

# Paralyzed by Fear: Rigid and Discrete Pricing under Demand Uncertainty

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# New theory of price rigidity

1. Key assumption: firms face Knightian uncertainty about their demand

$$q_t(p_t) = x(p_t) + z_t$$

- multiple priors differ in mean function  $m(p)$

$$m(p) \in [-\gamma - bp, \gamma - bp]$$

$$m'(p) \in [-p - \delta, -b + \delta]$$

- worst case scenario drives firm behavior
- *as-if* kink in profit function
- inaction region

## Additional elements

1. Learning from realized prices
  2. Forward looking: strategic price posting
- Even with information acquisition, the Knightian uncertainty of the world may be not “learnable”

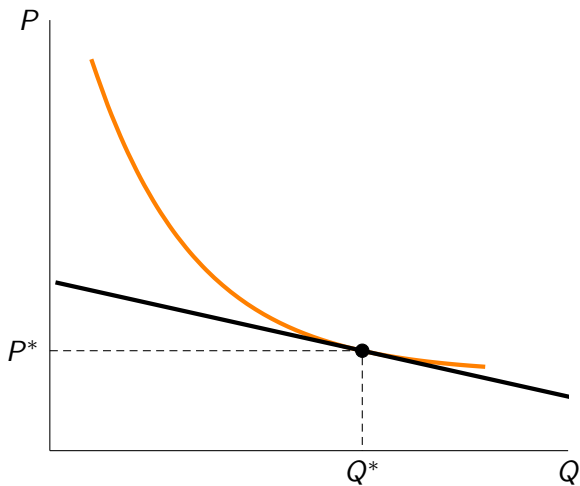
# Build a quantitative model

- New layer: industry
- uncertain about competitive environment: (1) industry level demand (2) own demand
  - (perceives link between industry and aggregate prices as ambiguous - periodic survey of industry price)
  - industry price affects firm (1) within industry - relative price (2) across industry - demand shifter

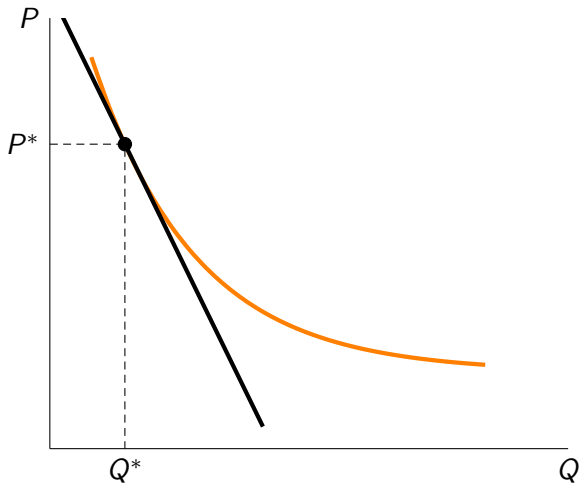
# Rich set of empirical implications

- Validate model empirically with price data
  1. memory in prices
  2. co-existence of small and large price changes
  3. product's life-cycle
  4. downward-sloping hazard function of price changes
  5. a price with a positive demand innovation is less likely to change
- Model implies persistent monetary non-neutrality

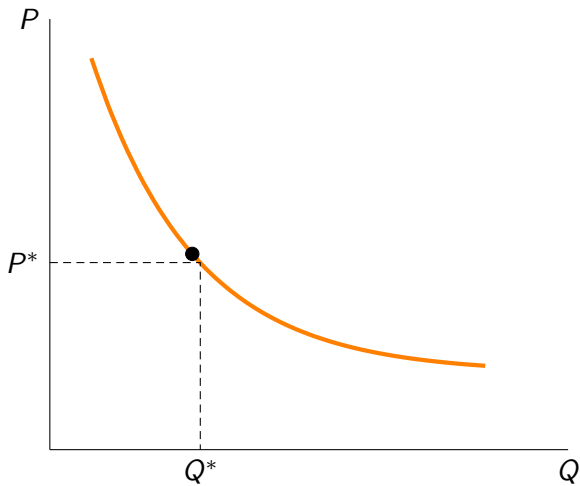
## Isoprofit curve – elastic demand



## Isoprofit curve – inelastic demand

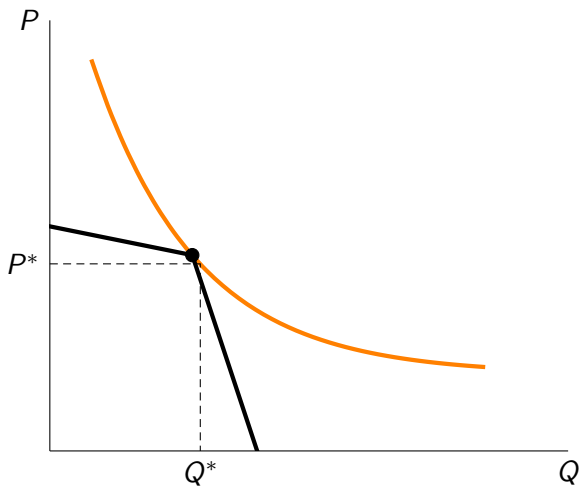


# Rosen's firm



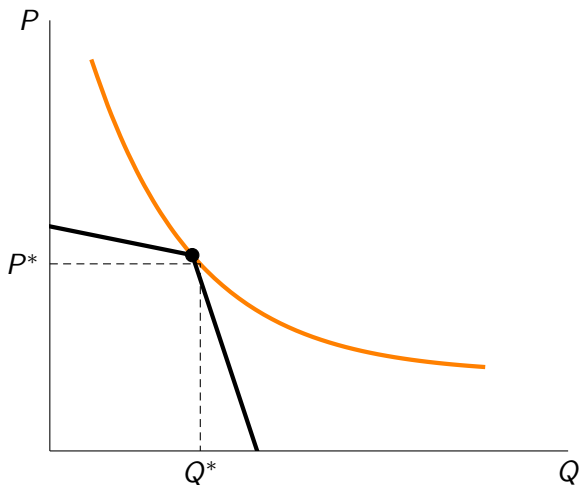


## Isoprofit curve – kinked worst case demand



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- **Learning:** more kinks at previous prices: firm inclined to repeat a price it has already seen in the recent past

## Forward looking firms - experimentation

$$K(p, p_t) = \sigma_x^2 e^{-\psi(p-p_t)^2}$$

- future worst-case expected demand depends on  $p_t, q_t(p_t)$
- firm can choose  $p_t$  to obtain new information
- ...also to minimize the effect on future profit (decrease future signal precision) after bad signal
  
- Similar to multi-arm-bandit: exploitation vs exploration
- Exploration motives are endogenous ( $\psi > 0$ )
- ... but future  $p_{t+k}$  also....(intractable problem, assume firm only considers  $p_t$ )

*Hauk, Lanteri, Marcet 2019*

- Observed signals are endogenous to policy ✓
- Signal extraction and policy has to be determined jointly

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$$s = h(\tau, A)$$

random variables  $A$  not observed.

Find policy function

$$\tau = \mathcal{R}(s)$$

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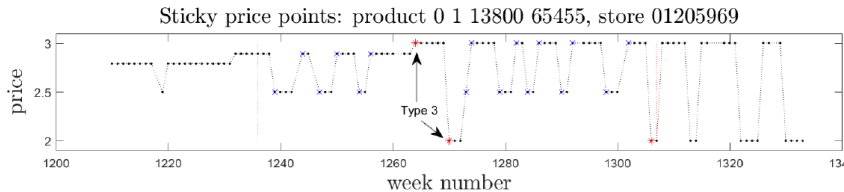
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## Some parallel results in *Costain, Nakov, Riva 2019*

- Firms tend to revisit a previous price
- Mechanism: lower control cost of an already visited price





# Data on Knightian firms – Business Tendency Survey (CESifo)

- Survey give firms an option to express expectations about their future sales growth with
  1. probabilities (70 – 80% )
  2. probability intervals (75% at least once in 4 years)
- Pricing differences Bayesian vs Knightian firms
- Switchers

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- *Bachmann, Carstensen, Lautenbacher, Schneider 2019*
  - Knightian responses more prevalent for small firms ↔ Rosen: young product-store more willing to experiment
  - Firms with low capacity utilization – Rosen: more likely to change price after bad demand shock
  - Knightian responses more prevalent after big macro shocks (Greek crises)

# Data on Knightian firms – Textual Analysis

- *Friberg, Seiler 2016*: 10-k statements
  1. probabilities: “variance”, “volatility”, “frequently”
  2. uncertainty
    - subjective probability: “believe”, “perhaps”
    - ambiguous outcomes: “ambiguous”, “indeterminate”
    - “sudden”, “unforeseen”
- Knightian: high-tech, drastic technological shock