OHAD KADAN AND ASAF MANELA
ESTIMATING THE VALUE OF INFORMATION

Discussion by **Jaroslav Borovička (NYU)**

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WHAT IS THE VALUE OF INFORMATION?

Value of being able to adjust choices to improve individual outcomes

- conventional measures: (abnormal) returns, profits
- based on ex-post measurement, including random 'luck'

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Required

- a model of equilibrium prices, probabilities and stochastic discount factor

IMPORTANCE

Massive! Covers key roles of the financial sector.

- **Incentives to produce information**
  - fundamental analysis, ...
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  - insider trading, ...

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Existing work

- Large theoretical literature
- Some reduced-form empirical work
- Combining theory with detailed empirics is hard.

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- general equilibrium asset pricing model of information production
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Once obtained

- Think about incentives to produce information, etc.

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- data-generating **probability measure**
- **stochastic discount factor**
- $\implies$ **prices** of traded assets (Arrow–Debreu securities)

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- receives an **imperfect signal** about next period state
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'Partial equilibrium' argument

- she is the only one who observes the signal
- her trades do not move equilibrium prices
- nobody else can infer anything from her behavior

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- Markov state of the world z_t
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Prices

- Equilibrium stochastic discount factor $m\left(z_t, z_{t+1}\right)$
- Prices of Arrow–Debreu securities

$$q\left(z_{t+1}|z_t\right) = m\left(z_t, z_{t+1}\right) p\left(z_{t+1}|z_t\right)$$

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$$q\left(z_{t+1}|z_t\right) = m\left(z_t, z_{t+1}\right) p\left(z_{t+1}|z_t\right)$$

Signal s_t at time t about state z_{t+1}: distribution $\alpha\left(s_t|z_{t+1}\right)$

$$\text{Bayes law: } p_\alpha\left(z_{t+1}|s_t, z_t\right) = \frac{\alpha\left(s_t|z_{t+1}\right) p\left(z_{t+1}|z_t\right)}{p_\alpha\left(s_t|z_t\right)}$$

Atomistic agent optimally makes

- a **consumption-saving decision** c_t
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to maximize utility (Epstein–Zin preferences)

$$V(a_t, z_t, s_t) = \max_{c_t, w_t} \left\{ (1-\beta)\, c_t^{1-\rho} + \beta E_t \left[V(a_{t+1}, z_{t+1}, s_{t+1})^{1-\gamma} \right]^{\frac{1-\rho}{1-\gamma}} \right\}^{\frac{1}{1-\rho}}$$

subject to

$$a_{t+1} = (a_t - c_t)(w_t \cdot R_t)$$

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Compare value functions with and without signal being available.

Inputs

- choice of the Markov state z_t (**S&P 500 index**)
- events with informative signals s_t (**releases of macro indicators**)
- prices of Arrow–Debreu securities $q\left(z_{t+1}|z_t\right)$ (from **option prices**)

Prices of Arrow–Debreu securities (state prices) $q\left(z_{t+1}|z_t\right)$

- from S&P 500 index European options (Breeden, Litzenberger (1978))
- smoothing using a parametric Carr, Wu (2010) model
- discretization of the state space as in Ross (2015)

Pretty standard in the literature

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Use asset price data

- before the release of macro indicator $q\left(z_{t+1}|z_t\right)$
- after the release of macro indicator $q\left(z_{t+1}|z_t, s_t\right)$

This is a hard problem!

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1) parametric specification of preferences/stochastic discount factor

- CRRA/Epstein–Zin preferences, iid growth and returns

$$m\left(z_t, z_{t+1}\right) \propto \exp\left(-\gamma R_p\left(z_{t+1}\right)\right)$$

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$$m\left(z_t, z_{t+1}\right) \propto \exp\left(-\gamma R_p\left(z_{t+1}\right)\right)$$

2) nonparametric specification

- separable stationary marginal utility (Ross (2015))

$$m\left(z_t, z_{t+1}\right) = \delta \frac{\bar{m}\left(z_{t+1}\right)}{\bar{m}\left(z_t\right)}$$

- solution to a Perron–Frobenius problem

Infer the transition probabilities $p\left(z_{t+1}|z_t\right)$ and $p_\alpha\left(z_{t+1}|s_t, z_t\right)$ as

$$\frac{q\left(z_{t+1}|z_t\right)}{m\left(z_t, z_{t+1}\right)}$$

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- using price data before and after the information release.

Construct two value functions

- **Uninformed agent**: Trades at prices $q\left(z_{t+1}|z_t\right)$ under beliefs $p\left(z_{t+1}|z_t\right)$
- **Informed agent**: Trades at prices $q\left(z_{t+1}|z_t\right)$ under beliefs $p_\alpha\left(z_{t+1}|z_t, s_t\right)$

Compare value functions to infer the value of information

COMMENTS

1. Sensitivity of results to changes in preference parameters
   - How to pin down these preference parameters?
2. Estimation of the data-generating probability
   - Recovery?
   - Nonparametric methods
   - Other sources of information
3. Equilibrium considerations

Table 2: **Estimated Value of Information as Percent of Wealth: Power U Recovery**

	$RRA = 5 = 1/EIS$			$RRA = 1 = 1/EIS$			$RRA = 5,\ EIS = 0.90$			
Event	$\hat{\Omega}$	$se(\hat{\Omega})$	$\tilde{\Omega}$	$\hat{\Omega}$	$se(\hat{\Omega})$	$\tilde{\Omega}$	$\hat{\Omega}$	$se(\hat{\Omega})$	$\tilde{\Omega}$	obs
GDP	1.23	(0.51)	1.23	94.00	(3.90)	94.00	7.49	(2.99)	7.49	222
Unemployment	1.13	(0.41)	1.13	89.94	(4.72)	89.94	6.83	(2.43)	6.83	218
Jobless Claims	1.51	(0.27)	1.51	93.79	(2.30)	93.79	9.13	(1.52)	9.13	940
Pre-FOMC	1.53	(0.98)	1.53	95.77	(5.18)	95.94	9.42	(5.93)	9.42	147
FOMC	0.84	(0.68)	0.84	95.73	(3.96)	95.19	5.66	(4.21)	5.66	147
Morgtage App.	2.49	(0.59)	2.49	96.51	(2.18)	96.51	14.67	(3.29)	14.67	596
Consumer Comf.	2.10	(0.46)	2.10	96.54	(2.04)	96.54	12.23	(2.47)	12.23	600

Results heavily depend on preference parameters (we don't agree on them!)

- **low risk aversion** / **high IES** allow to take advantage of knowing the signal

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How to discipline the preference parameters?

- portfolio positions, volume of trade
- it would be useful to see implied portfolio decisions and saving choices

WHY DO WE NEED THE DATA-GENERATING PROBABILITY MEASURE?

Arrow–Debreu prices $q\left(z_{t+1}|z_t\right)$ reflect risk-adjusted probabilities of alternative states.

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- Alvarez, Jermann (2004) — use asset prices to infer the cost of business cycles
  - see also Otrok (2001), Croce (2013)
- Feldman et al. (2016) — use $q(z_{t+1}|z_t)$ to study the welfare impact of monetary policy

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The data-generating probability measure is needed to infer informativeness of the signal.

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- Borovička, Hansen, Scheinkman (2016)— given arbitrary $h(z_t, z_{t+1})$ with mean one:

$$q(z_{t+1}|z_t) = m(z_t, z_{t+1})\, p(z_{t+1}|z_t)$$

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- Borovička, Hansen, Scheinkman (2016)— given arbitrary $h(z_t, z_{t+1})$ with mean one:

$$q(z_{t+1}|z_t) = m(z_t, z_{t+1})\, p(z_{t+1}|z_t) = \underbrace{\frac{m(z_t, z_{t+1})}{h(z_t, z_{t+1})}}_{\widetilde{m}(z_t, z_{t+1})} \underbrace{[h(z_t, z_{t+1})\, p(z_{t+1}|z_t)]}_{\widetilde{p}(z_{t+1}|z_t)}$$

- $\widetilde{p}(z_{t+1}|z_t)$ is a valid probability measures
- $\widetilde{m}(z_t, z_{t+1})$ is a valid stochastic discount factor

What can be done?

- pick form of preferences $\implies$ determine $m\left(z_t, z_{t+1}\right)$
- determine

$$p\left(z_t, z_{t+1}\right) = \frac{q\left(z_{t+1}|z_t\right)}{m\left(z_t, z_{t+1}\right)}$$

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- authors try two forms
  - **recursive/CRRA preferences** with a given relative risk aversion γ and **iid growth**

$$m\left(z_t, z_{t+1}\right) \propto \exp\left(-\gamma R_p\left(z_{t+1}\right)\right)$$

  - **separable preferences** in **stationary environment** (Ross (2015))

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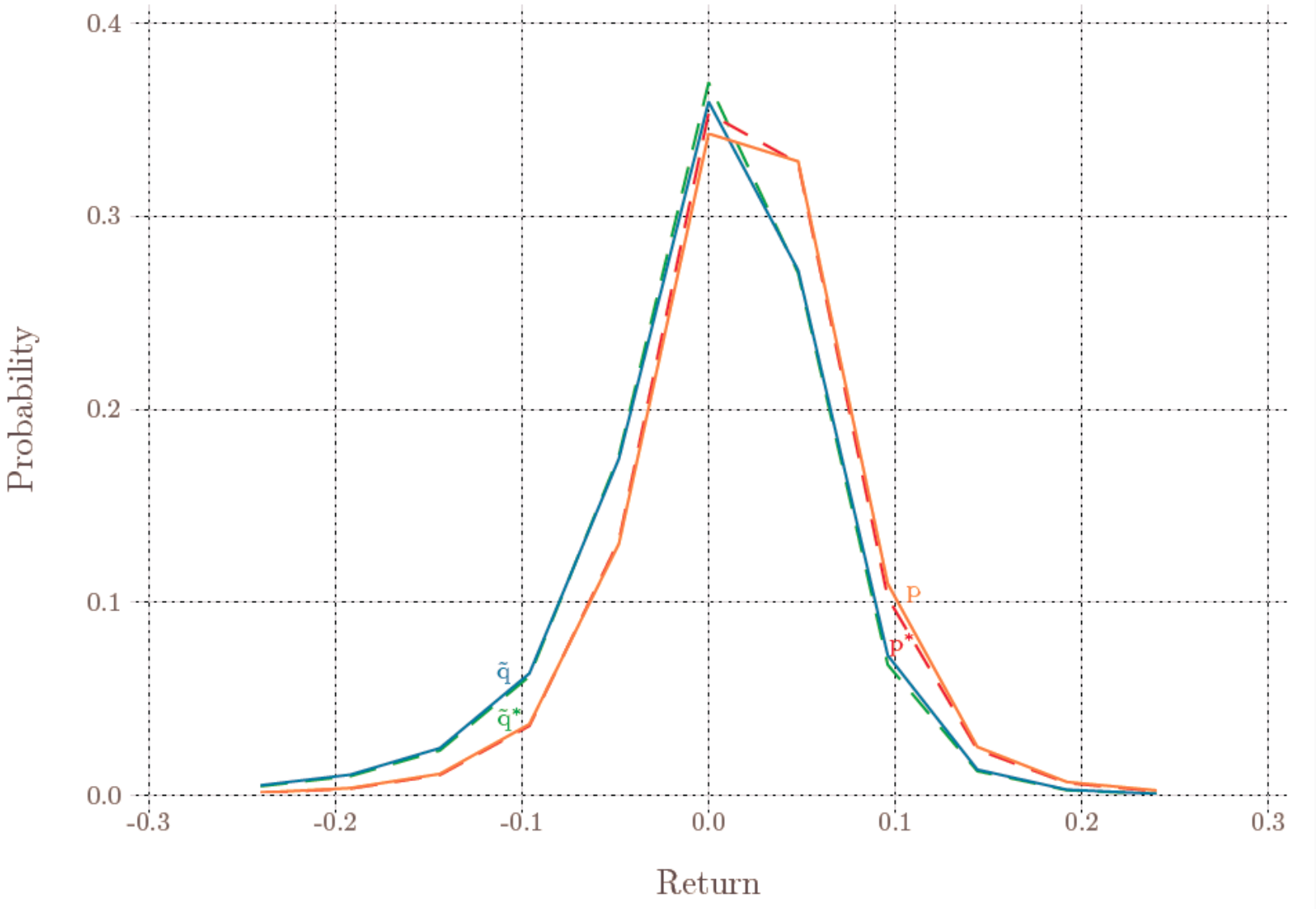

Figure 5: **Prior vs. Posterior Probabilities around Unemployment Releases**

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Table 3: **Estimated Value of Information as Percent of Wealth: Ross Recovery**

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GDP	2.72	(0.58)	2.72	97.40	(2.48)	97.40	15.38	(3.04)	15.38	222
Unemployment	3.08	(0.47)	3.08	99.16	(0.45)	97.35	17.29	(2.38)	17.29	218
Jobless Claims	2.75	(0.30)	2.75	97.82	(1.34)	97.82	15.61	(1.59)	15.61	940
Pre-FOMC	3.26	(1.20)	3.26	98.78	(1.60)	98.39	18.54	(6.39)	18.54	147
FOMC	3.19	(0.91)	3.19	98.79	(1.06)	96.57	18.00	(4.81)	18.00	147
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Consumer Comf.	3.79	(0.52)	3.79	99.24	(0.72)	99.24	20.46	(2.50)	20.46	600

Alternatives

- **Time series information** on transition probabilities
- **Surveys?** Do subjective beliefs correspond to rational expectations?
  - Bhandari, Borovička, Ho (2016)
- **Nonparametric estimation** of the pricing kernel
  - Christensen (2015, 2016)

The paper is about individual decisions of an agent vis-à-vis given equilibrium prices.

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What other questions would we like to answer?

1. What are the incentives to create information for private/public use in a **competitive environment**?
2. What are the incentives to share/reveal information?
   - price impact, diffusion of information
   - protection of information rents

SUMMARY

Moving away from the assumption of exogenous and common information is crucial.

- The right step in this direction.
- Quantitative empirical implementation (**very hard to do**).

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Next steps?

- Extensions see above.
- **More discipline on estimating the SDF** $\implies$ inference of the data-generating probability measure.