(Mis)information Diffusion and the Financial Market

CeNDEF Seminar
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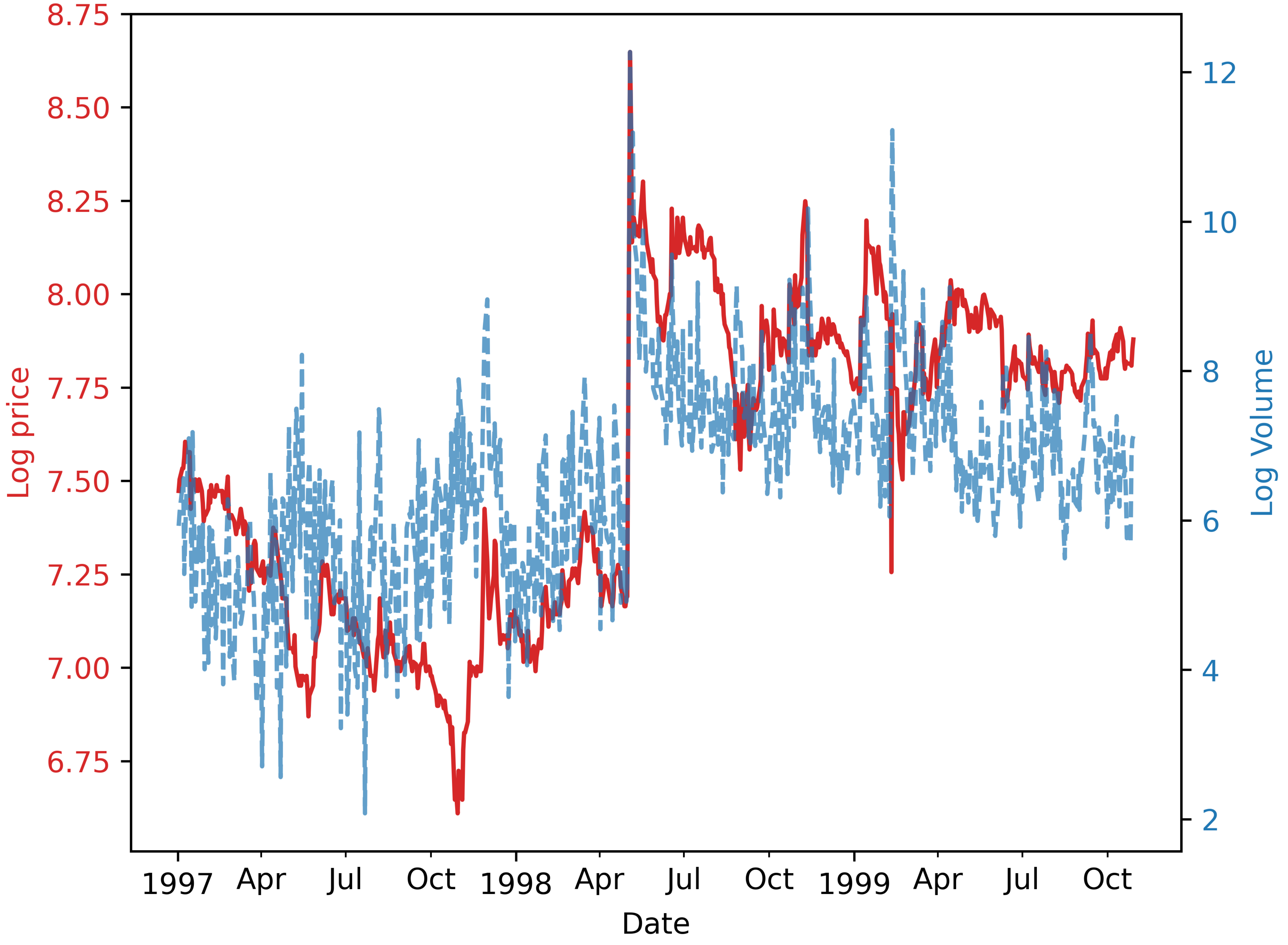
Introduction

Motivation



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Motivation

HOPE IN THE LAB: A special report.; A Cautious Awe Greets Drugs That Eradicate Tumors in Mice

Give this article

By Gina Kolata

May 3, 1998

Motivation

nature

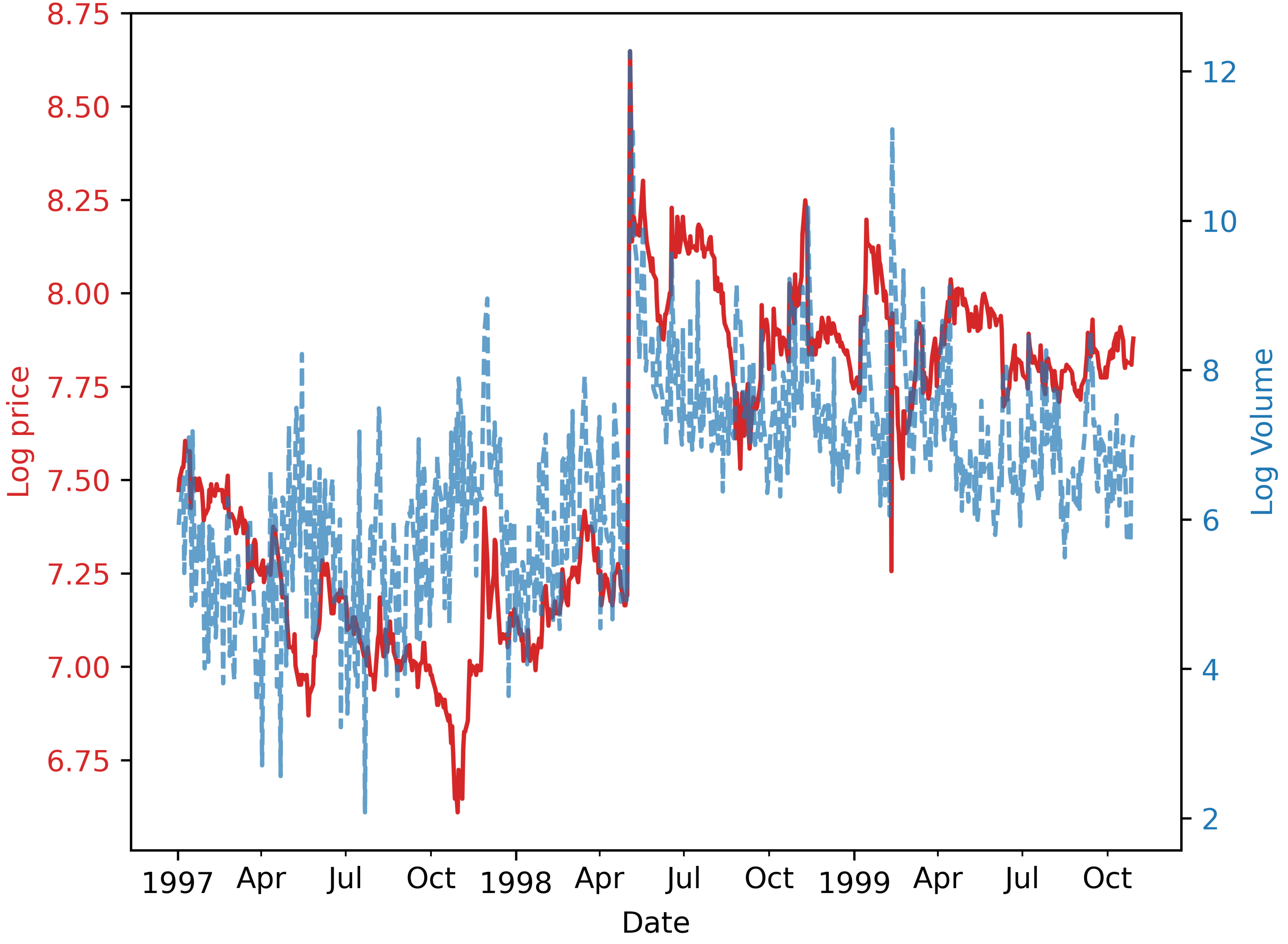
Published: 27 November 1997

Antiangiogenic therapy of experimental cancer does not induce acquired drug resistance

Thomas Boehm, Judah Folkman, Timothy Browder & Michael S. O'Reilly

Nature **390**, 404–407 (1997) | Cite this article

Motivation



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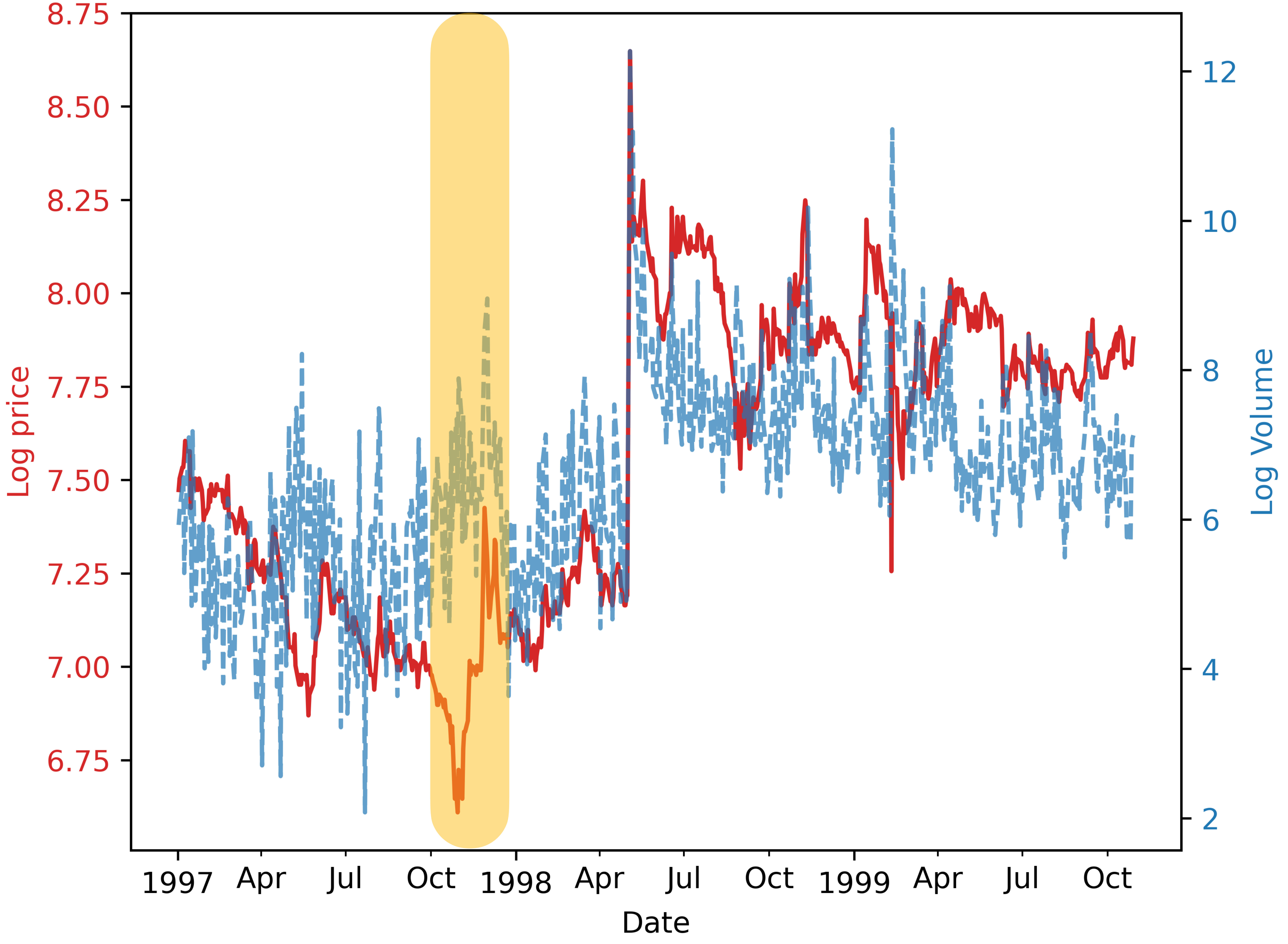
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Stylized Facts

Traditional

- Excess Volatility, Lepto-Kurtosis

Modern

- Delayed absorption of information

  Huberman and Regev (2001), Della Vigna and Pollet (2009), Hirshleifer et al. (2009)

- Misinformation is priced

  Logan et al. (2019), Clarke et al. (2021)

- Impact of Social Networks on Financial Markets

  Chen et al. (2014), Chen (2021), Wan et al. (2021)

Contribution

Agent Based Model of participants in a financial market, connected in a Social Network

Notable similar works: Tedeschi et al. (2012), Panchenko et al.(2013)

but focus on imitation of beliefs and not on Information Diffusion

(Mis)information diffusion in Network: Acemoglu et al. (2010), Golub and Jackson (2010), Acemoglu and Ozdaglar (2011).

We offer a novel mechanism of update, to obtain subjective expectation and variance, important for financial market

The Market

The Market

- Base model is a version of Grossman and Stiglitz (1980)
- I consumers living T periods, they transfer wealth to end of the period
- Risk-free asset, gross return R
- Risky asset with stochastic payoff

$$y_{t+1} = p_{t+1} + d_{t+1}$$

Dividends

$$d_{t+1} = d + \underbrace{\theta_{t+1}}_{\text{Observable}} + \underbrace{\varepsilon_{t+1}}_{\text{Unobservable}}$$

Observable component follows a stationary AR(1) model.

$$\theta_{t+1} = \beta\theta_t + \eta_{t+1}$$

Notice that innovations η_{t+1} are relevant for dividends indefinitely, although with an exponentially decreasing weight .

Demands and Market Clearing

Individual demand is

$$X_{i,t} = \frac{\mathbb{E}_{i,t}(y_{t+1}) - Rp_t}{a\mathbb{V}_{i,t}(y_{t+1})}$$

Zero external supply + market clearing implies

$$\sum_{i=1}^{I} X_{i,t} = \sum_{i=1}^{I} \left(\frac{\mathbb{E}_{i,t}(y_{t+1}) - Rp_t}{\mathbb{V}_{i,t}(y_{t+1})} \right) = 0$$

Expectations

All agents are forward looking fundamentalists (conditional on the fundamental value implied by their information scheme). Their beliefs regarding the payoff of the stochastic asset are

$$\mathbb{E}_{i,t}(y_{t+1}) = \frac{dR}{r} + \frac{R\mathbb{E}_{i,t}(\theta_{t+1})}{R-\beta}$$

$$\mathbb{V}_{i,t}(y_{t+1}) = \mathbb{V}_{i,t}(\theta_{t+1}) + \sigma_\varepsilon^2 + \frac{\mathbb{V}_{i,t}(\mathbb{E}_{i,t+1}(\theta_{t+2}))}{\left(R-\beta\right)^2} + \frac{2\mathbb{C}ov_{i,t}\left(\theta_{t+1}, \mathbb{E}_{i,t+1}(\theta_{t+2})\right)}{R-\beta}$$

(Mis)information Diffusion

Heterogeneity

Heterogeneity of beliefs relate the observable component of dividends.

Given the process, we have

$$\theta_{t+1} \,|\, t \sim \mathcal{N}\left(\beta\theta_t, \sigma_\eta^2\right)$$

Therefore we assume that all agents have normally distributed beliefs.

But prior beliefs are heterogeneous.

Prior Beliefs

Informed agents

$$\theta_{t+1} \mid t \sim \mathcal{N}\left(\theta_{t+1}, 0\right)$$

Misinformed agents

$$\theta_{t+1} \mid t \sim \mathcal{N}\left(\theta_{t+1} + \gamma_{t+1}, 0\right)$$

Uninformed Agents

$$\theta_{t+1} \mid t \sim \mathcal{N}\left(\beta\mu_{P,t-1}, \sigma_\eta^2\right)$$

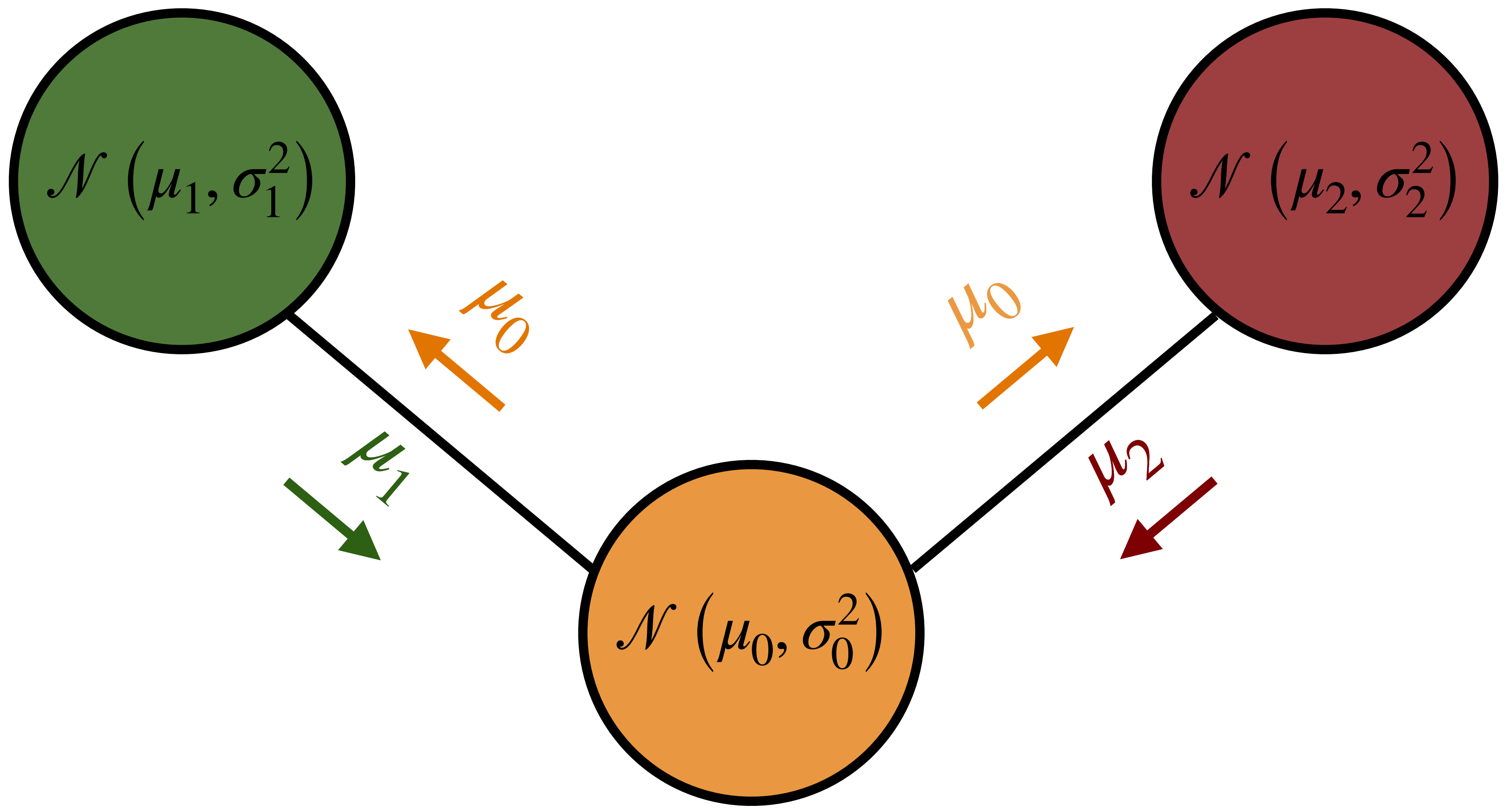
Information Flow

Agents are connected in an undirected Network.

Each node is characterized by the two parameters of the normal distribution.

An edge is information flowing from node i to node j and viceversa.

Information refers to agents observing the prior mean of the nodes to which they are connected.



Likelihood Function

We use a Normal Conjugate Distribution framework.

The standard assumption in this case is that of known variance of the likelihood of the observed data.

We replace this by a subjective measure of this variance, evaluated on past errors.

$$EMA_{j,t} = w \underbrace{\left(y_{t-1} - \left(\frac{dR}{r} + \frac{R\mu_{j,t-1}}{R-\beta} \right) \right)^2}_{\text{Payoff error implied by information of source j}} + (1-w)EMA_{j,t-1}$$

Likelihood Function cont'd

Then to obtain a comparable implied variance we rescale

$$\hat{\sigma}^2_{j,t} = \sigma^2_{0,t} \frac{EMA_{j,t}}{EMA_{i,t}}$$

So that for each source the implied likelihood is Normal with known variance $\hat{\sigma}^2_{j,t}$

Beliefs Updating

The posterior distribution is also Normal and given by

$$\mu_P = \frac{\sum_{k=0}^{K} \left(\mu_k \cdot \left[A\right]_k^K \right)}{\sum \left[A\right]^K} \qquad \sigma_P^2 = \frac{\prod_{j=0}^{K} \sigma_j^2}{\sum \left[A\right]^K}$$

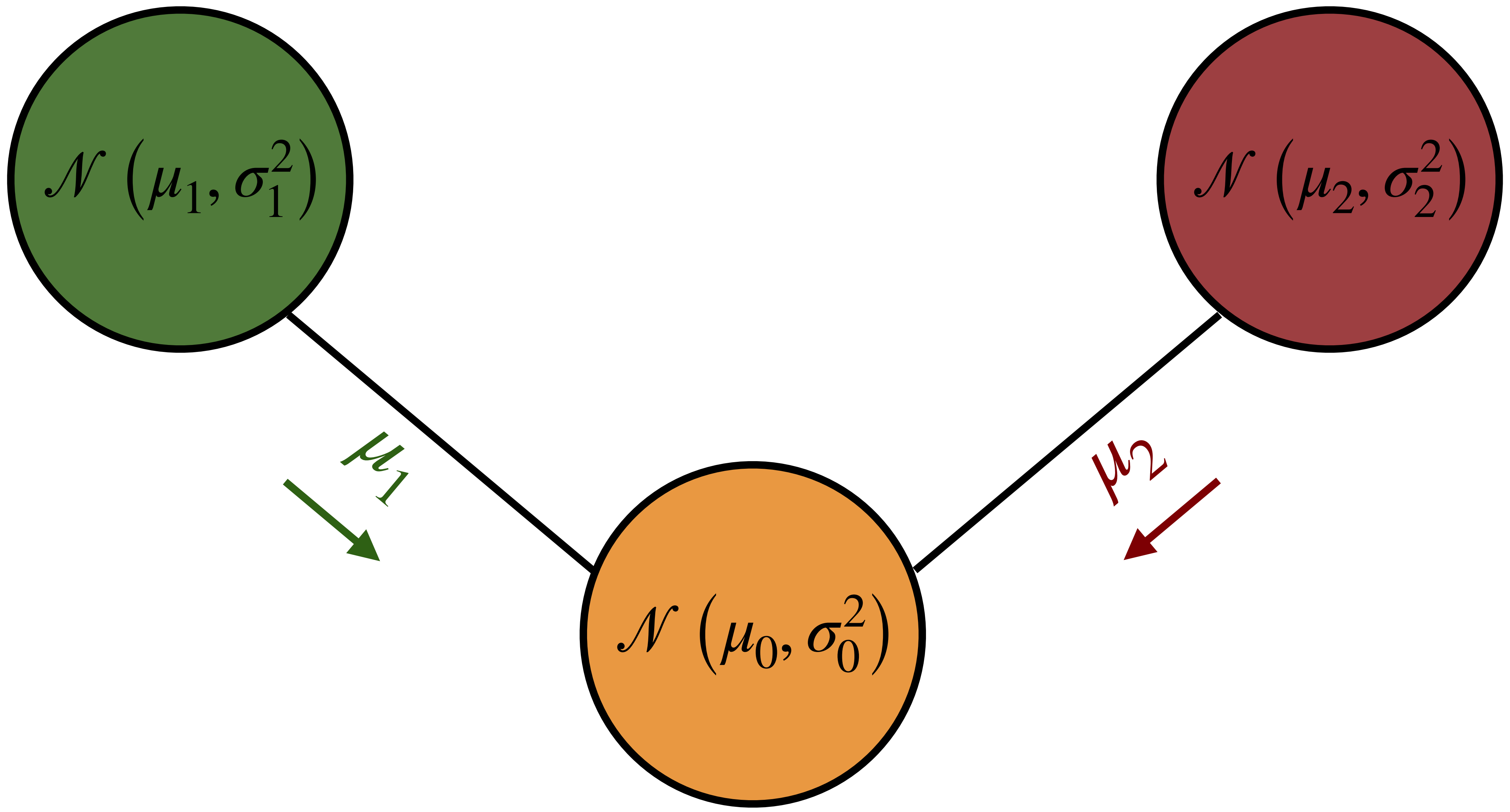
Which extends the usual updating to the case in which agents receive information from K different sources, and with

$$A = \{\sigma_0^2, \hat{\sigma}_1^2, \hat{\sigma}_2^2, \ldots \hat{\sigma}_K^2\}$$

$\left[A\right]^J$ set of all distinct combinations of products of size J from set A

$\left[A\right]_k^J$ combination that does not include $\hat{\sigma}_k^2$

An Example



$$\mu_P = \frac{\mu_0 \hat{\sigma}_1^2 \hat{\sigma}_2^2 + \mu_1 \sigma_0^2 \hat{\sigma}_2^2 + \mu_2 \sigma_0^2 \hat{\sigma}_1^2}{\hat{\sigma}_1^2 \hat{\sigma}_2^2 + \sigma_0^2 \hat{\sigma}_2^2 + \sigma_0^2 \hat{\sigma}_1^2}$$

$$\sigma_P^2 = \frac{\sigma_0^2 \hat{\sigma}_1^2 \hat{\sigma}_2^2}{\hat{\sigma}_1^2 \hat{\sigma}_2^2 + \sigma_0^2 \hat{\sigma}_2^2 + \sigma_0^2 \hat{\sigma}_1^2}$$

Minimal Departure from Rationality

Fundamentalist Forward Looking in Financial Market.

Rational | Own Information Set

$\neq$ Chiarella (1992), Brock and Hommes (1998), Lux(1998)

Naive in the Network Structure. Fail to account for repeated information.

De Marzo et al. (2003), Golub and Jackson (2010)

Numerical Simulations

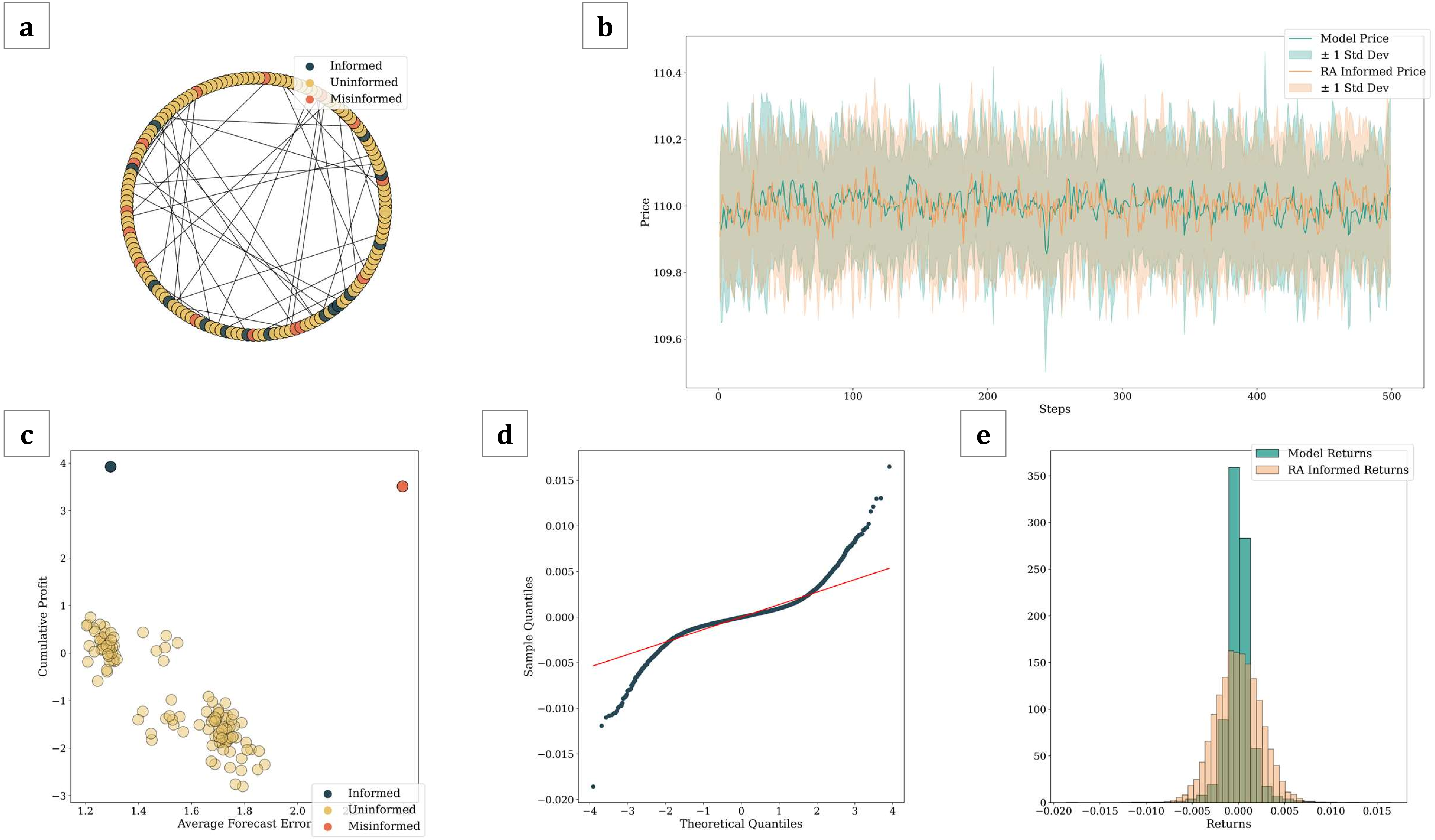
Sequence of events

1. Agents update their prior beliefs regarding the observable component of dividends θ_{t+1}according to their own category;
2. Agents compute the average forecast error over payoffs of the nodes they are connected to. The last payoff considered by them in the computation is y_{t-1};
3. Agents use the updating mechanism to obtain their posterior beliefs regarding the observable component of dividends θ_{t+1};
4. The implied expected payoff y_{t+1} is computed;
5. The resulting price p_t and individual demands are computed.

Variable Parameters

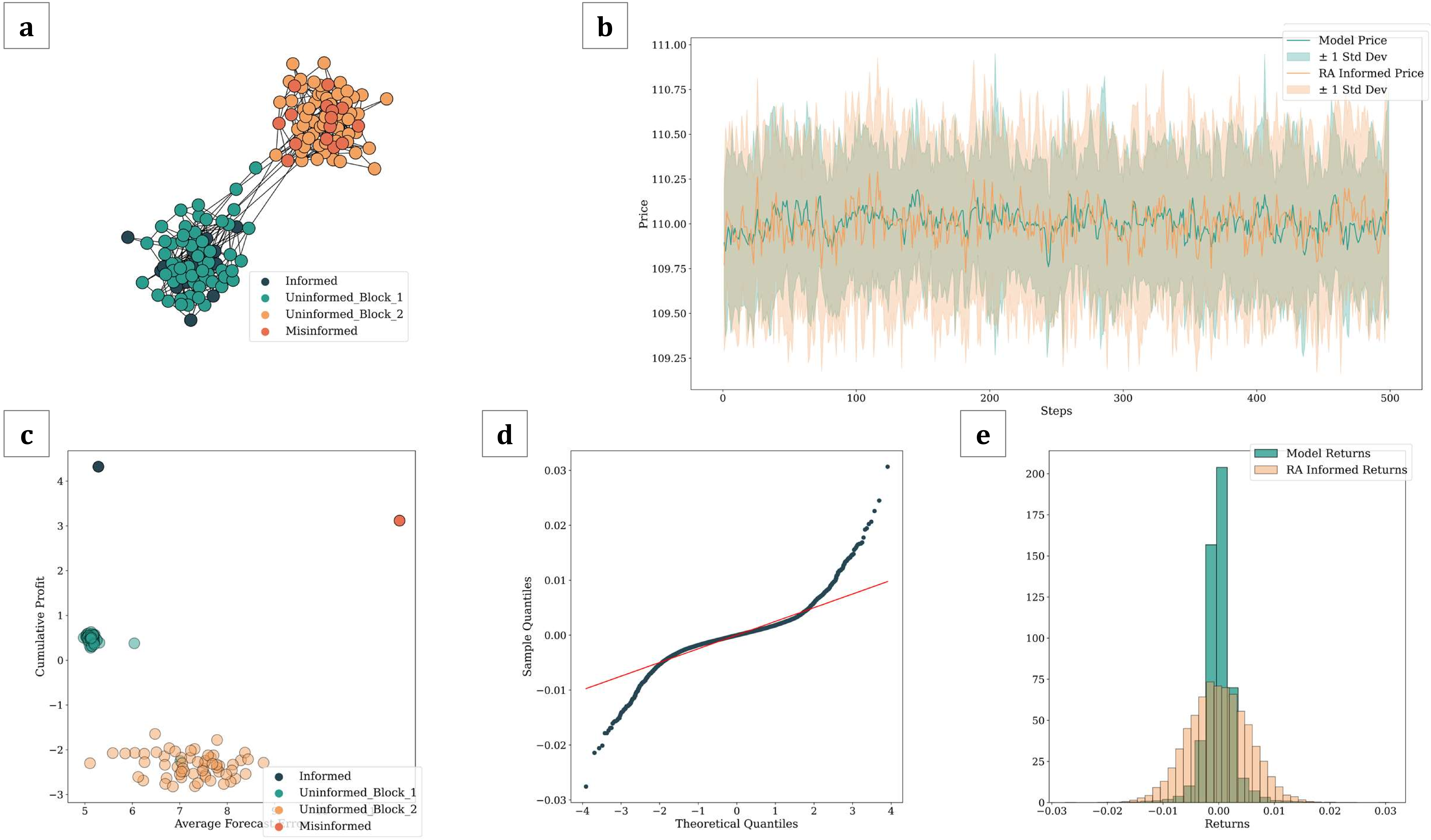
Parameter	Symbol	Range
Volatility of Shocks to the Observable Component of Dividends	σ_η^2	$[0.1, 2.0]$
Mean of the Misinformation Parameter	μ_γ	$[-1.0, 1.0]$
Volatility of the Misinformation Parameter	σ_γ^2	$[0.1, 2.0]$
Volatilty of the Unobservale Component of Dividends	σ_ε^2	$[0.1, 2.0]$
Autocrrelation Coefficient of the Observable Component of Dividends	β	$[0.05, 0.95]$
Proportion of Informed Agents	λ	$[0.01, 0.25]$
Proportion of Misinformed Agents	ξ	$[0.01, 0.25]$
Memory of the Exponential Moving Average	w	$[0.05, 0.9]$

Small World Network

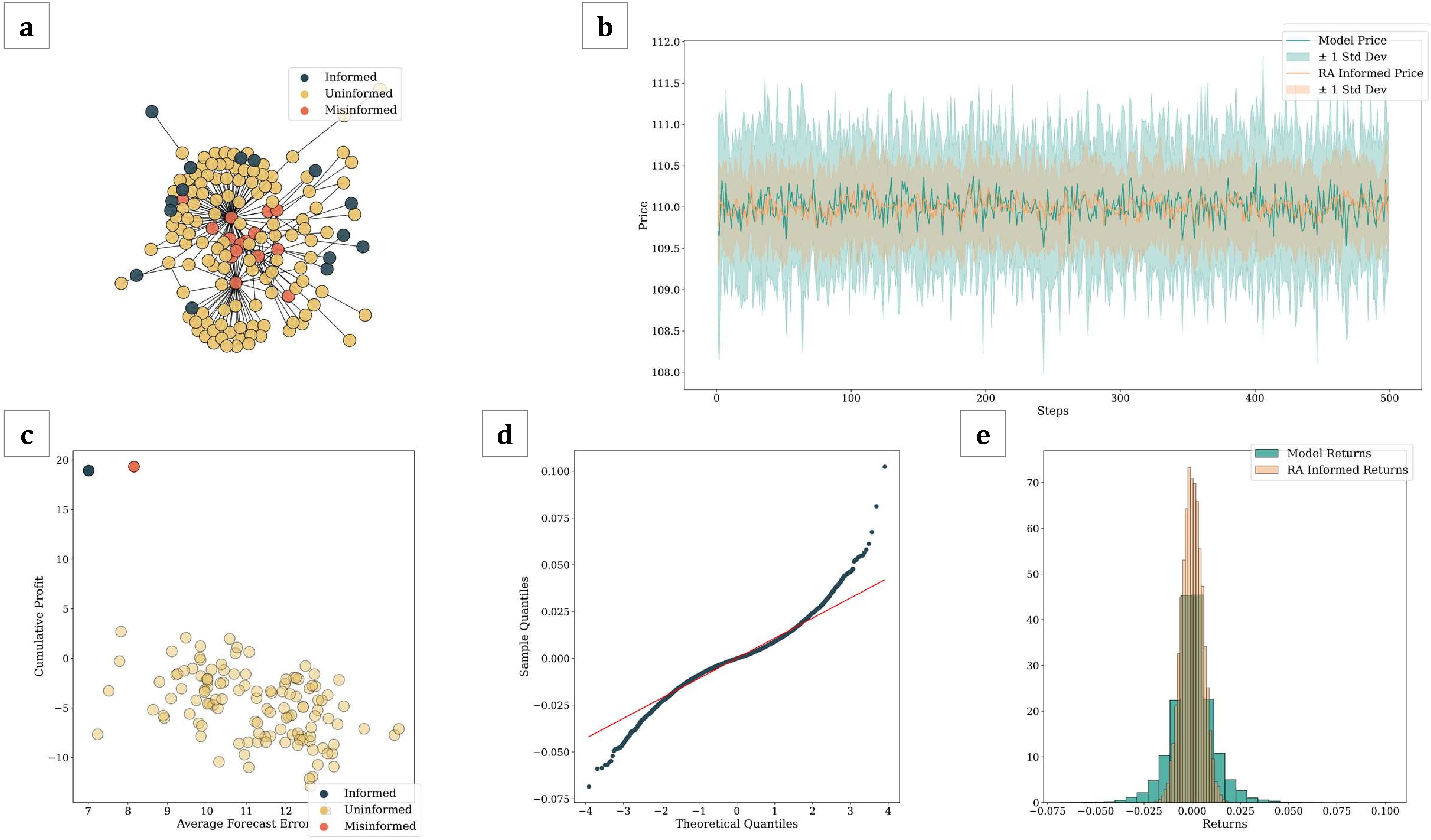


$$\sigma_\eta^2 = 2, \mu_\gamma = 0.0, \sigma_\gamma^2 = 2, \sigma_\varepsilon^2 = 0.3, \beta = 0.4, \lambda = 0.1, \xi = 0.1, w = 0.9$$

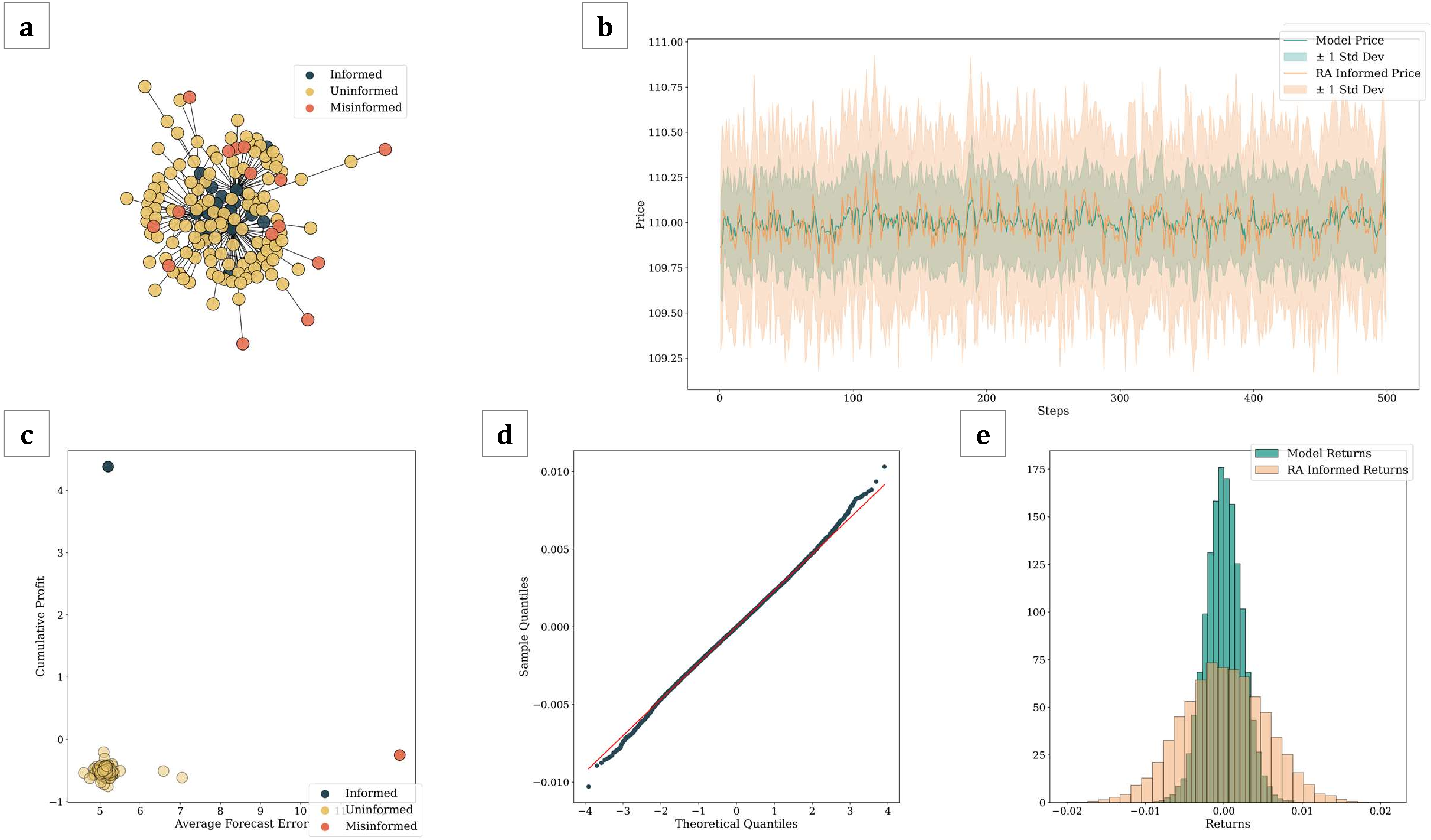
Stochastic Block Model



Scale-free Network, Misinformed



Scale-free Network, Informed

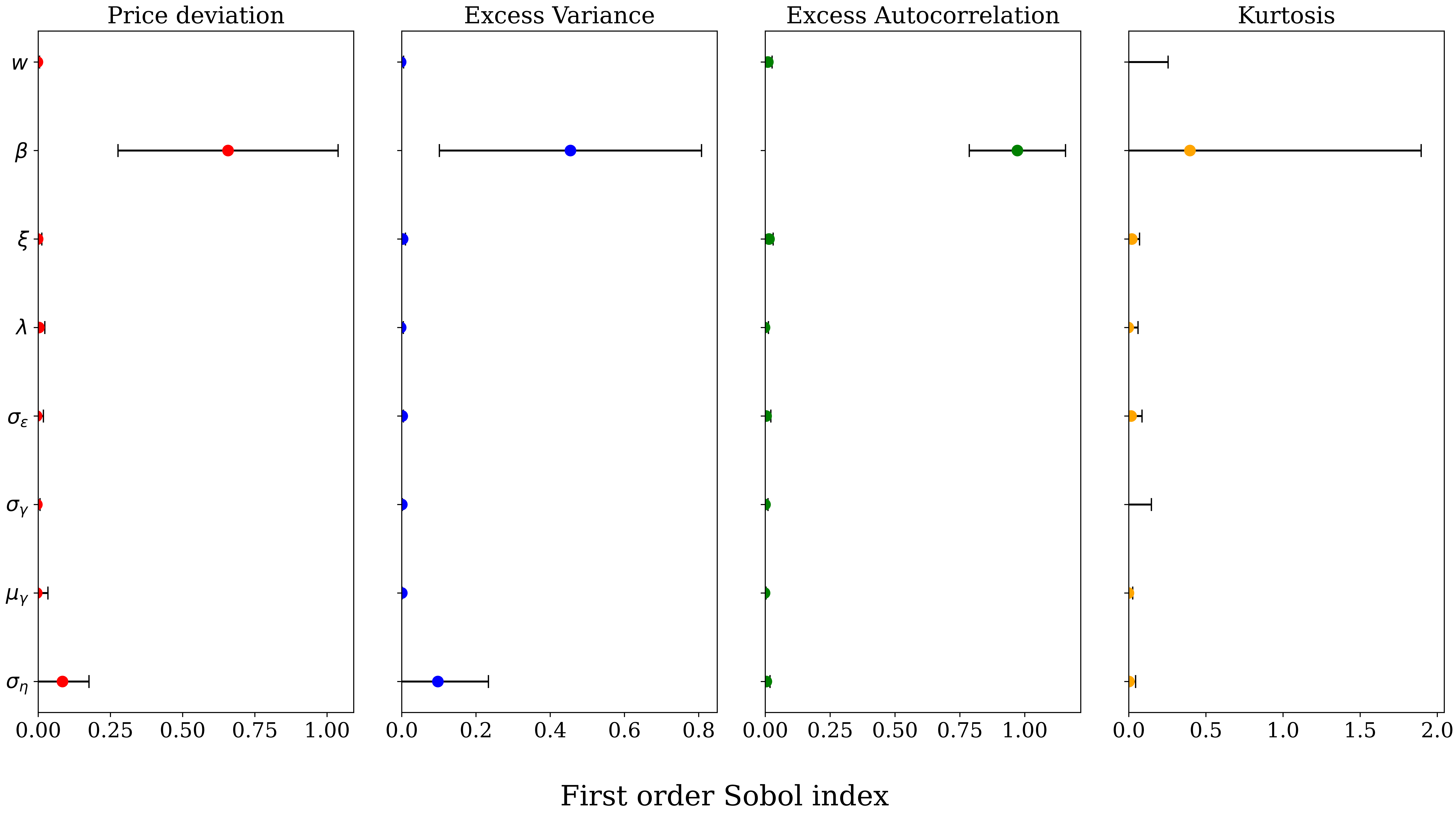


Summary

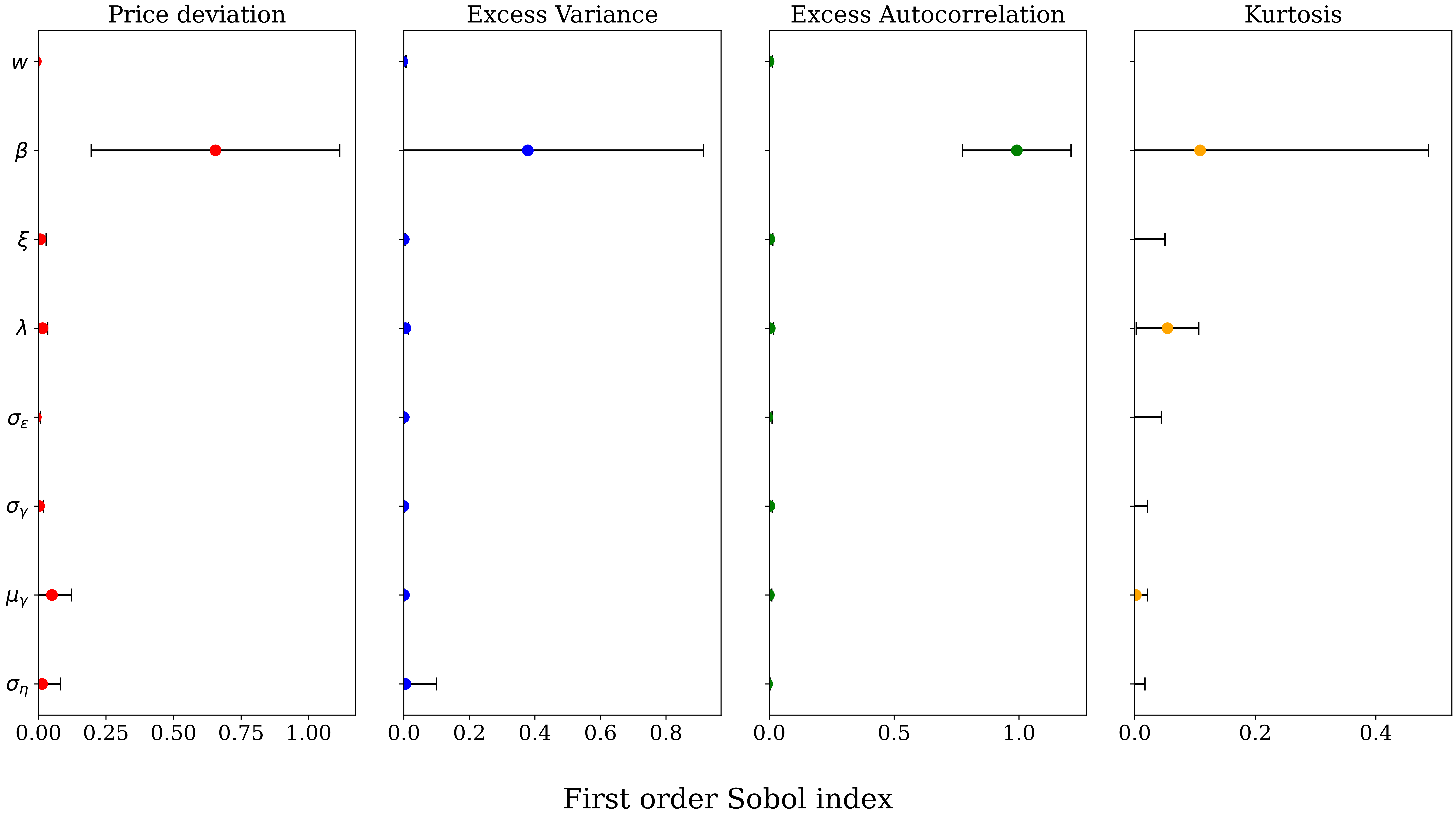
	Price	Variance	Autocorr	Kurtosis
Small World	110	0.23	0.72	12.23
Stochastic Block Network	110	0.19	0.77	8.40
Scale Free Informed	110	0.07	0.55	0.19
Scael Free Misinformed	110	0.86	0.28	2.96
RA Informed	110	0.28	0.40	0.00

Discussion

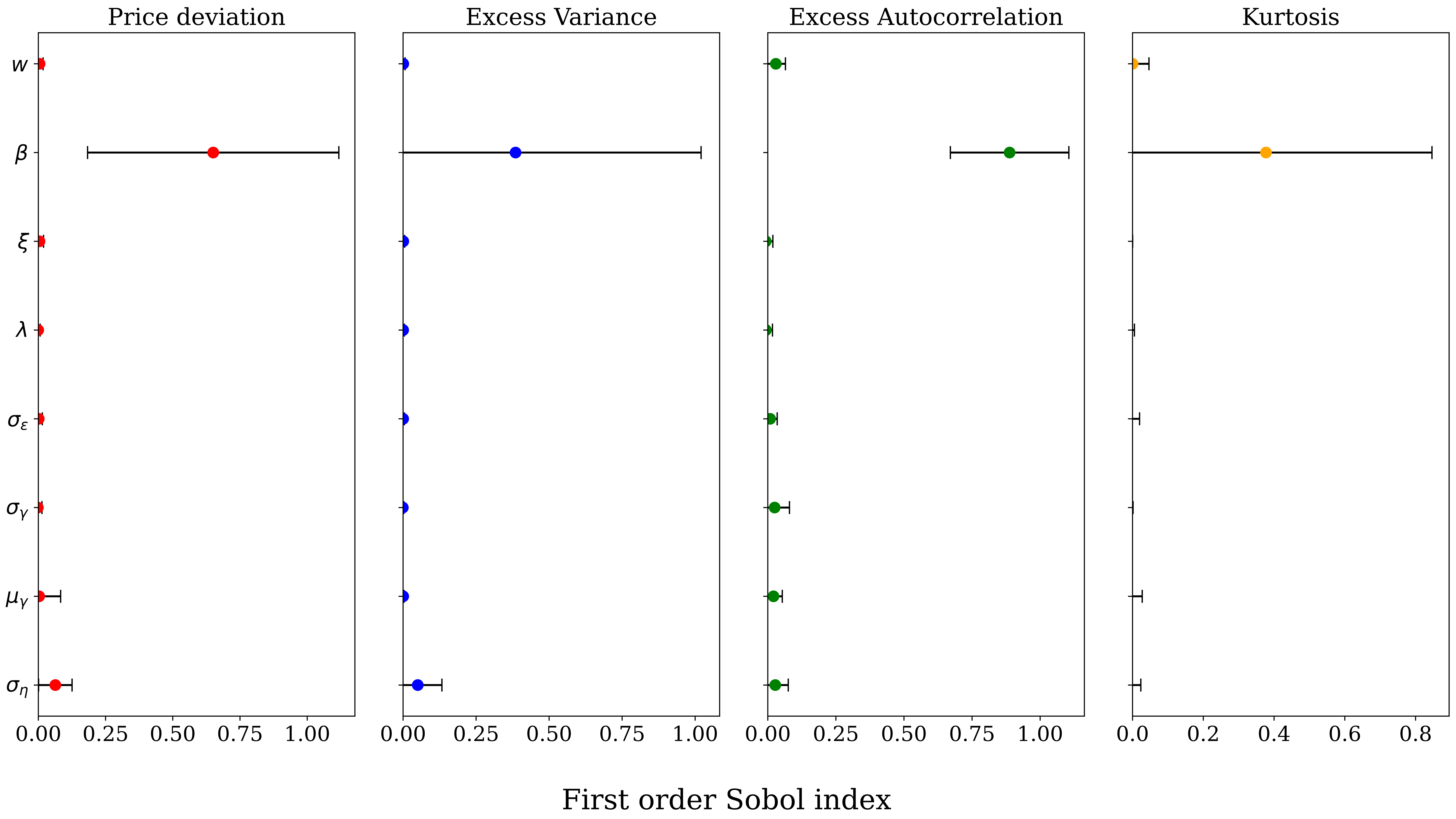
Small World Network



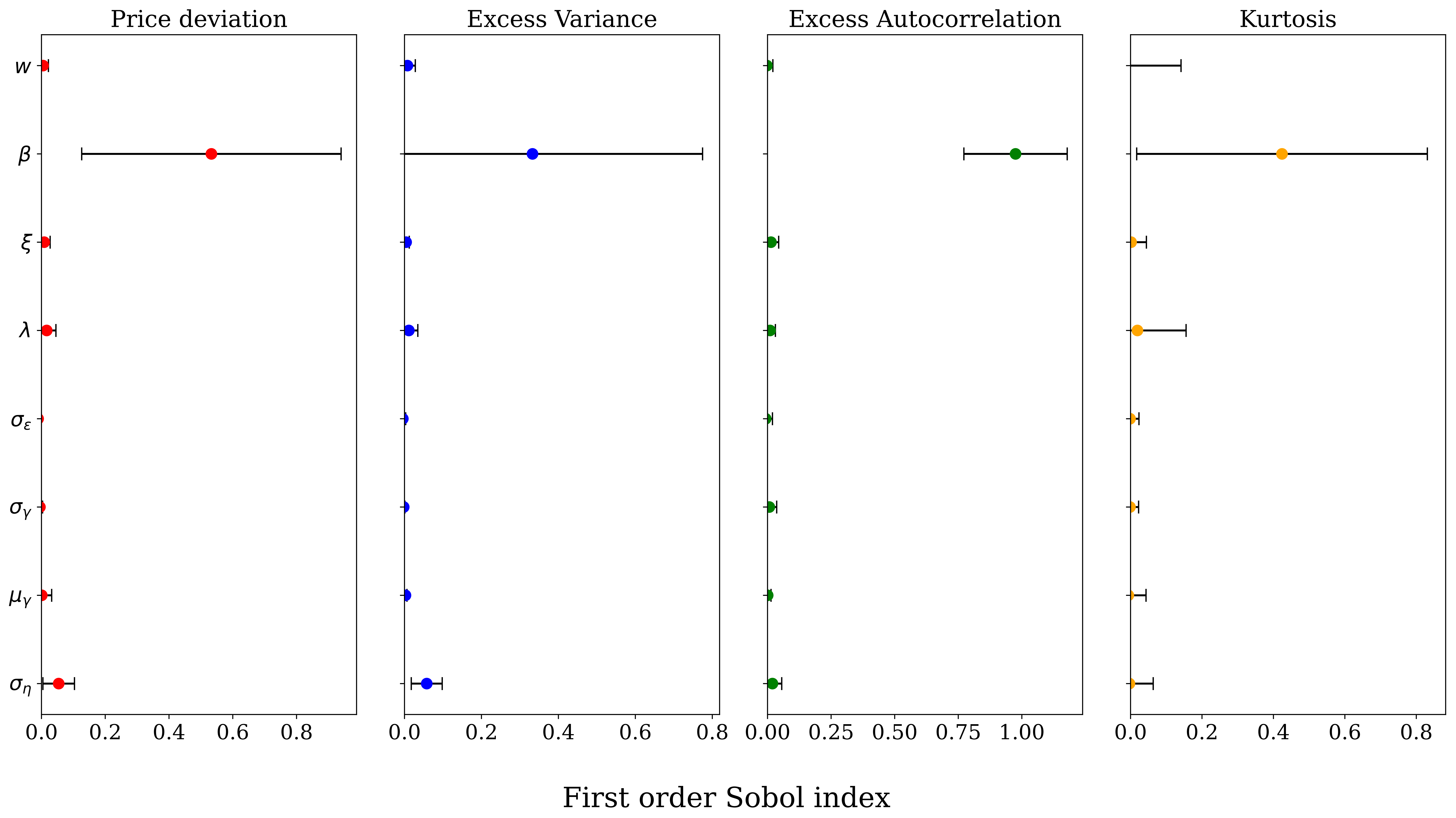
Stochastic Block Model



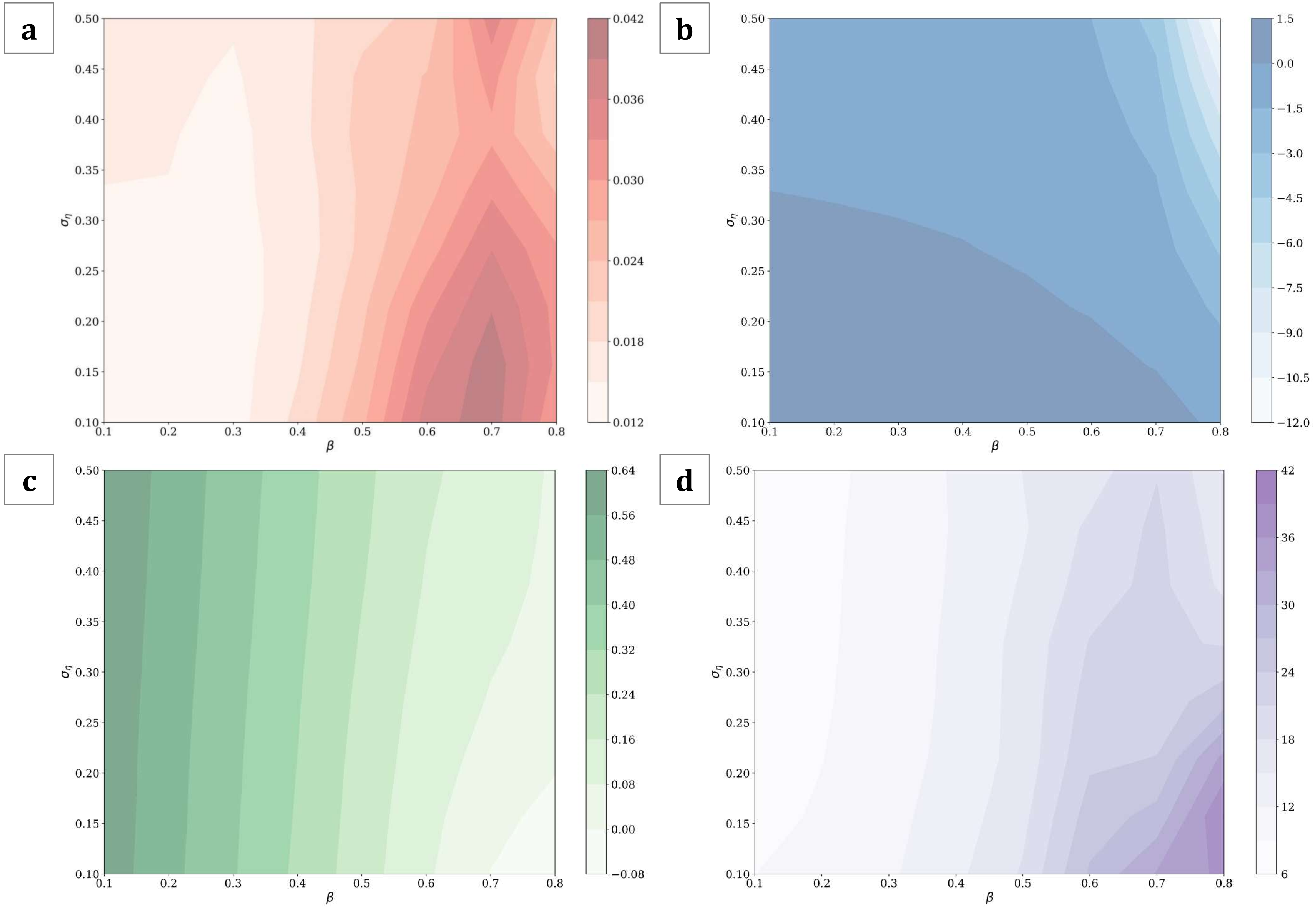
Scale-free Network, Misinformed



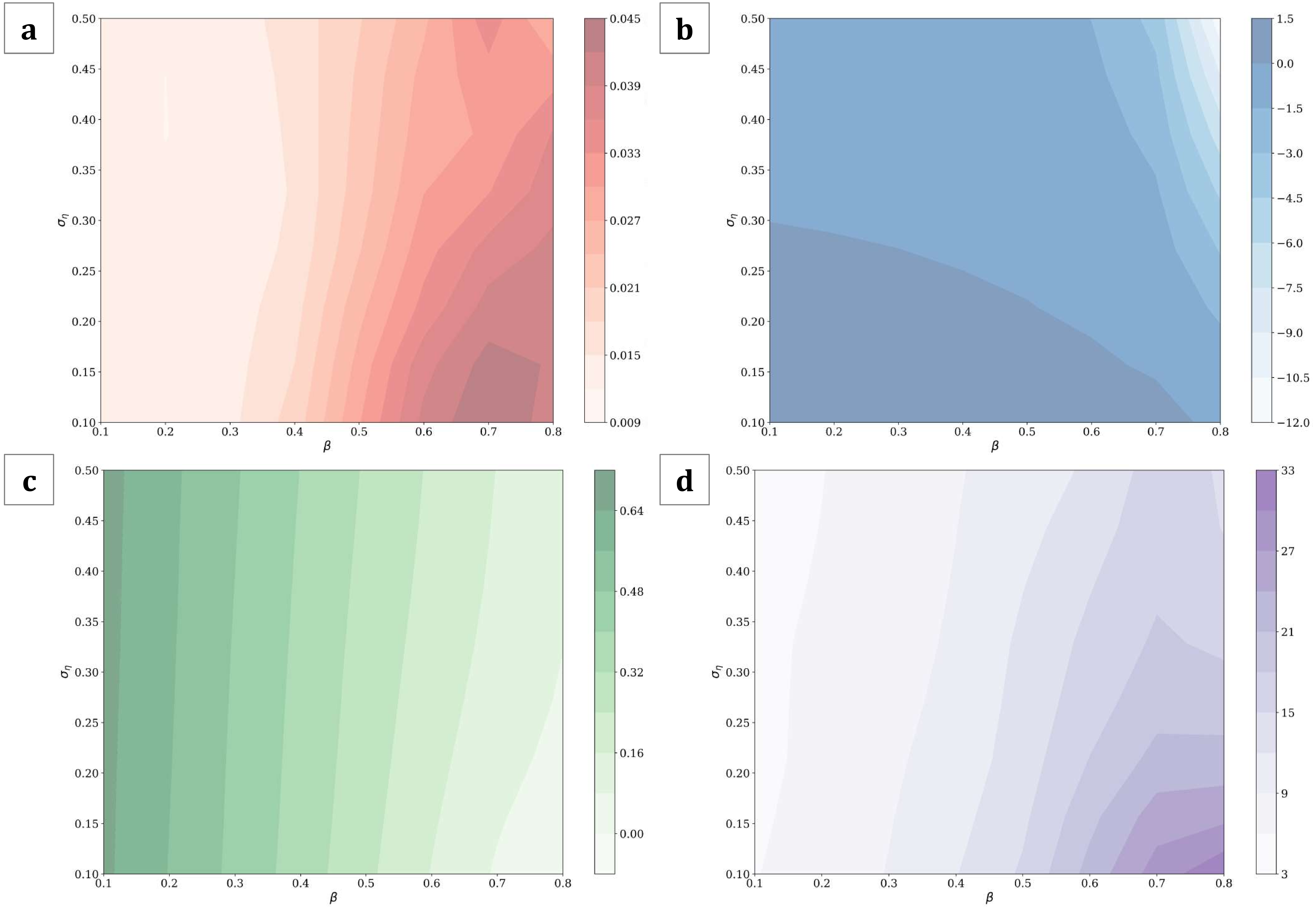
Scale-free Network, Informed



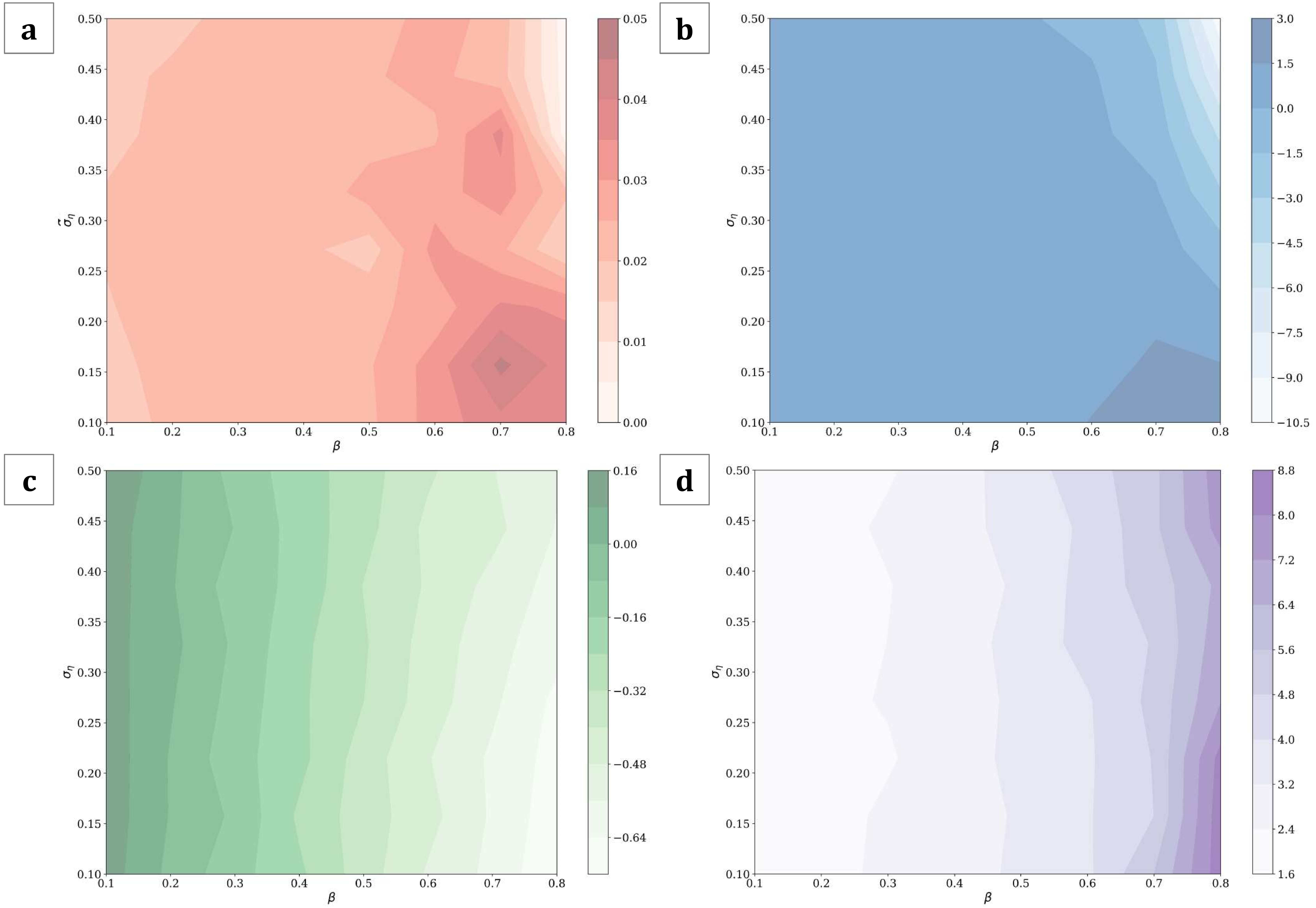
Small World Network



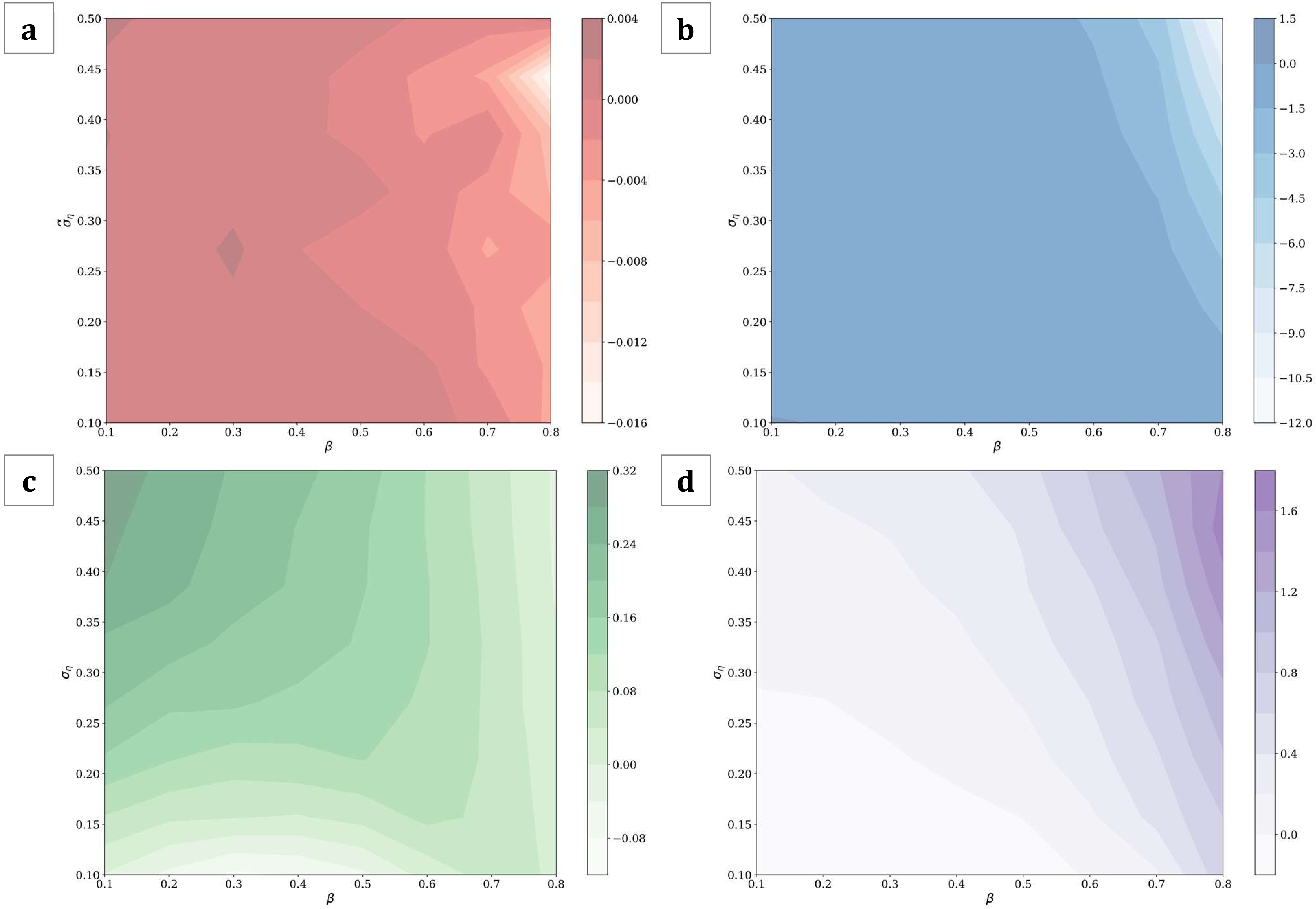
Stochastic Block Model



Scale-free Network, Misinformed



Scale-free Network, Informed



Conclusion

Conclusion

We presented an ABModel of market participants in a financial market, connected in a Social Network.

All agents are Forward looking, but have different information sets

They update their beliefs in a Bayesian way.

Lepto-kurtosis and persistance amplification are emergent properties of the model

Excess volatility depends on network topology and on the signal-to-noise ratio of dividends

$$\frac{\sigma_\eta^2}{\sigma_\varepsilon^2(1-\beta^2)}$$


THANK YOU

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