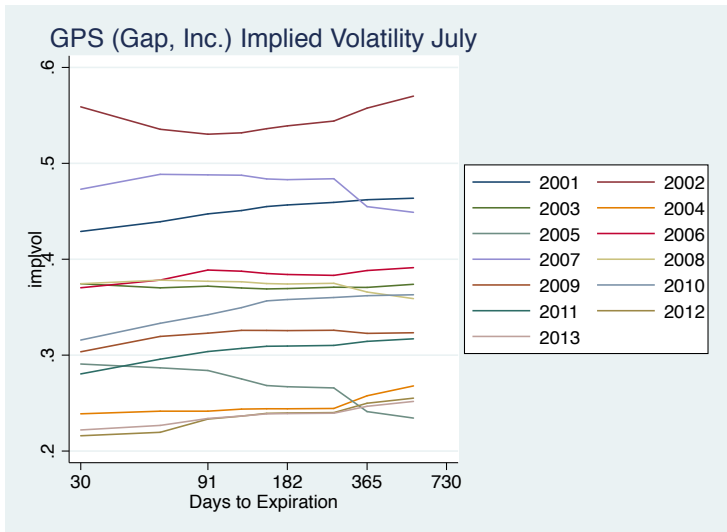
Notes: Average of put and call implied volatilities from standardized options on GPS (Gap, Inc.) for July of the year indicated. Source: Optionmetrics.

Characterizing Implied Vol. Curves

Stylized Fact: Volatility curves well-characterized by:

- *Level* of short-run (30-day) implied volatility
- *Slope* between medium- (6-month) and short-run (30-day) implied volatilities

Why is this is important?

- Implied vol. data does not populate well at long horizons
- Extrapolate off of short- and medium-run data, increases sample size massively

PREDICTING LONG-RUN IMPLIED VOLATILITY

Dependent Variable	(1) 2-year Firm Implied Vol	(2) 1-year VIX	(3) 2-year VIX	(4) 3-year VIX	(5) 5-year VIX
30-day Volatility	0.869***	0.950***	0.883***	0.838***	0.753***
	(0.00570)	(0.0110)	(0.0259)	(0.0334)	(0.0484)
6m - 30-day Volatility	1.157***	1.240***	1.360***	1.385***	1.349***
	(0.0350)	(0.0347)	(0.0771)	(0.0985)	(0.135)
Constant	4.537***	1.148***	2.918***	4.377***	7.171***
	(0.192)	(0.259)	(0.604)	(0.781)	(1.143)
Observations	21,400	2,638	2,638	2,638	2,638
R-squared	0.944	0.9945	0.9785	0.9615	0.9187

Column 1 regresses quarterly firm-level 2-year implied volatility (source: Optionmetrics) on 30-day and 6m minus 30-day implied volatility. Columns 2-6 regress the daily VIX for the specified horizon on 30-day and 6m minus 30-day VIX, data courtesy of Goldman Sachs. Columns 2-6 report Newey-West standard errors in parentheses, assuming autocorrelation up to 250 trading days. Column 1 standard errors clustered by firm.
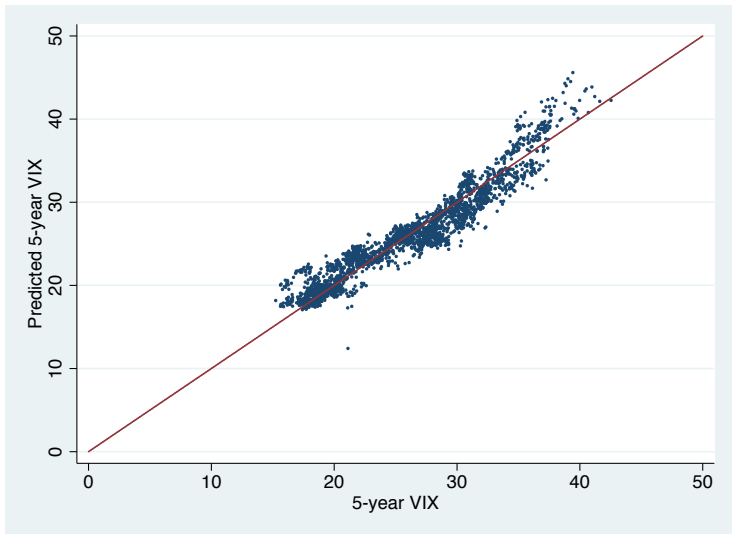
*** p<0.01, ** p<0.05, * p<0.1

PREDICTING 2-YEAR FIRM IMPLIED VOL. FROM 30-DAY AND 6-MONTH IMPLIED VOL.
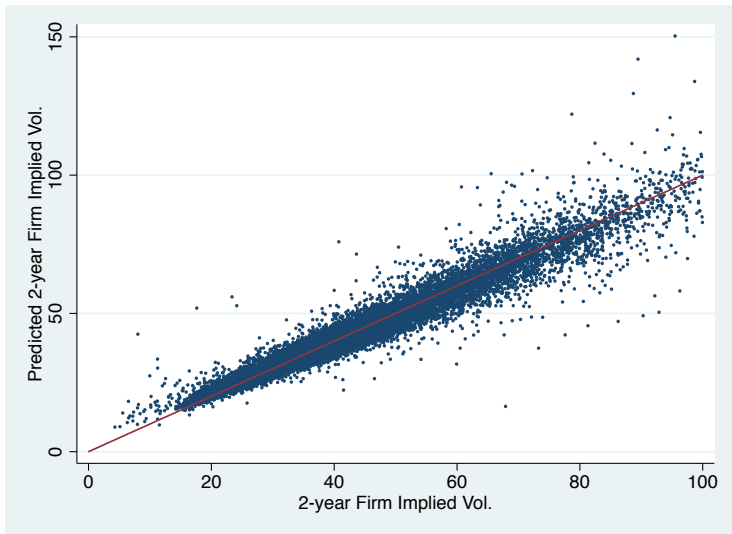
Note: $R^2 = .9503$

Predicting 5-year VIX from the 30-day and 1-year VIX

Note: $R^2 = .9187$

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DATA

Uncertainty: OptionMetrics

- ▶ Implied volatility on standardized at-the-money options
- ▶ Generate quarterly, annual implied vol. figures by firm

Firm-level Data: Compustat

- ▶ Quarterly: 1996Q2-2013Q1
- ▶ Annual: 1997-2013
- ▶ Exclude utilities and financial companies

Main Specification: for firm i on date t

$$\text{Investment Measure}_{i,t} = \alpha_i + \gamma_t + \beta_1 \log(\sigma^S_{i,t-1}) +$$
$$\beta_2 \log(\sigma^L_{i,t-1}) + \text{1stMomentControls}_{i,t} + \varepsilon_{i,t}$$

▶ SummaryStatistics

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Annual Employment & Capital Growth

Dependent Variable	(1) PPENT Growth	(2) Empl. Growth	(3) PPENT Growth	(4) Empl. Growth	(5) PPENT Growth	(6) Empl. Growth
Lagged log(30d IVOL)	-0.0290	-0.0712***	-0.0857***	-0.0496***	-0.0665***	-0.0312***
	(0.0266)	(0.0214)	(0.00944)	(0.00721)	(0.00895)	(0.00666)
Lagged log(6m IVOL)	-0.0567*	0.0215				
	(0.0290)	(0.0233)				
Lagged log(6m IVOL)-log(30d IVOL)			-0.0567*	0.0215	-0.0815***	-0.00533
			(0.0290)	(0.0233)	(0.0277)	(0.0210)
Lagged Tobin's Q	0.0512***	0.0312***	0.0512***	0.0312***	0.0394***	0.0198***
	(0.00240)	(0.00162)	(0.00240)	(0.00162)	(0.00238)	(0.00154)
Cash Flow / Assets					0.176***	0.0713***
					(0.0329)	(0.0246)
Proportional Sales Grow					0.488***	0.542***
					(0.0301)	(0.0291)
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Time Fixed Effects	YES	YES	YES	YES	YES	YES
Mean of Dep. Variable	0.070	0.056	0.070	0.056	0.070	0.056
Observations	20,132	20,132	20,132	20,132	20,132	20,132
R-squared	0.367	0.348	0.367	0.348	0.421	0.444
Firms	3416	3416	3416	3416	3416	3416

Robust standard errors in parentheses, clustered by firm. Annual balance sheet information from Compustat North America and implied volatility on standardized options, from Optionmetrics. Implied volatility measured as the average for the last quarter of the fiscal year. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

Relative (Net) Investment

$$(\Delta \text{PPENT}/\text{PPENT} - \Delta \text{EMP}/\text{EMP})_{i,t} =$$
$$\alpha_i + \gamma_t + \beta_1 \log(\sigma^S_{i,t-1}) + \beta_2 \log(\sigma^L_{i,t-1})$$
$$+ \text{CONTROLS}_{i,t} + \varepsilon_{i,t}$$

Hypothesis:

▶ Capital growth linked more closely to long-run uncertainty

▶ Employment linked roughly evenly to short- and long-run uncertainty

Expect:

▶ $\beta_1 > 0$

▶ $\beta_2 < 0$

RELATIVE (NET) INVESTMENT

Dependent Variable	(1)	(2)	(3)	(4)
	ΔPPENT/PPENT - ΔEMP/EMP			
Lagged log(30d IVOL)	0.0426	0.0581**	0.0616**	0.0618**
	(0.0296)	(0.0295)	(0.0295)	(0.0295)
Lagged log(6m IVOL)	-0.0889***	-0.0995***	-0.100***	-0.100***
	(0.0323)	(0.0322)	(0.0321)	(0.0321)
Lagged Tobin's Q		0.0302***	0.0285***	0.0285***
		(0.00277)	(0.00286)	(0.00288)
Cash Flow / Assets			0.123***	0.123***
			(0.0367)	(0.0372)
Proportional Sales Growth				0.00180
				(0.0256)
Firm Fixed Effects	YES	YES	YES	YES
Time Fixed Effects	YES	YES	YES	YES
Mean of Dep. Variable	0.043	0.043	0.043	0.043
1 SD log(30d IVOL)*ShortCoeff	0.019	0.026	0.027	0.028
1 SD log(6m IVOL)*LongCoeff	-0.038	-0.042	-0.042	-0.042
Observations	20,132	20,132	20,132	20,132
R-squared	0.221	0.236	0.237	0.237
Firms	3416	3416	3416	3416

Robust standard errors in parentheses, clustered by firm. Annual balance sheet information from Compustat North America. Implied volatility data from Optionmetrics, measured as average implied vol. for the last quarter of the fiscal year. All variables winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

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PARTIAL EQBM. MODEL OF INVESTMENT

Revenue: $R(A_t, K_t, L_t) = A_t K_t^{\alpha_1} L_t^{\alpha_2}$

Investment in Two Assets:

- $K_t = K_{t-1}(1 - \delta_K) + I_t^K$
- $L_t = L_{t-1}(1 - \delta_L) + I_t^L$

Adjustment Costs: Partial irreversibility, fixed

Revenue-generating & Uncertainty Shocks:

- $\log(A_t) = \rho_A \log(A_{t-1}) + \varepsilon_t$, $\varepsilon_t \sim N(0, \sigma_{t,L}^2 + \sigma_{t,S}^2)$
- $\sigma_{t,S}^2$, $\sigma_{t,L}^2$ independent Markov chains

Assumptions:

- K shorter-lived, less adjustable than L
- $\sigma_{t,L}^2$ more persistent than $\sigma_{t,S}^2$

▶ Full Model

Role of Adjustment Costs & Depreciation

Relative Investment regression under alternative calibrations:

$$\left(\frac{\Delta K}{K} - \frac{\Delta L}{L} \right)_{i,t} = \alpha_i + \gamma_t + \beta_1 \log(\sigma_{i,t-1}^S) + \beta_2 \log(\sigma_{i,t-1}^L)$$

$$+ \text{CONTROLS}_{i,t} + \varepsilon_{i,t}$$

Param.	Description	Baseline	1	2	3
δ_K	K effective depreciation	.2	.45	.2	.45
δ_L	L effective depreciation	.45	.45	.45	.45
γ_K	K resale loss	.25	.25	.25	.25
γ_L	L resale loss	.125	.125	.25	.25
F_K	Fixed K adj. cost	.01	.01	.01	.01
F_L	Fixed L adj. cost	.01	.01	.01	.01

RELATIVE (NET) INVESTMENT

Dependent Variable	(1)	(2)	(3)	(4)
		ΔK/K - ΔL/L		
Calibration	Baseline	Equal Depr.	Equal Adj. Costs	Equal Depr. & Adj. Costs
Lagged log(30d Expected Vol.)	0.193***	0.0189	0.268***	0.0466
	(0.0476)	(0.0235)	(0.0319)	(0.0366)
Lagged log(6m Expected Vol.)	-0.213***	-0.0898**	-0.112**	-0.0691
	(0.0712)	(0.0355)	(0.0474)	(0.0515)
Lagged Tobin's Q	-0.0701***	-0.00291**	-0.0275***	0.000691
	(0.00431)	(0.00120)	(0.00289)	(0.00123)
Cash Flow / (K + L)	-0.0763**	-0.0423***	0.145***	-0.00648
	(0.0300)	(0.00800)	(0.0203)	(0.00799)
Proportional Sales Growth	0.0545*	0.0773***	-0.146***	0.0225*
	(0.0284)	(0.0115)	(0.0192)	(0.0116)
Firm Fixed Effects	YES	YES	YES	YES
Time Fixed Effects	YES	YES	YES	YES
Observations	20,000	20,000	20,000	20,000
R-squared	0.136	0.110	0.123	0.088
Firms	5000	5000	5000	5000

Robust standard errors in parentheses, clustered by firm. Data is annual aggregate of 5000 firm simulation panel. Uncertainty measured as average expected volatility of shocks to revenue generation over the next 1-month or 6-month horizon, with the annual figure taken from the last quarter of the relevant year . All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

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SOURCES OF UNCERTAINTY

Economic Policy (EPU)

- ▶ Baker, Bloom, and Davis (2015) data

- ▶ Firm-level exposure to EPU based on lines of business & sectoral dependence on govt. purchases

- ▶ Interact exposure with word-search EPU index ▸ EPU Data

Currencies and Commodities

- ▶ Industry-level exposure to oil and currency fluctuations

- ▶ Interact exposure with oil & currency volatility

- ▶ Follow Stein & Stone (2013) approach ▸ Oil/Currency Vol. Exposure

CEO Churn

- ▶ Flag firm-quarters when CEO stepped down or new CEO appointed

- ▶ Execucomp data ▸ CEO Churn Data

DRIVERS OF FIRM-LEVEL UNCERTAINTY

Firm i in sector j, quarter t:

Slope specification:

$$\log(\sigma_{ijt}^L) - \log(\sigma_{ijt}^S) = \gamma_i + \gamma_t + \delta_1 \text{EPUExposure}_{ijt} +$$
$$\delta_2 \text{OilVolExposure}_{jt} + \delta_3 \text{CurrVolExposure}_{jt} + \text{CEOChurn}_{it} + \varepsilon_{ijt}$$

- ▶ $\delta_k > 0 \Rightarrow$ linked more closely to long-run uncertainty
- ▶ $\delta_k < 0 \Rightarrow$ linked more closely to short-run uncertainty

Restrict to industries that are sensitive to oil and at least one currency.

▶ Levels Specifications

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DRIVERS OF SHORT-RUN UNCERTAINTY

	(1)	(2)	(3)	(4)	(5)
Dependent Variable			log(30d IVOL)		
Economic Policy Unc. Exposure	0.147*				0.176**
	(0.0852)				(0.0873)
Oil Vol. Exposure		3.539***			3.070***
		(0.922)			(0.906)
Currency Vol. Exposure			0.0806**		0.0748**
			(0.0352)		(0.0329)
CEO Turnover				0.0259*	0.0249*
				(0.0146)	(0.0144)
Firm FE	Y	Y	Y	Y	Y
Date FE	Y	Y	Y	Y	Y
Observations	21,328	21,328	21,328	21,328	21,328
R-squared	0.888	0.888	0.887	0.887	0.889
Firms	1370	1370	1370	1370	1370

Robust standard errors in parentheses, clustered by firm. Firm-level implied volatility data from Optionmetrics. Economic Policy Uncertainty from Baker et al (2015). Exposure to oil and currencies constructed using CRSP data on stock returns, Bloomberg data on oil prices and exchange rates from 1985-1995, and implied volatility data for oil and currencies 2005-2013. CEO Turnover from Execucomp, is an indicator for whether there was a CEO taking office or stepping down during the quarter. Regressions with EPU exposure also control for federal spending as percent of GDP multiplied by firm-level exposure to government purchases. Regressions are weighted by employment at the firm level and restricted to 2-digit industries with significantly positive sensitivity to oil prices and to at least one currency. *** p<0.01, ** p<0.05, * p<0.1

Drivers of Short-/Long-run Uncertainty

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	log(6m IVOL) - log(30d IVOL)				
Economic Policy Unc. Exposure	0.0858**				0.0856**
	(0.0341)				(0.0347)
Oil Vol. Exposure		-1.194**			-1.164**
		(0.487)			(0.458)
Currency Vol. Exposure			-0.00975		-0.00333
			(0.0149)		(0.0126)
CEO Turnover				-0.00396	-0.00369
				(0.00577)	(0.00575)
Date Fixed Effects	Y	Y	Y	Y	Y
Firm Fixed Effects	Y	Y	Y	Y	Y
Observations	21,328	21,328	21,328	21,328	21,328
R-squared	0.513	0.514	0.512	0.512	0.515
Firms	1370	1370	1370	1370	1370

Robust standard errors in parentheses, clustered by firm. Firm-level implied volatility data from Optionmetrics. Economic Policy Uncertainty from Baker et al (2015). Exposure to oil and currencies constructed using CRSP data on stock returns, Bloomberg data on oil prices and exchange rates from 1985-1995, and implied volatility data for oil and currencies 2005-2013. CEO Turnover from Execucomp, is an indicator for whether there was a CEO taking office or stepping down during the quarter. Regressions with EPU exposure also control for federal spending as percent of GDP multiplied by firm-level exposure to government purchases. Regressions are weighted by employment at the firm level and restricted to 2-digit industries with significantly positive sensitivity to oil prices and at least one currency. *** p<0.01, ** p<0.05, * p<0.1

▶ Sample Selection Robustness

THE WALL STREET JOURNAL.
WSJ.com

December 1, 2015, 2:45 PM ET

Why Business Investment Is Slumping in Five Charts

By Andrew Van Dam and Eric Morath

New York dairy farmer David Wood sold milk in the spring for less than it cost to produce it. Falling farm incomes, a reflection of commodity prices, have caused spending on tractors and similar equipment to decline.
MIKE GROLL/ASSOCIATED PRESS

U.S. business investment advanced just 2.2% from a year earlier in the third quarter, a slowdown that marks one of the worse performances of the six-year-old economic expansion. The trend seems at odds with ultralow interest rates, consistent hiring and steady, if unspectacular, overall economic growth.

So what's causing business investment to slump?

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1. Use implied volatility to measure short- vs. long-run uncertainty at the aggregate and firm levels

2. Firms react to both short- and long-run uncertainty
   - Less reversible, longer-lived investment more strongly associated with long-run rather than short-run uncertainty
   - Employment and investment in adjustable, shorter-lived assets associated more closely with short-run uncertainty

3. Potential drivers of short- and long-run uncertainty
   - Long-run: Economic policy uncertainty
   - Short: oil price volatility
   - Both: currency volatility, CEO changes

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SUMMARY STATISTICS

ANNUAL DATA	Mean	SD	**QUARTERLY DATA**	Mean	SD
Total Assets ($M)	5,368	9,681	Total Assets ($M)	4,081	8,013
Capital Expenditures ($M)	296.6	612	Capital Expenditures ($M)	56.71	123.5
Sales ($M)	4,734	8,599	Sales ($M)	943.5	1,904
Cash Flow / Assets	0.0986	0.14	Cash Flow / Assets	0.0203	0.0497
Capital Stock ($M)	2,359	6,455	Capital Stock ($M)	1,541	4,087
Tobin's Q	1.923	1.696	Tobin's Q	2.045	1.911
Proportional Sales Growth	0.0394	0.1393	Proportional Sales Growth	0.0628	0.155
30day IVOL	52.79	24.22	30day IVOL	52.63	23.75
6m - 30day IVOL	-2.508	4.967	6m - 30day IVOL	-2.498	4.672
Employees ('000s)	20.43	43.13	PPENT ($M)	1,294	2,939
PPENT Growth	0.1098	0.326	CAPX/K	0.0654	0.0647
Employment Growth	0.0713	0.27	CAPX/PENT	0.0812	0.0923
N		20,132	N		97,733
Date Range: 1997-2013			Date Range: 1996Q2 - 2013Q1		

▸ Data

Revenues and Investment Technology

Revenue: $R(A_t, K_t, L_t) = A_t K_t^{\alpha_1} L_t^{\alpha_2}$

Investment Technology:

- $K_t = K_{t-1}(1 - \delta_K) + I_t^K$
- $L_t = L_{t-1}(1 - \delta_L) + I_t^L$

Adjustment Costs:

$$C(I_t^K, I_t^L, K_{t-1}, L_{t-1}) = I_t^K(1 - \gamma_K \cdot \mathbf{1}(I_t^K < 0)) + I_t^L(1 - \gamma_L \cdot \mathbf{1}(I_t^L < 0))$$
$$+ F_K \cdot K_{t-1} \mathbf{1}(I_t^K \neq 0) + F_L \cdot L_{t-1} \mathbf{1}(I_t^L \neq 0)$$

Parametric Assumptions: $\delta_L > \delta_K$, $\gamma_K \geq \gamma_L$, $F_K \geq F_L$

- K longer-lived, less reversible
- L shorter-lived, more reversible

Uncertainty Shocks

Revenue-generation shocks:

- $\log(A_t) = \rho_A \log(A_{t-1}) + \varepsilon_t$
- $\varepsilon_t \sim N(0, \sigma_{t,L}^2 + \sigma_{t,S}^2)$

Short- and Long-run Uncertainty Shocks:

- $\sigma_{t,L}, \sigma_{t,S}$ independent, 2-point Markov chains
- Transition matrices: $\begin{bmatrix} \rho_X & 1 - \rho_X \\ 1 - \rho_X & \rho_X \end{bmatrix}$ for $X \in \{L, S\}$
- $\rho_L > \rho_S$

Firms Invest to Maximize Firm Value

$$V(A_t, K_{t-1}, L_{t-1}, \sigma_{S,t}, \sigma_{L,t}) =$$

$$\max_{I_t^K I_t^L} A(K_{t-1}(1-\delta_K) + I_t^K)^{\alpha_1}(L_{t-1}(1-\delta_L) + I_t^L)^{\alpha_2}$$

$$- C(I_t^K, I_t^L, K_{t-1}, L_{t-1})$$

$$+ \frac{1}{1+r}\mathbb{E}[V(A_{t+1}, K_{t-1}(1-\delta_K)+I_t^K, L_{t-1}(1-\delta_L)+I_t^L, \sigma_{S,t+1}, \sigma_{L,t+1})]$$

$$s.t.$$

$$K_t = K_{t-1}(1-\delta) + I_{K,t} \geq 0$$

$$L_t = L_{t-1}(1-\delta) + I_{L,t} \geq 0$$

BASELINE CALIBRATION

Period = 1 Month

Parameter	Description	Value	Notes
$\frac{1}{1+r}$	Discount Rate	.996	$r = 5\%$ annualy
α_1, α_2	Elast. of Rev. wrt. K, L	0.4	CRS and 25% markups
σ_{Sl}, σ_{Ll}	Low Volatility State	.24	33% monthly in LL state
σ_{Sh}, σ_{Lh}	High Volatility State	.46	66% monthly in HH state
ρ_S	persistence σ_S	.85	annual autocorrelation .15
ρ_L	persistence σ_L	.95	annual autocorrelation .49
δ_K	effective K monthly deprec.	.018	20% annual
δ_L	effective L monthly deprec.	.035	45% annual
γ_K	resale loss K	.25	25% resale loss
γ_L	resale loss K	.125	$1/2\gamma_K$
F_L	Fixed L adj. cost	.01	NA
F_K	Fixed K adj. cost	.01	NA
ρ_A	monthly persistence of A	.983	.95 quarterly, Khan & Thomas (2008)

Generating Data off of the Model

Simulation panel of 5000 firms for 5 years

Firm Aggregation:

▶ Firms consist 25 'units', each solving the investment problem

▶ Independent A shocks

▶ Common volatility shocks

Time Series Aggregation: Monthly into quarterly/annual

Add 5% measurement error

‣ Measuring uncertainty in the simulation

Uncertainty in the Model

Model: Firms know uncertainty process and 'true' uncertainty shocks $\sigma_{S,t}$, $\sigma_{L,t}$

Data: Observe implied volatility at several horizons

Identify:
Short-run uncertainty $= \mathbb{E}_t[\sigma_{t+1}] =$ expected vol. of next month's productivity

Long-run uncertainty $= \mathbb{E}_t[\frac{1}{6}\sum_{s=1}^{6}\sigma_{t+s}] =$ avg. expected vol. of productivity over next 6 months

Note: $\sigma_t = \sqrt{\sigma_{S,t}^2 + \sigma_{L,t}^2}$

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Economic Policy Uncertainty (EPU)

Data from Baker, Bloom, and Davis (2015)

EPU index based on news coverage about economic policy uncertainty

Firm-specific exposure to EPU based on firms' line of business and industry-level dependence on government purchases

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Sensitivity to Commodities and Currencies

Sensitivities:

$$r_{ijt} = \alpha_i + \beta_{jm}r_{mt} + \sum_k \beta_{jk}r_{kt} + \varepsilon_{it}$$

- ▶ r_{ijt} - daily equity returns for firm i in industry j
- ▶ r_{mt} - daily returns on S&P 500
- ▶ r_{kt} - daily returns on commodity/currency k ▸ List
- ▶ β_{jk} - **sensitivity** of industry j to commodity/currency k

Run on 1985-1995 "pre-sample"

Volatility Exposure

Collect $\hat{\beta}_{jk}$ sensitivity estimates.

Impute $\hat{\beta}_{jk} = 0$ if insignificant at 99% level

Generate exposure of industry j to oil and currencies k:

- OilVolExposure$_{ijt} = |\hat{\beta}_{j,\text{Oil}}| \cdot \log(\sigma_{\text{Oil},t})$
- CurrVolExposure$_{ijt} = \sum_{k \text{ currencies}} |\hat{\beta}_{jk}| \cdot \log(\sigma_{kt})$

Data for 2005-present

CEO Churn

Execucomp database links firms and CEOs

Flag firm-quarters in which CEO stepped down and/or new CEO appointed

$CEOChurn_{it} = \mathbf{1}(\text{Leaving and/or entering CEO during qtr. } t)$

List of Commodities and Currencies

WTI Oil
Canadian Dollar (CAD)
Mexican Peso (MXN)
Chinese Yuan (CNY)
Euro / European Currency Unit
(EUR/XEU)
Japanese Yen (JPY)
Australian Dollar (AUD)
Hong Kong Dollar (HKD)

South Korean Wong (KRW)
New Zealand Dollar (NZD)
Norwegian Krone (NOK)
Swedish Krona (SEK)
Swiss Franc (CHF)
Taiwan Dollar (TWD)
Pound Sterling (GBP)

DRIVERS OF SHORT-RUN UNCERTAINTY

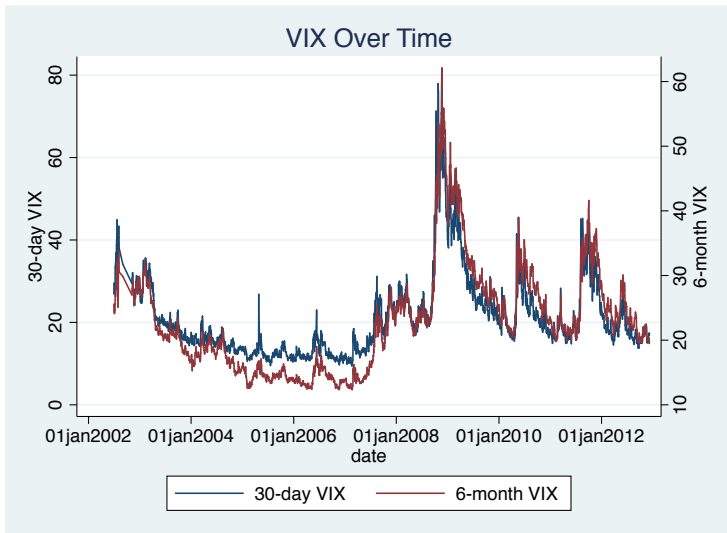|	(1)	(2)	(3)	(4)	(5)
Dependent Variable			log(30d IVOL)		
Economic Policy Unc. Exposure	0.147*				0.176**
	(0.0852)				(0.0873)
Oil Vol. Exposure		3.539***			3.070***
		(0.922)			(0.906)
Currency Vol. Exposure			0.0806**		0.0748**
			(0.0352)		(0.0329)
CEO Turnover				0.0259*	0.0249*
				(0.0146)	(0.0144)
Firm FE	Y	Y	Y	Y	Y
Date FE	Y	Y	Y	Y	Y
Observations	21,328	21,328	21,328	21,328	21,328
R-squared	0.888	0.888	0.887	0.887	0.889
Firms	1370	1370	1370	1370	1370

Robust standard errors in parentheses, clustered by firm. Firm-level implied volatility data from Optionmetrics. Economic Policy Uncertainty from Baker et al (2015). Exposure to oil and currencies constructed using CRSP data on stock returns, Bloomberg data on oil prices and exchange rates from 1985-1995, and implied volatility data for oil and currencies 2005-2013. CEO Turnover from Execucomp, is an indicator for whether there was a CEO taking office or stepping down during the quarter. Regressions with EPU exposure also control for federal spending as percent of GDP multiplied by firm-level exposure to government purchases. Regressions are weighted by employment at the firm level and restricted to 2-digit industries with significantly positive sensitivity to oil prices and to at least one currency. *** p<0.01, ** p<0.05, * p<0.1
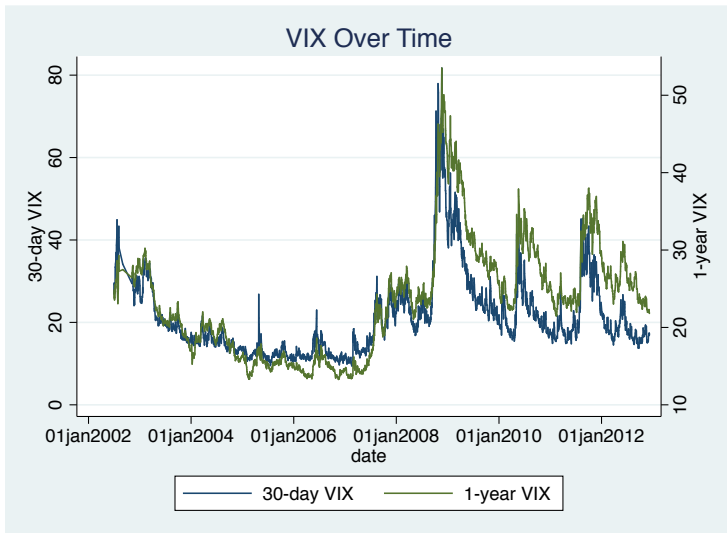
DRIVERS OF LONG-RUN UNCERTAINTY

	(1)	(2)	(3)	(4)	(5)
Dependent Variable			**log(6m IVOL)**		
Economic Policy Unc. Exposure	0.232***				0.262***
	(0.0863)				(0.0882)
Oil Vol. Exposure		2.344***			1.907**
		(0.768)			(0.811)
Currency Vol. Exposure			0.0708**		0.0715**
			(0.0298)		(0.0306)
CEO Turnover				0.0219*	0.0212*
				(0.0125)	(0.0122)
Firm FE	Y	Y	Y	Y	Y
Date FE	Y	Y	Y	Y	Y
Observations	21,328	21,328	21,328	21,328	21,328
R-squared	0.900	0.899	0.899	0.899	0.901
Firms	1370	1370	1370	1370	1370

Robust standard errors in parentheses, clustered by firm. Firm-level implied volatility data from Optionmetrics. Economic Policy Uncertainty from Baker et al (2015). Exposure to oil and currencies constructed using CRSP data on stock returns, Bloomberg data on oil prices and exchange rates from 1985-1995, and implied volatility data for oil and currencies 2005-2013. CEO Turnover from Execucomp, is an indicator for whether there was a CEO taking office or stepping down during the quarter. Regressions with EPU exposure also control for federal spending as percent of GDP multiplied by firm-level exposure to government purchases. Regressions are weighted by employment at the firm level and restricted to 2-digit industries with significantly positive sensitivity to oil prices and to at least one currency. *** p<0.01, ** p<0.05, * p<0.1

VIX Over Time

Notes: Daily VIX time series, by horizon. Source: Goldman Sachs.

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VIX Over Time

Notes: Daily VIX time series, by horizon. Source: Goldman Sachs.

FIRM IMPLIED VOLATILITY OVER TIME

Notes: Daily average of put and call implied volatilities from standardized options on XOM (Exxon-Mobil). Source: Optionmetrics.

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FIRM IMPLIED VOLATILITY OVER TIME

Notes: Daily average of put and call implied volatilities from standardized options on XOM (Exxon-Mobil). Source: Optionmetrics.

Firm Implied Volatility Over Time

Notes: Daily average of put and call implied volatilities from standardized options on XOM (Exxon-Mobil). Source: Optionmetrics.

DRIVERS OF SHORT- AND LONG-RUN UNCERTAINTY

	(1)	(2)	(3)	(4)	(5)
Dependent Variable	log(6m IVOL) - log(30d IVOL)				
Economic Policy Unc. Exposure	0.0757**				0.0810**
	(0.0317)				(0.0328)
Oil Vol. Exposure		-0.853***			-0.857**
		(0.283)			(0.335)
Currency Vol. Exposure			-0.00276		0.00189
			(0.00905)		(0.00785)
CEO Turnover				-0.00369	-0.00416
				(0.00571)	(0.00535)
Date Fixed Effects	Y	Y	Y	Y	Y
Firm Fixed Effects	Y	Y	Y	Y	Y
Observations	40,802	40,802	40,802	40,802	40,802
R-squared	0.499	0.500	0.499	0.499	0.501
Firms	2547	2547	2547	2547	2547

Robust standard errors in parentheses, clustered by firm in columns 1, 4, 5; by SIC-2 in columns 2, 3. Firm-level implied volatility data from Optionmetrics. Economic Policy Uncertainty from Baker et al (2015). Exposure to oil and currencies constructed using CRSP data on stock returns, Bloomberg data on oil prices and exchange rates from 1985-1995, and implied volatility data for oil and currencies 2005-2013. CEO Turnover from Execucomp, is an indicator for whether there was a CEO taking office or stepping down during the quarter. Regressions with EPU exposure also control for federal spending as percent of GDP multiplied by firm-level exposure to government purchases. Regressions are weighted by employment at the firm level. *** p<0.01, ** p<0.05, * p<0.1

SIC2 with Nonzero Sentivity to Oil & Currencies

SIC-2 Industries with Non-zero Sensitivity to Oil and Currencies	
SIC-2	Description
10	Metal Mining
13	Oil and Gas Extraction
22	Textile Mill Products
29	Petroleum Refining and Related Industries
32	Stone, Clay, Glass, and Concrete Products
35	Industrial and Commercial Machinery and Computer Equipment
36	Electronic and Other Electrical Equipment and Components, Exc. Computer Equipment
37	Transportation Equipment
42	Motor Freight Transportation and Warehousing
45	Transportation by Air
48	Communications
73	Business Services
80	Health Services

WHO HAS 30-DAY IMPLIED VOLATILITY?

	(1)	(2)	(3)	(4)	(5)	(6)
				OLS		
Dependent Variable			Non-missing 30-day Implied Volatility			
log(Quarterly Sales)	0.285***			0.234***	0.167***	0.149***
	(0.0139)			(0.0152)	(0.0166)	(0.00785)
Sales Growth		0.664**		0.404***	0.286***	0.355***
		(0.288)		(0.116)	(0.0832)	(0.0400)
Lagged log(91-day Realized Vol.)			-1.204***	-0.751***	-1.571***	-0.638***
			(0.0874)	(0.0988)	(0.117)	(0.0400)
Date Fixed Effects	N	N	N	N	N	Y
Firm Fixed Effects	N	N	N	N	N	Y
Years in Sample	2012	2012	2012	2012	2002	2000-2013
Standard Errors	Robust	Robust	Robust	Robust	Robust	Clustered by Firm
R-squared	0.061	0.005	0.033	0.078	0.102	0.298
Observations	8,718	8,718	8,718	8,718	6,348	95,619

Robust standard errors in parentheses, clustered by firm. Data is annual balance sheet information from Compustat and yearly average implied volatility on standardized options, taken from Optionmetrics. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

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WHO HAS 30-DAY IMPLIED VOLATILITY?

	(1)	(2)	(3)	(4)	(5)	(6)
				PROBIT		
Dependent Variable			**Non-missing 30-day Implied Volatitility**			
log(Quarterly Sales)	0.285***			0.234***	0.167***	0.149***
	(0.0139)			(0.0152)	(0.0166)	(0.00785)
Sales Growth		0.664**		0.404***	0.286***	0.355***
		(0.288)		(0.116)	(0.0832)	(0.0400)
Lagged log(91-day Realized Vol.)			-1.204***	-0.751***	-1.571***	-0.638***
			(0.0874)	(0.0988)	(0.117)	(0.0400)
Date Fixed Effects	N	N	N	N	N	Y
Years in Sample	2012	2012	2012	2012	2002	2000-2013
Standard Errors	Robust	Robust	Robust	Robust	Robust	Clustered by Firm
Observations	8,718	8,718	8,718	8,718	6,348	95,427

Robust standard errors in parentheses, clustered by firm. Data is annual balance sheet information from Compustat and yearly average implied volatility on standardized options, taken from Optionmetrics. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

WHO HAS 182-DAY IMPLIED VOLATILITY?

	(1)	(2)	(3)	(4)	(5)	(6)
				OLS		
Dependent Variable			Non-missing 6-month Implied Volatitility			
log(Quarterly Sales)	0.285***			0.234***	0.167***	0.149***
	(0.0139)			(0.0152)	(0.0166)	(0.00785)
Sales Growth		0.664**		0.404***	0.286***	0.355***
		(0.288)		(0.116)	(0.0832)	(0.0400)
Lagged log(91-day Realized Vol.)			-1.204***	-0.751***	-1.571***	-0.638***
			(0.0874)	(0.0988)	(0.117)	(0.0400)
Date Fixed Effects	N	N	N	N	N	Y
Firm Fixed Effects	N	N	N	N	N	Y
Years in Sample	2012	2012	2012	2012	2002	2000-2013
Standard Errors	Robust	Robust	Robust	Robust	Robust	Clustered by Firm
R-squared	0.061	0.005	0.033	0.078	0.102	0.298
Observations	8,718	8,718	8,718	8,718	6,348	95,619

Robust standard errors in parentheses, clustered by firm. Data is annual balance sheet information from Compustat and yearly average implied volatility on standardized options, taken from Optionmetrics. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

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WHO HAS 182-DAY IMPLIED VOLATILITY?

	(1)	(2)	(3)	(4)	(5)	(6)
			PROBIT			
Dependent Variable			**Non-missing 6-month Implied Volatitility**			
log(Quarterly Sales)	0.255***			0.223***	0.154***	0.163***
	(0.0127)			(0.0138)	(0.0144)	(0.00781)
Sales Growth		0.449**		0.334***	0.261***	0.333***
		(0.214)		(0.0974)	(0.0679)	(0.0342)
Lagged log(91-day Realized V			-0.907***	-0.436***	-1.141***	-0.445***
			(0.0744)	(0.0836)	(0.0940)	(0.0380)
Date Fixed Effects	N	N	N	N	N	Y
Years in Sample	2012	2012	2012	2012	2002	2000-2013
Standard Errors	Robust	Robust	Robust	Robust	Robust	Clustered by Firm
Observations	8,718	8,718	8,718	8,718	6,348	95,427

Robust standard errors in parentheses, clustered by firm. Data is annual balance sheet information from Compustat and yearly average implied volatility on standardized options, taken from Optionmetrics. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

Puts and Calls

Correlation: 30-day Put and Call Implied Volatility

	Average	Call	Put
Average	1		
Call	0.9958	1	
Put	0.9963	0.9851	1

Correlation: 182-day Put and Call Implied Volatility

	Average	Call	Put
Average	1		
Call	0.995	1	
Put	0.9956	0.9821	1

NOTES: Correlation of firm-quarter implied volatility figures based on puts, calls, and the average of the two.

Industry Heterogeneity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent Variable			log(CAPX/K)			
Lagged log(30d IVOL)	-0.253***		-0.223***	-0.336***		-0.341***
	(0.0781)		(0.0805)	(0.0342)		(0.0376)
Lagged log(6m IVOL)		-0.275***			-0.355***	
		(0.0848)			(0.0379)	
Lagged log(6m IVOL)-log(30d IVOL)			0.281***			-0.0305
			(0.106)			(0.0691)
Lagged log(30d IVOL)*K-intensity	-0.00948		-0.0238			
	(0.0154)		(0.0158)			
Lagged log(6m IVOL)*K-intensity		-0.00783				
		(0.0166)				
(Lagged log(6m IVOL)-log(30d IVOL))*K-intensity			-0.00183***			
			(0.000424)			
Lagged log(30d IVOL)*R&D-intensity				0.0377***		0.0338**
				(0.0112)		(0.0133)
Lagged log(6m IVOL)*R&D-intensity					0.0452***	
					(0.0127)	
(Lagged log(6m IVOL)-log(30d IVOL))*R&D-intensity						-0.000496
						(0.000614)
First Moment Controls (Tobin's Q, Cash Flow/Assets, Proportional Sales Growth)	YES	YES	YES	YES	YES	YES
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Date Fixed Effects	YES	YES	YES	YES	YES	YES
Observations	97,732	97,732	97,732	89,588	89,588	89,588
R-squared	0.405	0.405	0.405	0.400	0.400	0.400
Firms	4521	4521	4521	4220	4220	4220

Robust standard errors in parentheses, clustered by firm. Balance sheet information from Compustat North America Annual. Implied volatility data is from Optionmetrics, and is lagged to reflect quarterly average implied vol. for the last quarter of the previous fiscal year. Capital- and R&D-intensity respectively measured as the log of mean Capital/Worker or RDX/Worker by SIC-2 industry. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1

AGGREGATE VOL: QUARTERLY CAPITAL INVESTMENT

Dependent Variable	-1	(2)	(3)	(4)	(5)
			log(CAPX/K)		
Lagged log(S&P500 30d IVOL)	-0.444***	-0.0516*	-0.0955***	-0.0905***	-0.0731***
	(0.0241)	(0.0303)	(0.0278)	(0.0277)	(0.0267)
Lagged log(S&P500 6m IVOL) - log(S&P500 30d IVOL)	-1.021***	-0.686***	-0.718***	-0.711***	-0.588***
	(0.0687)	(0.0698)	(0.0657)	(0.0654)	(0.0637)
Lagged Tobin's Q			0.147***	0.144***	0.116***
			(0.00504)	(0.00503)	(0.00476)
Cash Flow/Assets				1.369***	1.021***
				(0.128)	(0.123)
Proportional Sales Growth					1.274***
					(0.0550)
Lagged Chicago Fed National Activity Index		0.00544	0.0183**	0.0179**	0.00252
		(0.00893)	(0.00865)	(0.00864)	(0.00829)
Lagged Default Spread		-0.359***	-0.227***	-0.231***	-0.198***
		(0.0200)	(0.0183)	(0.0182)	(0.0177)
Lagged Term Spread		0.0900***	0.0172	0.0188	0.0209
		(0.0186)	(0.0183)	(0.0182)	(0.0177)
Firm Fixed Effects	YES	YES	YES	YES	YES
Observations	97,733	97,733	97,733	97,733	97,733
R-squared	0.318	0.332	0.365	0.367	0.390
Firms	4522	4522	4522	4522	4522

Robust standard errors in parentheses, clustered by firm. Balance sheet information from Compustat North America Annual. Implied volatility data is from Optionmetrics and is lagged to reflect quarterly average implied vol. for the last quarter of the previous fiscal year. All variables are winsorized at the 1st and 99th percentiles. *** $p<0.01$, ** $p<0.05$, * $p<0.1$

AGGREGATE VOL: PPENT/EMP GROWTH

	(1) PPENT Growth	(2) Employment Growth	(3) PPENT Growth	(4) Employment Growth	(5) PPENT Growth	(6) Employment Growth
Dependent Variable						
Lagged log(S&P500 30d IVOL)	-0.0527***	-0.00246	-0.00375	0.0440***	-0.0223**	0.0254***
	(0.00917)	(0.00689)	(0.0109)	(0.00829)	(0.00919)	(0.00673)
Lagged log(S&P500 6m IVOL) - log(S&P500 30d IVOL)	0.0140	0.205***	-0.0658**	0.124***	-0.0989***	0.0658***
	(0.0297)	(0.0232)	(0.0296)	(0.0232)	(0.0261)	(0.0203)
Lagged Tobin's Q					0.0422***	0.0211***
					(0.00234)	(0.00149)
Cash Flow/Assets					0.193***	0.0832***
					(0.0336)	(0.0247)
Proportional Sales Growth					0.482***	0.546***
					(0.0297)	(0.0289)
Lagged Chicago Fed National Activity Index			0.0403***	0.0429***	0.0265***	0.0272***
			(0.00468)	(0.00374)	(0.00444)	(0.00354)
Lagged Default Spread			-0.00777	-0.00750	0.0324***	0.0177***
			(0.00811)	(0.00643)	(0.00759)	(0.00602)
Lagged Term Spread			-0.00760	0.0352***	-0.0401***	0.0101
			(0.00905)	(0.00743)	(0.00851)	(0.00684)
Firm Fixed Effects	YES	YES	YES	YES	YES	YES
Observations	20,132	20,132	20,132	20,132	20,132	20,132
R-squared	0.296	0.293	0.305	0.308	0.414	0.439
Firms	3416	3416	3416	3416	3416	3416

Robust standard errors in parentheses, clustered by firm. Balance information from Compustat North America Annual. Implied volatility data is from Optionmetrics and is lagged to reflect quarterly average implied vol. for the last quarter of the previous fiscal year. All variables are winsorized at the 1st and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1