A Model of Financialization of Commodities

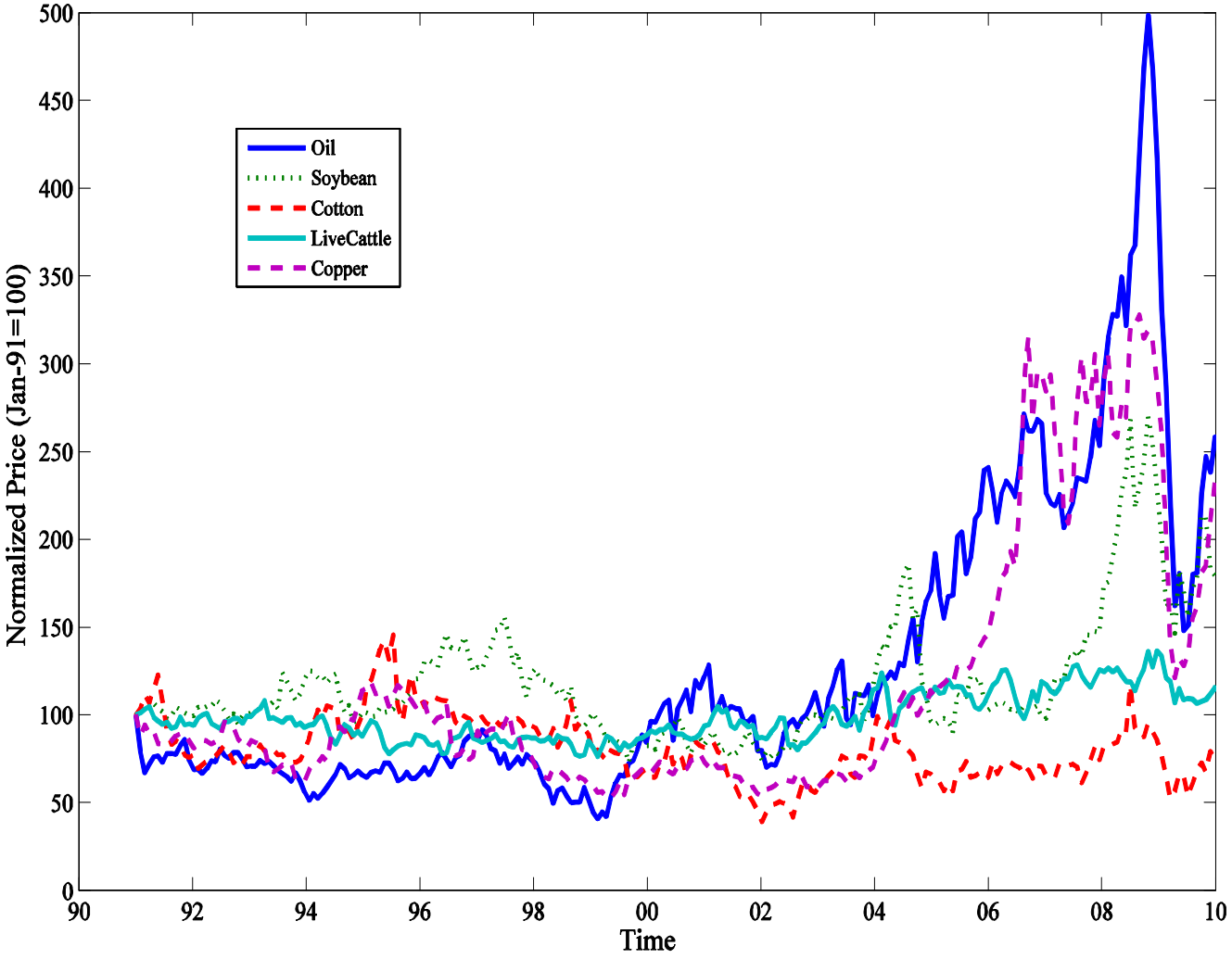
Suleyman Basak Anna Pavlova

London Business School and CEPR

New Trends in Commodity Futures Markets (post 2004)

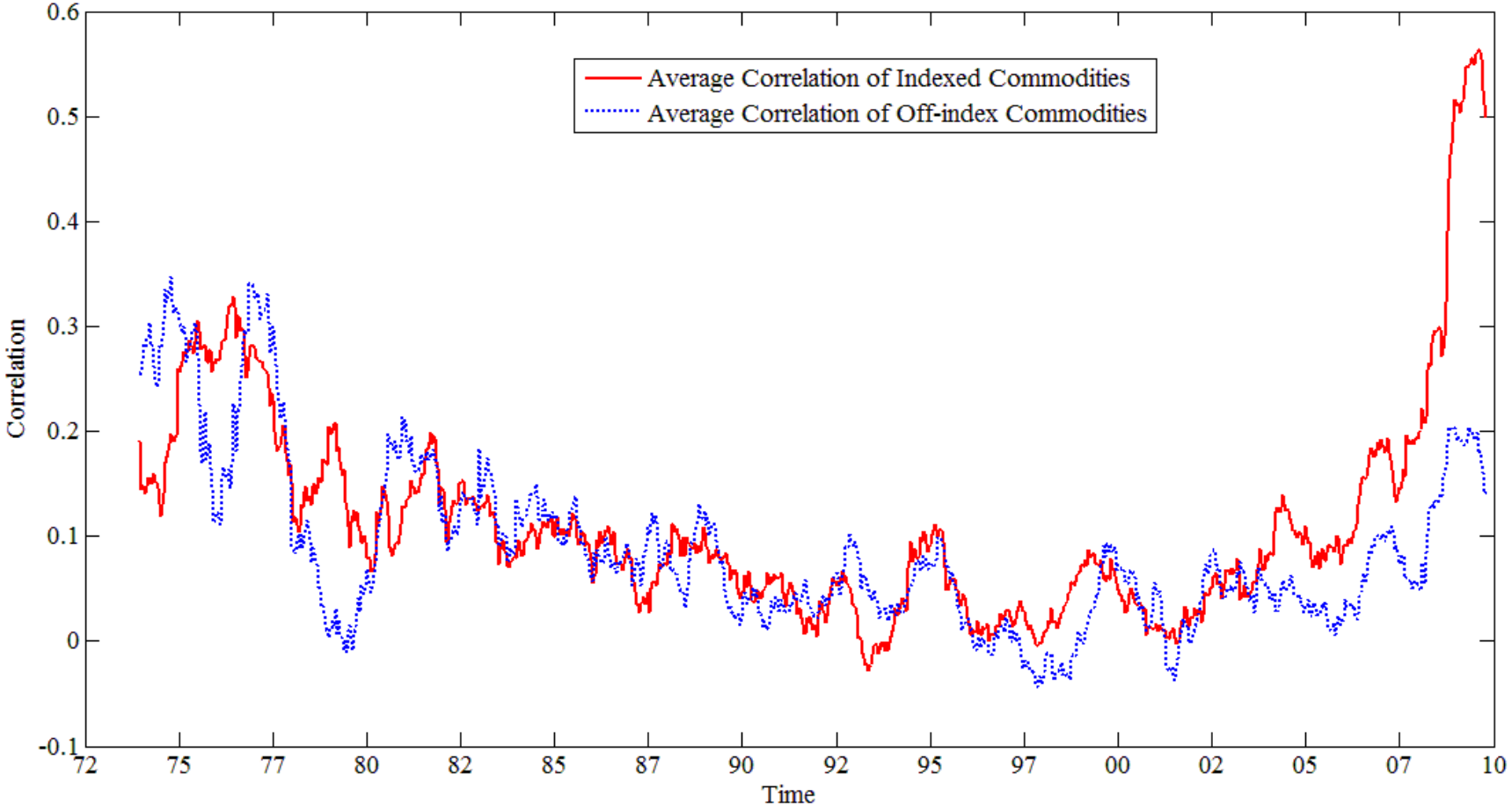
- A sharp increase in the popularity of commodity investing; large inflows of money from pension funds, endowments, and other institutional investors
  - Institutional holdings went up from $15 billion in 2003 to over $200 billion in 2008
- Unprecedented booms and busts in commodity prices
- Sharp increase in correlations among commodities
- Increase in equity-commodity correlations
- ...and especially so for commodities included in commodity indices

Commodity Futures Prices



Source: Tang and Xiong (2012)

Correlations Have Gone Up Significantly



Source: Tang and Xiong (2012)

Our Work

- Main question: How do institutional investors affect commodity futures prices, volatilities, and their comovement?
- A theoretical model of financialization of commodity futures markets
  - Disentangles how much of price rise can be attributed to financialization and how much to rising demand for commodities
- Features institutional investors alongside traditional market participants
  - institutions care about their performance relative to a commodity market index
  - otherwise, a conventional asset pricing model

Effects of Financialization: Our Main Results

- Commodity futures prices:
  - all go up, index futures rise by more
  - news about index commodity fundamentals spill over to all other commodities
- Volatilities of all futures go up, but those of index futures increase by more
- Correlations:
  - cross-commodity correlations rise
  - equity-commodity correlations rise
  - rise more for index commodities
- Financialization accounts for 11% to 17% of commodity futures prices and the rest is attributable to fundamentals

Related Literature

- Empirical evidence directly supporting our findings:
  Tang and Xiong (2012), Singleton (2013)
- Evidence from other markets (equity):
  - *index effects:*
    Harris and Gurel (1986), Shleifer (1986) and others
  - *asset class effects:*
    Barberis, Shleifer, and Wurgler (2005), Boyer (2011)
- An alternative view of financialization:
  Fattouh, Kilian, and Mahadeva (2012), Hamilton and Wu (2012)
- Modeling of institutional investors:
  Basak and Pavlova (2013)

The Model

- K commodities. Supply news of commodity k:

$$dD_{kt} = D_{kt}[\mu_k dt + \sigma_k d\omega_{kt}] \qquad GBM$$

- Generic good 0, with supply news:

$$dD_t = D_t[\mu dt + \sigma d\omega_{0t}] \qquad GBM$$

  – the numeraire
  – supply news uncorrelated across commodities

- Prices of commodities are p_{kt}

The Model

- K futures contracts; one for each commodity k:
  – Maturity T, payoff at maturity p_{kT}, futures price f_{kt}

$$df_{kt} = f_{kt}[\mu_{f_k t} dt + \sigma_{f_k t} d\omega_t]$$

- Commodity index includes $L < K$ commodities

$$I_t = \prod_{i=1}^{L} f_{it}^{1/L}$$

  – geometrically-weighted, as S&P Commodity Index

- Stock market: claim to time-T aggregate output:
  $D_T + \sum_{k=1}^{K} p_{kT} D_{kT}$

$$dS_t = S_t[\mu_{St} dt + \sigma_{St} d\omega_t]$$

- Risk-free bond

Investors

- "Normal" investor $\mathcal{N}$

$$u_{\mathcal{N}}(W_{\mathcal{N}T}) = \log(W_{\mathcal{N}T})$$

- "Institutional" investor $\mathcal{I}$

$$u_{\mathcal{I}}(W_{\mathcal{I}T}) = (a + bI_T)\log(W_{\mathcal{I}T}), \qquad a,\, b > 0$$

  - Dislikes to perform poorly when benchmark does well
  - Less concerned about performance when ahead of the benchmark
  - Formally, marginal utility is increasing in index level

- Cobb-Douglas consumption index (real wealth)

$$W_n = C_{n_0}^{\alpha_0} C_{n_1}^{\alpha_1} \cdot \ldots \cdot C_{n_K}^{\alpha_K}, \qquad n \in \{\mathcal{N}, \mathcal{I}\}$$

- Institution's endowment λS_0, normal investor's $(1-\lambda)S_0$

Time-T Commodity Prices: Effects of Fundamentals

- Price of commodity k:

$$p_{kT} = \overline{p}_{kT} = \frac{\alpha_k}{\alpha_0} \frac{D_T}{D_{kT}}$$

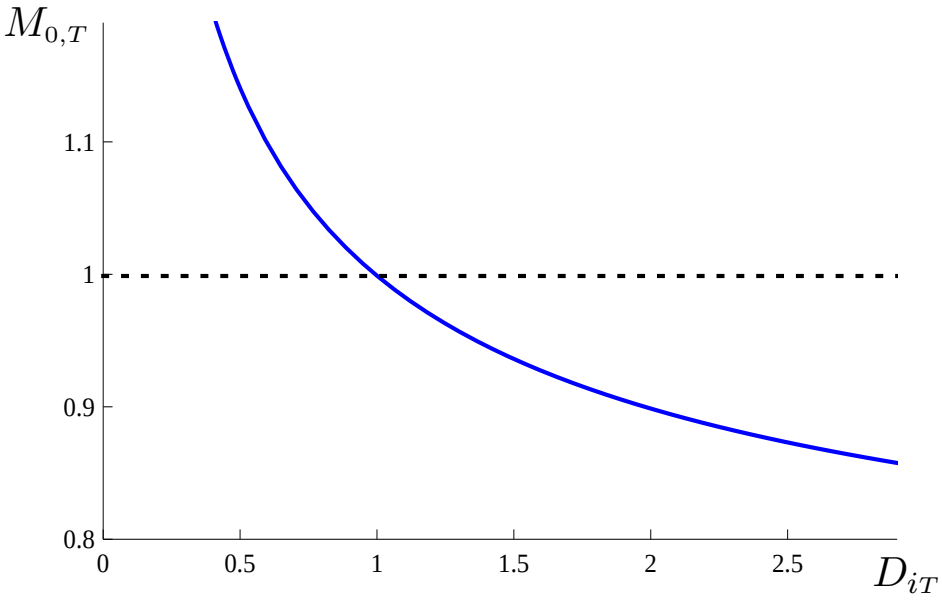
  – $\overline{p}_{kT}$ price in benchmark economy with no institutions

	Supply $D_k \nearrow$	Aggregate output $D \nearrow$	Demand $\alpha_k \nearrow$
Price p_{kT}	$-$	$+$	$+$

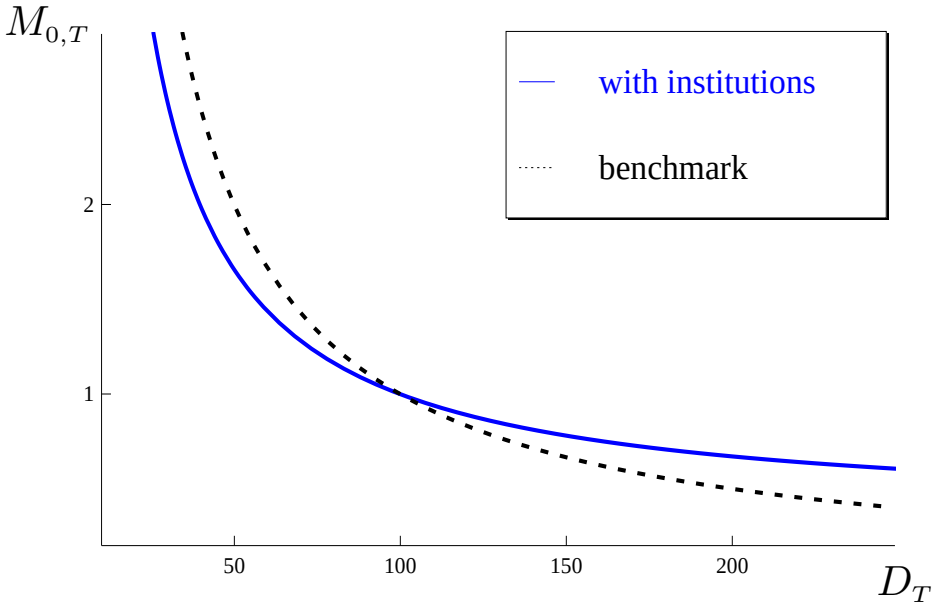
- Commodity index I_T inherits properties of $p_{1T}, \ldots, p_{LT}$

Discount Factor $M_{0,T}$ (from $f_{kt} = E_t[M_{t,T}\, p_{kT}]$)

- Benchmark with no institutions: $\overline{M}_{0,T} = \frac{e^{(\mu-\sigma^2)T} D_0}{D_T}$
- With institutions: $M_{0,T} = \overline{M}_{0,T}\left(1 + \frac{b\,\lambda(I_T - E[I_T])}{a + b\,E[I_T]}\right)$



D_{iT} – supply of index commodity i



D_T – aggregate output

- States with high payoffs of commodity index are priced higher than in benchmark economy

Commodity Futures Prices

- Equilibrium futures prices in benchmark economy:

$$\bar{f}_{kt} = \frac{\alpha_k}{\alpha_0} e^{(\mu-\mu_k-\sigma^2+\sigma_k^2)(T-t)} \frac{D_t}{D_{kt}}$$

- In the economy with institutions:

$$f_{kt} = \bar{f}_{kt} \underbrace{\frac{Const + b\,\lambda\, e^{1_{\{k\leq L\}}\sigma_k^2(T-t)/L}\, D_t \prod_{i=1}^{L} (g_i(t)/D_{it})^{1/L}}{Const + b\,\lambda\, e^{-\sigma^2(T-t)}\, D_t \prod_{i=1}^{L} (g_i(t)/D_{it})^{1/L}}}_{>1}$$

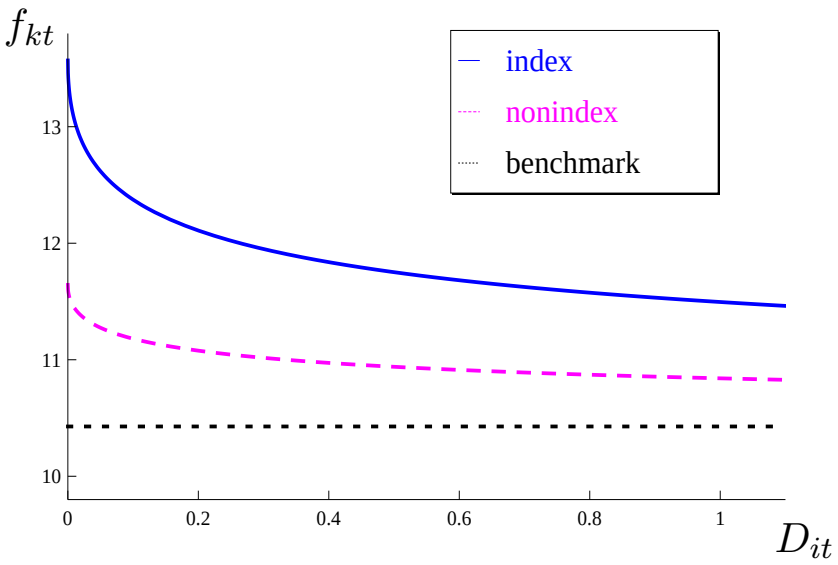
with $g_i(t) = \frac{\alpha_i}{\alpha_0} e^{(\mu-\mu_i+(1/L-1)\sigma_i^2/2)(T-t)}$

– Futures prices are higher than in benchmark
– Index futures prices rise more than nonindex ones

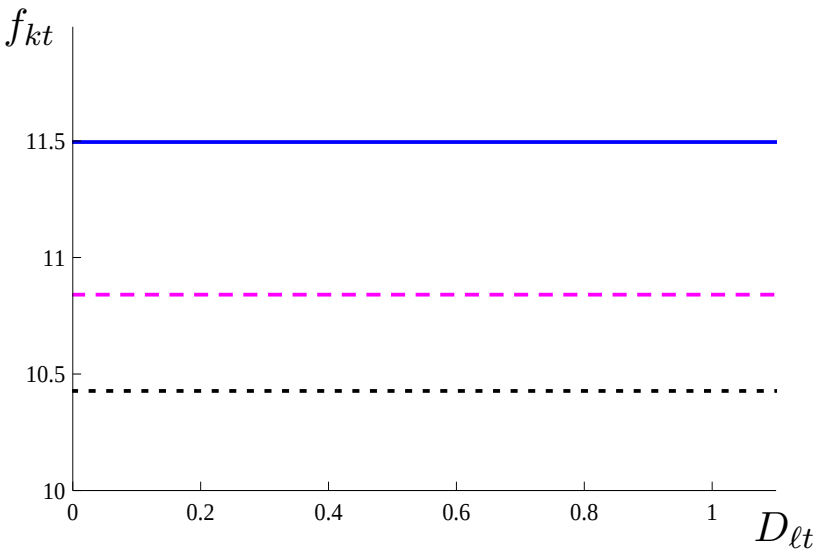
Why?

- Institutions care about the index
- Their marginal utility is increasing in index level
- They value assets that pay off more in states when index does well
- Hence, they value index futures more than nonindex

Supply News and Commodity Futures Prices



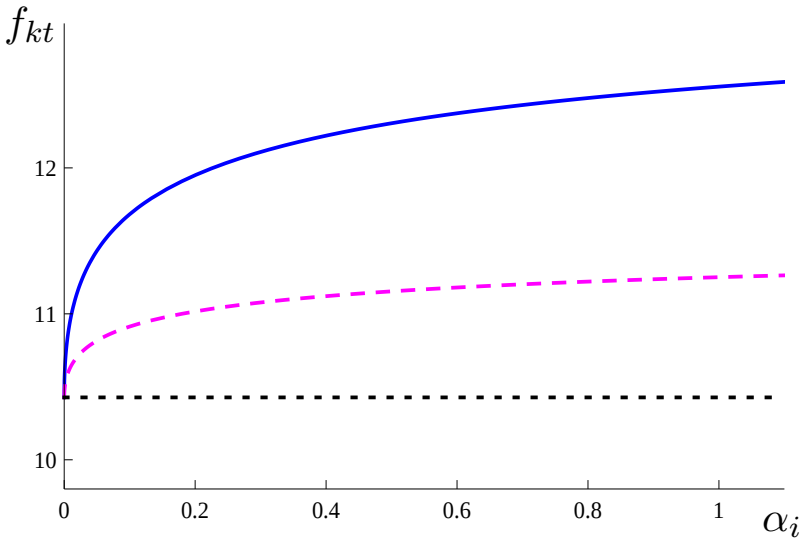
D_{it} – index commodity supply news



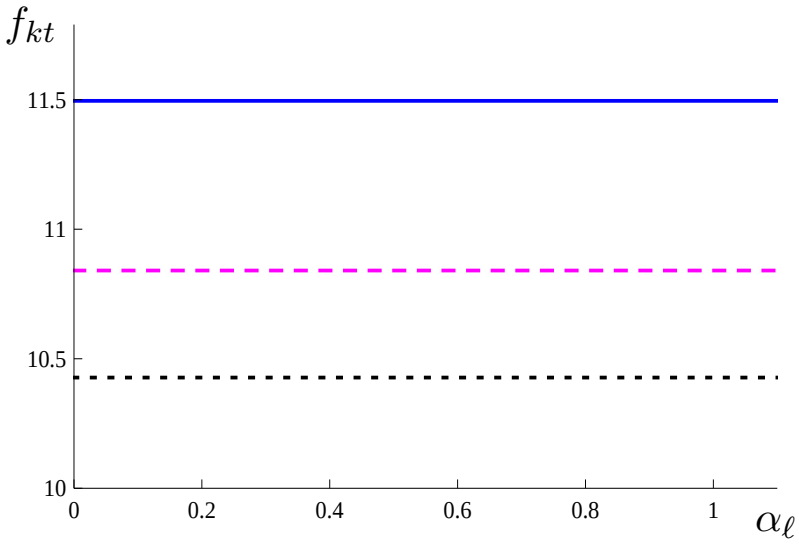
$D_{\ell t}$ – nonindex commodity supply news

- If a commodity is included in the index, its supply news affect all other commodities
- If not, its supply news affect just that commodity alone

Demand Shifts and Commodity Futures Prices



α_{it} – index commodity demand shift



$\alpha_{\ell t}$ – nonindex commodity demand shift

- If a commodity is included in the index, its demand shifts affect all other commodities
- If not, its demand shifts affect just that commodity alone

Commodity Futures Volatilities

- Recall: $df_{kt} = f_{kt}[\mu_{f_k t} dt + \sigma_{f_k t} d\omega_t]$

- Equilibrium loadings on sources of risk of
  - index commodity futures:

$$\sigma_{f_k t} = \overline{\sigma}_{f_k} + h_{kt}\, \sigma_{It}, \quad h_{kt} > 0$$

  - nonindex commodity futures:

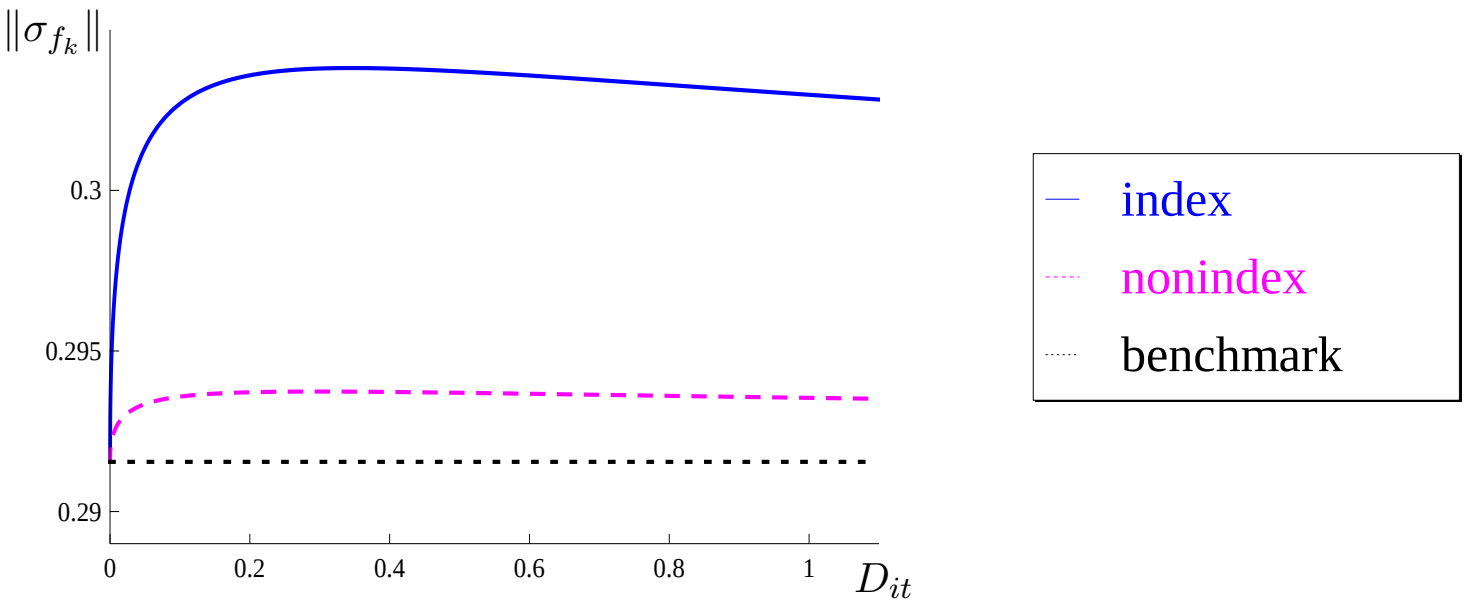
$$\sigma_{f_k t} = \overline{\sigma}_{f_k} + h_t\, \sigma_{It}, \quad h_t > 0$$

  – $\overline{\sigma}_{f_k}$ (constant) loadings in benchmark economy
  – σ_{It} loadings on (expected) index
  – $h_{kt} > h_t$

- Volatilities of all futures prices, $\|\sigma_{f_k t}\|$, are higher than in benchmark economy

- Volatilities of index futures rise more than those of nonindex

Commodity Futures Volatilities



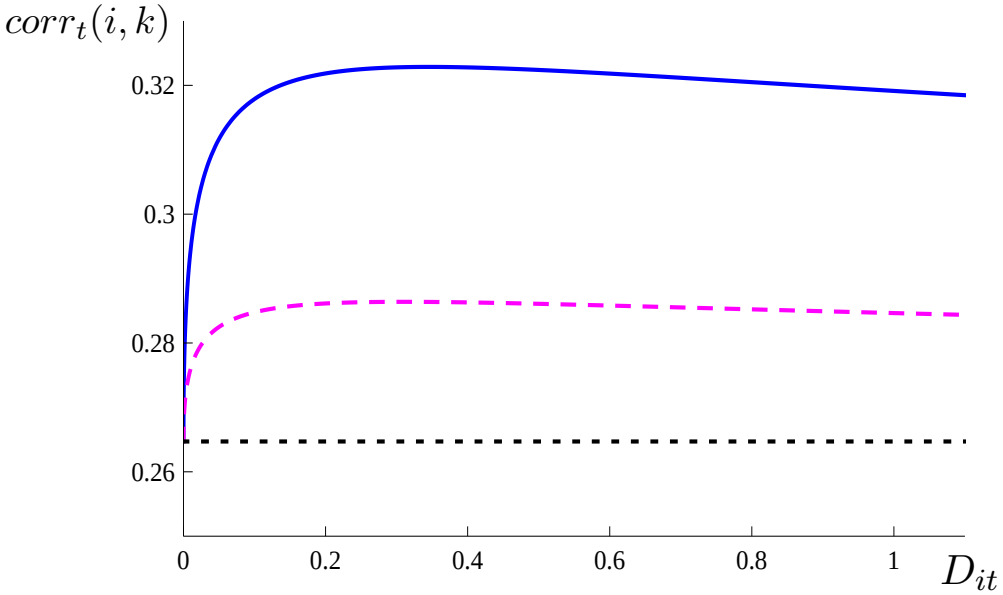
D_{it} – index commodity supply news

- Index commodities supply news D_i emerge as new sources of risk
- Aggregate output news D_t is amplified
- Hence, volatilities go up

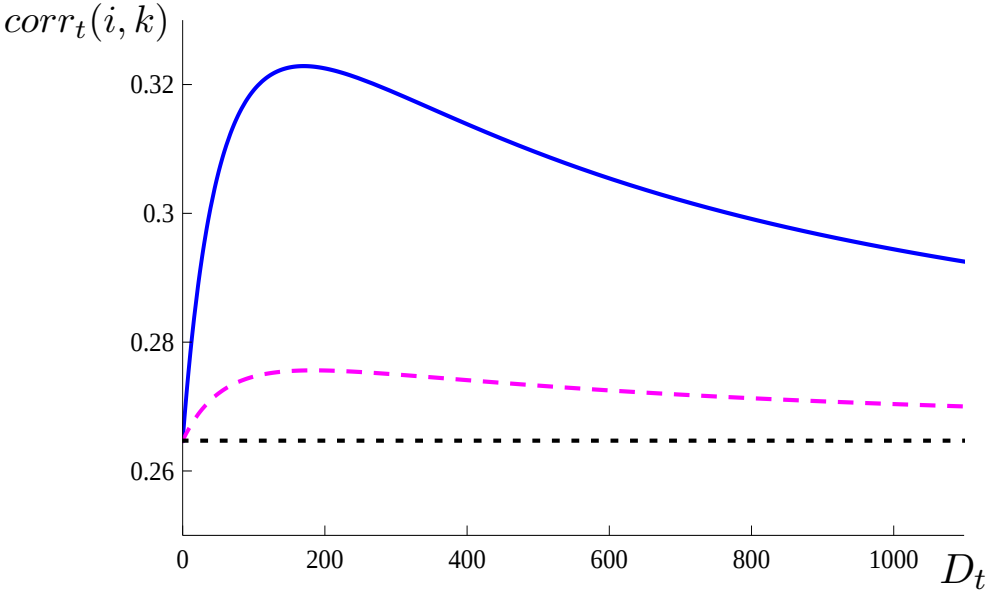
Commodity Futures Comovement

- Covariances and correlations among all commodity futures rise
- Covariances and correlations among index commodities rise more than nonindex – an asset class effect

Commodity Futures Correlations



D_{it} – index commodity supply news



D_t – aggregate output news

- All futures load on a new common factor: commodity index
- Factor loadings are all positive
- Hence, covariances go up

Transmission to Stock Market

- Stock market value

$$S_t = \overline{S}_t \underbrace{\frac{Const + b\,\lambda\, D_t \prod_{i=1}^{L} \left(g_i(t)/D_{it}\right)^{1/L}}{Const + b\,\lambda\, e^{-\sigma^2(T-t)}\, D_t \prod_{i=1}^{L} \left(g_i(t)/D_{it}\right)^{1/L}}}_{>1}$$

with $\overline{S}_t = \frac{\sum_{k=0}^{K} \alpha_k}{\alpha_0} e^{(\mu-\sigma^2)(T-t)} D_t$

- Stock market volatility components

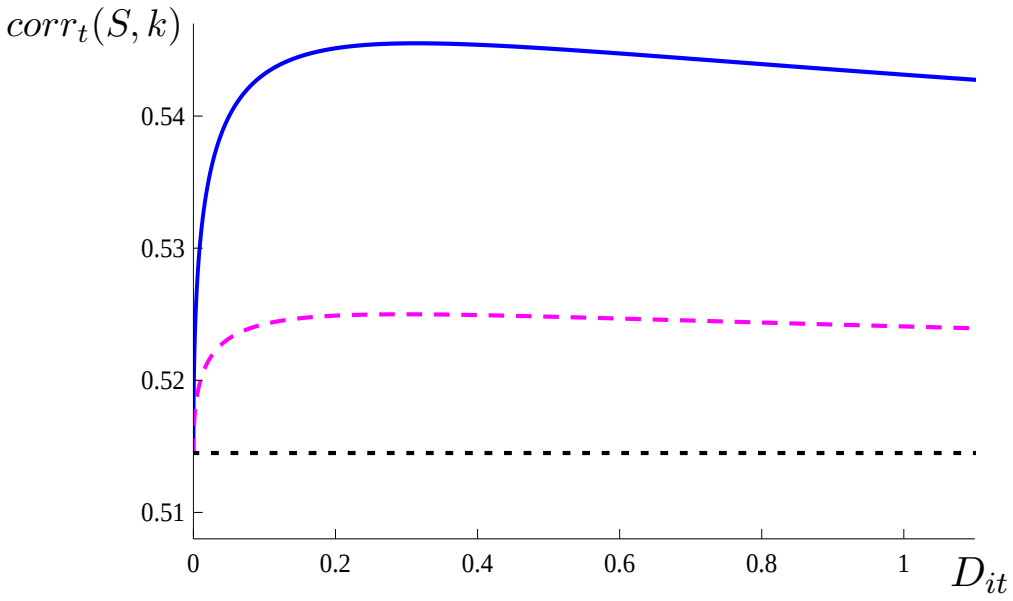
$$\sigma_{St} = \overline{\sigma}_S + h_{St}\sigma_{It}, \quad h_{St} > 0$$

with $\overline{\sigma}_S = \sigma$

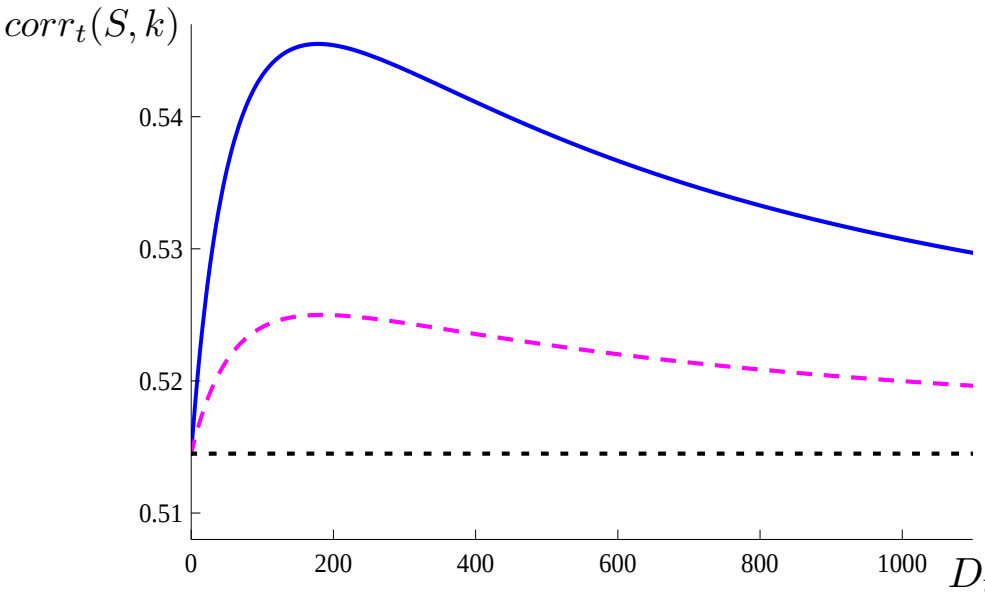
- Stock market value is higher than in benchmark economy

- Stock market volatility is higher than in benchmark economy

Equity-Commodity Correlations



D_{it} – index commodity supply news



D_t – aggregate output news

- Stock is valued using the same discount factor $M_{t,T}$ as other assets
- Stocks and commodity futures load on the new (common) factor: the index

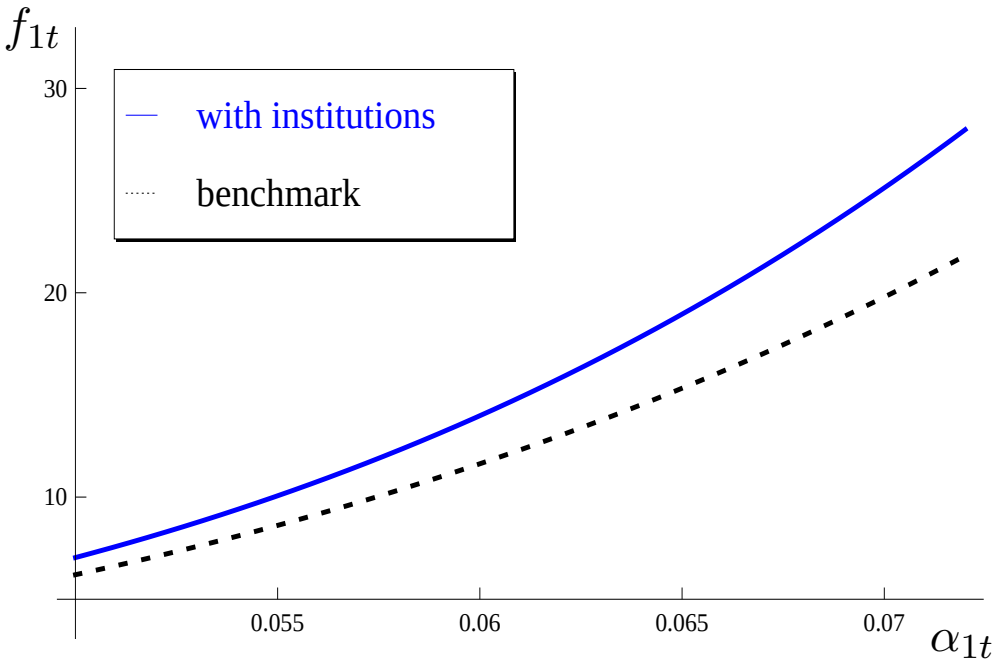
Quantitative Implications

- Calibrate the model with supply and demand shocks
- Commodity 1 represents energy
- Demand shocks = stochastic energy expenditure share α_1 in

$$W = C_0^{\alpha_0} C_1^{\alpha_1} \cdot \ldots \cdot C_K^{\alpha_K}$$

  – α_1 is increasing with aggregate output

Demand Shocks and Energy Futures Prices



α_{1t} – energy demand parameter

- Demand shocks – additional source of risk affecting index
- As demand increases, financialization accounts for a bigger fraction of futures prices

Fraction of Futures Prices Explained by Financialization

- Energy futures:

		Volatility of non-energy supply news σ_k		
		0.19	0.24	0.29
Volatility of energy supply news σ_1	0.24	14.39%	14.43%	14.46%
	0.29	16.79%	16.83%	16.86%
	0.34	19.68%	19.72%	19.76%

- Non-energy futures:

		Volatility of non-energy supply news σ_k		
		0.19	0.24	0.29
Volatility of energy supply news σ_1	0.24	9.09%	11.00%	13.35%
	0.29	9.16%	11.04%	13.40%
	0.34	9.19%	11.08%	13.44%

Summary: Effects of Financialization

- Prices of all commodity futures go up, but those of index futures rise by more
- If a commodity is in index, news about its fundamentals affect all other commodities
- Volatilities of both index and nonindex futures go up, but those of index futures increase by more
- Correlations among index commodities rise more than nonindex – an asset class effect
- Equity-commodity correlations go up, and especially so for index commodities
- Financialization accounts for 11% to 17% of commodity futures prices and the rest is attributable to fundamentals

Commodity Spot Prices

- The model pins down time-T commodity spot prices but not time $t < T$. Need a model with intermediate consumption.
- Let us extrapolate from our model. Assume that
  - commodities are storable
  - one can freely buy or sell commodities at any time $t \leq T$
  - convenience yield/storage costs are constant fraction δ_k of price
- Then

$$f_{kt} = p_{kt} e^{\delta_k (T-t)}$$

- A great question to explore in future research!