Equilibrium Commodity Trading

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Research Question

How does the capital invested on commodity futures markets affect the underlying spot market?

- Which channel?
- Stabilizing?
- Beneficial?

Commodity Prices

- Sharp movements since 2002

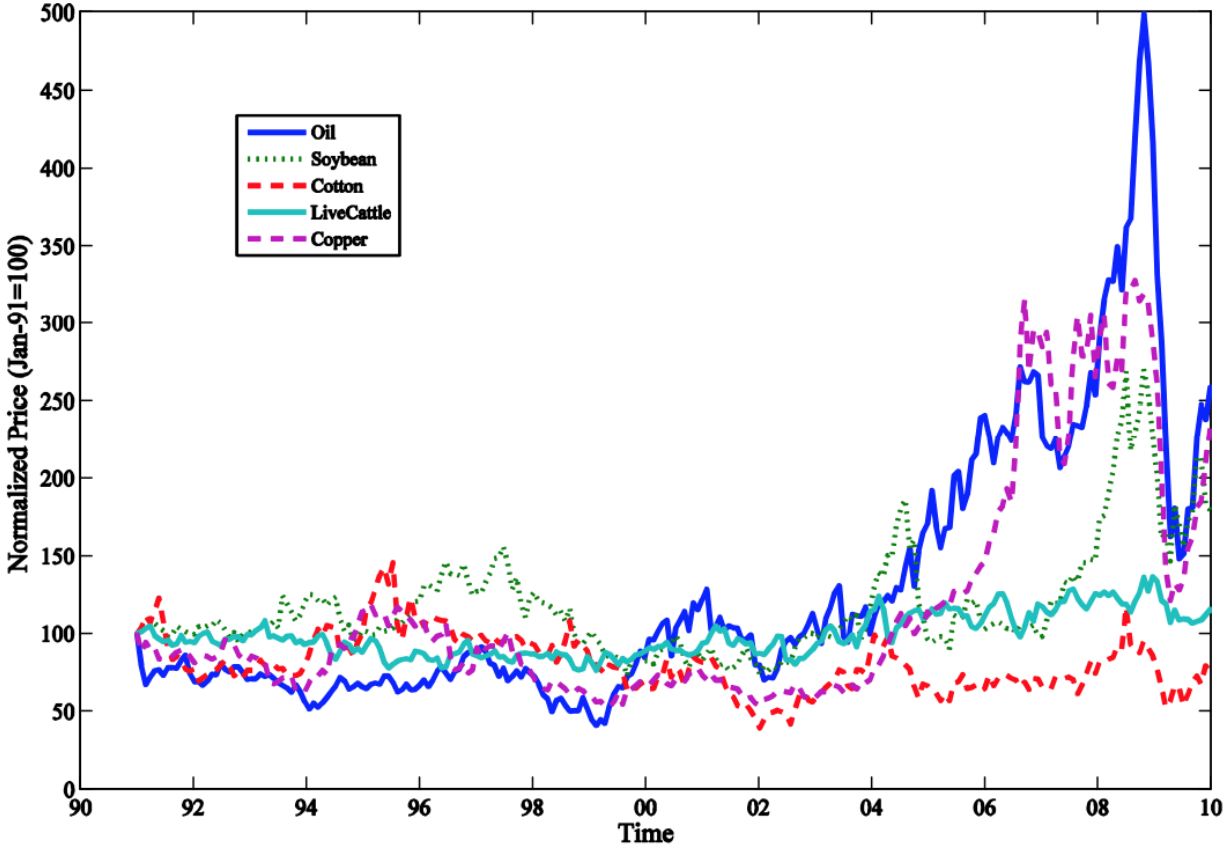


Figure : from TANG AND XIONG 2010

Commodity Futures Markets

- sharp increase (and variations) of the open interest

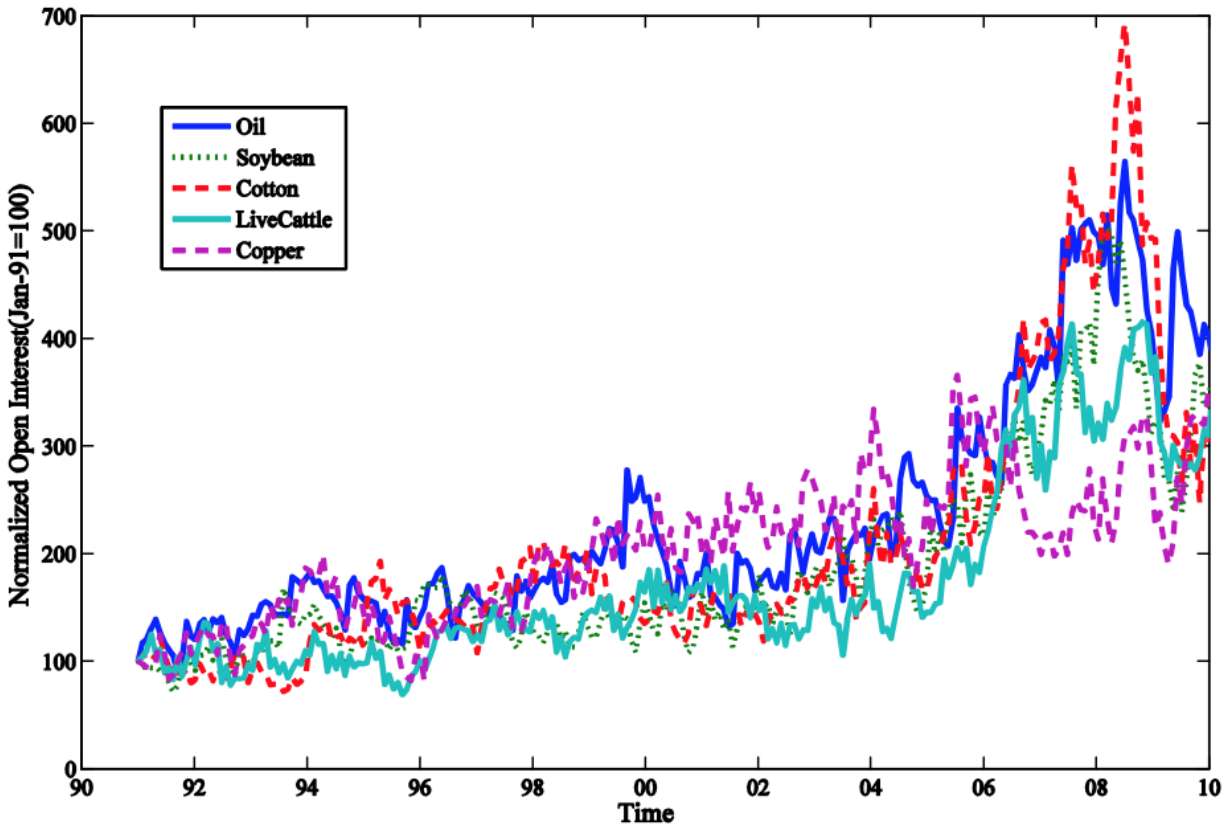
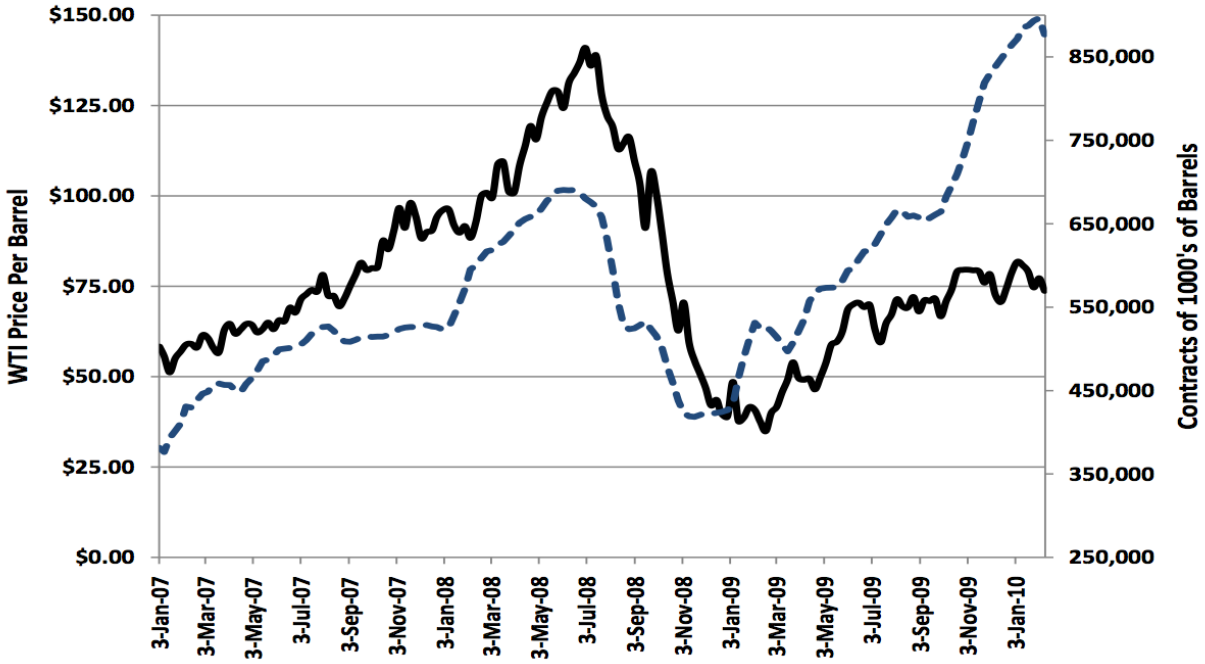


Figure : from TANG AND XIONG 2010

- Index funds

Is the Open Interest driving the Spot Price?

- Media, lawmakers and regulators, Michael W. Masters say yes.
- Singleton (forth) say maybe



- Fattouh, Kilian, and Mahadeva (2013), Hamilton and Wu (forth) say no

Model

- The commodity supply is endogenous
- Futures are used for both hedging and speculation

Preview of findings

When more investors trade the commodity futures contracts

- Production increases because hedging becomes easier
- Effect on spot price volatility is ambiguous
- Effect on expected utility is ambiguous

Literature

Classic

Anderson and Danthine (1983), Scheinkman and Schechtman (1983), Deaton and Laroque (1992), Deaton and Laroque (1996), Hirshleifer (1988), Hirshleifer (1988), Hirshleifer (1990), Hong (2000), Routledge, Seppi, and Spatt (2000)

Recent: (also) Empirical

Acharya, Lochstoer, and Ramadorai (2013), Christoffersen, Jacobs, and Li (2013), Hamilton and Whu (forth), Hong and Yogo (2012), Knittel and Pindyck (2013), Singleton (forth), Tang and Xiong (2012)

Recent: Theoretical

Basak and Pavlova (2013), Ekeland, Lautier, and Villeneuve (2014), Sockin and Xiong (2013), Baker (2014)

Derivatives on Underlying

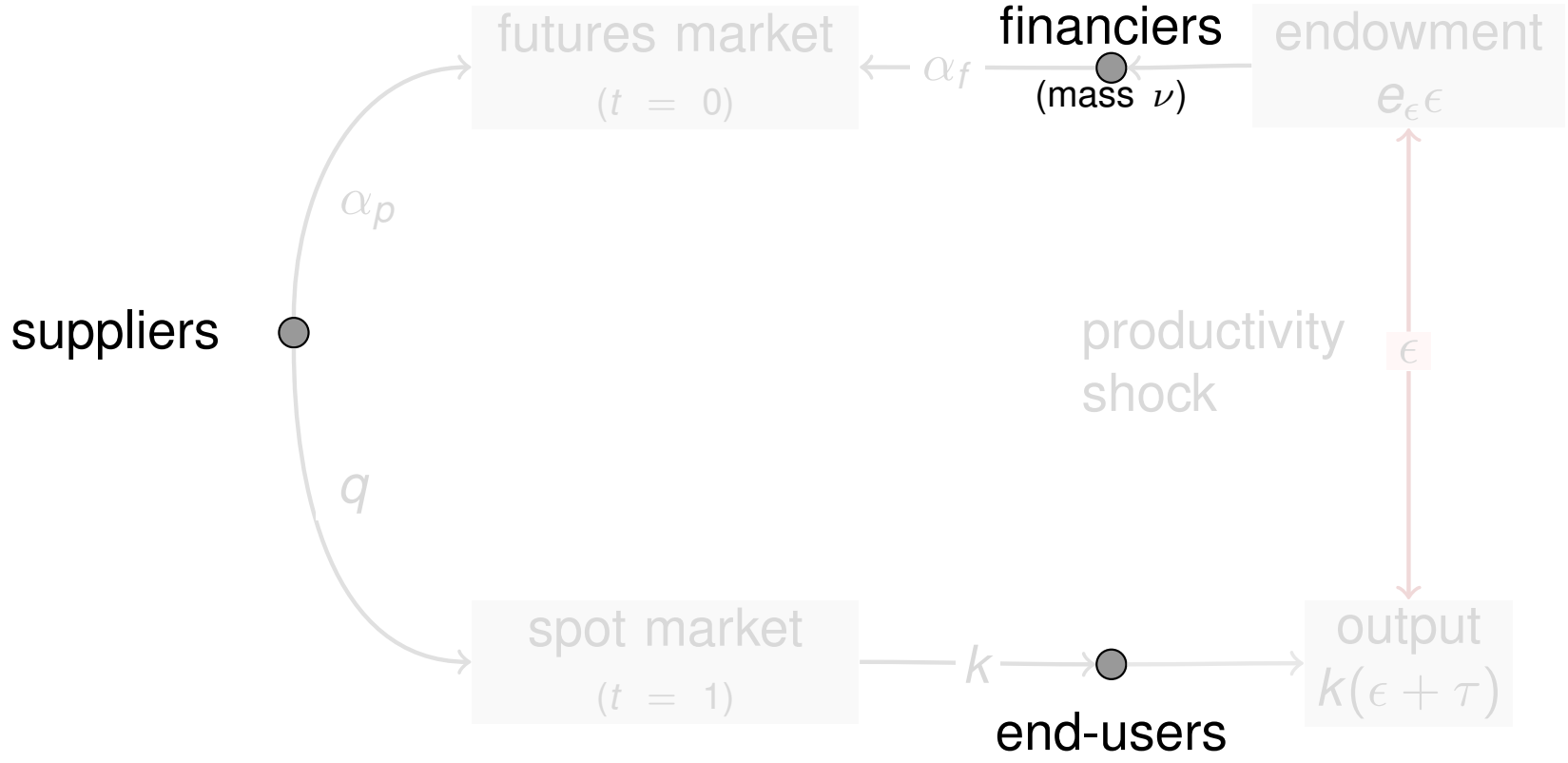
Frey and Stremme (1997), Platen and Schweizer (1998), Sircar and Papanicolaou (1997), Schoenucher and Wilmott (2000), Grossman (1988), Genotte and Leland (1990)

Outline

1. Futures markets for hedging
2. Futures markets for hedging and learning

Hedging on the Futures Markets

$t \in \{0, 1\}$



CARA-normal setting $\begin{pmatrix} \tau, \epsilon & \sim & \mathcal{N} \\ c & \mapsto & -e^{-\gamma c} \end{pmatrix}$

Linear extraction costs: $q \mapsto \kappa q$

Hedging on the Futures Markets

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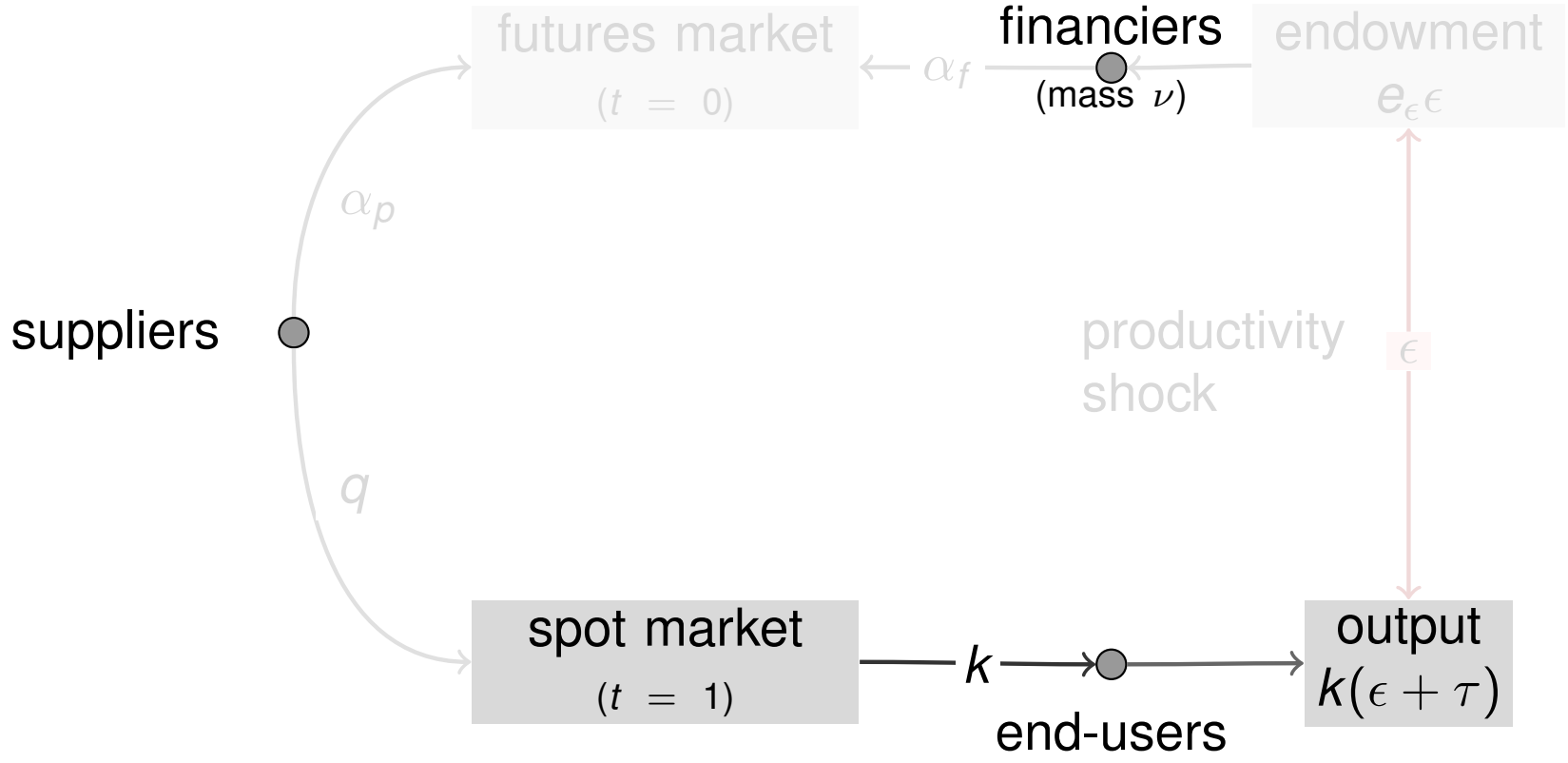

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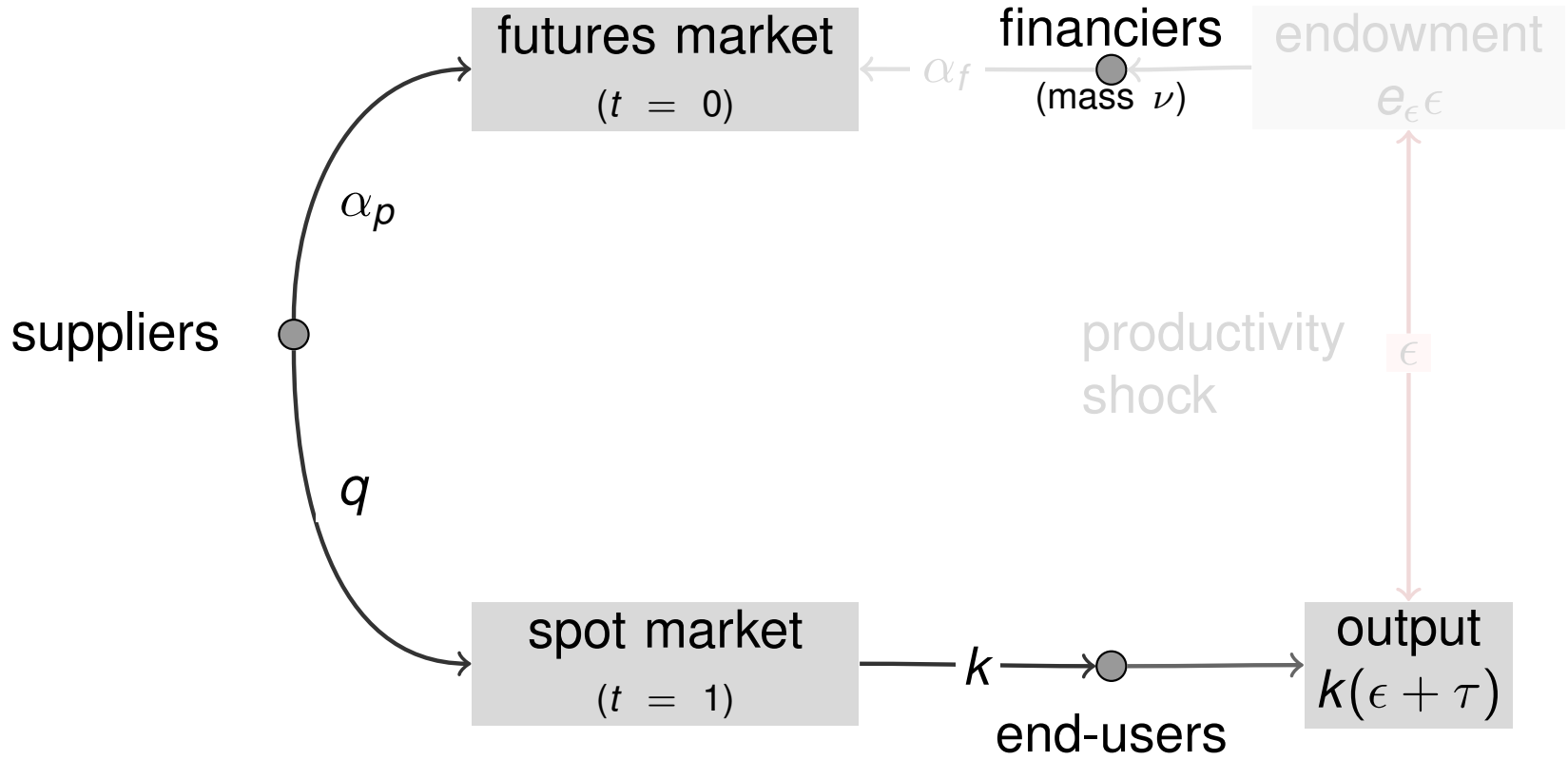

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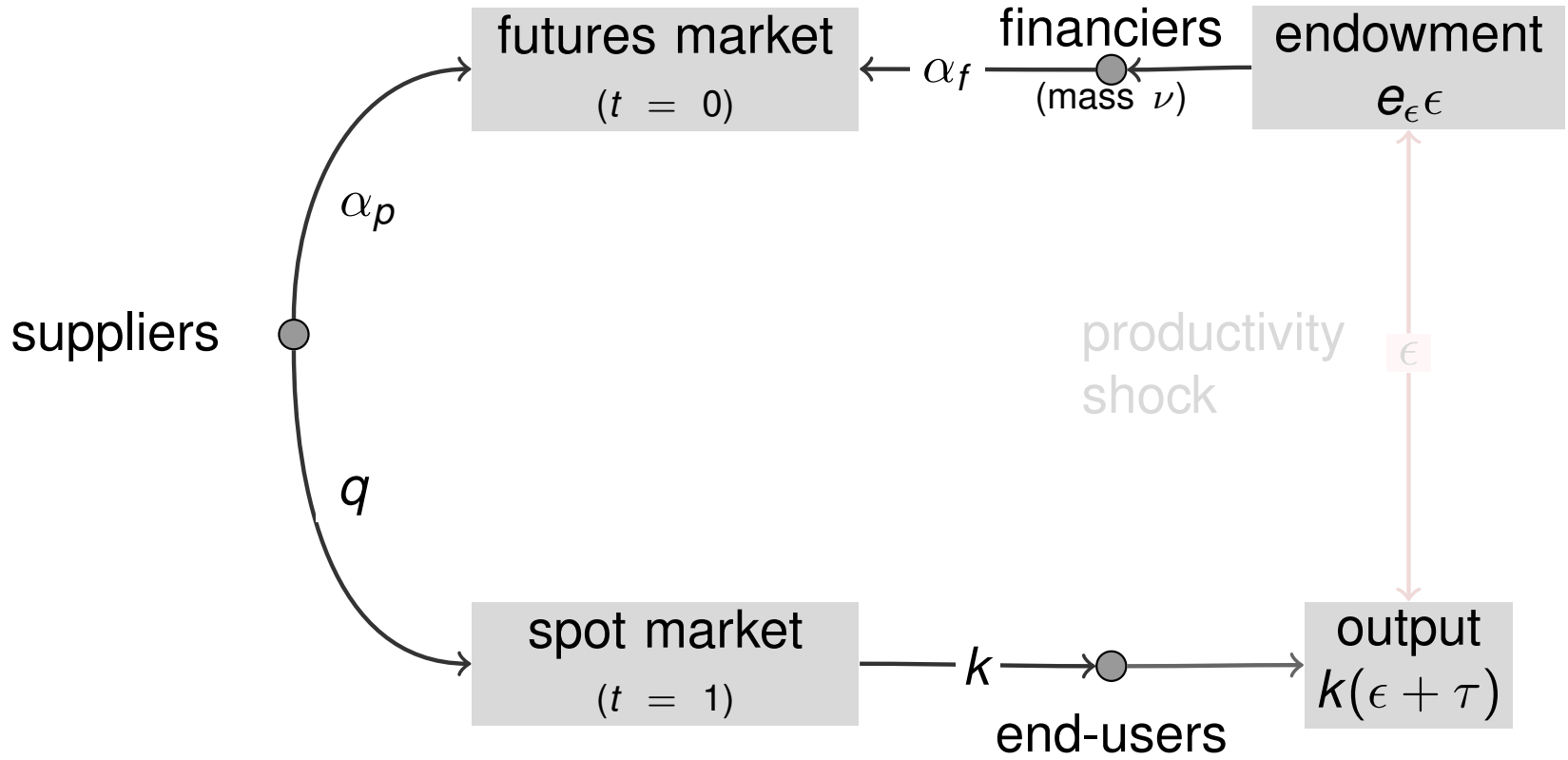

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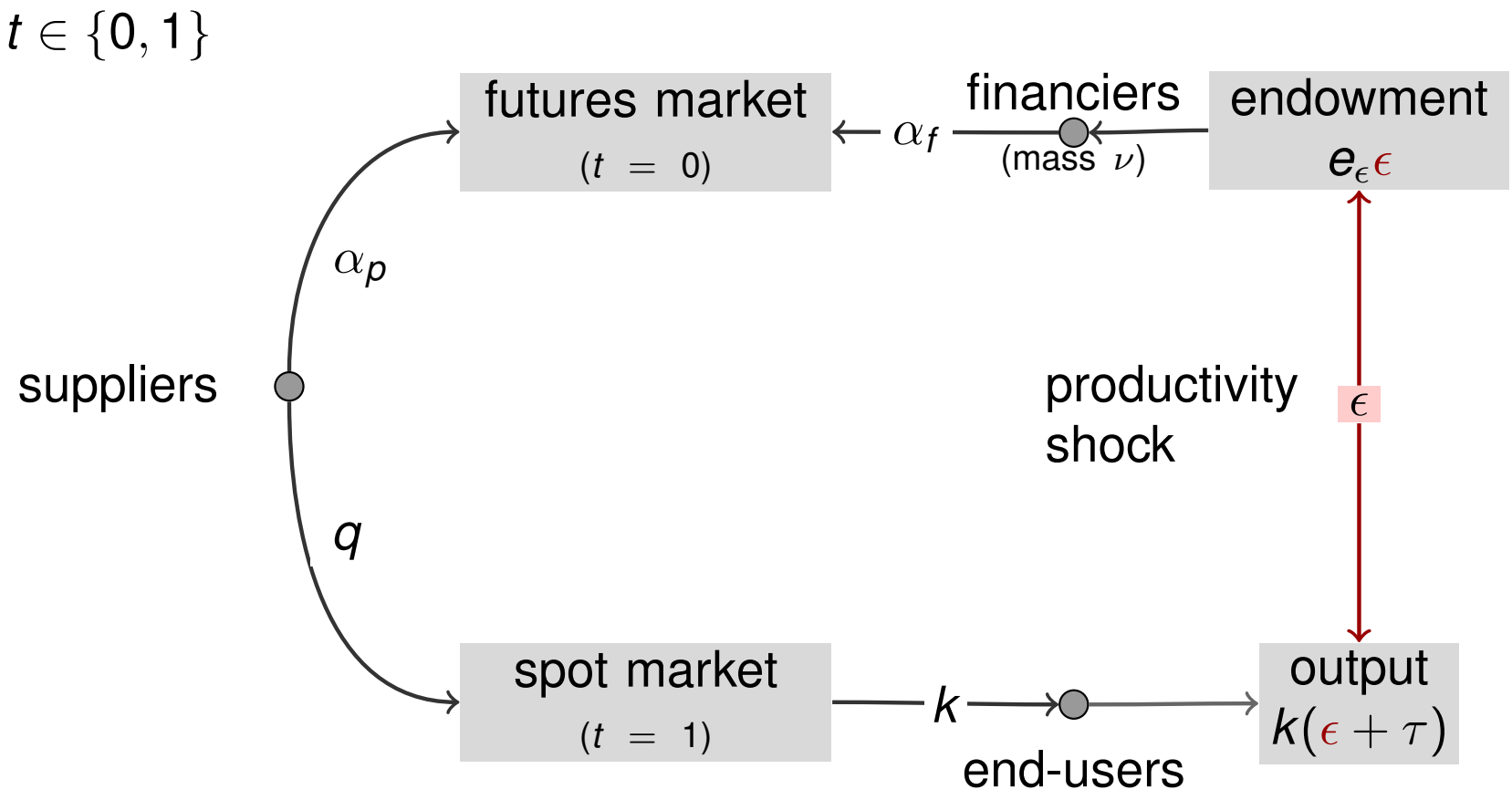

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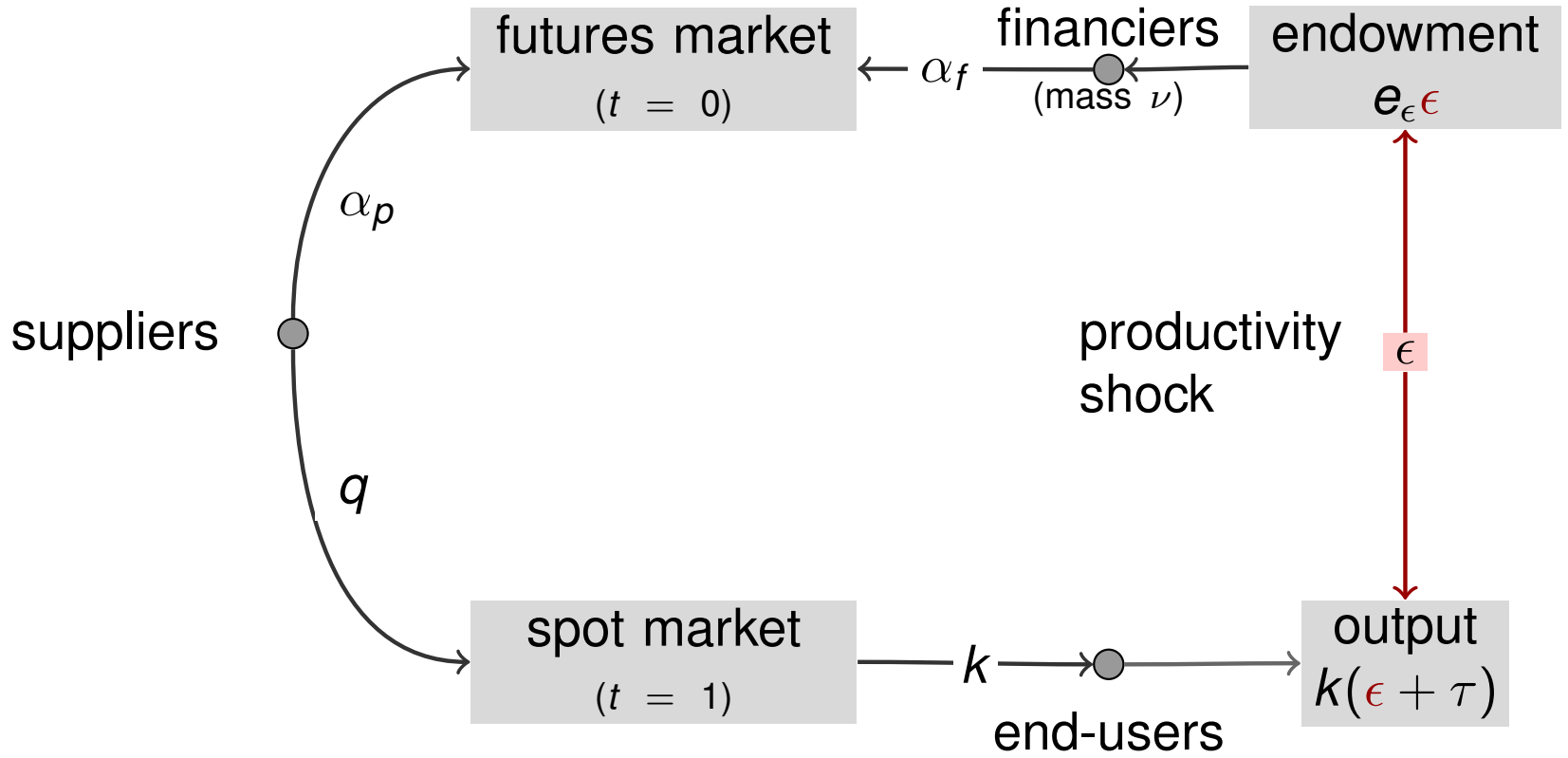

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Producer's Problem

$$\sup_{\tilde{q},\tilde{\alpha}_p} \tilde{\mathrm{E}}\left[U\left(\tilde{w}\right)\middle|\mathcal{F}_{0,p}\right] \text{ u.c. } \tilde{w} = \tilde{q}\left(p-\kappa\right) + \tilde{\alpha}_p\left(p-F\right)$$

- Horizon large enough for the supply level to be adjusted
- Elasticity of supply not that small: see Roberts and Schlenker (2010) for agriculturals

Financier's Problem

$$\sup_{\tilde{\alpha}_f} \tilde{\mathrm{E}}\left[U\left(\tilde{w}\right)\middle|\mathcal{F}_{0,f}\right] \text{ u.c. } \tilde{w} = \tilde{\alpha}_f\left(p-F\right) + e$$

End-User's Problem

$$\sup_{\tilde{k}} \mathrm{E}\left[U\left(\tilde{w}\right)\middle|\epsilon, p\right] \text{ u.c. } \tilde{w} = \tilde{k}\left(\epsilon+\tau-pR\right)$$

▸ model 1

Parametric Restrictions

Positive Supply

extraction costs κ not too high

$$\kappa \leq K_1$$

Suppliers Hedge

financiers not too exposed to spot price risk

$$e_\epsilon \leq K_2$$

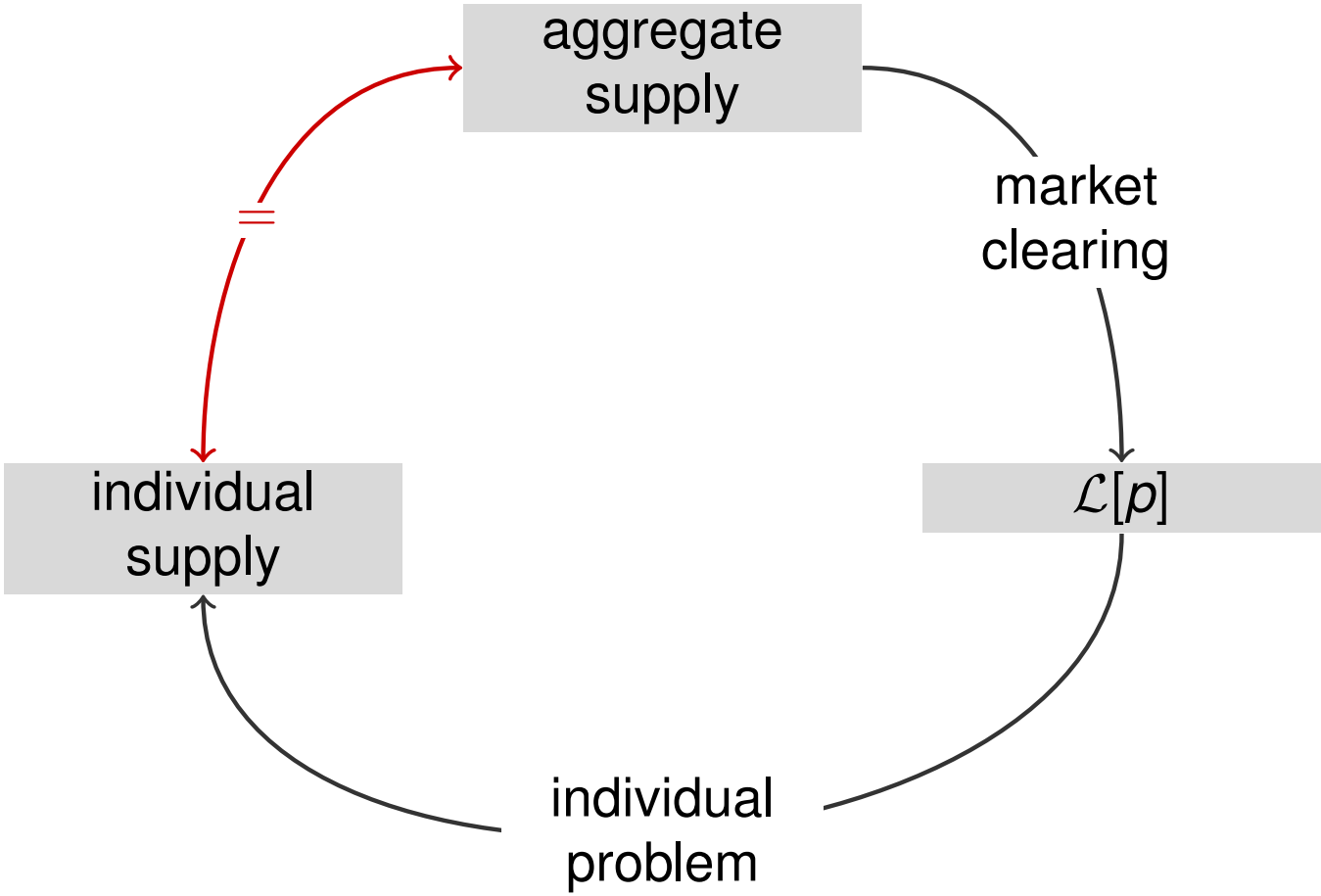
Equilibrium

Definition: Rational Expectations Equilibrium (REE)

Futures price F, distribution for p, individual strategies

- markets clear
- individual strategies optimal
- rational expectations

REE



proposition

$\exists!$ equilibrium

Spot Price

Proposition

When the mass ν of financiers increases

- the supply increases
- the expected spot price decreases

- Cornaggia (2013)
- Perez-Gonzales and Yun (2013)

Expected Utilities

Proposition

Increasing of the mass ν of financiers is

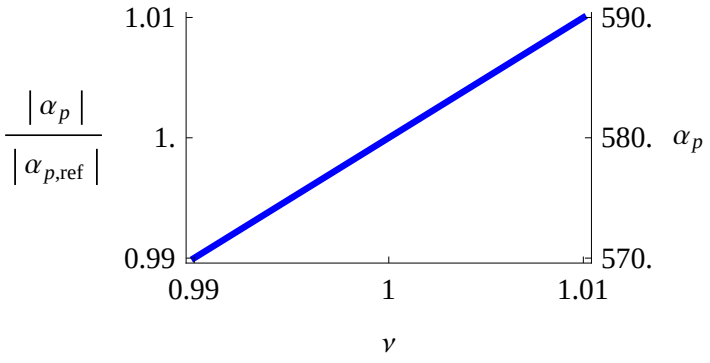
- beneficial to the end-users
- detrimental to the incumbent financiers
- ambiguous for the suppliers

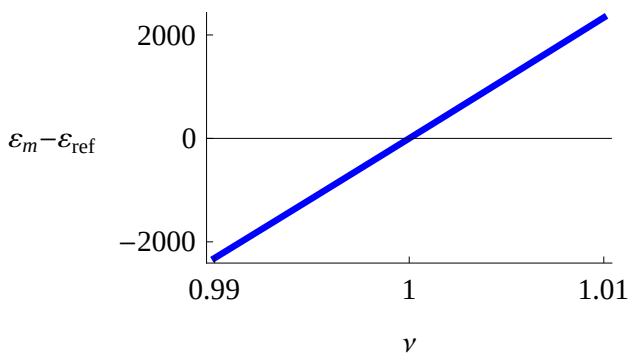
  (beneficial exactly when $\dfrac{d_0 + \frac{\nu \sigma_{e,p}}{\sigma_p^2}}{d_1} < \kappa$ and $\sigma_{e,p} < 0$)

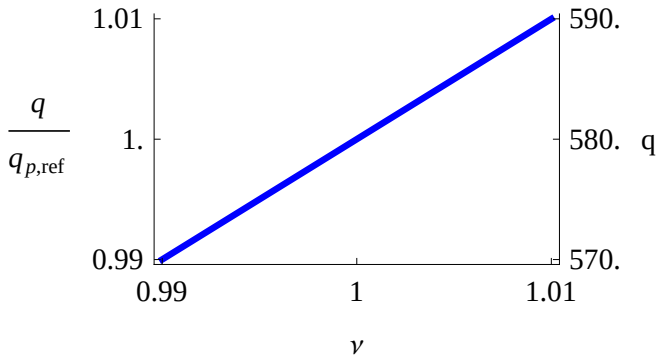
corollary

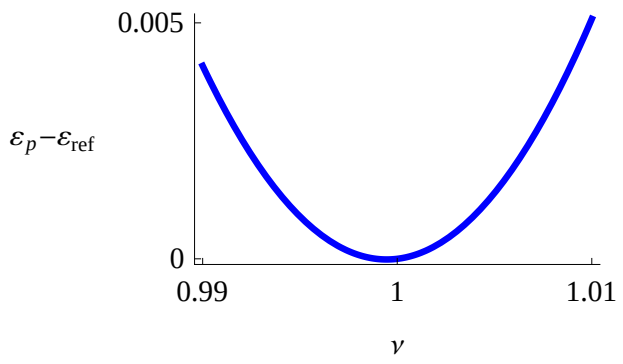
- Welfare improving

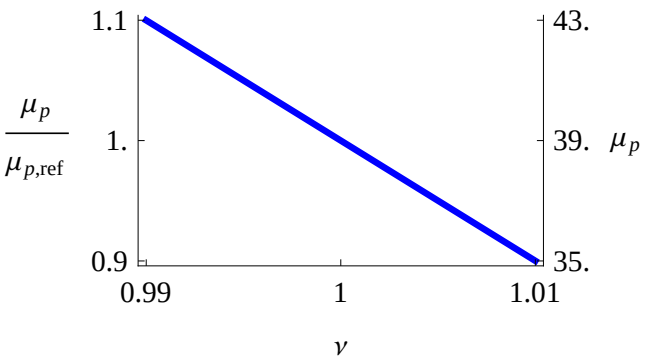
numerical results

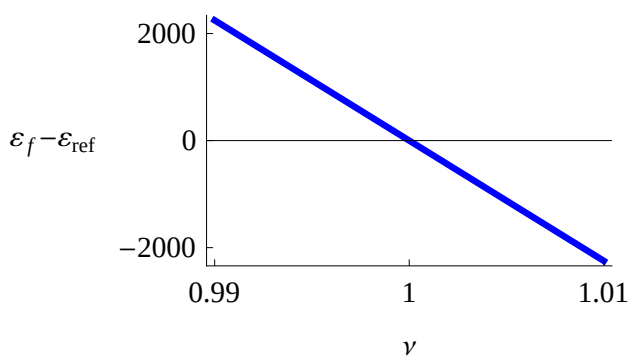












▸ parameters

Futures Markets and Information

Futures markets allow to

- speculate according to one's view regarding spot prices
- learn about the views of others
- HASBROUCK (1995)

In the model

- the financiers have superior information
- suppliers learn from the futures market

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Hedging and Learning on the Futures Markets

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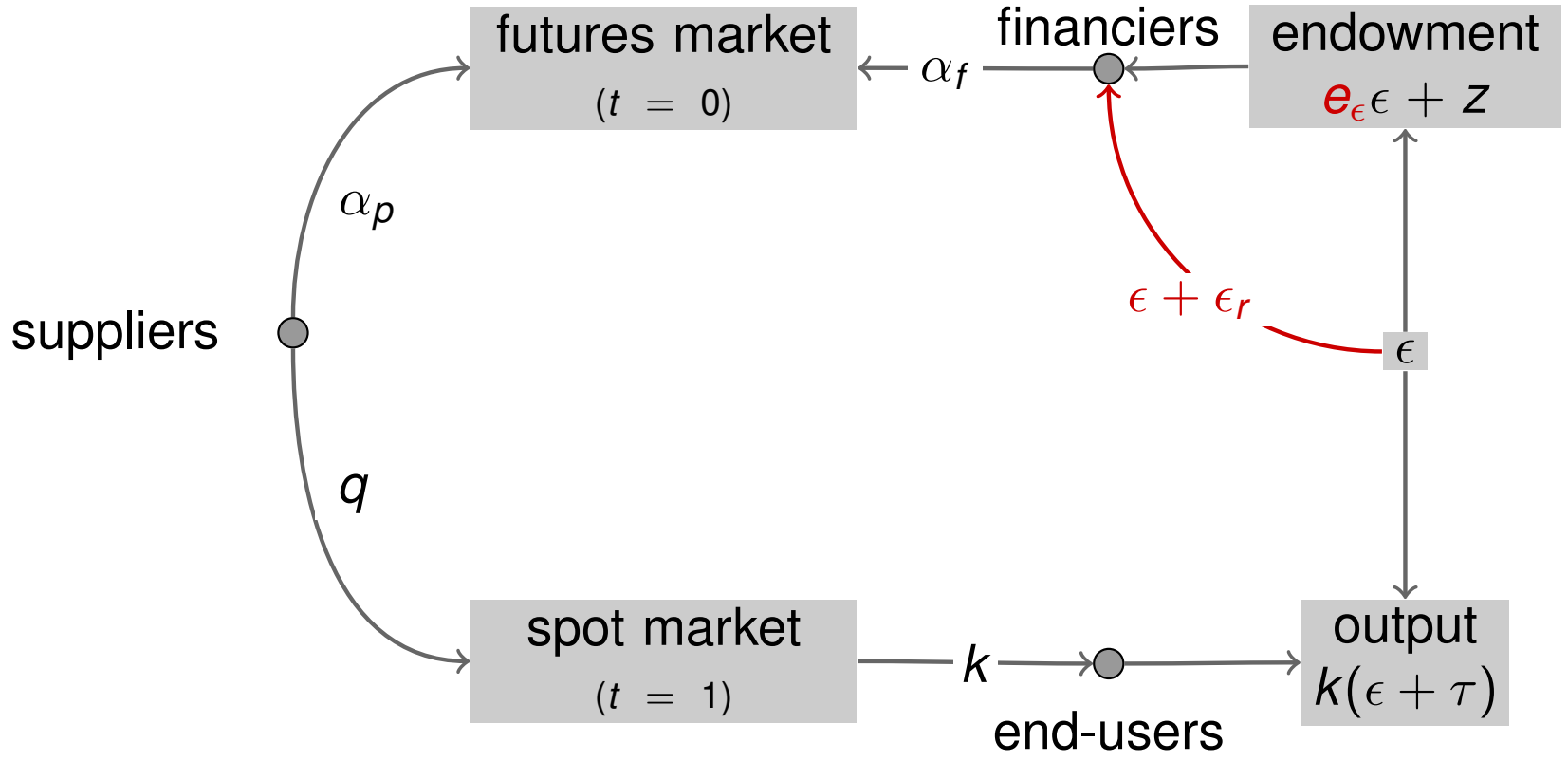


CARA-normal setting $\left(\begin{array}{rcl} \tau,\ \epsilon,\ \epsilon_r,\ e_\epsilon & \sim & \mathcal{N} \\ c & \mapsto & -e^{-\gamma c} \end{array} \right)$

▸ individual problems

Information Sets

Financier's Futures Trading α_f based on

futures price F
signal $S = \epsilon + \epsilon_r$
exposure e_ϵ
beliefs regarding aggregate production Q

Supplier's Policy based on

futures price F
open-interest α_f
beliefs regarding aggregate production Q

End-User's Policy based on

productivity shock ϵ
spot price p

Equilibrium

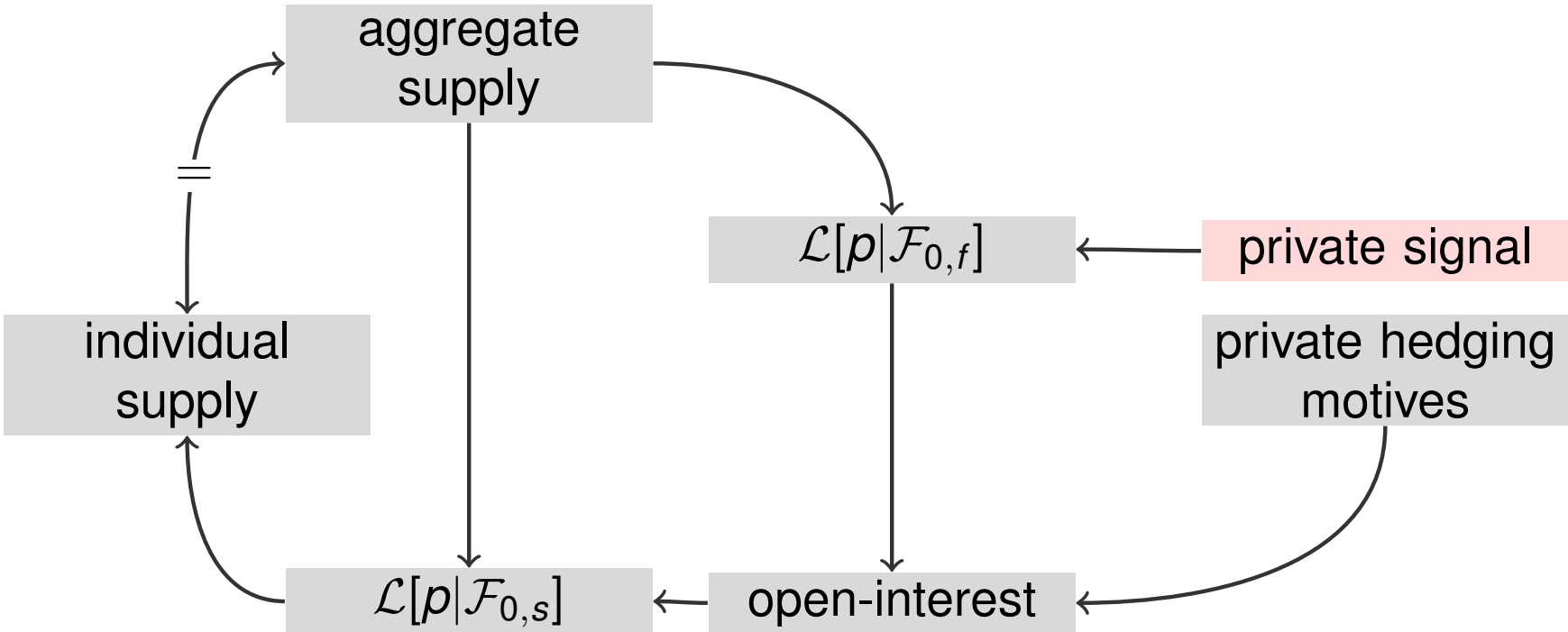
Definition: REE

Futures price F, conditional distribution for p, individual strategies

- markets clear
- individual strategies optimal
- rational expectations

in any state of the world

Rational Expectations Again



Equilibrium

Proposition

- $\exists!$ continuous equilibrium
- it is linear
- F is constant
- open-interest partially reveals the signal

- Yuan (2005), Breon-Drish (2012), Venter (2014)
- cf. Hong and Yogo (2012)
- Last two points rely on the linear extraction costs

Variance of the Spot Price

Proposition

An increase of the mass ν of financiers only decreases the variance of the spot price if the signal is accurate enough

$$\partial_\nu \operatorname{Var}[p] < 0 \;\Leftrightarrow\; \sigma_r^2 \sigma_{e_\epsilon}^2 < K_3$$

- Financiers can have a destabilizing effect
- Effect driven by supply side: not present in standard noisy REE models
- NEWBERY (1987)

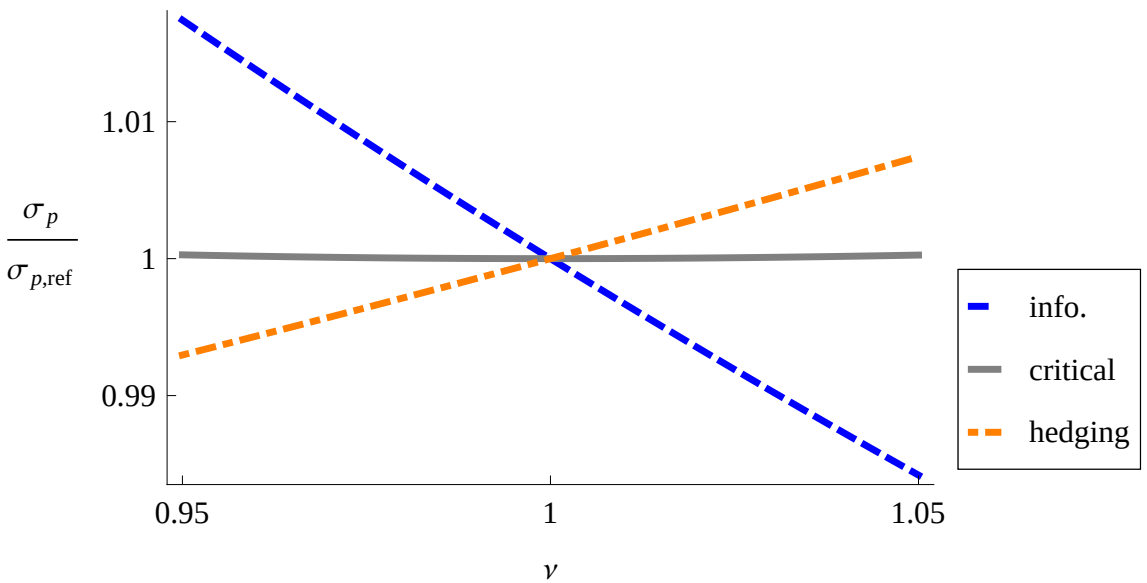
The financiers trade because of

Exogenous hedging motives

- $\sigma_r^2 \sigma_{e_\epsilon}^2$ is large
- Spot market is contaminated by non-fundamental shocks
- Variance of spot price increases with ν

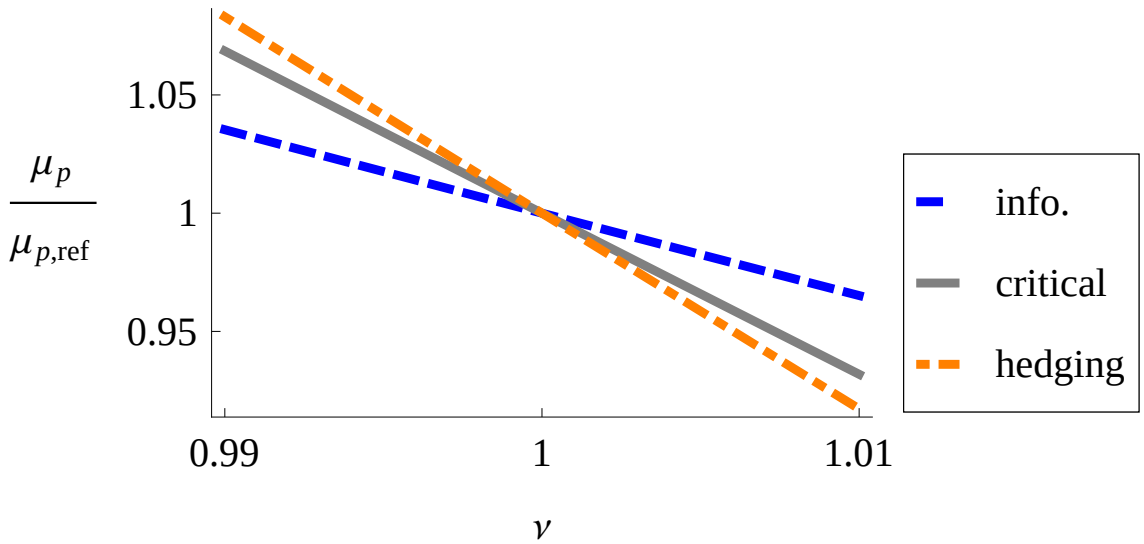
Superior information

- $\sigma_r^2 \sigma_{e_\epsilon}^2$ is small
- Futures markets synchronize demand and supply
- Variance of spot price decreases with ν



▸ parameters

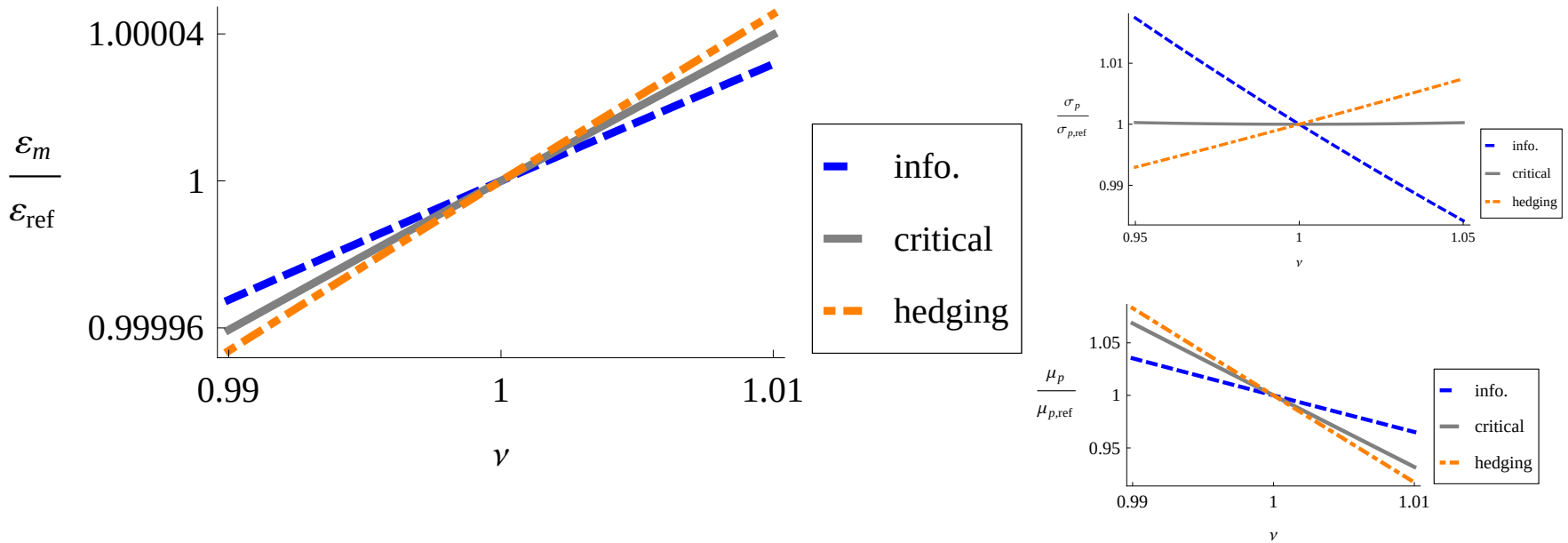
Expected Spot Price



Financiers

- Reduce risk: a fixed contribution
- Transfer risk: a proportional contribution
- More capital for absorbing shocks makes a larger impact in a riskier world

Expected Utility of the End-Users



- The effect on expected returns dominates the effect on variance

Summary

- When more investors trade on futures market
  - More hedging and production
  - Expected prices decrease
  - Ambiguous effects on volatility and expected utilities
- Open-interest can provide more information than futures prices

Current Work

Mismatch between horizon of futures contract and planning horizon for commodity suppliers

- Study stationary model
- Sometimes impossible to adjust production: nothing changes
- Costly production adjustments: results are robust

Current Work

- Actual suppliers do not hedge that much. Why?
- Non-competitive suppliers

Thank you

calibration

base model

$$\begin{aligned} \gamma &= 2 \\ \nu &= 1 \\ R &= 1.035 \\ \mu_p &= 38.74 \\ \sigma_p &= 28.58 \\ q &= 580.4 \\ \text{elast. of demand} &= 0.1 \end{aligned}$$

with learning

$$\sigma_{e_\epsilon} = \frac{1}{20}\mu_{e_\epsilon}$$

hedging

$$\sigma_r = 1.5 \times \sigma_{r,\text{crit.}}$$

speculation

$$\sigma_r = 0.5 \times \sigma_{r,\text{crit.}}$$

▸ numerical results 0 ▸ numerical results 1