Does Uncertainty Matter?
A Competing Risks Analysis of Investment in Petroleum Refining Industry

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Outline

- Introduction
- Investment in the Refining Industry
- Measuring Uncertainty
- The Competing Risks Framework and Empirical Findings
- Conclusion

The only thing certain is that uncertainty will remain.

Introduction

- Energy Economics Examples
  - When natural gas price increases, drilling activity may not follow.
  - When refining margin rises, investment in the refining industry may not increase (*as it is NOW*).
- Policy Implications
  - The effectiveness of policies designed to influence investment may be affected by uncertainty.

Introduction

- A hot debate in the literature
- Theories have contradictory predictions
  - Positive

  Hartman (1972), Abel (1983), Abel and Eberly (1994).
  - Negative

  McDonald & Siegel (1986), Pindyck (1988), Dixit and Pindyck (1994)
  - Positive for perfect competition, negative for oligopoly. Caballero (1991)

Introduction

- Empirical evidence
  - General consensus using macro data
  - Less conclusive using micro data
- Two challenges to empiricists
  - How should uncertainty be captured?
  - How should the economic value of capital and investment be measured?

Introduction

- Accounting data rarely allows a researcher to correctly measure the economic value of capital.
  - Economic depreciation rate
  - Many investments are for replacement

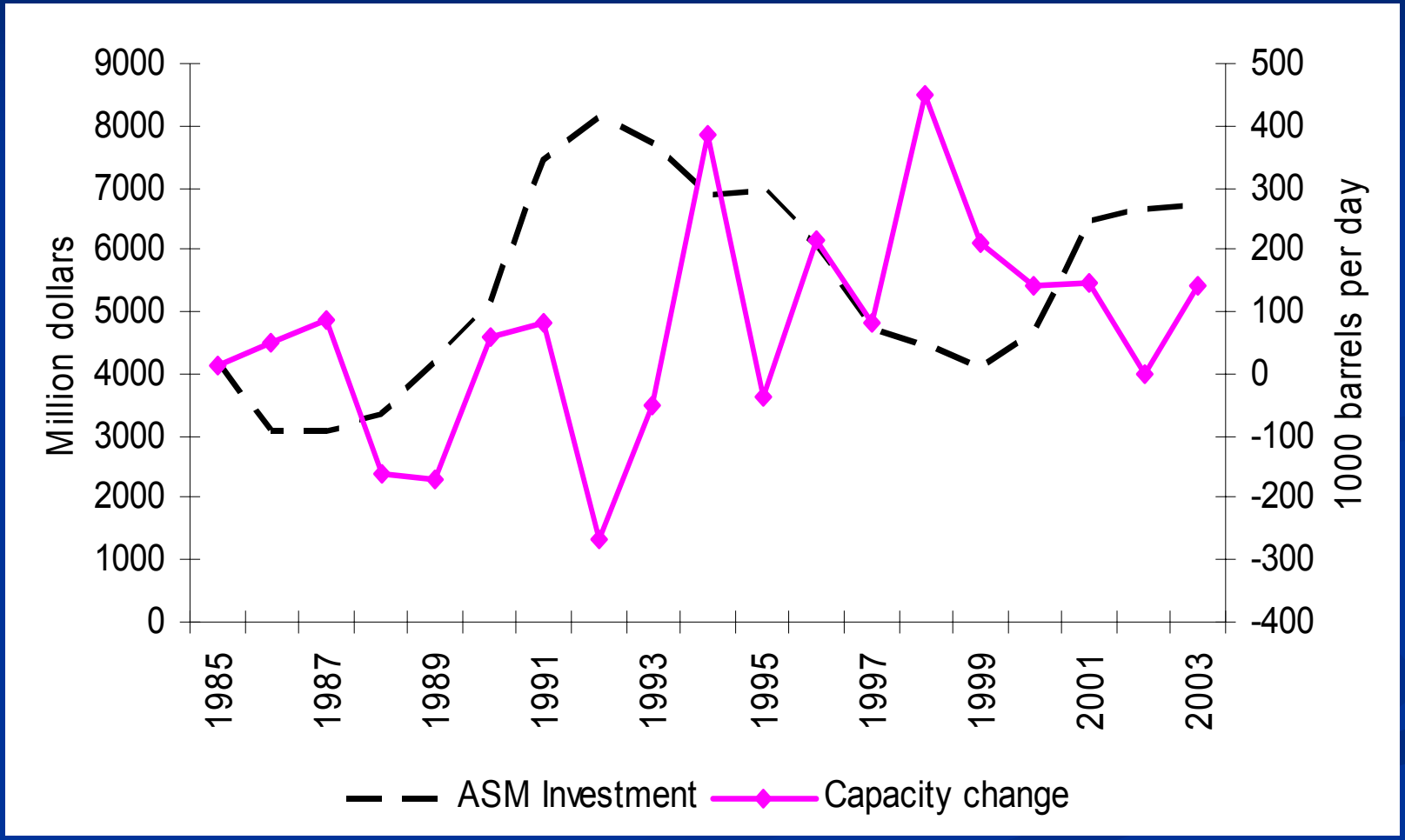
"The empirical investment literature is full of disappointments. … There are at least as complex, and perhaps insurmountable data problems. Both right- and left-hand side variables are seldom measured properly."

---- Caballero, Engle and Haltiwanger (1995)

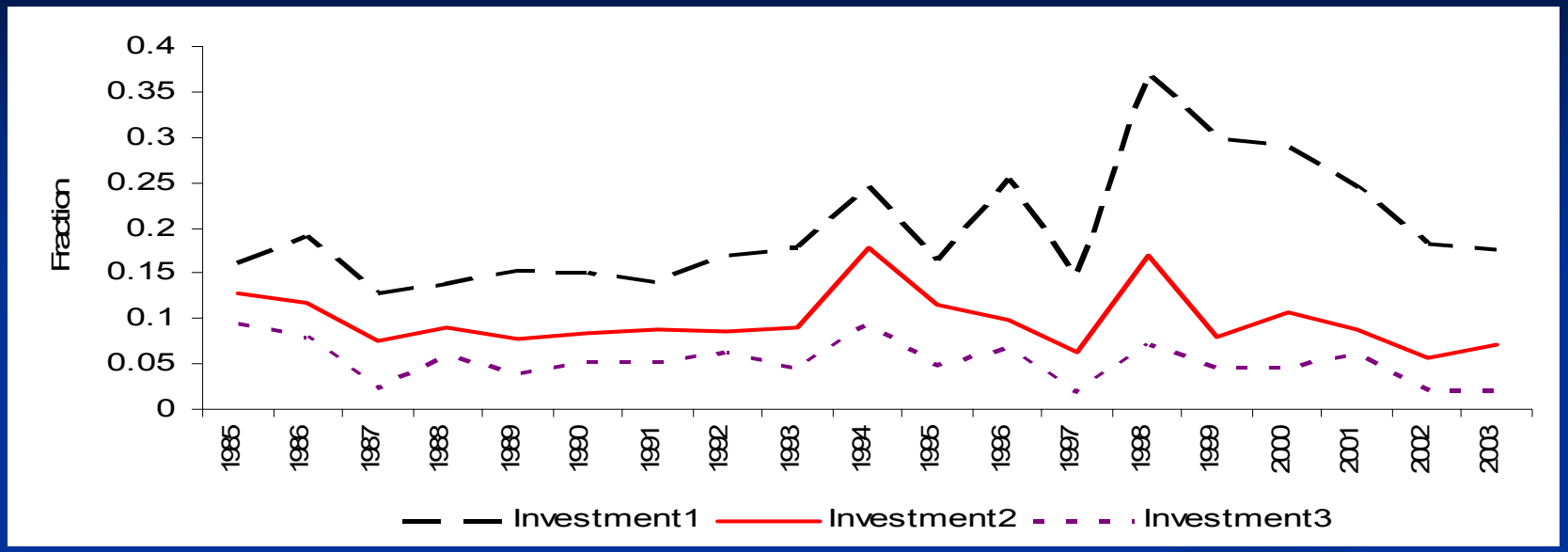
Introduction

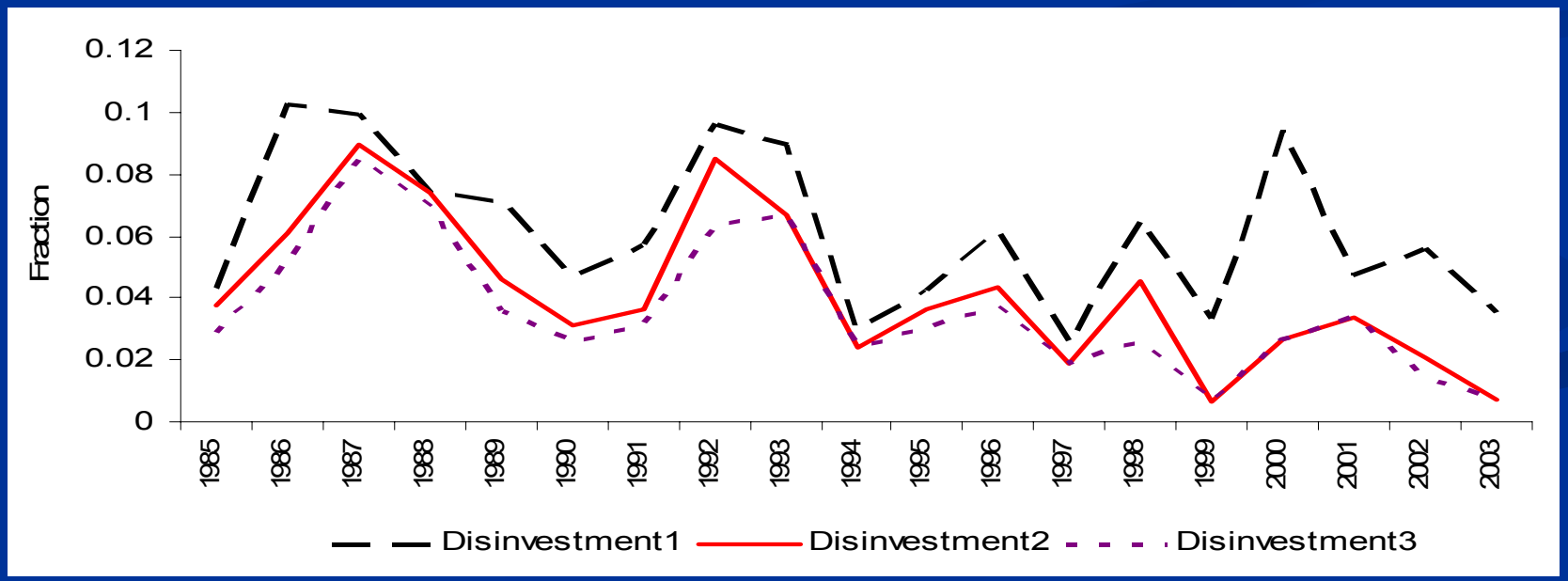
- This paper confronts these problems by studying investment in the refining industry.
  - Construct uncertainty measures from forward refining margins
  - Use capacity change to measure investment rather than relying on account data

Aggregate Investment

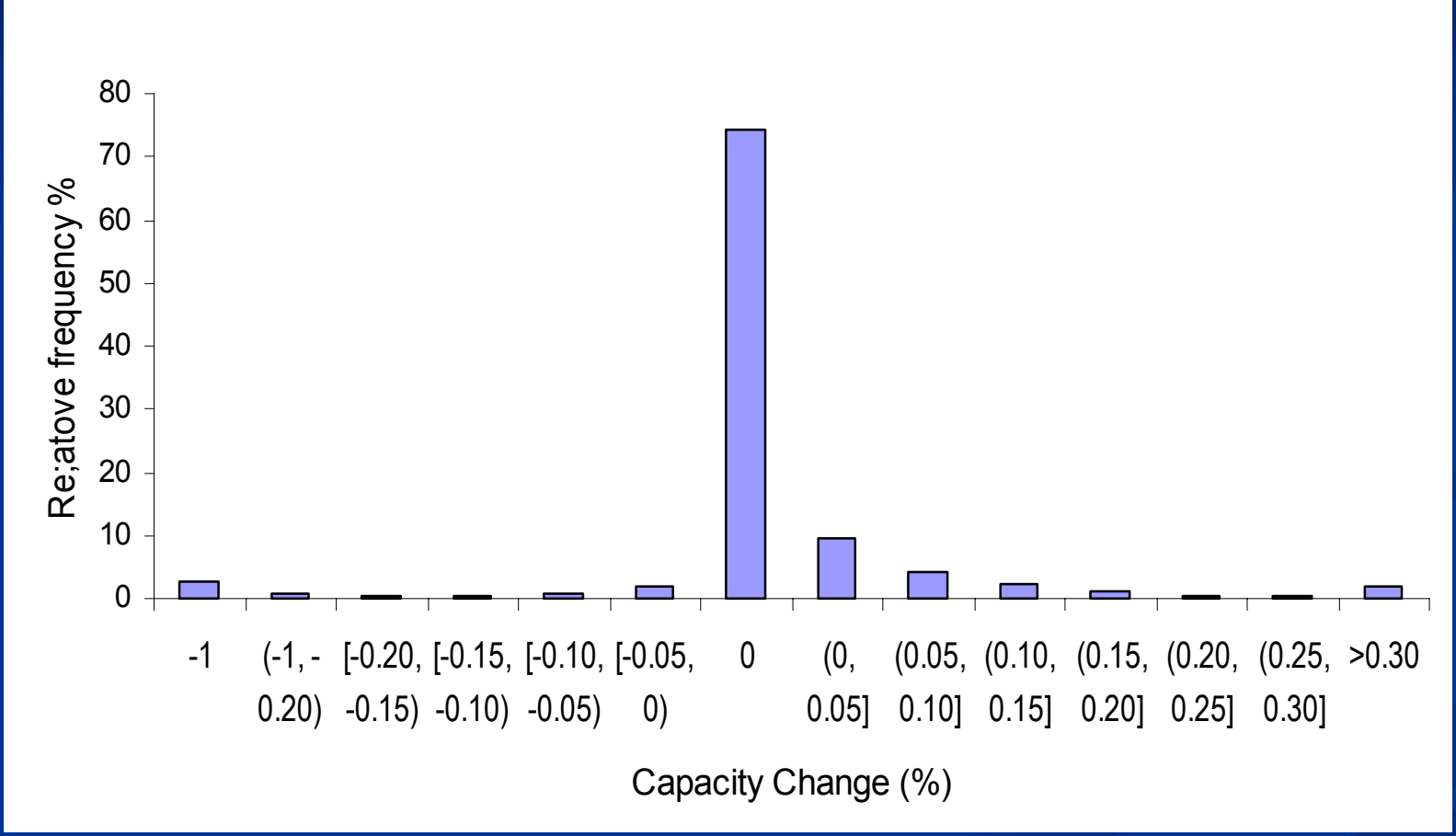


Fraction of Investment



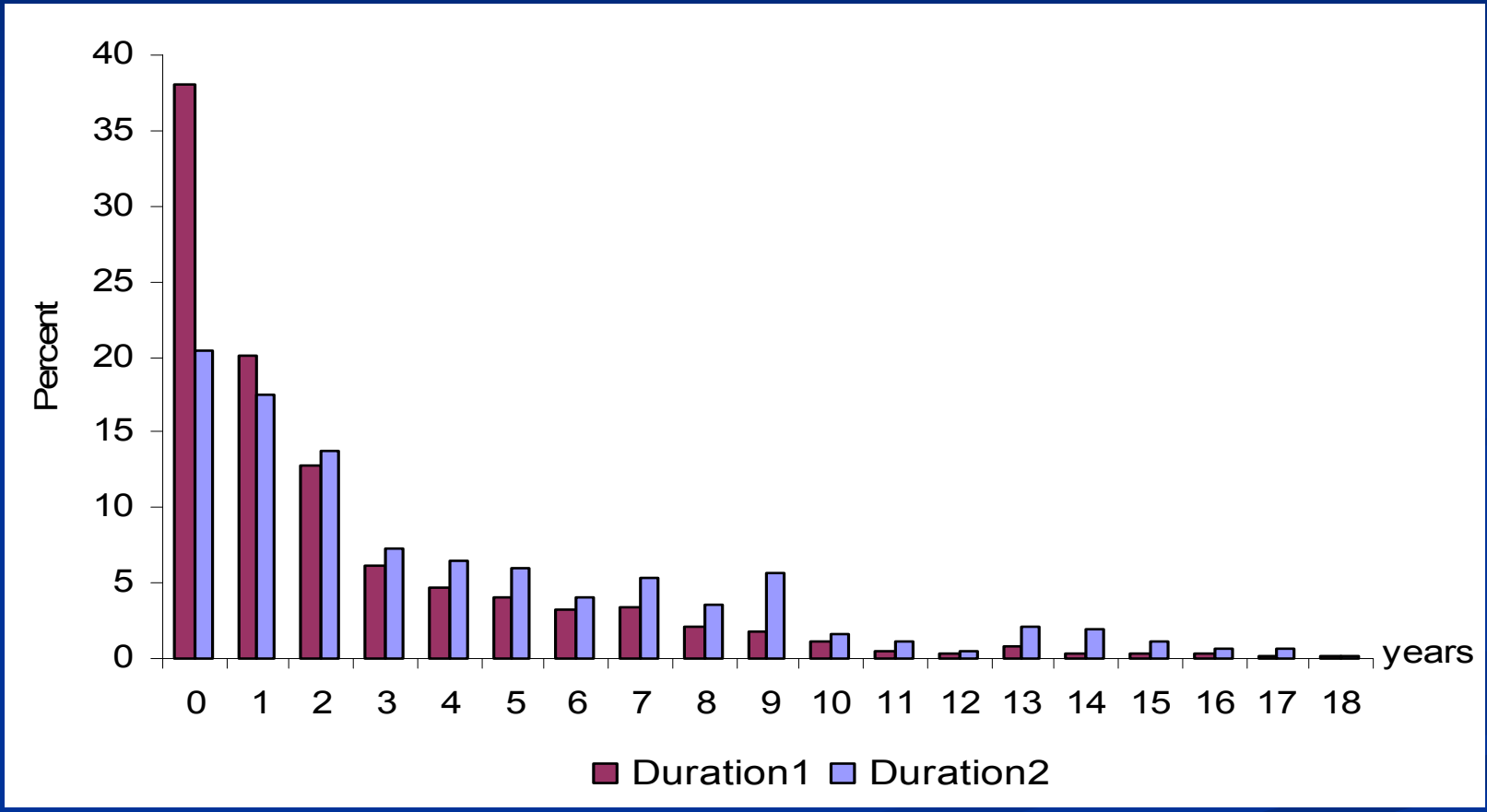


Refinery Capacity Change Distribution



Total number of observations (refinery-year): 3324.
The far left bar (-1) represents complete shut-down refineries.

Distribution of Durations between Two Capacity Changes



Duration1: Years of duration between two capacity changes with zero threshold.
Duration2: Years of duration between two capacity changes with 5% threshold.

Measuring Uncertainty

- Uncertainty is subject to investors' mental judgment about the distribution of future returns.
  - Forward-looking
  - Corresponds to future profitability
  - Subjective
- We construct uncertainty measures from forward refining margins.
  - Ma (1989): On average futures markets outperform econometric (time series) models for all the three petroleum commodities.
  - Fujihara and Mougoue (1997): Petroleum futures markets are weak form efficient.

Measuring Uncertainty

- Daily forward refining margin

$$FRM_t = 2*F_{GO}^{T,t} + 1*F_{HO}^{T,t} - 3*F_{CO}^{T,t}$$

Daily close price of NYMEX with 6 months maturity

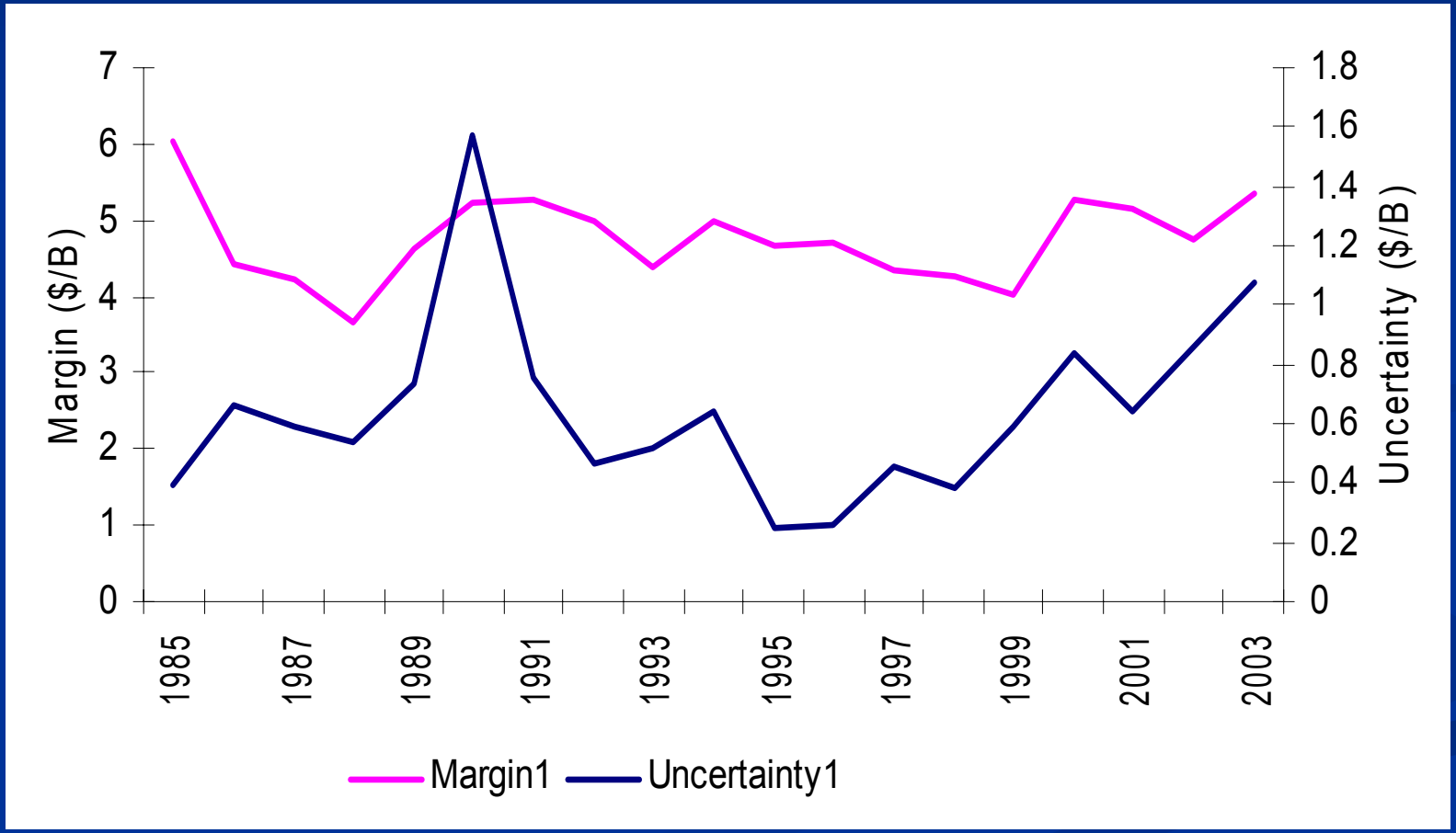
- Annual Margin

$$Margin = \left(\sum_{i=1}^{N} FRM^t\right) / N$$

and $$Uncertainty = \sqrt{\frac{\sum_{n=1}^{N} (FRM^t - MARGIN)^2}{N-1}}$$

Where N is the number of trading days in a year.

Forward Refining Margin and Uncertainty Measure



The Competing Risks Framework

- Focus on the effect of uncertainty on the timing of investment.
- Hazard: the conditional probability that a refinery will invest or disinvest given it stays in inaction until *t*
  - Survival variable: Duration of a refinery staying in inaction
  - Two competing risks: investment and disinvestment
  - Proportional hazard
  - Shared frailty

$$\lambda(t, x, \beta, \lambda_0) = \exp(x'\beta)\lambda_0(t)\nu$$

The Competing Risks Framework

- Baseline hazard: Weibull $\lambda_0(t) = \rho t^{\rho-1}$
  - $\rho > 1$, positive duration dependence.
  - $\rho = 1$, constant hazard, no duration dependence.
  - $\rho < 1$, negative duration dependence.
- Other control variables
  - Capacity utilization rate
  - Ownership change
  - Dummy for small refineries

Estimation Result with 5% Threshold

	Investment	Disinvestment
Margin1	0.187* (0.104)	-0.192 (0.148)
Uncertainty1	-0.543*** (0.207)	-0.707** (0.354)
Urate	-0.012 (0.010)	-0.069*** (0.016)
Ownchg	-0.036 (0.205)	0.007 (0.331)
Small	-0.406*** (0.157)	2.248*** (0.299)
ρ (H_0: ρ=1)	1.187*** (0.060)	1.505*** (0.116)
LR test (H0: θ=0)	16.65***	12.03***
No of spells	546	288
Log likelihood	-694.48	-319.68

Estimation Result with 5% Threshold

	Investment	Disinvestment
Margin2	0.267*** (0.102)	0.025 (0.143)
Uncertainty2	-0.822*** (0.266)	-0.679* (0.411)
Urate	-0.011 (0.010)	-0.067*** (0.016)
Ownchg	-0.064 (0.205)	-0.030 (0.331)
Small	-0.412*** (0.159)	2.312*** (0.303)
ρ (H_0: ρ=1)	1.209** (0.060)	1.521*** (0.113)
LR test (H0: θ=0)	18.23***	13.68***
No. of spells	546	288
Log likelihood	-692.91	-322.00

Estimation Result with 5% Threshold

	Investment	Disinvestment
Margin2	0.268*** (0.102)	0.024 (0.143)
Uncertainty2	-0.695** (0.277)	-1.351*** (0.461)
Urate	-0.012 (0.010)	-0.066*** (0.016)
Ownchg	-0.082 (0.205)	0.025 (0.333)
Small	-0.488*** (-2.92)	2.732*** (0.326)
Integ*Uncertainty2	-0.359 (0.244)	1.687*** (0.390)
ρ (H_0: ρ=1)	1.211*** (0.06)	1.530*** (0.113)
χ^2	17.54***	13.20***

Conclusion

- Uncertainty measures have a significantly negative impact on refiners decision to invest.
  - Robust to investment thresholds and uncertainty measures.
  - Support theories emphasizing irreversibility.
- Main contributions
  - Uncertainty measures
    - Constructed from forward market
    - Reflects uncertainties in both I/O prices
  - Capacity changes to measure investment episodes.
  - Investment episodes are lumpy, supportive of non-convex costs of K adjustment.