Equilibrium Commodity Trading

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Swiss Finance Institute
Ecole Polytechnique Fédérale de Lausanne

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sharp commo price movements since 2002

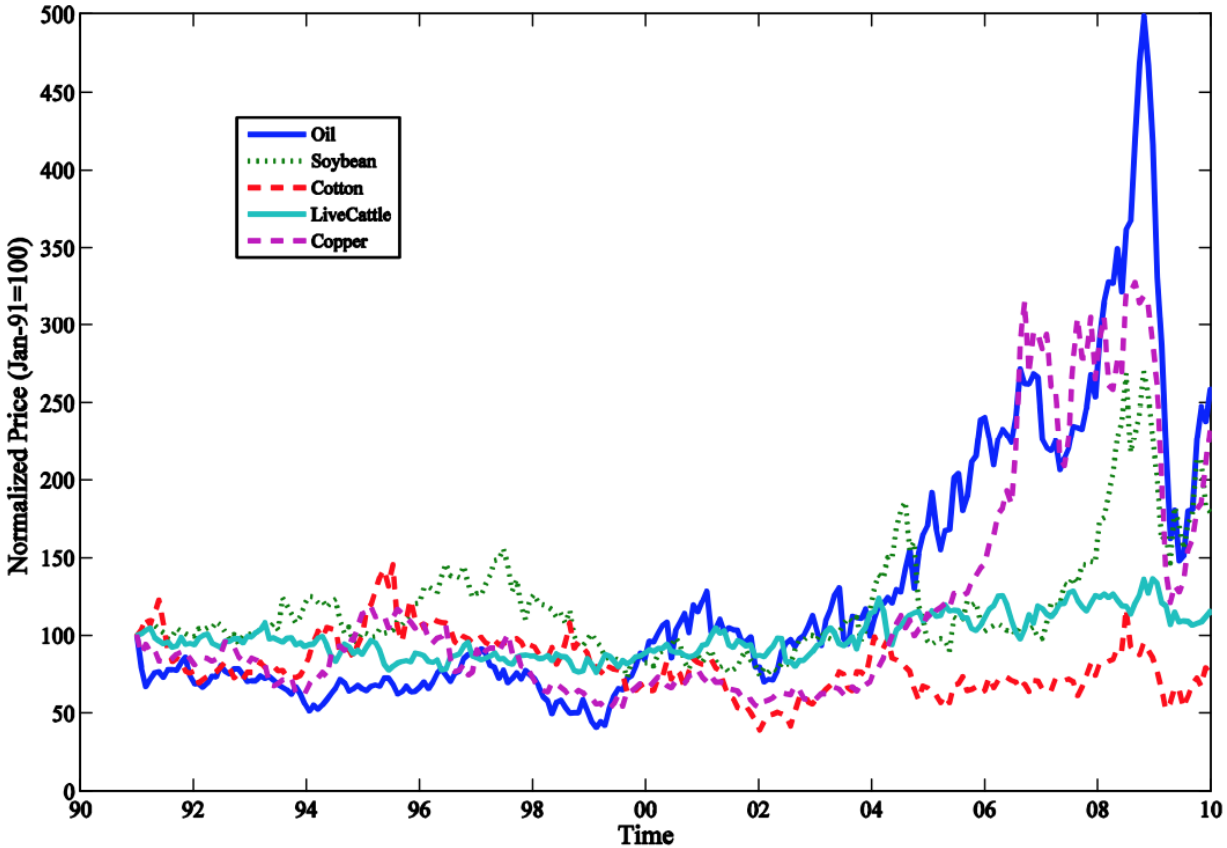

Figure : from Tang and Xiong 2010

- oil, copper, zinc, tin, soybeans
- prices doubled/halved within a year

commodity futures markets

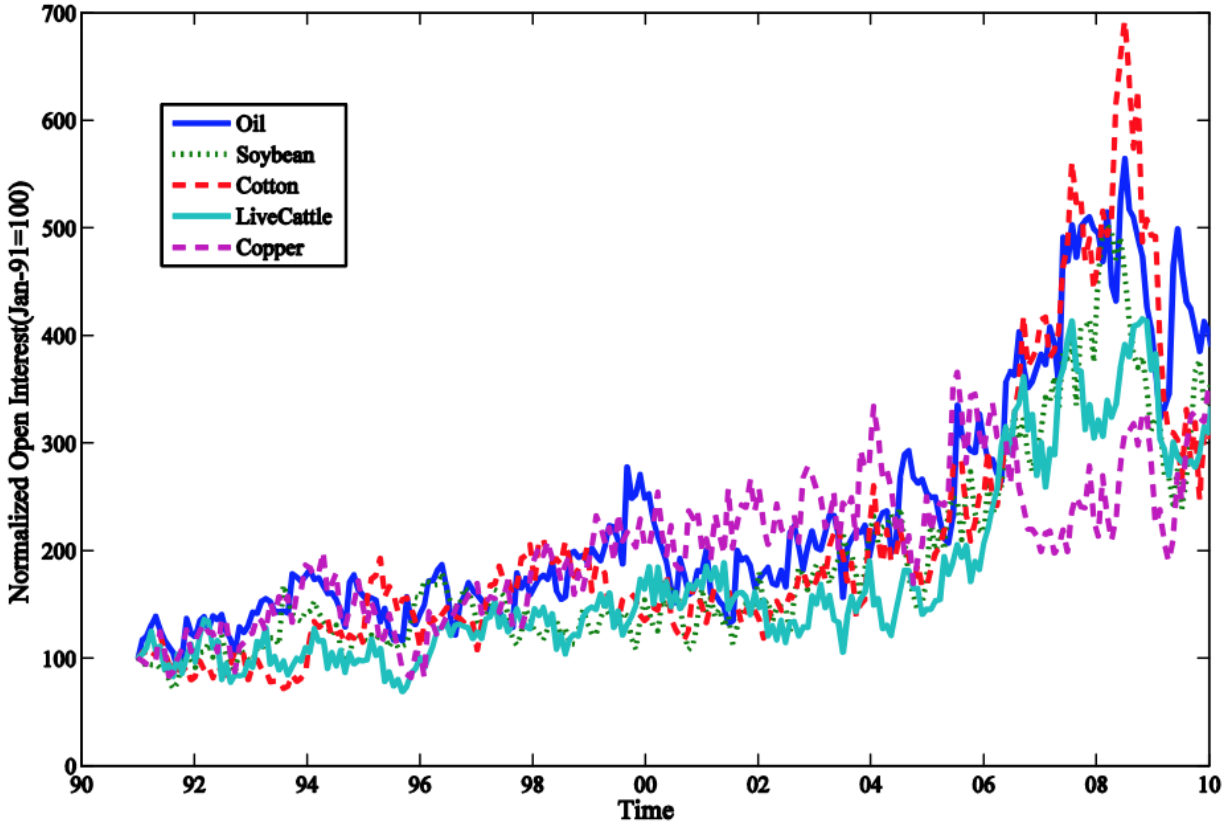

Figure : from Tang and Xiong 2010

- sharp increase (and variations) of the open interest
- ETF's

is there a link?

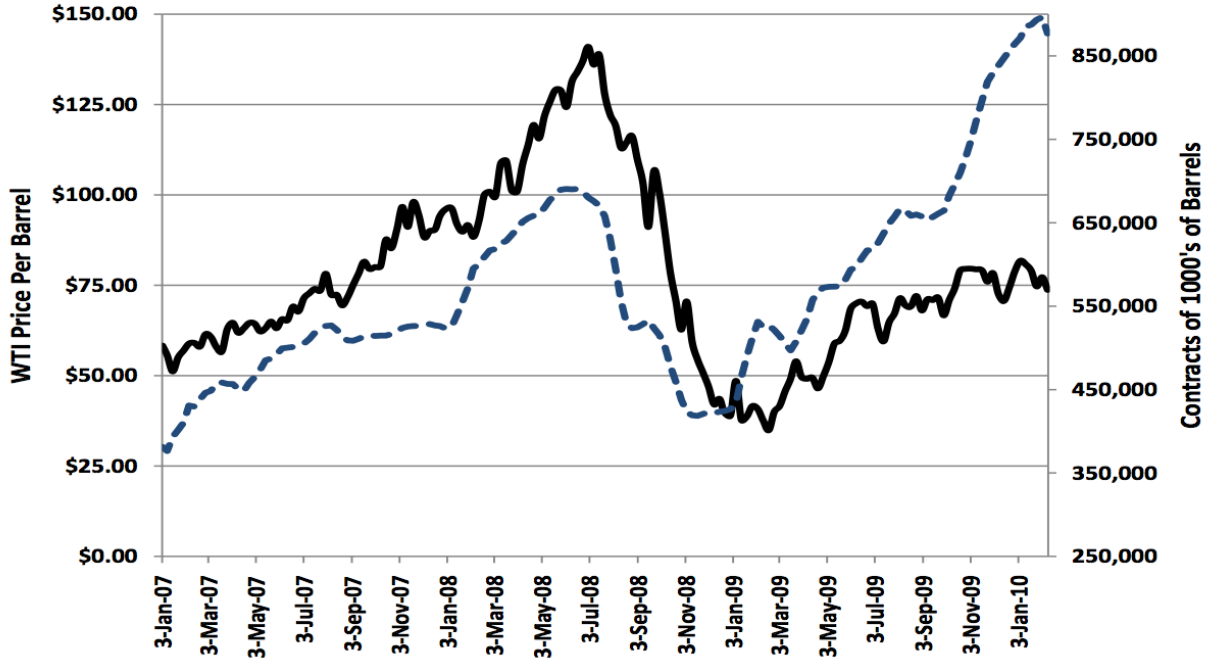

Figure : from SINGLETON WP 2012

- *looks like* open-interest and prices move together

model features and results

features

- commodity production, consumption, and speculation are endogenously determined
- asymmetric information model
- futures are used for both hedging and speculation

results

- commodity supply is a channel by which speculators on the futures market impact the spot market
- both open-interest and futures price are informative (consistent with Hong and Yogo (2012), *JFE*)
- If accuracy of private information is low, more speculators makes both production and spot prices more volatile.
- More speculators typically increases correlation between financial and commodity markets (consistent with Silvennoinen and Thorp (2013), *JIFMIM*)

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literature

classic

Scheinkman and Schechtman RES '83, Deaton and Laroque RES '92, Deaton and Laroque JPE '96, Hirshleifer RFS '88, Hirshleifer JPE '88, Hirshleifer ECMA '90, Hong JF '00, Merton JF '87, Routledge, Seppi, and Spatt JF '00

recent: (also) empirical

Acharya, Lochstoer, and Ramadorai JFE '13, Christoffersen, Jacobs, and Li WP '13, Hamilton WP '09, Hamilton and Whu WP '12, Hong and Yogo JFE '12, Knittel and Pindyck WP '13, Singleton WP '12, Tang and Xiong FAJ '12, Silvennoinen and Thorp JIFMIM '13

recent: theoretical

Basak and Pavlova WP '13, Basak and Pavlova WP '13, Ekeland, Lautier, and Villeneuve WP '13, Sockin and Xiong WP '13, Goldstein, Li, and Yang RFS '13

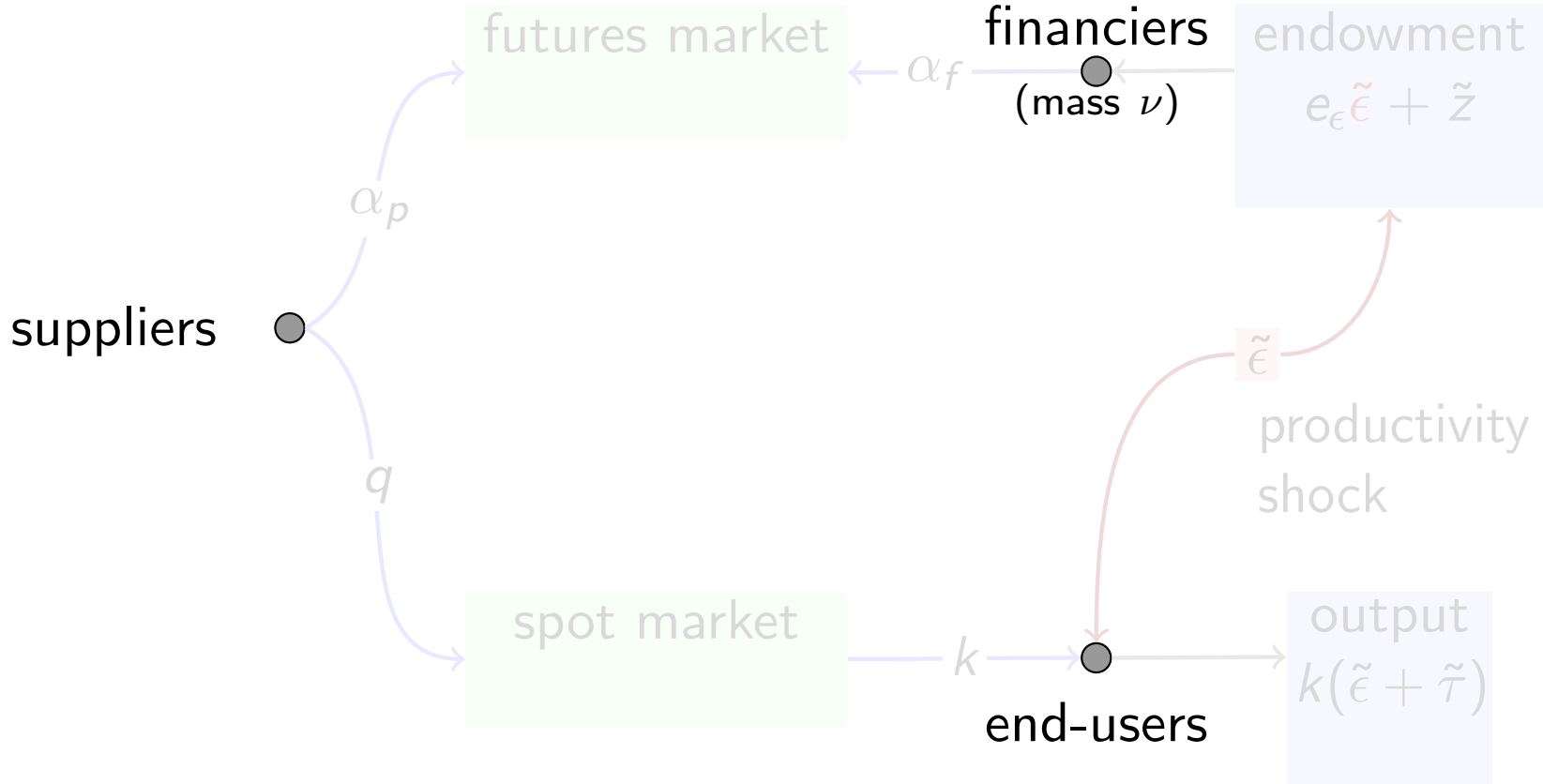
derivatives on underlying

Frey and Stremme MF '97, Platen and Schweizer MF '98, Sircar and Papanicolaou AMF'97, Schoenucher and Wilmott SIAM JoAM '00, Grossman JB '88, Genotte and Leland AER '90

outline

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

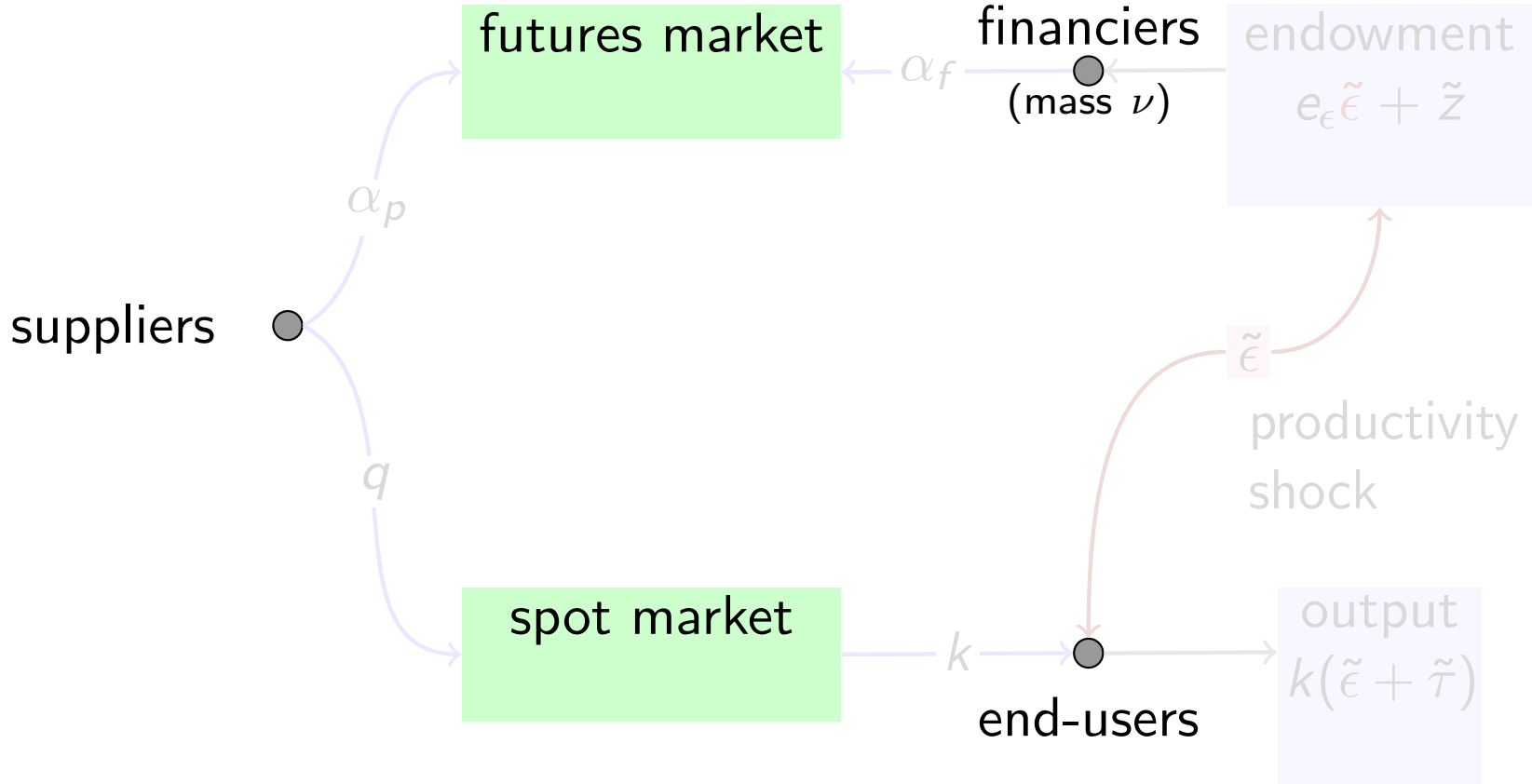
futures markets for hedging



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

extraction costs: $q \mapsto \kappa q$

futures markets for hedging



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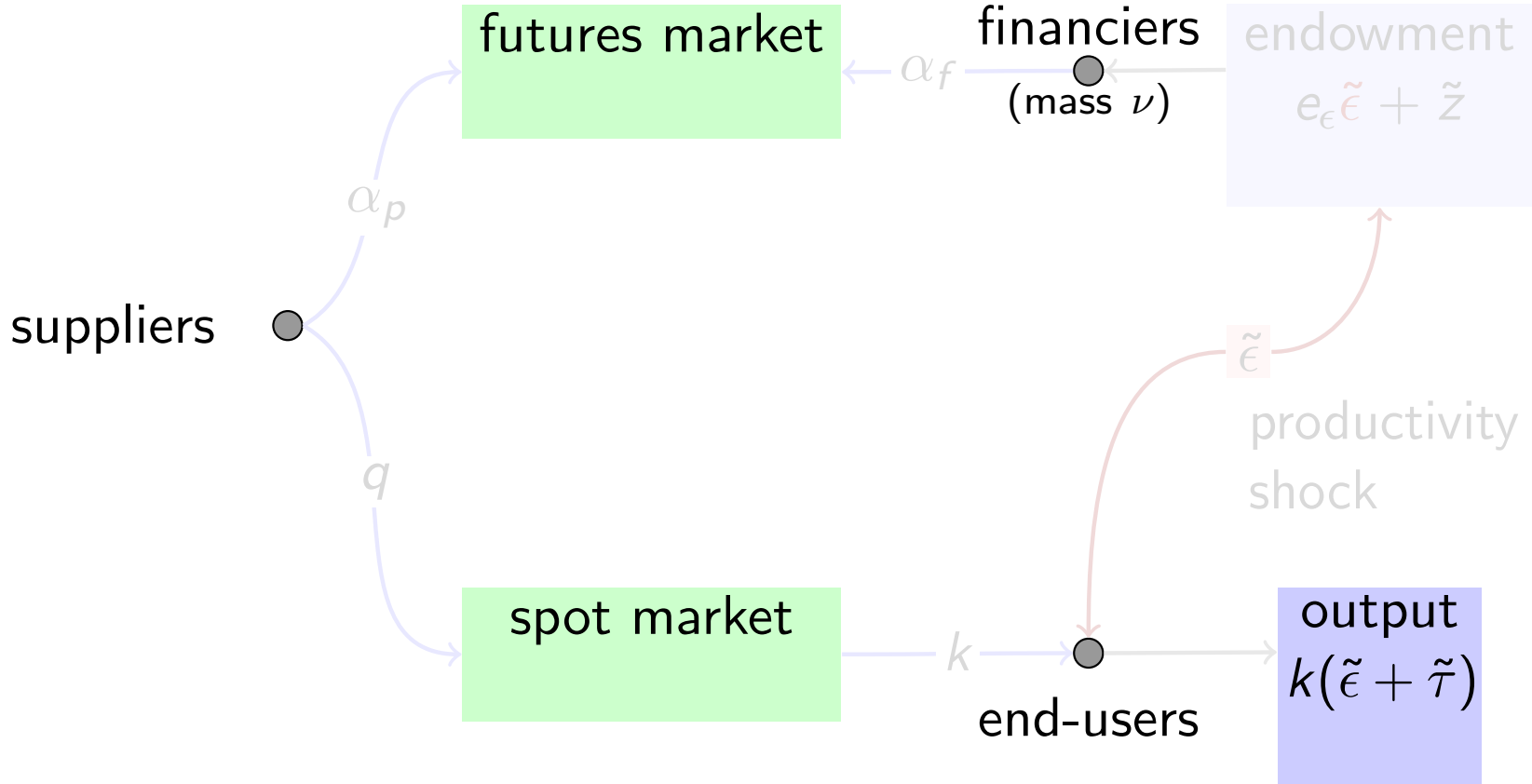

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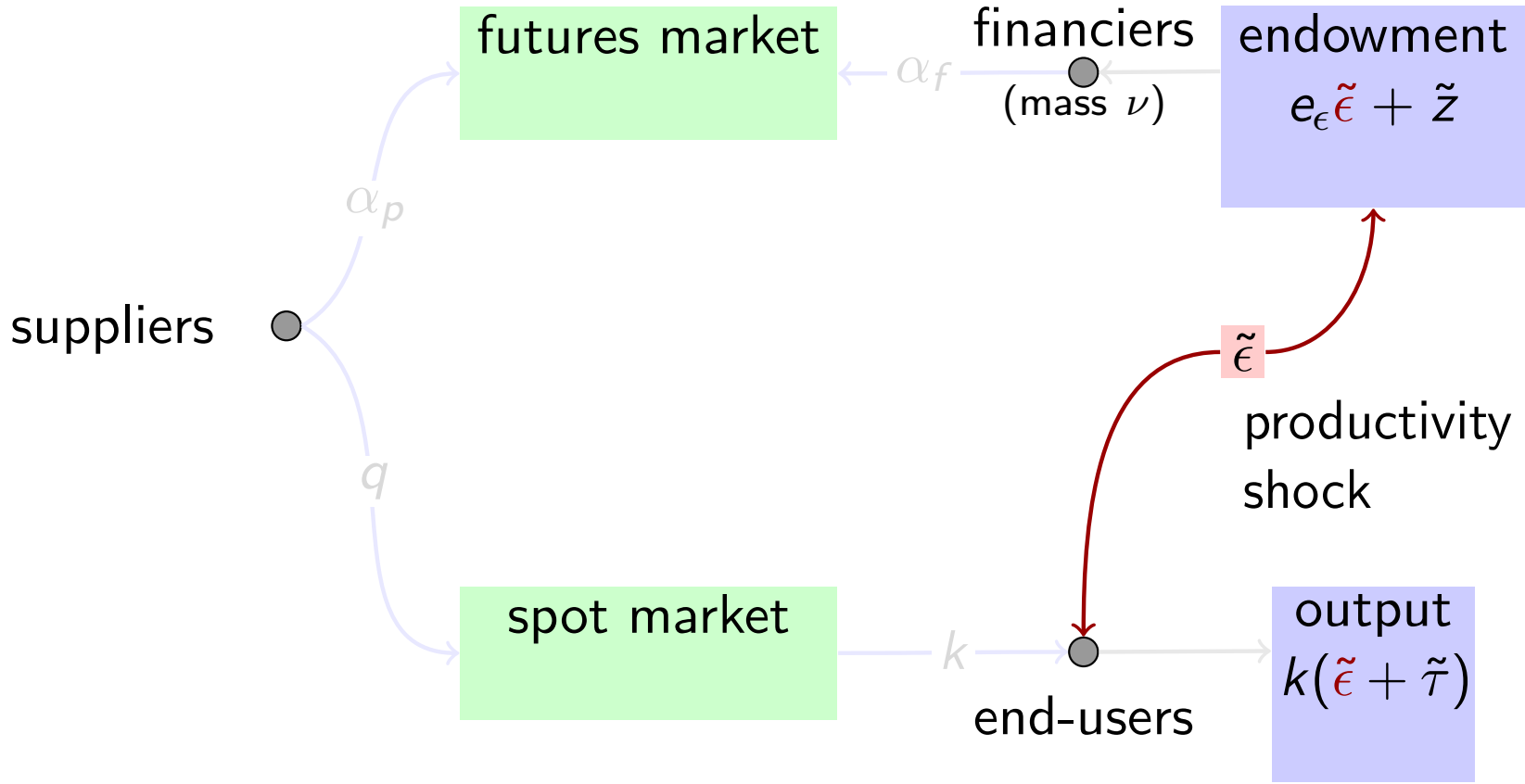

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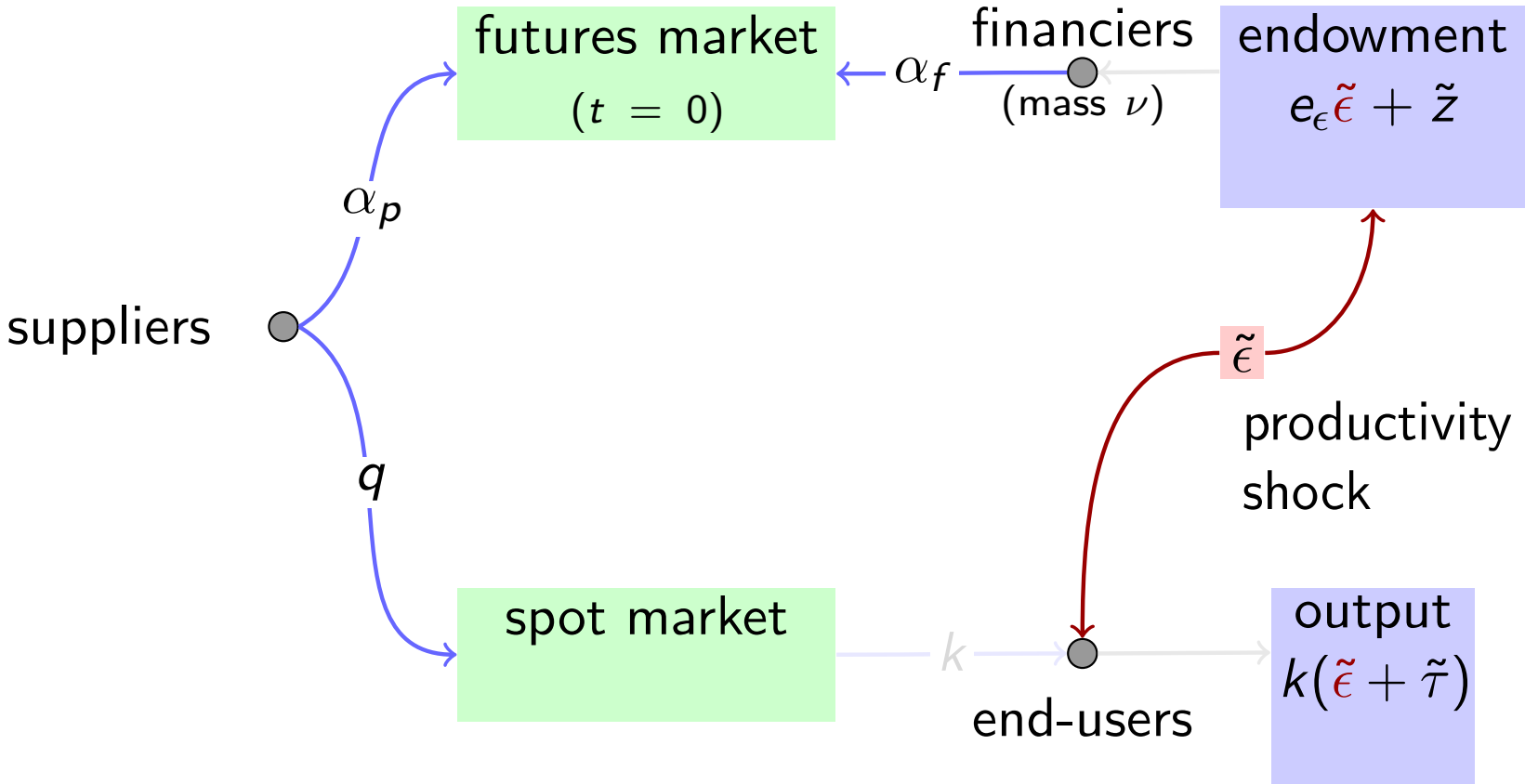

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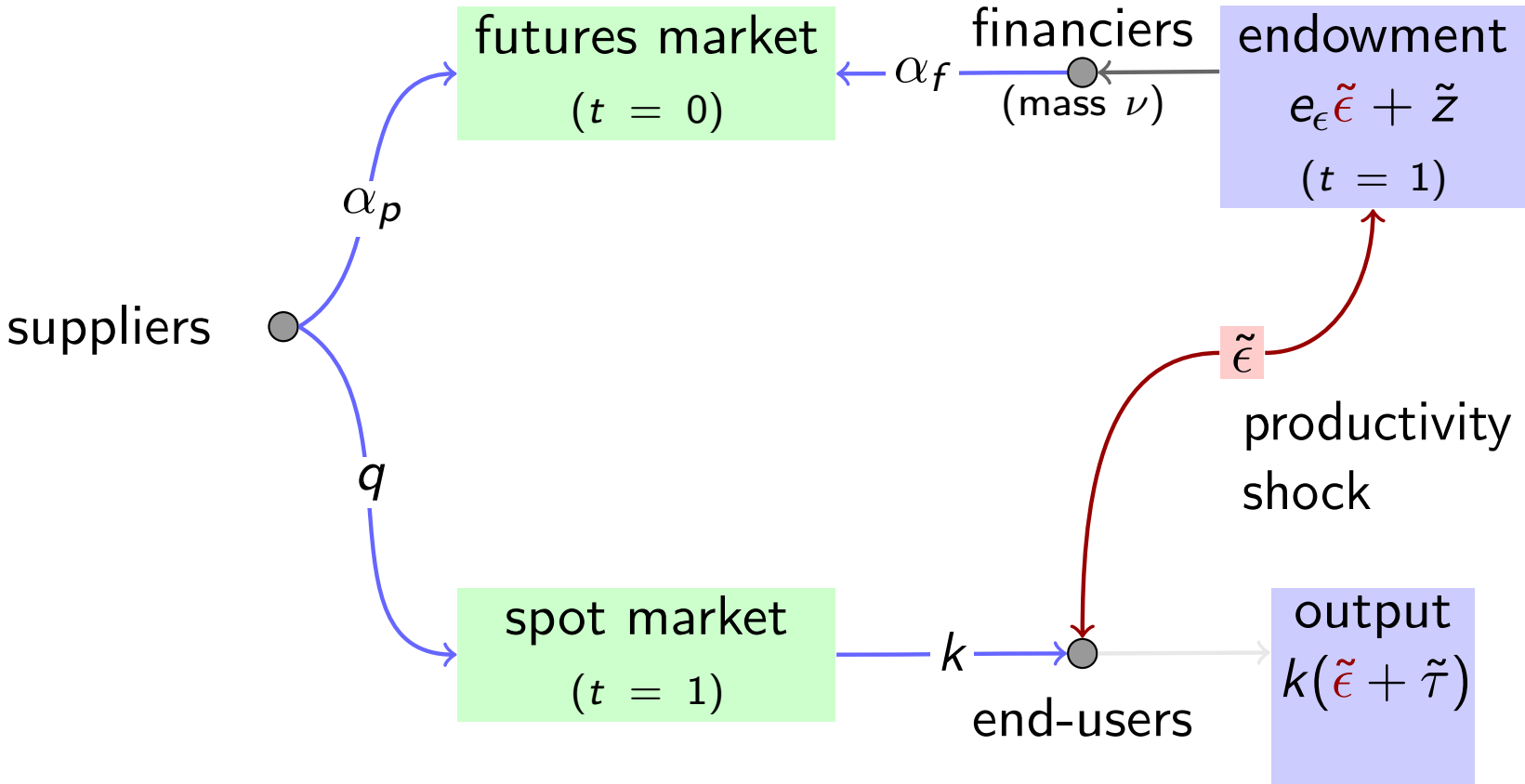

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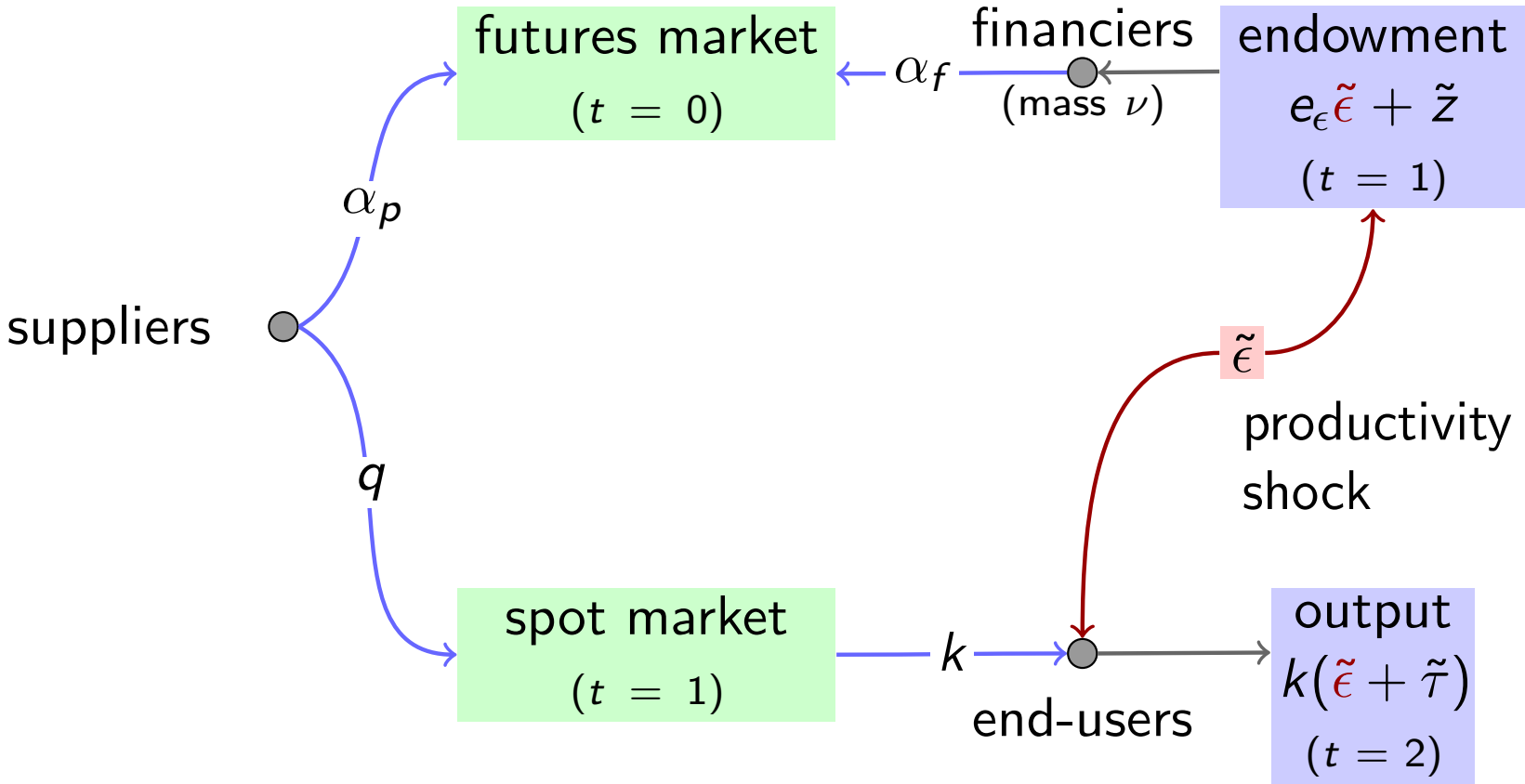

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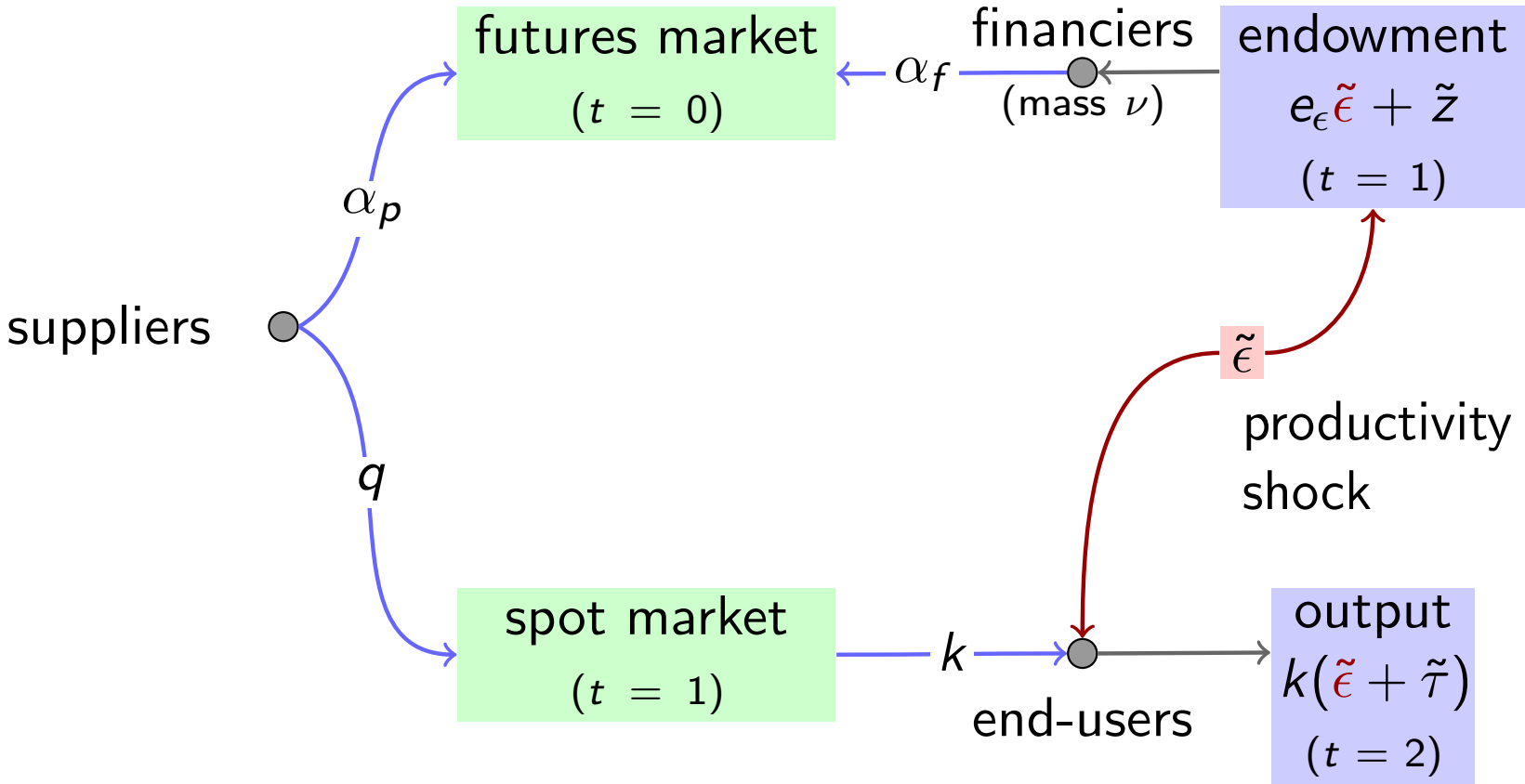

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supplier's problem

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

Note 1 large enough horizon for the supply level to be adjusted

end-user's problem

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

financier's problem

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

▸ model 1

restrictions on the parameters

positive supply

extraction costs κ not too high

$$\kappa \leq \frac{1}{R}\left(\mu_\tau - \frac{1}{\frac{1}{\gamma_f} + \frac{1}{\nu\gamma_s}} e_\epsilon \sigma_\epsilon^2\right)$$

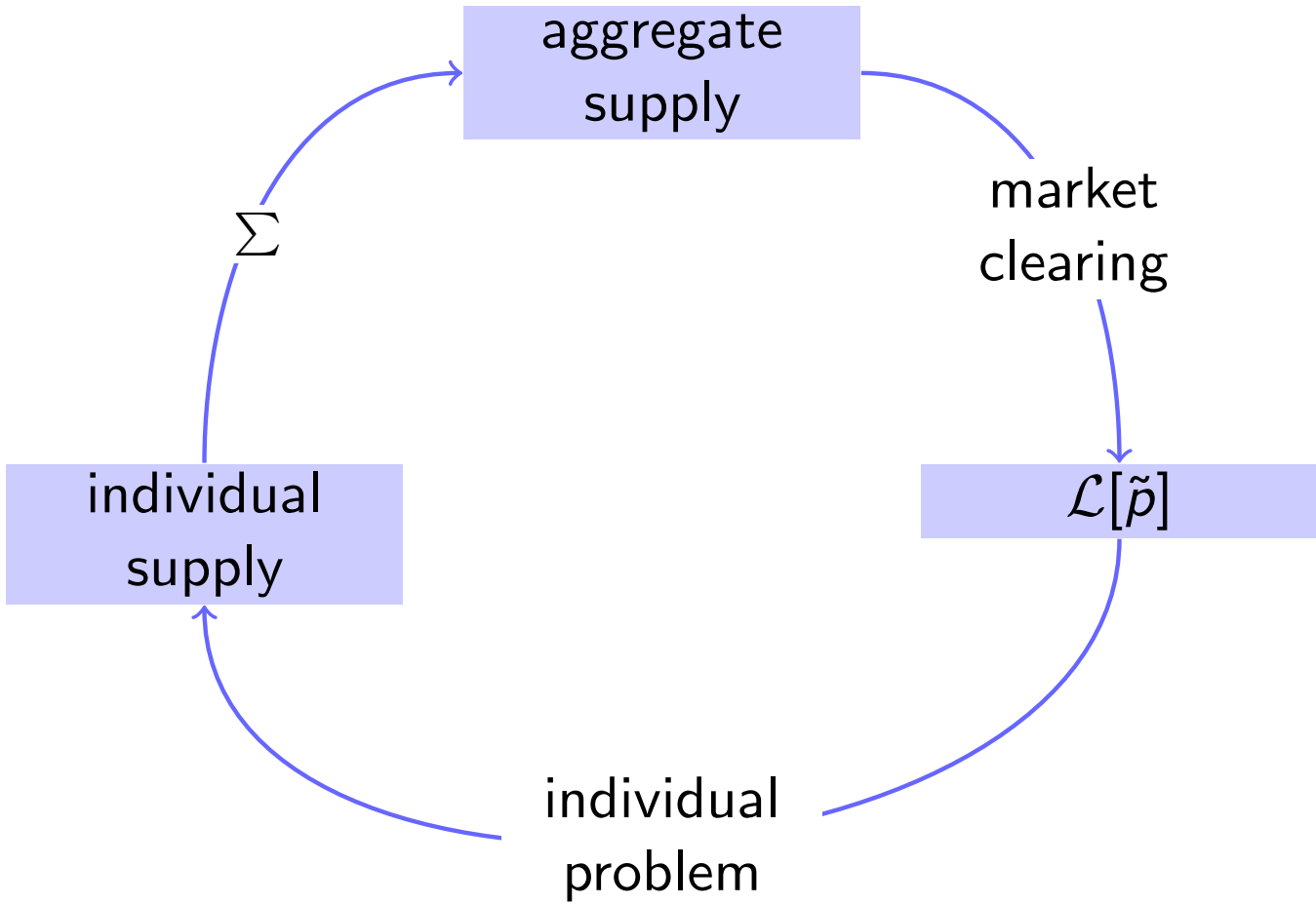
equilibrium

definition: rational expectations equilibrium (REE)

futures price F, distribution for $\tilde{p}$, individual strategies

- markets clear
- individual strategies optimal
- rational expectations (supply)

rational expectations



proposition

$\exists!$ equilibrium

proposition

If the financiers are negatively exposed to the commodity price risk, i.e. $\sigma_{e,p} \leq 0$, or if the extraction costs are low enough, then

- the financiers buy futures contracts
- when the mass ν of financiers increases
  - the supply increases
  - the expected spot price decreases

Conversely, if both $\sigma_{e,p} > 0$ and the extraction costs are high enough, then

- the financiers sell futures contracts
- when the mass ν of financiers increases
  - the supply decreases
  - the expected spot price increases

expected utilities

proposition

an increase of the mass ν of financiers is

- beneficial to the end-users, if $\sigma_{e,p} \leq 0$ or κ low enough.
- detrimental to the end-users, if $\sigma_{e,p} > 0$ and κ high enough.
- detrimental to the financiers
- ambiguous for the suppliers

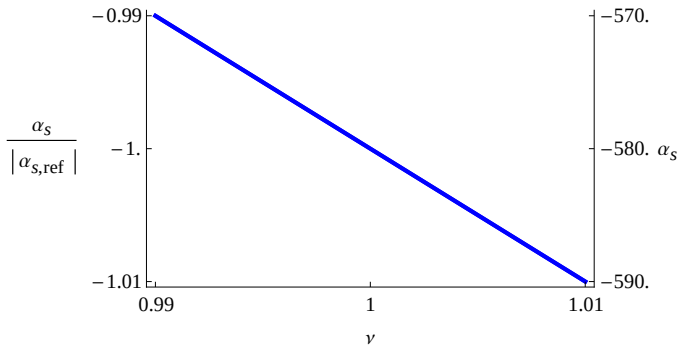
ambiguous for the suppliers because

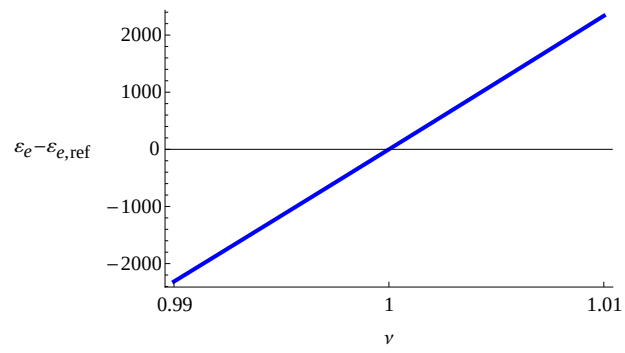
- each supplier sells more of the commodity
- but they collectively increase the supply
- and do not internalize the adverse effect on prices

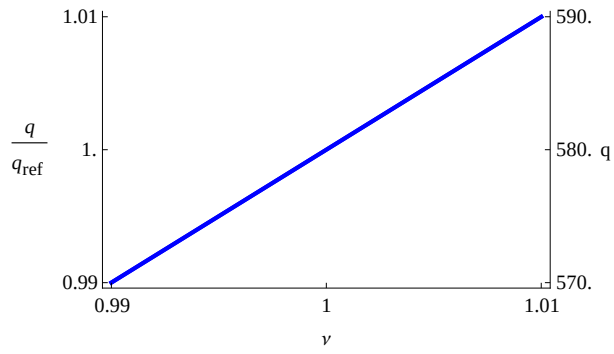
corollary

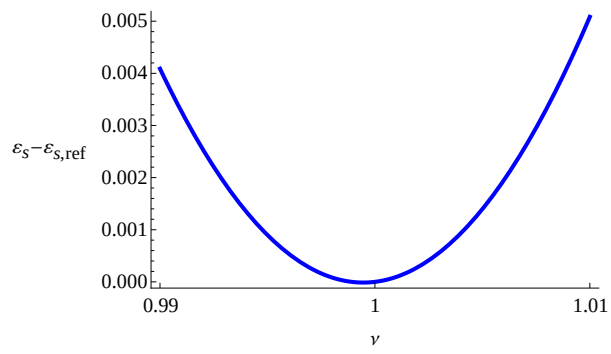
- welfare improving

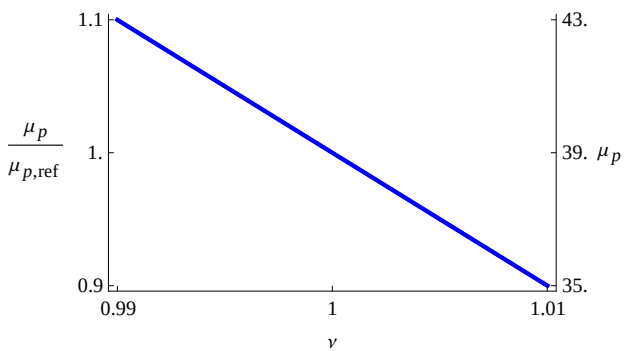
numerical results

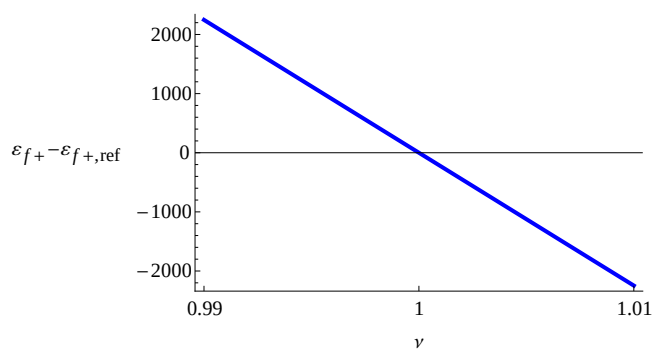












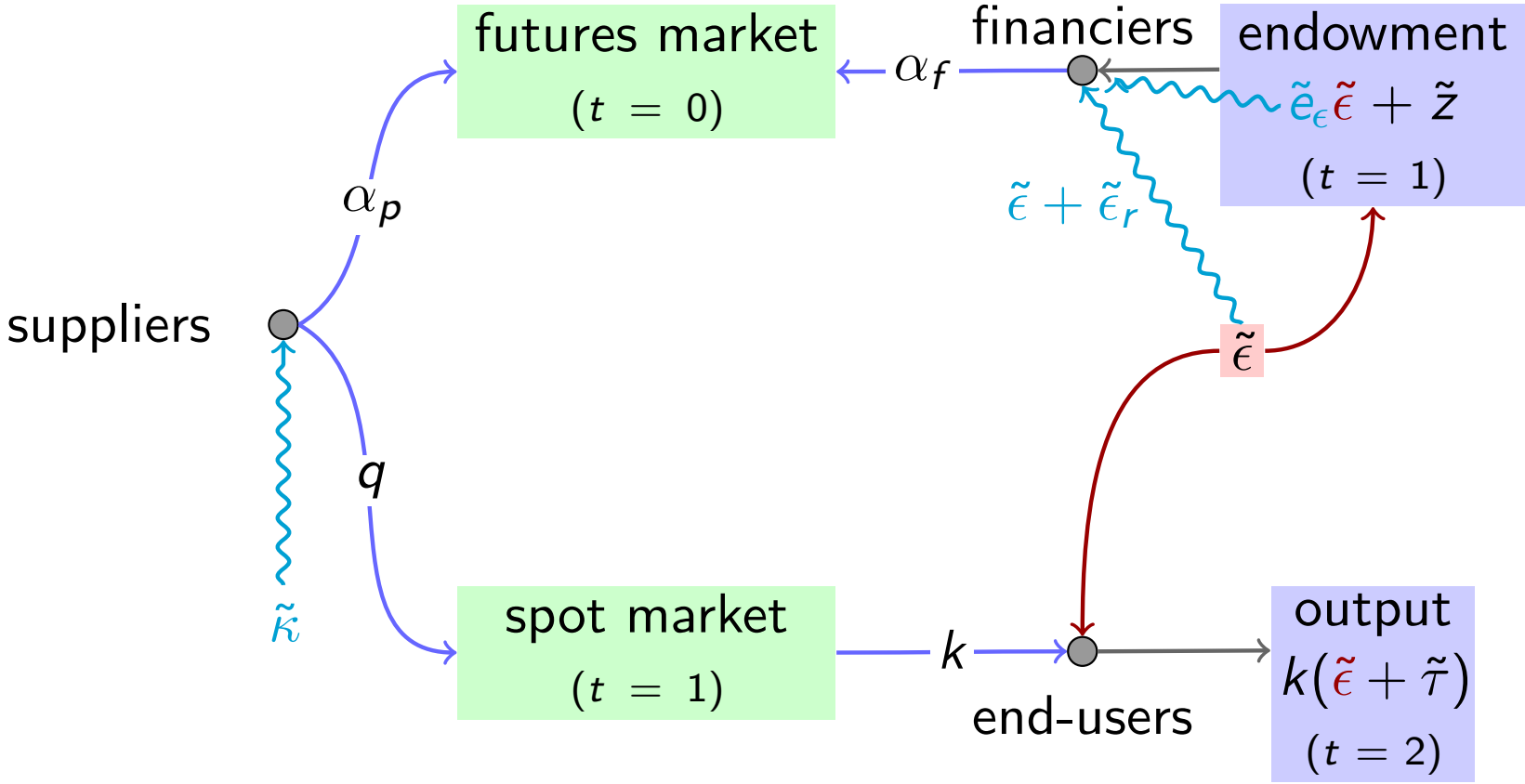
▸ calibration

futures markets and information

futures markets allow to

- speculate according to one's view regarding spot prices/demand
- learn about the views of others
- learn about non public information

futures markets for hedging and learning



CARA-normal setting $\begin{pmatrix} \tilde{z},\ \tilde{\tau},\ \tilde{\epsilon},\ \tilde{\epsilon}_r,\ \tilde{e}_\epsilon & \sim & \mathcal{N} \\ \text{supp}(\tilde{\kappa}) & = & [\underline{\kappa}, \overline{\kappa}] \\ c & \mapsto & -e^{-\gamma c} \end{pmatrix}$

▸ individual problems

$\exists!$ equilibrium

proposition

- $\exists!$ equilibrium
- it is linear
- futures price reveals the extraction costs
- open-interest partially reveals the signal

spot price and endowment results

proposition

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

$$\partial_\nu \operatorname{Var}[p] < 0 \;\Leftrightarrow\; \sigma_r^2 \sigma_{e_\epsilon}^2 < \frac{d_1 \sigma_e^2}{R^2 \nu \gamma}$$

- the correlation between spot price and endowment increases with ν if and only if the average exposure of the endowment to the commodity price risk is non-positive

$$\partial_\nu \rho_{e,p} \geq 0 \;\Leftrightarrow\; \mu_{e_\epsilon} \leq 0.$$

note financiers can have a destabilizing effect

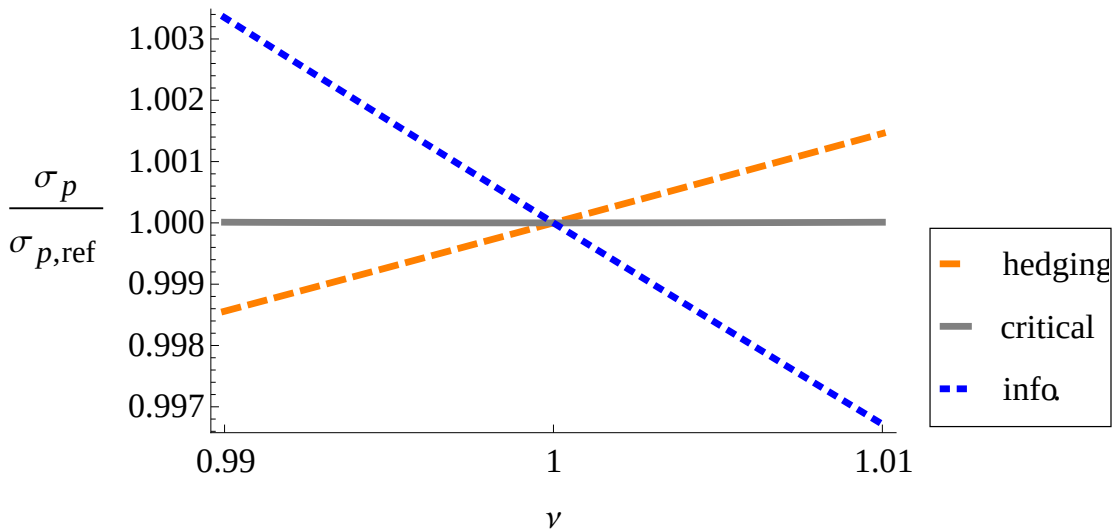
the exposure of the financiers is driven by

exogenous hedging motives

- $\sigma_r^2 \sigma_{e_\epsilon}^2$ "large"
- supply driven by exogenous factors
- spot market "contaminated"
- variance of spot price increases with ν

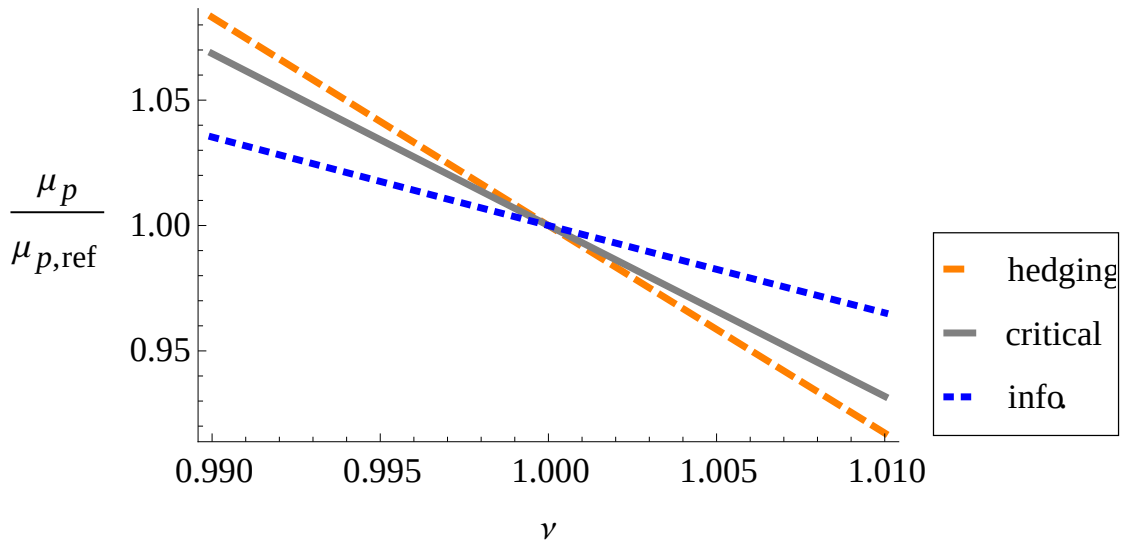
superior information

- $\sigma_r^2 \sigma_{e_\epsilon}^2$ "small"
- futures markets synchronize demand and supply
- variance of spot price decreases with ν



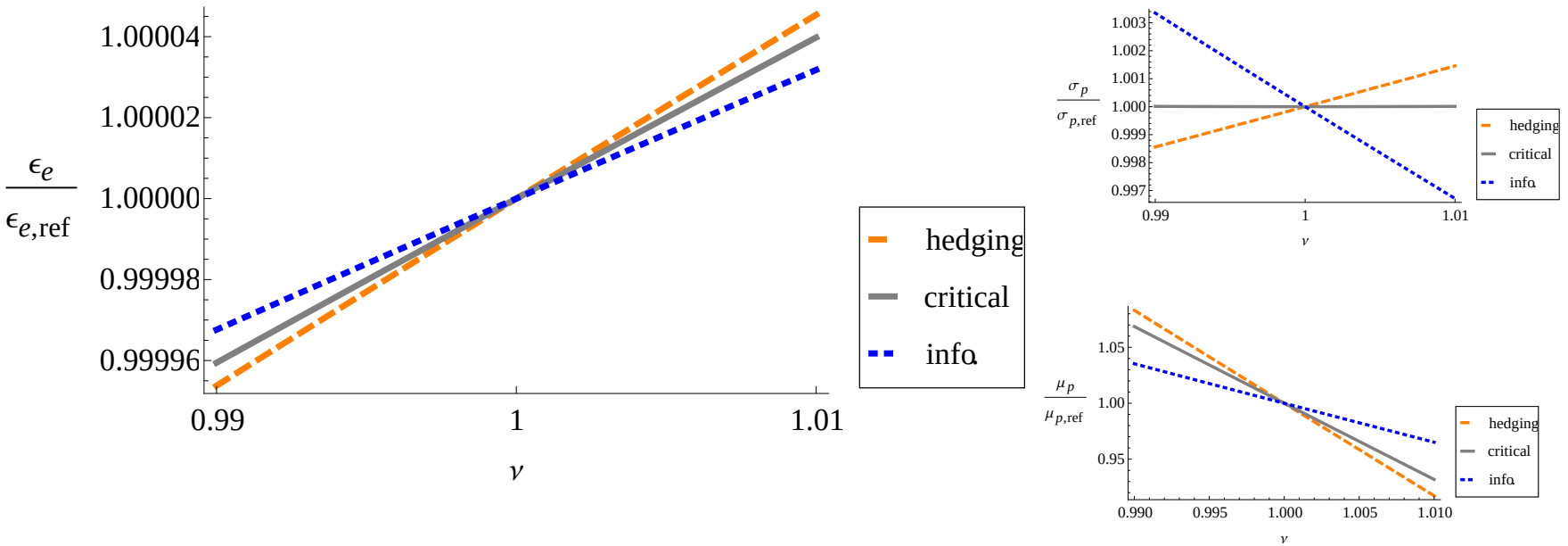
▸ parameters

expected spot price



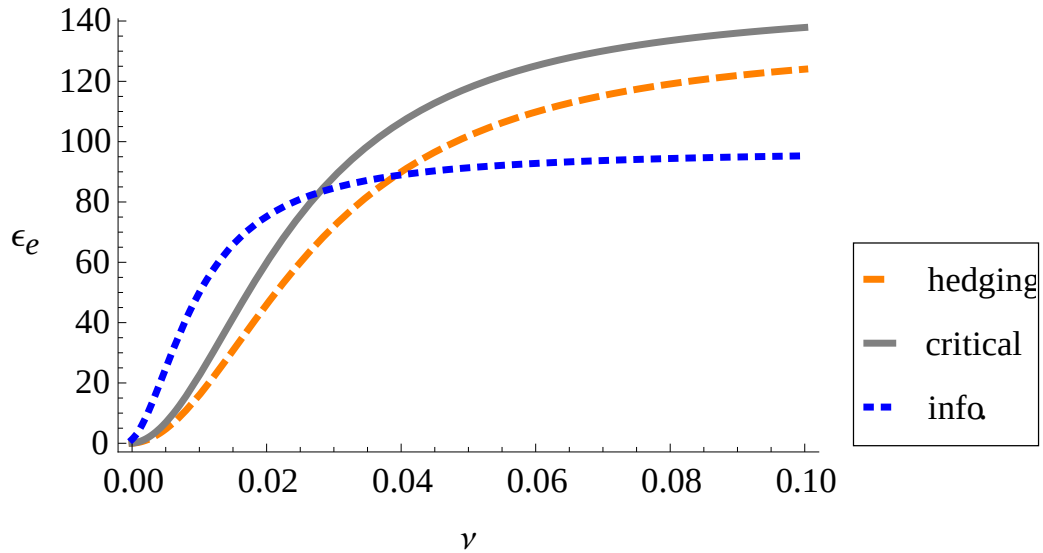
- more accurate signals make the expected spot price less sensitive to ν
- more capital for absorbing shocks makes a larger impact in a riskier world

relative expected utility of the end-users



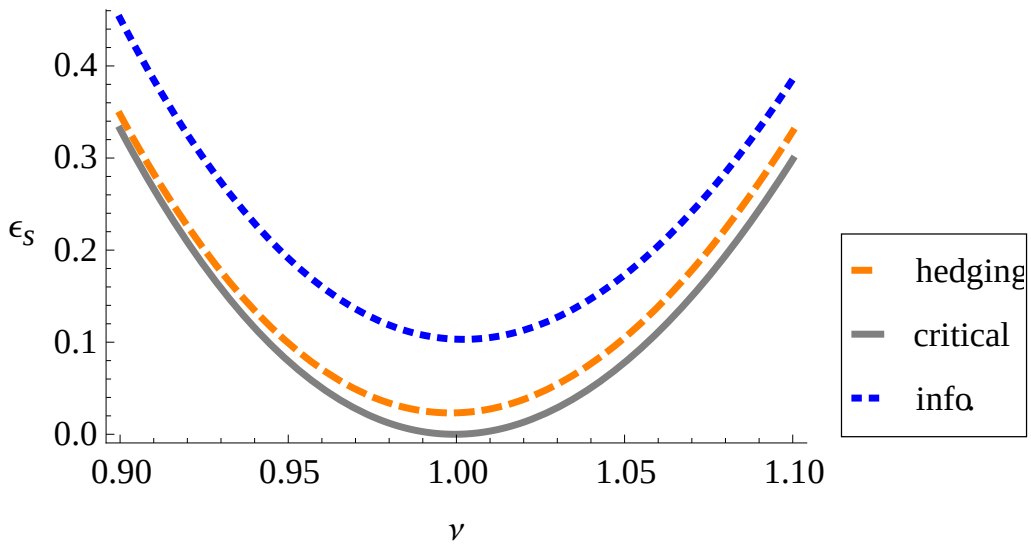
- effect of ν on expected returns dominates the effect on variance

expected utility of the end-users



- with few financiers: better to have them well informed
- with many financiers: better to have them not too well or too badly informed

expected utility of the suppliers



- as in the symmetric information model, ambiguous for the suppliers, who do not internalize the price effect
- also true in the signal dimension

conclusion

- study the impact of more investors trading on futures markets
- role of production channel highlighted
  - more hedging and production
  - expected prices decrease
  - ambiguous effect on volatility
- open-interest and futures price can provide distinct information
- correlation between commodity spot and endowment typically increases with the mass of financiers

Thank you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calibration

base model

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

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

rational expectations