The financialization of the term structure of risk premia in commodity markets

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Overview of the paper

The *financialization*:

- An in-depth modification of commodity derivative markets after 2000
- Mainly in the trading participation: trading floor with specialists $\Rightarrow$ electronic trading with new investors and algo traders
- Often assimilated to a modification in the behavior of commodity prices

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- Via the study of the trading behavior of cross-asset investors
- To assess its impact on the functioning of commodity markets
- Taking into account the heterogeneity of commodity markets and the maturity component

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How:

- Equilibrium model for commodity futures markets
- Financialization = entry of cross-asset investors into a commodity market

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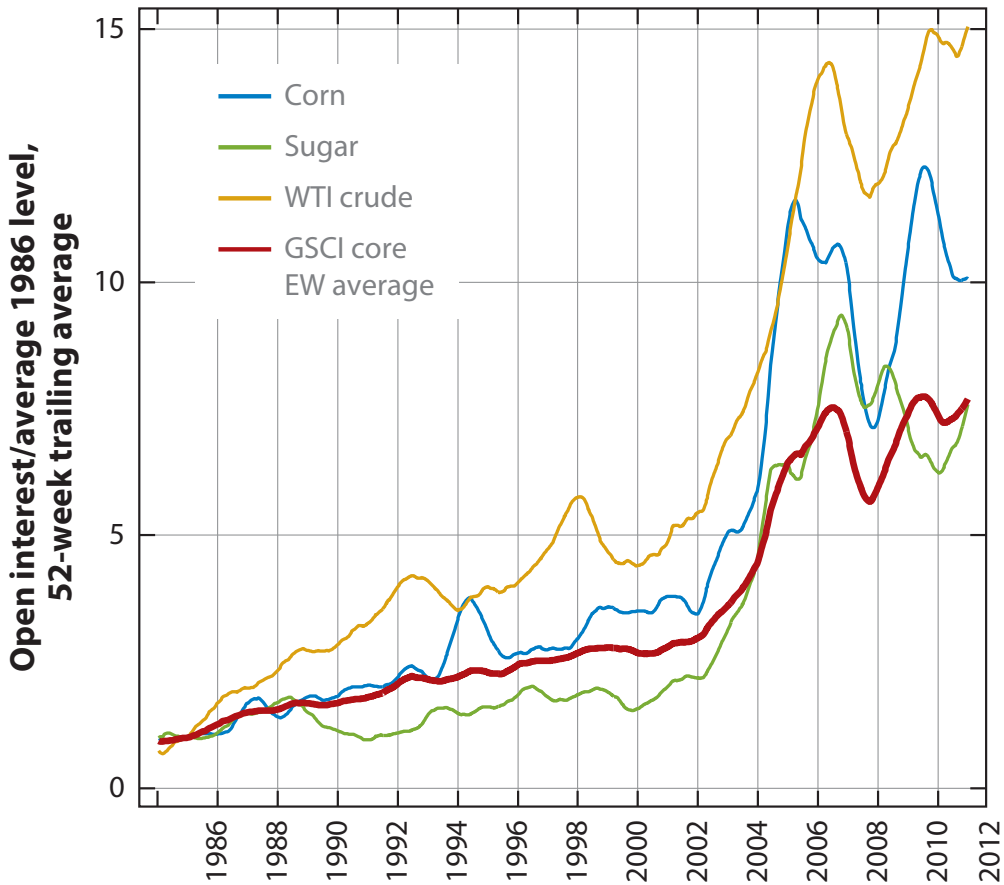
Financialization: facts on the participation in commodity markets

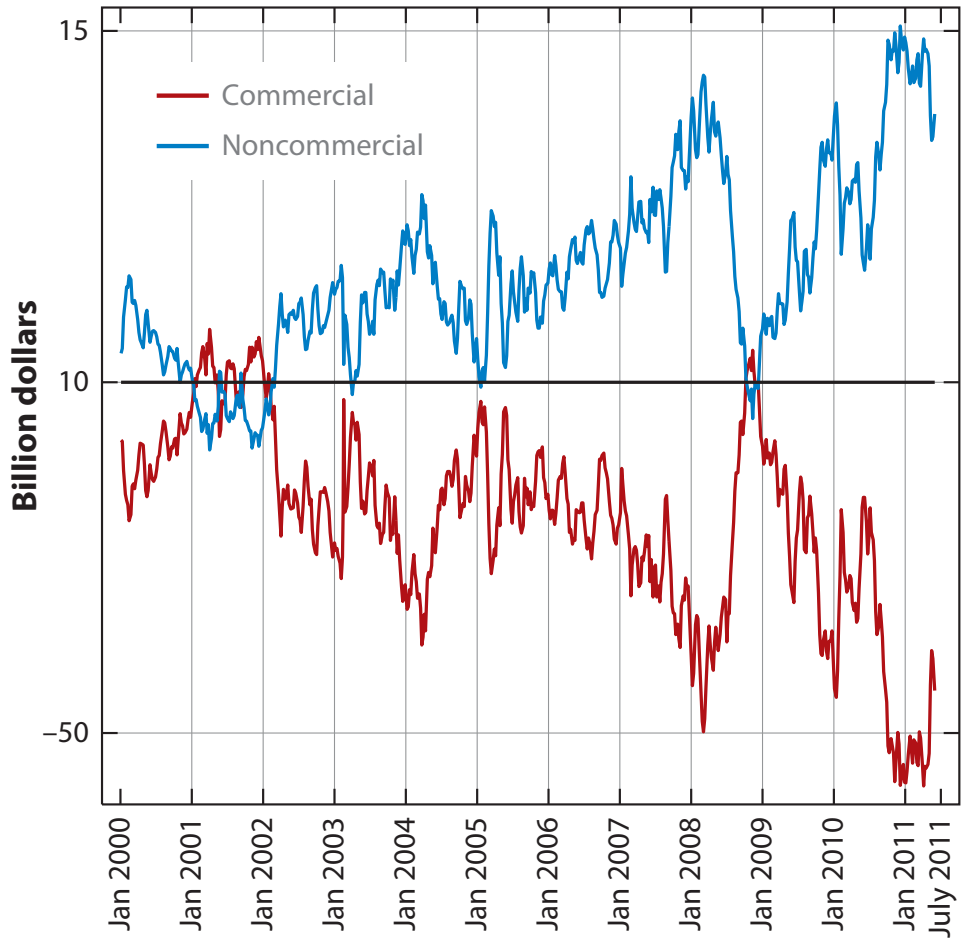
More trading takes place in commodity markets: open interest has boomed



Source: Cheng and Xiong [2014]

Financialization: facts on the participation in commodity markets

Financial traders are more important and want to buy



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Why this modification in the trading participation of commodity markets?

1. Investors want to diversify their portfolios
   - commodity markets are segmented from other financial markets
   - low correlation between commodity markets and equity/bond markets

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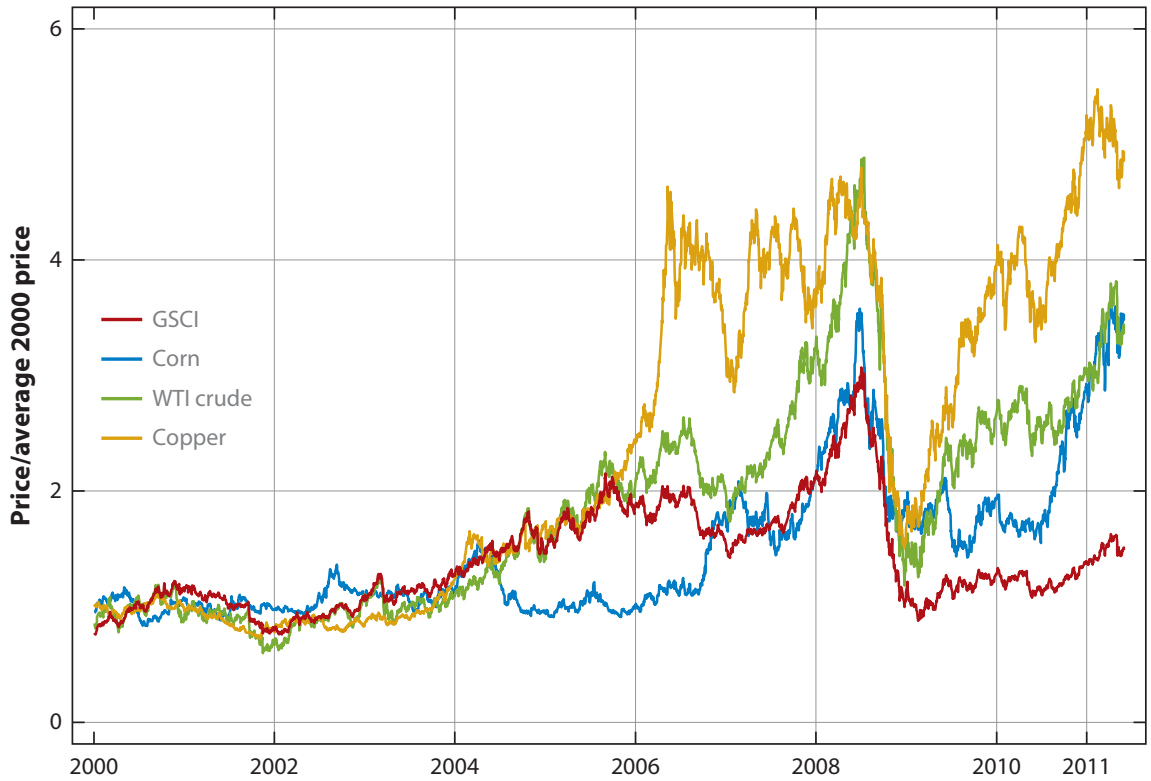
   $\Rightarrow$ why now?

2. Development of new investment vehicles for index investing
   - ETFs, CITs...
   - trading as any other financial product (daily liquidity, no margin call...)
   - very low costs (compared to hedge funds)

Financialization: facts on the behavior of commodity prices

Commodity markets experienced boom/bust cycles



Source: Cheng and Xiong [2014]

Correlation between commodity and equity markets increases

Accident or causality?

Does the modification of the trading participation has lead to the modification in the behavior of commodity prices?

- Michael Master (2008): direct link between investment flows from CITs and boom/bust cycle
- The initial academic research (Brunetti and Buyuksahin [2009], Buyuksahin and Harris [2011], Singleton [2013]...): mixed results, because of econometric issues

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$\Rightarrow$ no clear response, empirical literature try to assess the effects on the fundamental economic functions of commodity markets!

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Effects of the financialization on the risk sharing function:

- Lower risk premia: Hamilton and Wu [2014] and Baker [2016] for Crude Oil, Brunetti and Reiffen [2014] for agricultural markets
- Higher integration of commodity markets between themselves (Tang and Xiong [2012]) and with other asset classes (Silvennoinen and Thorp [2013], Buyuksahin and Robe [2014] and Boons et al. [2014])

My paper in this context:

Goal: understand the consequences of the financialization for the functioning of commodity markets

- focus on the risk sharing function of commodity markets: risk premia $\Rightarrow$ Commodity markets are characterized by inefficient risk sharing (cf Keynes [1930])
- emphasize the maturity component of commodity markets: term structure $\Rightarrow$ often ignored in the literature on the behavior of commodity prices (Anderson and Danthine [1983], Hirshleifer [1988], Acharya et al. [2013], Ekeland et al. [2016]) or the literature on the financialization

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Methodology: three-date equilibrium model of commodity markets

- limited participation
- Mean-Variance Framework with heterogeneous agents
- Commodity and stock markets
- Existence of a term structure
- 3-step reasoning: one pre- and two post-financialization economies
- Solved analytically but with visual representations

Take away

Pre-financialization:

- Commodity markets are segmented from the stock market
- Risk premia if hedging pressure
- Speculators link the futures contracts for different maturities
- Speculators both provide and consume liquidity

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- Commodity markets are less segmented form the stock market
- Investment pressure creates risk premia
- Financialization always affects all the term structure (even with constrained investors)
- Investors both provide and consume liquidity

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Generally: the effects of the financialization are market-specific

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The time, the assets and the markets

Three dates: $t = 0, 1, 2$; agents make decisions during the two first

Three assets:

- a risk-free asset with a null risk-free rate
- a stock market index, traded at $t = 0, 1 \Rightarrow R_{r_t}$, μ_{r_t}, and $\sigma^2_{r,t}$
- a term structure of futures contracts
  - at $t = 0$ two contracts with maturities $t = 1$ (front-month) and $t = 2$ (deferred)
  - at $t = 1$ one contract with maturity $t = 2$ (front-month)
  - $R_{F_{t,T}}$, $\mu_{F_{t,T}}$, and $\sigma^2_{t,T}$

The three risk-averse agents

N_p producers with a preferred habitat:

- two types of producers (identical in terms of number and risk aversion)
  - preferred habitat theory from Modigliani and Sutch [1966] for interest rates and Lautier [2005] for commodities
  - short-term: between $t = 0$ and $t = 1$ with random production at $t = 1 \Rightarrow$ trade only the contract maturing at $t = 1$
  - long-term: between $t = 0$ and $t = 2$ with random production at $t = 1 \Rightarrow$ trade only the contract maturing at $t = 2$
- positions $f^p_{t+1,T}$ in the futures contract with maturity T to hold until $t + 1$

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N_s specialized speculators:

- two successive generations of short-term speculators
- no physical exposure to the commodity
- positions $f^s_{t+1,T}$ in the futures contract with maturity T to hold until $t + 1$

The three risk-averse agents

N_{in} **cross-asset investors:**

- two successive generations of short-term cross-asset investors
- hold a commodity risk (inflation risk)
- positions $f^{w}_{t+1,T}$ in the futures contract with maturity T to hold until $t+1$
- can have different investment strategies
  - constrained: trade only the front-month contract; proxy for CITs
  - unconstrained: trade the entire term structure; proxy for hedge funds

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Why hedgers as producers? Empirically aggregated hedgers short the commodity (normal backwardation theory of Keynes [1930])

Why different time-horizons? Kang et al. [2014] show that speculators trade more impatiently

The randomness and the physical market

Random productions:

- $\tilde{q}_t$ at $t = 1, 2$; independent and normally distributed
- no physical decisions (production or storage)

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The physical market:

- Aggregated production at time t: $\tilde{Q}_t = N_p * \tilde{q}_t$
- Linear demand Q_t^D from consumers
- Spot price S_t is such that $\tilde{Q}_t = Q_t^D$
- $R_{s,t}$ and $\sigma^2_{s,t}$

Optimal positions

Each agent i solves:

$$\max_{f^i_{t+\mathbf{1},T}} \; E_t[\pi_{t+1}] - \frac{\gamma_i}{2} Var_t[\pi_{t+1}]$$

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Short-term specialized peculators:

- at $t = 1$, second generation: $\pi_2 = R_{F_{\mathbf{2},\mathbf{2}}} f^s_{2,2} \Rightarrow$

$$f^{s\star}_{2,2} = \frac{\mu_{F_{\mathbf{2},\mathbf{2}}}}{\gamma_s \sigma^2_{2,2}}$$

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- at $t = 0$, first generation: $\pi_1 = R_{F_{\mathbf{1},\mathbf{1}}} f^s_{1,1} + R_{F_{\mathbf{1},\mathbf{2}}} f^s_{1,2} \Rightarrow$

$$f^{s\star}_{1,1} = \frac{\mu_{F_{\mathbf{1},\mathbf{1}}} \sigma^2_{1,2} - \mu_{F_{\mathbf{1},\mathbf{2}}} \sigma_{[11,12]}}{\gamma_s (\sigma^2_{1,1}\sigma^2_{1,2} - \sigma^2_{[11,12]})}$$

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Optimal positions

Producers with a preferred habitat: trade only on the futures market but hold a physical exposure

- Short-term producer, at $t = 0$: $\pi_1 = \tilde{q}_1 R_{s,1} + R_{F_{\mathbf{1},\mathbf{1}}} f^p_{1,1} \Rightarrow$

$$f^{p\star}_{1,1} = \frac{\mu_{F_{\mathbf{1},\mathbf{1}}}}{\gamma_p \sigma^2_{1,1}} - \frac{\rho_{[1,11]}}{\sigma^2_{1,1}}$$

with $\rho_{[t,t_{\mathbf{1}}T_{\mathbf{1}}]}$ is the covariance between the physical revenue between $t-1$ and t and the return $R_{F_{t_{\mathbf{1}},T_{\mathbf{1}}}}$.

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- Long-term producer, at $t = 1$: $\pi_2 = \pi_1 + \tilde{q}_2 R_{s,2} + R_{F_{\mathbf{2},\mathbf{2}}} f^p_{2,2} \Rightarrow$

$$f^{p\star}_{2,2} = \frac{\mu_{F_{\mathbf{2},\mathbf{2}}}}{\gamma_p \sigma^2_{2,2}} - \frac{\rho_{[2,22]}}{\sigma^2_{2,2}}$$

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- Long-term producer, at $t = 1$: $\pi_2 = \pi_1 + \tilde{q}_2 R_{s,2} + R_{F_{\mathbf{2},\mathbf{2}}} f^p_{2,2} \Rightarrow$

$$f^{p\star}_{2,2} = \frac{\mu_{F_{\mathbf{2},\mathbf{2}}}}{\gamma_p \sigma^2_{2,2}} - \frac{\rho_{[2,22]}}{\sigma^2_{2,2}}$$

- Long-term producer, at $t = 0$ solves $\max_{f^p_{\mathbf{1},\mathbf{2}}} E_0[\pi_2] - \frac{\gamma_p}{2} Var_0[\pi_2] \Rightarrow$

$$f^{p\star}_{1,2} = \frac{\mu_{F_{\mathbf{1},\mathbf{2}}}}{\gamma_p \sigma^2_{1,2}} - \frac{\mu_{F_{\mathbf{2},\mathbf{2}}} \sigma_{[12,22]}}{\gamma_p \sigma^2_{1,2} \sigma^2_{2,2}} + \frac{\rho_{[2,22]} \sigma_{[12,22]}}{\sigma^2_{1,2} \sigma^2_{2,2}} - \frac{\rho_{[2,12]}}{\sigma^2_{1,2}}$$

Optimal positions

Short-term cross-asset investors (constrained):

- same set of investment for the two generations $\Rightarrow$ same optimal positions
- between $t-1$ and t: $\pi_t = w_t R_{r_t} + \varphi_t R_{s,t} + f^w_{t,t} R_{F_{t,t}} \Rightarrow$

$$w_t^\star = \frac{\mu_{r_t}\sigma^2_{t,t} - \mu_{F_{t,t}}\sigma_{[r_t,F_{t,t}]}}{\gamma_{in}(\sigma^2_{t,t}\sigma^2_{r,t} - \sigma^2_{[r_t,F_{t,t}]})} + \frac{\varphi_t\left\{\sigma_{[r_t,F_{t,t}]}\sigma_{[s_t,F_{t,t}]} - \sigma^2_{t,t}\sigma_{[r_t,s_t]}\right\}}{(\sigma^2_{t,t}\sigma^2_{r,t} - \sigma^2_{[r_t,F_{t,t}]})}, \forall t = 1,2$$

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where $\sigma_{[s_t,F_{t_1,T_1}]}$ is the covariance between the return of the spot price between $t-1$ and t and the return $R_{F_{t_1,T_1}}$; and $\sigma_{[r_t,F_{t_1,T_1}]}$ is the covariance between the return of the stock index between $t-1$ and t and the return $R_{F_{t_1,T_1}}$.

For unconstrained investors: same components, but less tractable

Pre-financialization economy

Clearing of the markets:

$$\text{t=0, maturing in 1: } N_s f_{1,1}^{s\star} + N_p f_{1,1}^{p\star} = 0$$

$$\text{t=0, maturing in 2: } N_s f_{1,2}^{s\star} + N_p f_{1,2}^{p\star} = 0$$

$$\text{t=1, maturing in 2: } N_s \left(f_{2,2}^{s\star} - f_{1,2}^{s\star}\right) + N_p \left(f_{2,2}^{p\star} - f_{1,2}^{p\star}\right) = 0$$

Pre-financialization economy

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Results:

1. Risk premia: only with risk-averse producers and hedging pressure (see Keynes [1930], De Roon et al. [2000], Ekeland et al. [2016])
2. Risk premia: $\nearrow$ or $\searrow$ with speculators
   - against results in a mono-commodity framework
   - diversification behavior of speculators on the term structure
3. Risk premium of the front-month contract maturing in $t = 1$: affected by long term variables
   - no need for hedgers to exit their preferred habitat
   - arbitrage behavior of the speculators

Post-financialization economies: clearing

Clearing of the markets with constrained investors:

t=0, maturing in 1: $N_s f_{1,1}^{s\star} + N_p f_{1,1}^{p\star} + N_{in} f_{1,1}^{w\star} = 0$

t=0, maturing in 2: $N_s f_{1,2}^{s\star} + N_p f_{1,2}^{p\star} = 0$

t=1, maturing in 2: $N_s \left(f_{2,2}^{s\star} - f_{1,2}^{s\star}\right) + N_p \left(f_{2,2}^{p\star} - f_{1,2}^{p\star}\right) + N_{in} f_{2,2}^{w\star} = 0$

Clearing of the markets with unconstrained investors:

t=0, maturing in 1: $N_s f_{1,1}^{s\star} + N_p f_{1,1}^{p\star} + N_{in} f_{1,1}^{w\star} = 0$

t=0, maturing in 2: $N_s f_{1,2}^{s\star} + N_p f_{1,2}^{p\star} + N_{in} f_{1,2}^{w\star} = 0$

t=1, maturing in 2: $N_s \left(f_{2,2}^{s\star} - f_{1,2}^{s\star}\right) + N_p \left(f_{2,2}^{p\star} - f_{1,2}^{p\star}\right) + N_{in} \left(f_{2,2}^{w\star} - f_{1,2}^{w\star}\right) = 0$

Post-financialization economies: results

1. Risk premia: even without producers because of investment pressure from investors

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3. Risk premia: depend on financial variables (μ_r, σ^2_r,...)

4. Term structure: all the maturities are impacted, even with constrained investors
   - With constrained investors: results hold for the risk premium of the deferred contract (not traded by cross-asset investors)
   - arbitrage behavior of speculators and producers
   - propagation depends on the integration of the market

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Parameters

Remarks:

- some parameters are based on S&P 500 and WTI prices
- some assumptions are made (stationary time series)
- some parameters are arbitrary

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Important choices:

- Hedgers are producers: positive covariance between the physical revenue and the futures contract
- Investors have a negative exposure to the commodity: inflation risk as in Boons et al. [2014]

Parameters

Parameters	Description	Value
$\sigma^2_{1,1}$, $\sigma^2_{2,2}$	Variance of the front-month futures contract	1.25
$\sigma^2_{1,2}$	Variance of the deferred futures contract	.98
$\sigma_{[11,12]}$	Cov between the front-month and the deferred futures contracts	1.07
μ_{r_1}, μ_{r_2}	Expected return of the stock market index	0.08
$\sigma^2_{r,1}$, $\sigma^2_{r,2}$	Variance of the return of the stock market index	.5
$\sigma_{[r_1,F_{1,1}]}$, $\sigma_{[r_2,F_{2,2}]}$	Cov between the front-month contract and the stock market	.31
$\sigma_{[r_1,F_{1,2}]}$	Cov between the deferred contract and the stock market	.29
$\sigma_{[s_1,F_{1,1}]}$, $\sigma_{[s_2,F_{2,2}]}$	Cov between the front-month contract and the spot market	1.26
$\sigma_{[s_1,F_{1,2}]}$	Cov between the deferred contract and the spot market	1.06
$\sigma_{[r_1,s_1]}$, $\sigma_{[r_2,s_2]}$	Cov between the spot and the stock markets	.3

Parameters	Description	Value
$\sigma_{[11,22]}$, $\sigma_{[12,22]}$	Cov between non-contemporaneous futures contracts	0
$\rho_{[1,11]}$, $\rho_{[2,22]}$	Cov between the physical revenue and the front-month contract	1
$\rho_{[1,12]}$	Cov between the physical revenue and the deferred contract	.7
$\rho_{[2,11]}$, $\rho_{[2,12]}$	Cov between the physical revenue and non-contemporaneous futures contracts	0
φ_1, φ_2	Commodity risk of the investors	-2
γ_i, γ_p, γ_s	Risk aversion of the agents	1
λ_s	Elasticity of the speculators	2

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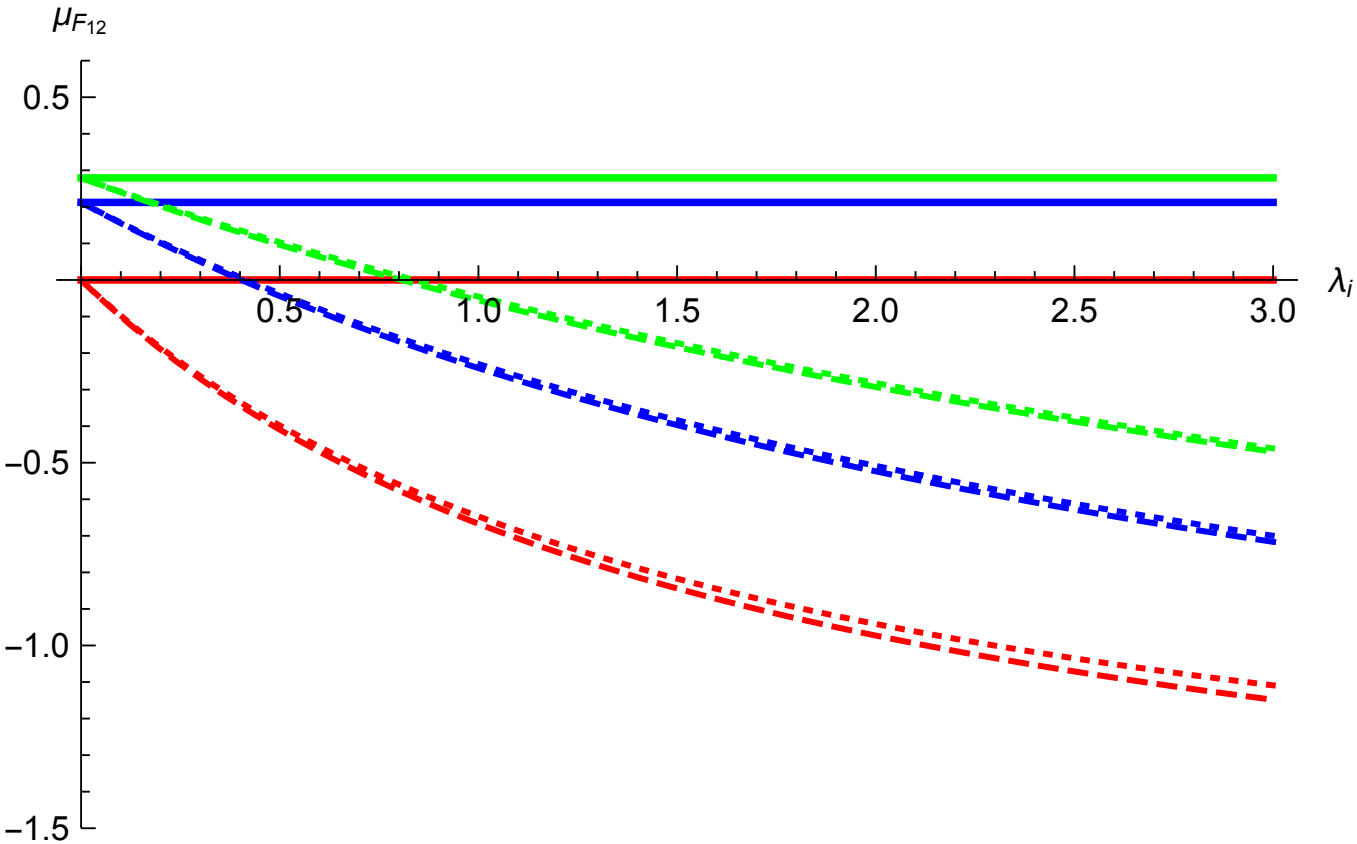
Risk premia as a function of the investors



The red lines are for $\lambda_p = 0$, the blue lines are for $\lambda_p = 1$, and the green lines are for $\lambda_p = 2$. The thick lines are for the pre-financialization, the dashed lines are for the financialization with constrained investors, and the dotted lines are for the financialization with unconstrained investors.

Risk premia as a function of the investors: comments

1. Previous analytical results:
   - pre-fi, no producers no risk premia
   - post-fi, risk premia even without producers
   - risk premia $\nearrow$ with investment and hedging pressures

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2. Investment pressure compensate the hedging pressure
   - Lower and negative risk premia: Hamilton and Wu [2014]
   - But can be negative and more important $\Leftrightarrow$ investment pressure $>$ hedging pressure

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2. Investment pressure compensate the hedging pressure
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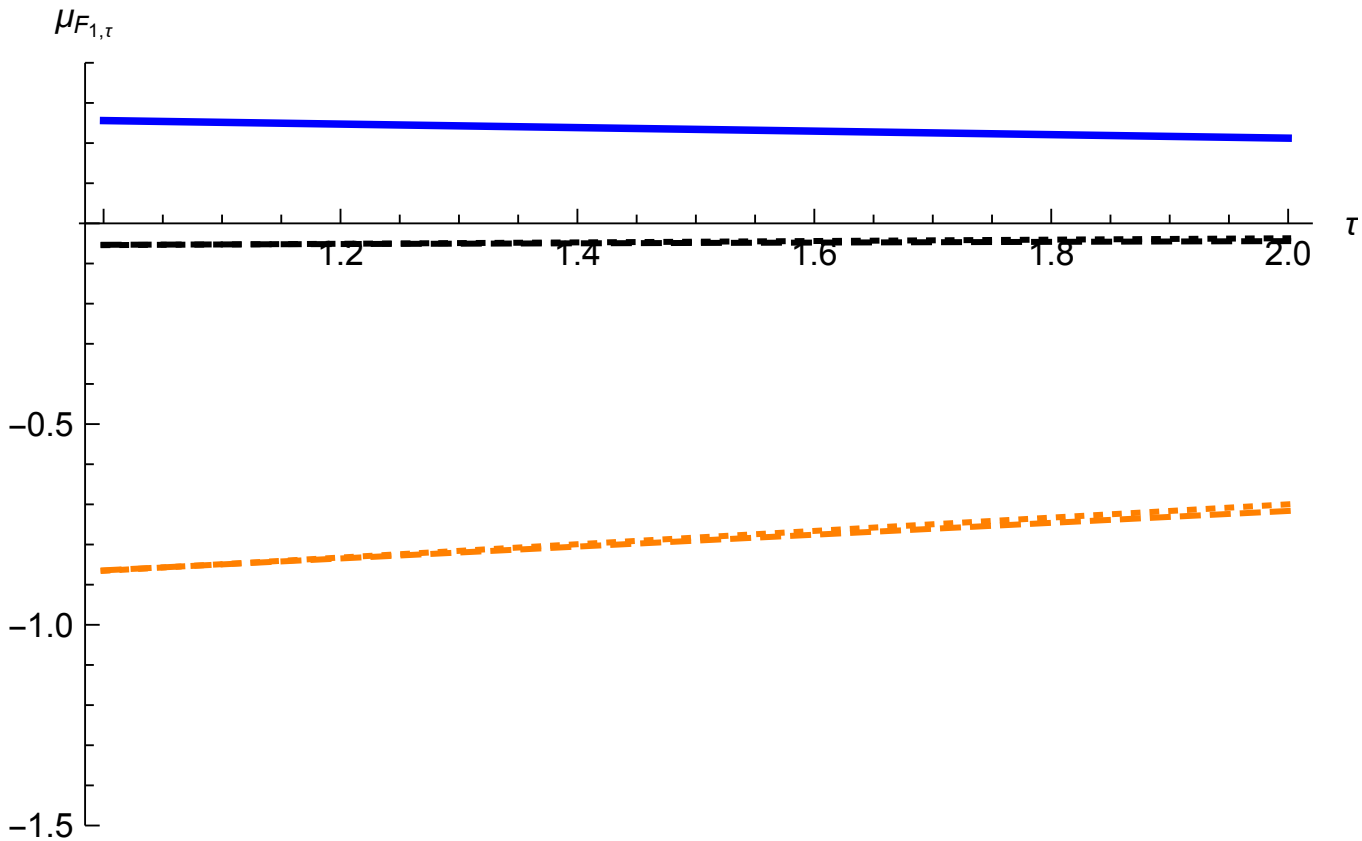
   - But can be negative and more important $\Leftrightarrow$ investment pressure $>$ hedging pressure

3. Important propagation effect, even with constrained investors (high integration)

The term structure of risk premia



The blue line is for the pre-financialization economy ($\lambda_{in} = 0$), the black lines are for the post-financialization economies with $\lambda_{in} = 0.5$, and the orange lines are for the post-financialization economies with $\lambda_{in} = 3$. The dashed lines are for the financialization with constrained investors, and the dotted lines are for the financialization with unconstrained investors.

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The term structure of risk premia: comments

Shape of the term structure of risk premia:

- Changes with the financialization
- Backwardation $\Rightarrow$ contango
- front-month contract is the most used for trading and hedging
- no dislocation with constrained investors

The term structure of risk premia: comments

Shape of the term structure of risk premia:

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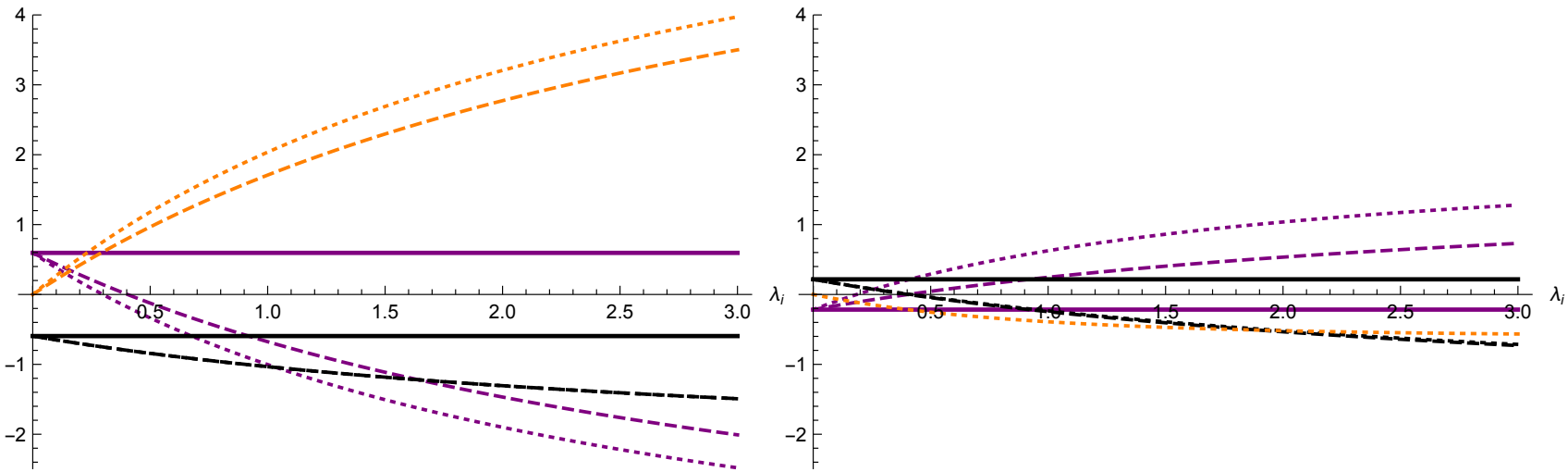
Extension to the term structure of futures prices (under some restrictive assumptions):

$$\begin{aligned}\mu_{F_{\mathbf{1},\mathbf{1}}} - \mu_{F_{\mathbf{1},\mathbf{2}}} &= E_0[S_1] - F_{0,1} - E_0[S_2] + F_{0,2} \\ &= Basis - E_0[\Delta S] = Basis\end{aligned}$$

- Changes with the financialization
- Contango $\Rightarrow$ backwardation

Liquidity provision by the agents: front-month and deferred contracts



The purple lines are for speculators, the black lines for producers, and the orange lines for investors. The thick lines are for the pre-financialization, the dashed lines are for the financialization with constrained investors, and the dotted lines for the financialization with unconstrained investors.

Liquidity provision by the agents: comments

Traditional view: speculators provide liquidity to hedgers $\Rightarrow$ higher the speculation, lower the risk premium (Ekeland et al. [2016])

Liquidity provision by the agents: comments

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Seems incomplete:

- Speculator provides and consumes liquidity: empirical illustration by Kang et al. [2014]
- With the financialization, speculators and hedgers provide liquidity to investors: empirical illustration by Cheng and Xiong [2014]
  - speculators start to short
  - hedgers short more and more

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Heterogeneity of commodity markets and the financialization

Commodity markets are heterogeneous

- commodities have different physical characteristics (storability, storage cost, transportation cost...)
- markets have different structures (oligopolistic or high competition, imbalance between producers and consumers...)

$\Rightarrow$ quantitatively, the effects of the financialization vary

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Two examples:

- a non-integrated market: electricity
- a market dominated by long hedgers

Non-integrated markets

Context:

- market with a low temporal integration (low covariance)
- low temporal integration because of limits to arbitrage (non storability, high cost of storage...)
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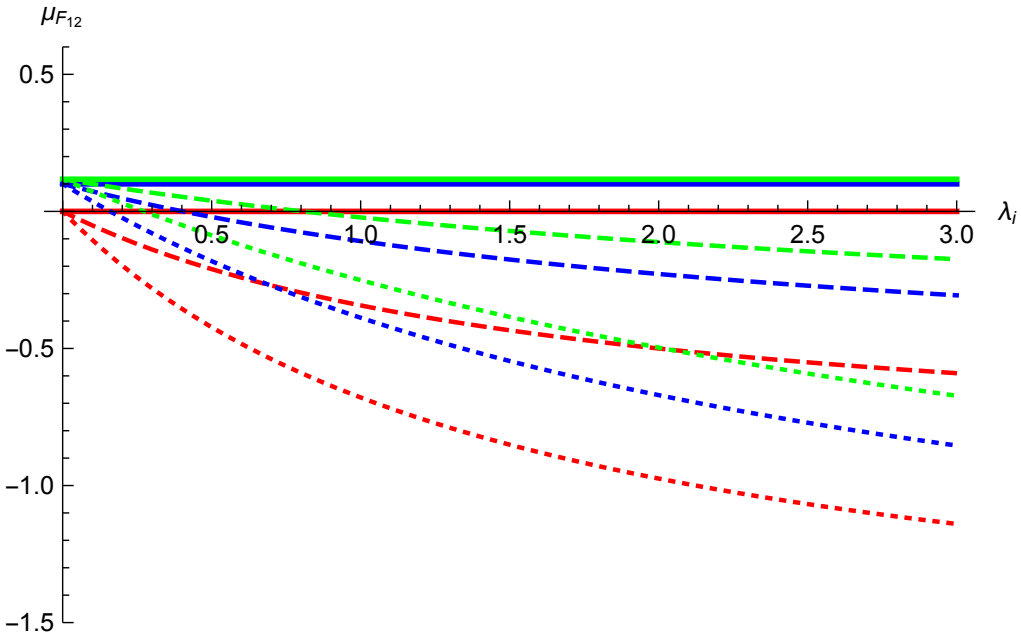
What do I do: decrease the correlation between contemporaneous futures prices

Non-integrated markets: risk premia



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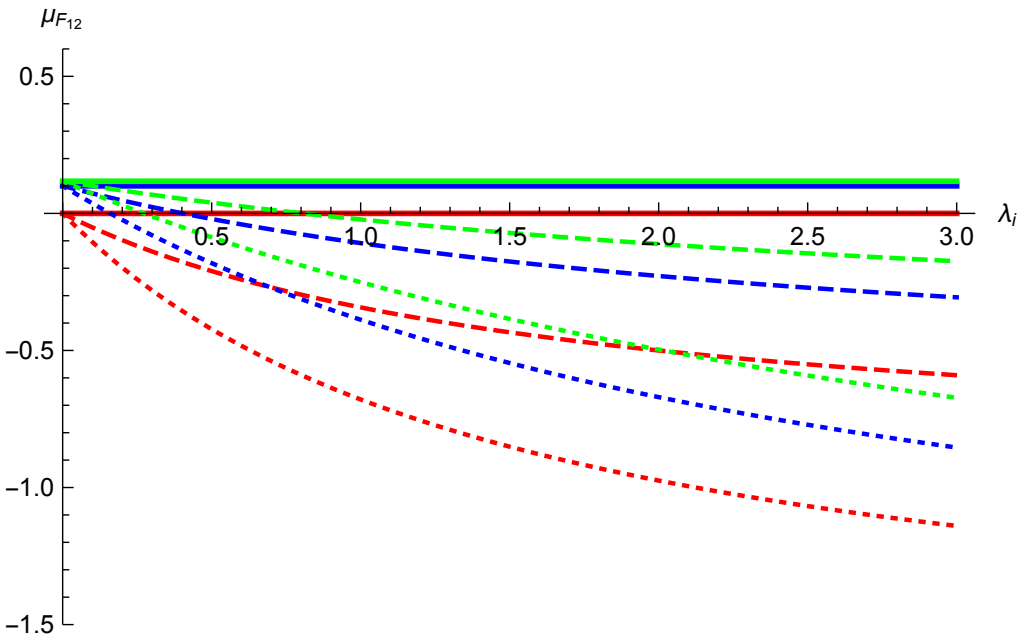
Unchanged results for the front month risk premium

Non-integrated markets: risk premia



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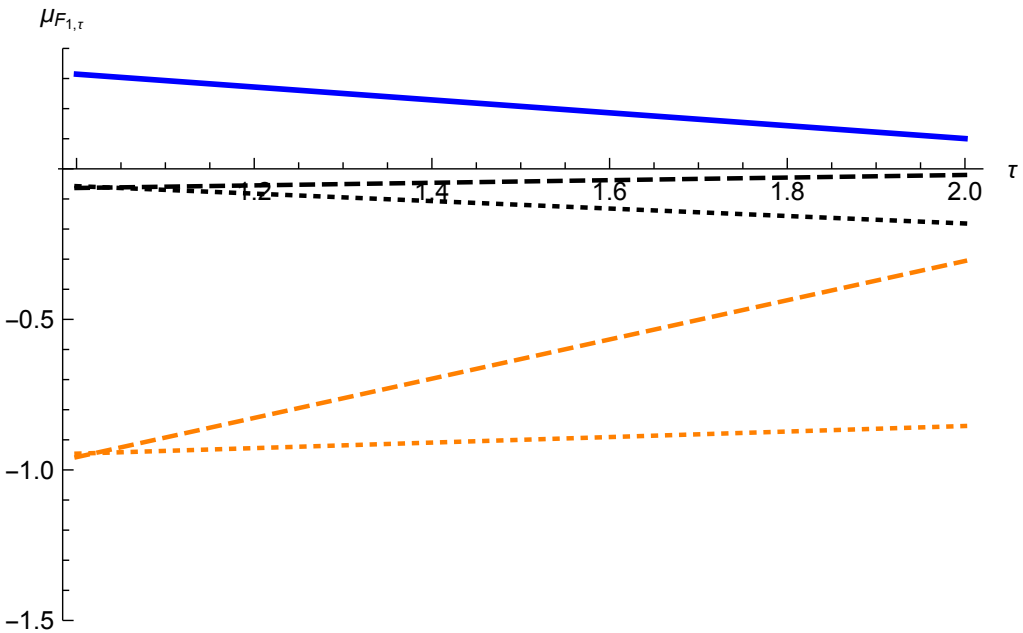
Unchanged results for the front month risk premium

Results for the deferred risk premium:

- Type of investors matters
- Lower impact with constrained investors
- Low diversification effect
- No direct investment pressure effect

Non-integrated markets: term structure of risk premia



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Results:

- Unchanged with unconstrained investors
- Term structure can be steeper
- Constrained investors reinforce the non-integration

Markets dominated by long hedgers

Context:

- De Roon et al. [2000]: substantial variations inside each commodity market and form market to market in the level and the sign of the hedging pressure
- main hedgers are not only producers

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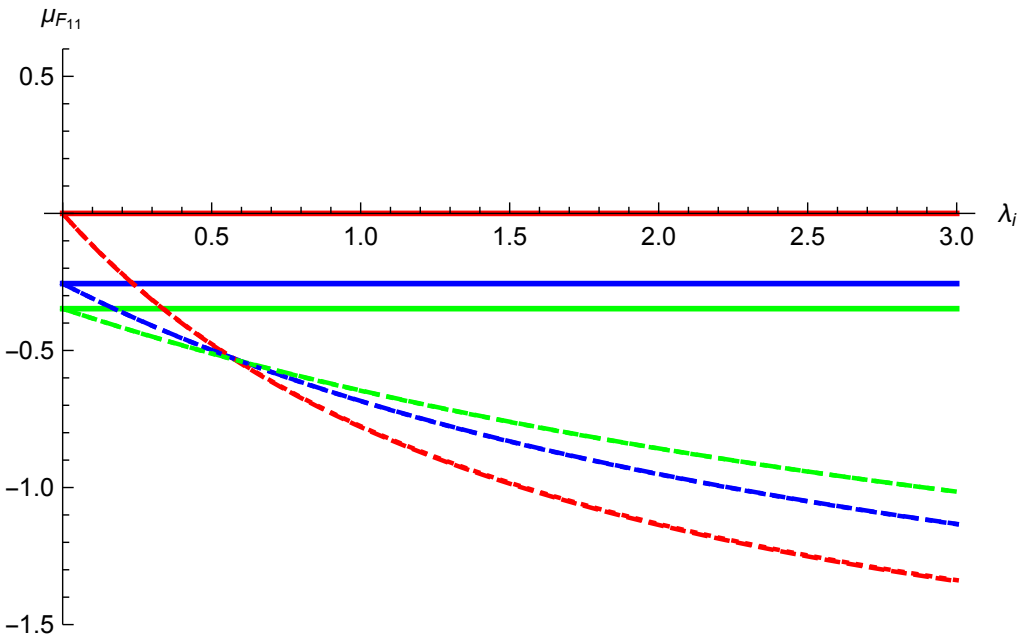
What do I do: change the sign of the covariance between the physical revenue and the futures price

Non-integrated markets: risk premia



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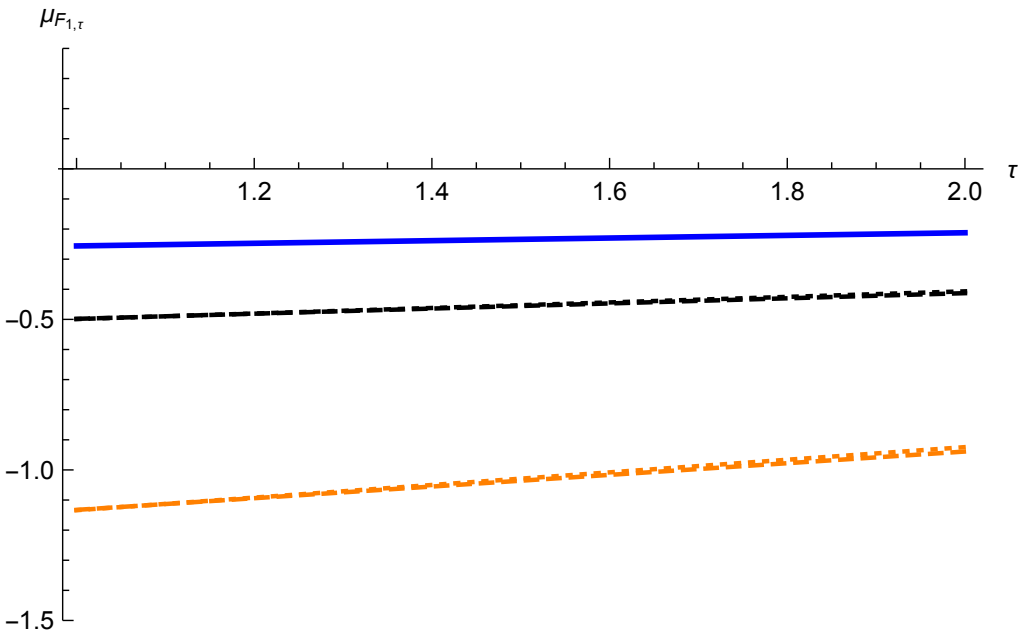
Results:

- Pre-fi: negative risk premia because of long hedging
- Post-fi: investment pressure reinforces the hedging pressure
- Post-fi: hedgers provide liquidity to investors

Non-integrated markets: term structure of risk premia



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Results:

- Term structure of risk premia always in contango
- Term structure always steeper with financialization
- Term structure of prices always in backwardation

Conclusion

An equilibrium model of commodity futures markets which...

1. ... extend results regarding the functioning of commodity markets before financialization to a framework with a term structure
   - dual role of speculators: provide and consume liquidity
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Economic implications:

- the cost of hedging of hedgers changes
- speculators can both face more competition and have new profit opportunities
- more efficient risk sharing because of the decreased fragmentation of the markets $\Rightarrow$ but higher spillover and higher systemic risk?

Thank you for your attention !!

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