Contents

Causes and Implications of Shifts in Financial Participation in Commodity Markets

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Outline

- The financial participation of those who have no capacity to store oil in international energy markets has increased tremendously in the 2000s ([Domanski and Heath, 2007]). Eg. Hedge Funds, Index Investors, CLNs
- A mostly empirical economic literature has sprung up linking greater financialization participation to changes in behaviour of oil prices (see [Fattouh et al., 2012] for a survey).
- When can shifts in financial participation be associated with suboptimal pricing, costly volatility or bubbles?
- Anticipations of supply and demand shifts (with a convenience yield) are competing explanations of correlated movements in participation, spreads and inventory.

Testing the Financialization Hypothesis I

- Financial futures volume and the volume of physical trade in oil need not be cointegrated, with no adverse consequences for welfare
- Financial futures volume and spreads can be jointly determined by expectations of fundamentals
- Question is *Can changes in the incentives and constraints of purely financial players affect prices and, thus, the welfare of spot purchasers?*
- We build a (semi-)structural model (macro-finance) to answer this question.
- We match the model to the data before 2003 (pre-financialization).
- We experiment with structural financialization changes (lower risk aversion and lower wealth for financial speculators), and also lower net supply and high net supply volatility.
- We see if structural financial changes predict higher and more volatile prices and a worse outcome for consumers.

Testing the Financialization Hypothesis II

- We see if the predictions of the model match what data tells us happened after 2003.
- We see if the model predictions for supply and demand do a better job in explaining facts.

Speculators I

- Physical speculators: buy oil on the spot market and store it. They can sell it forward or wait and sell it next period. They also hold a risk-free asset. Two periods.
- The choice of how much to hedge is a powerful lever.
- There is a convenience yield to holding oil and a re-distributive cost/margin to futures transactions.
- We solve for their decision as a portfolio maximization with utility — depends on distribution of prices.
- Financial speculators: contract to buy oil on the futures market, and sell it at delivery. They hold shares and a risk-free asset.
- Their financial gamble is a bet.
- We solve for their decision as a portfolio maximization with utility (risk aversion).

Physical Speculators

$$U_{r,1} = \mathbb{E}_0[\frac{(W_{r,1})^{1-\tau_r}}{1-\tau_r}] \quad (1)$$

and

$$W_{r,1} = W_{r,0}((1 - \alpha_{r1,0} - \alpha_{r2,0})(1 + r_f) + \alpha_{r1,0}\frac{P_1 C_{q1,1}}{P_0} + \alpha_{r2,0}\frac{F_0^1 C_{q2,1}}{P_0}) \quad (2)$$

where

- P_s is the price of oil in period s $(s = 0, 1)$
- F_0^1 is the price of oil contracted at time 0 to be delivered at time 1.
- Wealth in period s is denoted by $W_{r,s}$.
- $\alpha_{r1,0} + \alpha_{r2,0}$ is the share of wealth in physical oil
- $\frac{\alpha_{r2,0}}{\alpha_{r1,0}+\alpha_{r2,0}}$ is the share of oil sold forward.
- also bonds earning a risk-free rate of r_f.

In log terms, we write $C_{q1,1}$ and $C_{q2,1}$ as:

$$c_{q1,1} = \varrho_1 prob(P_1 > P^*) + \bar{c}_{q1}$$
$$\text{and } c_{q2,1} = \varrho_2 prob(P_1 > P^*) + \bar{c}_{q1} - c_{g,1} \quad (3)$$

where

- $prob(P_1 > P^*) = prob(p_1 > p^*) = 1 - \phi(\frac{p^* - \mathbb{E}_0[p_1]}{Var_0[p_1]^{0.5}})$, given standard normal cumulative distribution $\phi(.)$.
- ϱ_1 and ϱ_2 are the elasticities of the convenience yield.
- A stochastic proportionate transaction gain for writing short futures contracts equal to the log of the cost paid by those going long ($c_{g,1}$).

The Financial Speculator's Return I

The financial speculators' problem is to maximise the objective

$$U_{s,1} = \mathbb{E}_0[\frac{(W_{s,1})^{1-\tau_s}}{1-\tau_s}] \tag{4}$$

subject to a budget constraint,

$$W_{s,1} = W_{s,0}((1-\alpha_{s2,0})(1+r_f) + \alpha_{s1,0}\frac{P_1 C_{g,1}}{F_0^1} + \alpha_{s2,0} R_{e,1}) \tag{5}$$

where wealth in period 1 denoted by $W_{s,1}$, $\alpha_{s2,0}$ is the share of wealth held in risky equity as opposed to riskless bonds and $\alpha_{s1,0}$ is the value of the futures commitment in terms of period 0 wealth. $\alpha_{s1,0}$ is not a share, as a futures position is essentially a bet rather than an investment.

The Financial Speculator's Return II

The solution to the financial speculators' problem of maximizing 4 subject to 5 by choice of $\alpha_{s1,0}$ and $\alpha_{s2,0}$ is approximately given by:

$$\frac{1}{(1+\alpha_{s1,0})}\boldsymbol{\alpha}_{s,0}^{T} = \frac{1}{1+\tau_s}$$

$$(\mathbb{E}_0[\mathbf{r}_{ss,1}] - r_f\boldsymbol{\iota} + \frac{1}{2}diag(\mathbf{Var}_0[\mathbf{r}_{ss,1}]) + \frac{1}{2}diag([\mathbb{E}_0[\mathbf{r}_{ss,1}] - r_f\boldsymbol{\iota}][\mathbb{E}_0[\mathbf{r}_{ss,1}] - r_f\boldsymbol{\iota}]^T))$$

$$\times\left(\mathbf{Var}_0[\mathbf{r}_{ss,1}] + [\mathbb{E}_0[\mathbf{r}_{ss,1}] - r_f\boldsymbol{\iota}][\mathbb{E}_0[\mathbf{r}_{ss,1}] - r_f\boldsymbol{\iota}]^T\right)^{-1} \qquad (6)$$

Consumers I

- Final consumers: buy oil each period and take the demand for other goods as given.
- Model is solved by equating supply and demand each period, with carryover between the two.
- All three prices are endogenous as is carry over, volumes etc.

Consumers' welfare I

The objective of final consumers is to maximize their utility from consumption over both periods

$$U(C_{c,0}) + \beta \mathbb{E}_0 U(C_{c,1}) \tag{7}$$

where β is the discount rate and it is assumed that each period's utility is of the power form,

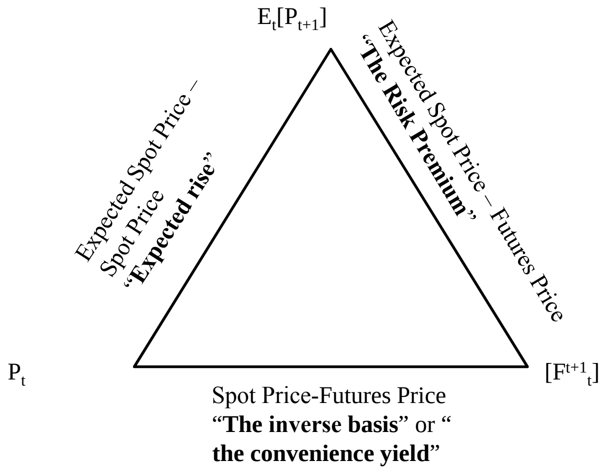
$$U(z) = \frac{(z)^{1-\chi} - 1}{1-\chi} \tag{8}$$

and that total consumption $C_{c,s}$ is a CES aggregate of the consumption of purchases of spot oil (X_s) and other items (Y_s),

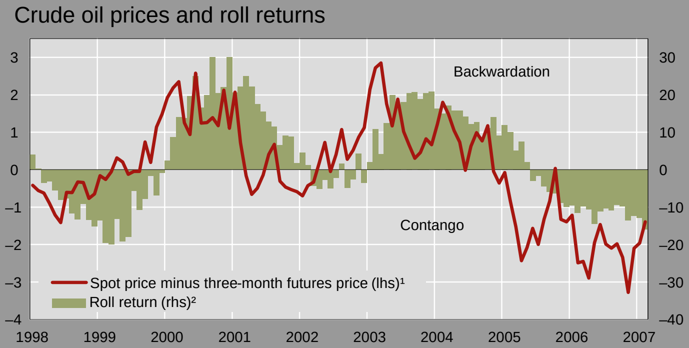
$$C_{c,s} = \lambda_s \left[\Gamma_s^{\frac{1}{\omega}} (X_s)^{\frac{\omega-1}{\omega}} + (Y_s)^{\frac{\omega-1}{\omega}} \right]^{\frac{\omega}{\omega-1}} \tag{9}$$

with $\lambda_s \equiv (\frac{1}{1+\Gamma_s^{\frac{1}{\omega}}})^{\frac{\omega-1}{\omega}}$ for $s = 1, 2$.

Spreads I


$E_t[P_{t+1}]$
Expected Spot Price – Spot Price
"Expected rise"
Expected Spot Price – Futures Price
"The Risk Premium"
P_t
$[F^{t+1}_t]$
Spot Price-Futures Price
"**The inverse basis**" or "**the convenience yield**"

Basis and the Roll Return ([Domanski and Heath, 2007]) I



[1] In US dollars per barrel. [2] Annual returns from rolling over consecutive three-month futures at maturity in excess of spot price returns.

Sources: Bloomberg; BIS calculations. Graph 2

Summary of Behaviour Changes I

Table: Pre- and Post-Financialization.

Variable	July 1986 — Dec. 2002 Avge.	Jan. 2003 — Jan. 2012 Avge.	Notes and Units
Financial Partptn	Probably higher		Difficult to estimate
Stocks	Higher		Rel. to flow capac.?
Real Oil Price	15.2	36.4	Jan. 1986 $s
Std Devn of Oil Price	31.3 pp	34.4p	Annual Arith.
Real Inverted Basis	9.4%	1.9%	Avge Annual Arith. Retn.
Real Oil Price Apptn	Ex-post lower		Difficult to estimate
Risk Premium	Probably lower		See [Plante and Thies, 2012

Generalized from [Conroy and Rendleman, 1983]. Farmers ^{r} choose to sell their crop forward to protect from exogenous price (P) and output volatility Y. There is no storage, no intertemporal production smoothing: future output and price are stochastic and exogenous. Financial speculators ^{s} receive an exogenous stochastic investment return R from other assets and can bet on futures.

$$F_0^1 - \mathbb{E}_0[P_1] = -\frac{2\sigma_P^2}{\frac{W^r}{\tau^r} + \frac{W^s}{\tau^s}}[(\mu_Y + \beta_{Y_1 \text{ on } P_1}\mathbb{E}_0[P_1]) + \beta_{R \text{ on } P_1} + 4\frac{Cov_0[P_1, P_1 Y_1]}{\sigma_P^2}]. \tag{10}$$

τ^s is risk aversion of financial speculators and W^s is their wealth. μ^Y is average farm output, μ^R is average return on other financial assets. Equation 10 suggests that *without storage*, the relationship between financial layer changes and the risk premium is complex, ambiguous in sign and time-varying.

- If $\beta_{\ln Y \text{ on } \ln P}$ is -1, then revenues are certain and there is less need to hedge. If $\beta_{\ln Y \text{ on } \ln P}$ is 0 or positive, then revenues are very uncertain and there is a great need to hedge.

- Similarly if there is a greater covariance of financial assets and commodity prices, then financial speculators will want to short futures.
- skew also can matter

Spot Term Structure Response to Financialization

Consider an inverted spot market clearing relationship at time 0: $P_0 = f(\Gamma_0, Q_0)$ where Q_0 is the change in inventory and Γ_0 is supply and demand fundamentals. Let $\%\delta X|_f$ indicates the percentage change in X as a consequence of a shift in the financial layer.
Then

$$\begin{aligned} & P_0 = f(R_0, Q_0) \text{ and } \mathbb{E}_0[P_1] = \mathbb{E}_0 g(R_1, Q_0) \\ & \text{with } \frac{\partial f(.)}{\partial Q_0} \approx -\frac{\partial g(.)}{\partial Q_0} > 0 \\ & \Rightarrow \%\delta \mathbb{E}_0[P_1]|_f \approx -\%\delta P_0|_f \end{aligned} \tag{11}$$

as Γ_0 and Γ_1 are independent of Financialization.

- Equal and opposite proportionate reaction in spot prices.
- Final consumers' losses from a higher future spot price offset by a lower current spot price (or vice versa).
- Even if consumers cannot temporally shift, welfare losses limited (better off than market manipulation w/o frictions).

Spot Term Structure Response to Financialization: Multiperiod Model

Now the spot market clearing relationship at time t would be $ST_t - ST_{t-1} = (P_t^{elas_s \cdot} \Gamma_{s,t} - P_t^{-elas_d \cdot} \Gamma_{d,t})$ where $ST_t - ST_{t-1}$ is the change in inventory, $elas._d$ is the elasticity of demand, $\Gamma_{d,t}$ is the demand fundamentals and $elas._s$ and $\Gamma_{s,t}$ are the equivalent for supply. Rolling this forward, we have

$$
\begin{aligned}
(P_t^{elas_s \cdot} \Gamma_{s,t} - P_t^{-elas_d \cdot} \Gamma_{d,t}) &= ST_t - ST_{t-1} \\
\Rightarrow ST_{t-1} &= \sum_{k=t}^{\infty} (P_k^{elas_s \cdot} \Gamma_{s,k} - P_k^{-elas_d \cdot} \Gamma_{d,k}) \qquad (12)
\end{aligned}
$$

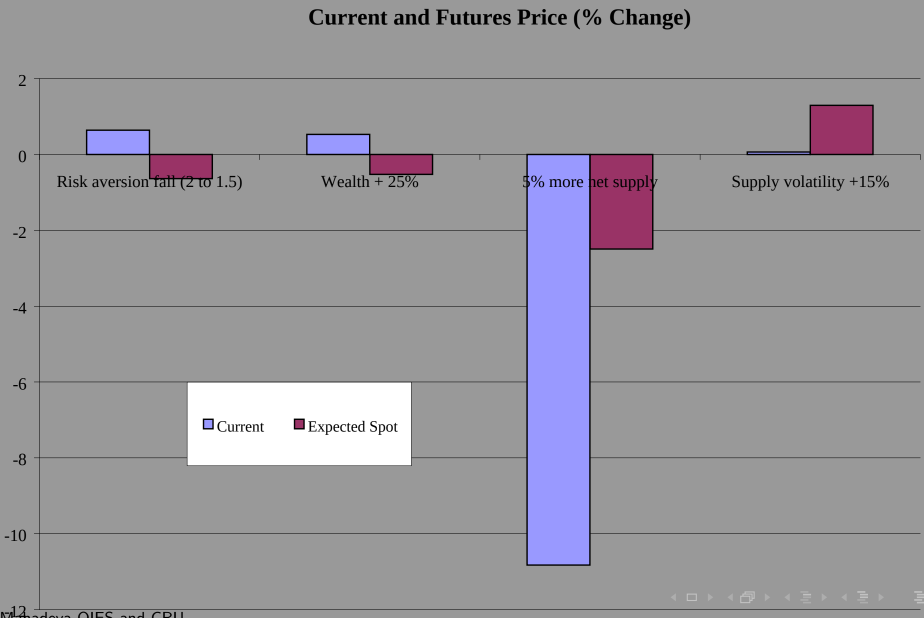
As $\Gamma_{s,k}$, $\Gamma_{d,k}$ and ST_{t-1} $(k = t, \ldots, \infty)$ are unchanged for a pure change in the financial layer, then a change in prices at one point in the term structure will have to be matched by a near equally proportionate change in the opposite direction at another point.

Risk Premium & Inverse Basis reaction to Financialization shifts

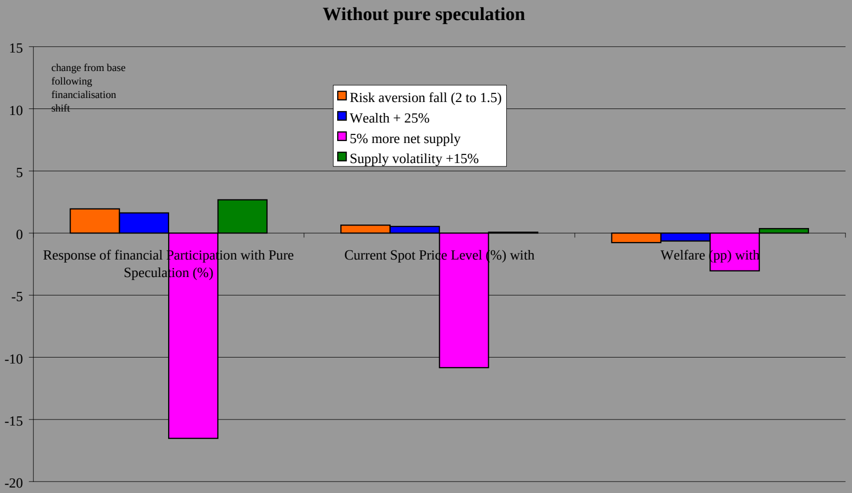
$$\%\delta\mathbb{E}_0[P_1]|_f - \%\delta F_0^1|_f \approx \%\delta P_0|_f - \%\delta F_0^1|_f + \%\delta\mathbb{E}_0[P_1]|_f - \%\delta P_0|_f \quad (13)$$
$$\Rightarrow \%\delta\mathbb{E}_0[P_1]|_f - \%\delta F_0^1|_f + (\%\delta F_0^1|_f - \%\delta P_0|_f) \approx -2\%\delta P_0|_f$$

- Large differential reaction in risk premium and inverse basis needed to explain large rise in spot price.

Results — Price levels



Results — summary



Pure Speculation I

- So far, futures trade is about risk-sharing.
- Earlier [Hirshleifer, 1977] and now [Sismek, 2012] have demonstrated that trade in a financial instrument can combine both a risk-sharing and a pure speculation motive when there are persistent belief disagreements.
- Rational traders will not trade in a complete market even if they have private information.
- [Shalen, 1993] demonstrated that a widening dispersion of beliefs leads to a rise in volume and unconditional volatility in futures markets.
- [Söderlind, 2009] neatly demonstrates that this depends on risk aversion being not too high: beliefs generate volatility as well as trade opportunities.
- Naturally worth exploring for commodities, where there are huge belief disagreements about important unobservables: the convenience yield and future technology trends.

Formal model I

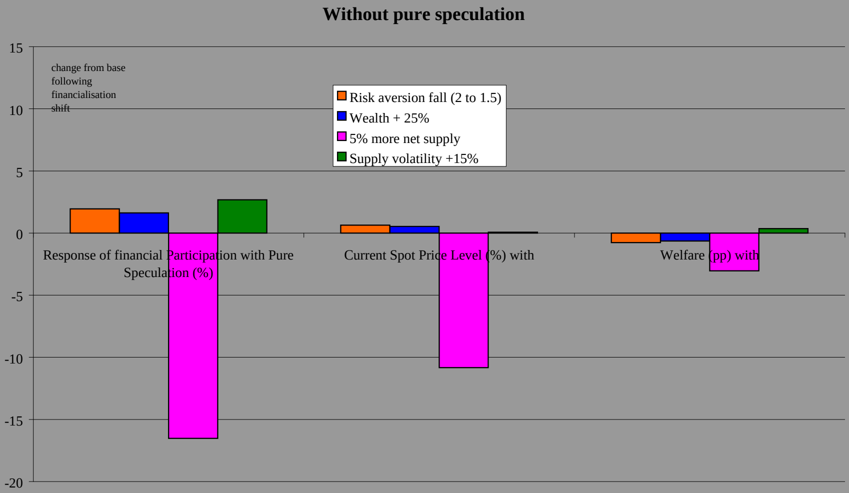
Hence

$$\mathbb{E}_0^r[p_1] = \mathbb{E}_0[p_1] - \epsilon \text{ and } \mathbb{E}_0^s[p_1] = \mathbb{E}_0[p_1] + \epsilon, \text{ where } \epsilon = 0.2 \tag{14}$$

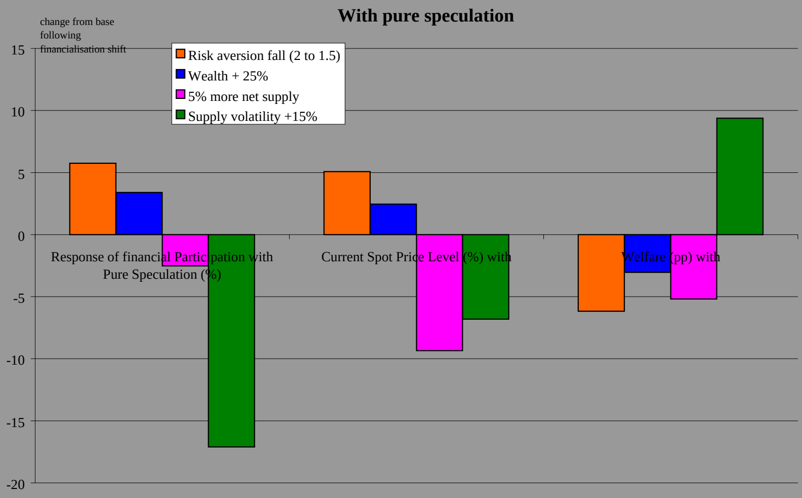
and solve for the portfolio shares which reflect these disagreements. All other expressions in the model remain as they were.

- In the new baseline the real value of futures contract is larger (20%) larger: this is pure speculation

Results — without pure speculation



Results — with pure speculation



Financial Layer Changes and Commodity Prices: History

- Tulipmania
- Grain and Sugar in the Seven Years War
- US Agriculture in the 1920's Depression
- Amaranth and Gas Futures

Grain and Sugar in the Seven Years War ([Schnabel and Shin, 2001]) I

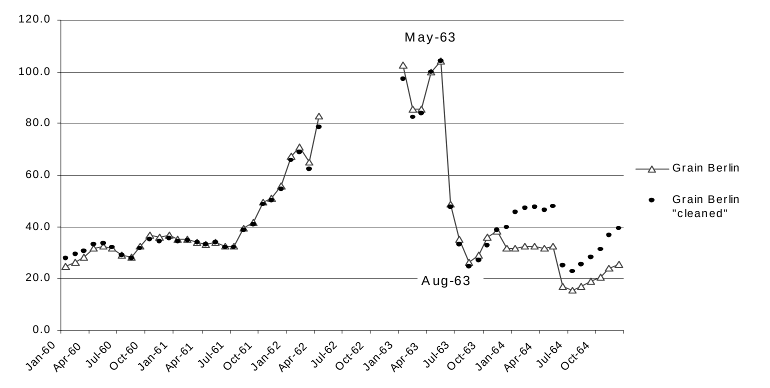


Figure 4.3: Berlin grain prices, April 1763 = 100. "Cleaned" prices are adjusted for exchange rate.

Grain and Sugar in the Seven Years War ([Schnabel and Shin, 2001]) II

Berlin grain price rises in August 1761 and falls by 75% between May and August 1763 following the signing of a peace agreement in February. Eventually holders of grain and sugar "were forced to sell their trading goods in public auctions, thus strongly depressing prices. . . Since May complaints are heard concerning these auctions and hurried sales that damaged the market."

- Correlations between prices increased, especially those heavily traded by merchant bankers.
- Grain price fall coincides with bankruptcies in Hamburg
- Evidence on low capital and liquidity of key banks involved
- Grain prices rose in Prussia's most difficult period

What can create sharp changes in the wealth available in the investment of commodities?

- Too few investors (liquidity risk) $\Rightarrow$ concentration/position limits
- Highly leveraged investors (funding risk) $\Rightarrow$ microprudential policy
- Many investors but with interlocking liability structure $\Rightarrow$ macroprudential policy
- Marked to market margins, risk-averse market making which is not perfectly elastic, execution order is not perfectly sequential [Bernardo and Welch, 2004], clearing rules and collateral liquidation mechanism [?]$\Rightarrow$ market microstructure frictions during crisis

Results on Financialization I

Underlying shifts in Financialization (as either a huge rise in financial speculators wealth or a fall in their risk aversion) cannot explain the scale of recent movements in oil prices.

Greater financial wealth or lower risk aversion have (if anything) beneficial effects on consumer welfare (as they lower volatility and raise stocks).

Even if we allow for pure speculation, and volatility in financing costs for commodity speculation.

Supply and demand forces matter more in lowering basis and can even explain the movements in participation.

This may be different in the presence of poorly designed financial system, which leads to large proportionate fluctuations in net wealth

... suggesting there is role for policy with clear objectives and institutional design.

References I

Bernardo, A. E. and Welch, I. (2004).
Liquidity and Financial Market Runs.
The Quarterly Journal of Economics, 119(1):135–158.

Conroy, R. M. and Rendleman, R. J. (1983).
Pricing commodities when both price and output are uncertain.
Journal of Futures Markets, 3(4):439–450.

Domanski, D. and Heath, A. (2007).
Financial investors and commodity markets.
BIS Quarterly Review, pages 53–67.

Fattouh, B., Kilian, L., and Mahadeva, L. (2012).
The role of speculation in oil markets: What have we learned so far?
CEPR Discussion Papers 8916, C.E.P.R. Discussion Papers.

Hirshleifer, J. (1977).
Stochastic convenience yield implied from commodity futures and interest rates.
The Journal of Finance, 32(4):975–99.

References II

Plante, M. and Thies, J. (2012).
Commodity futures investing: method to the madness.
Economic Letter: Insights from the Federal Reserve Bank of Dallas, 7(5):1–4.

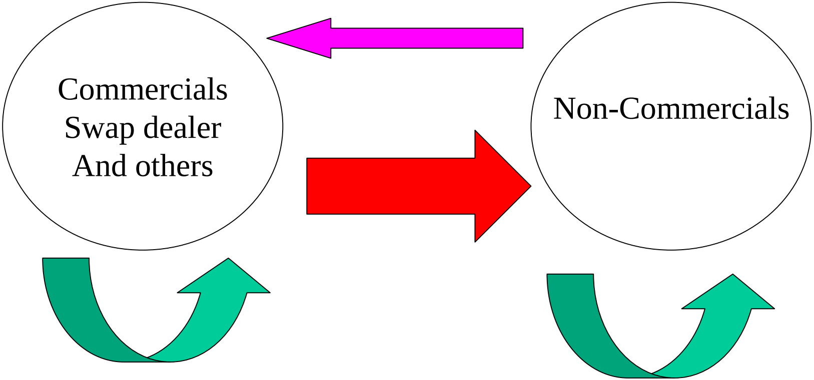
Schnabel, I. and Shin, H. S. (2001).
Foreshadowing LTCM: The Crisis of 1763.
Sonderforschungsbereich 504 Publications 02-46, Sonderforschungsbereich 504, Universität Mannheim & Sonderforschungsbereich 504, University of Mannheim.

Shalen, C. T. (1993).
Volume, volatility, and the dispersion of beliefs.
Review of Financial Studies, 6(2):405–34.

Sismek, A. (2012).
Speculation and risk sharing with new financial assets.
Working Paper 17506, NBER.

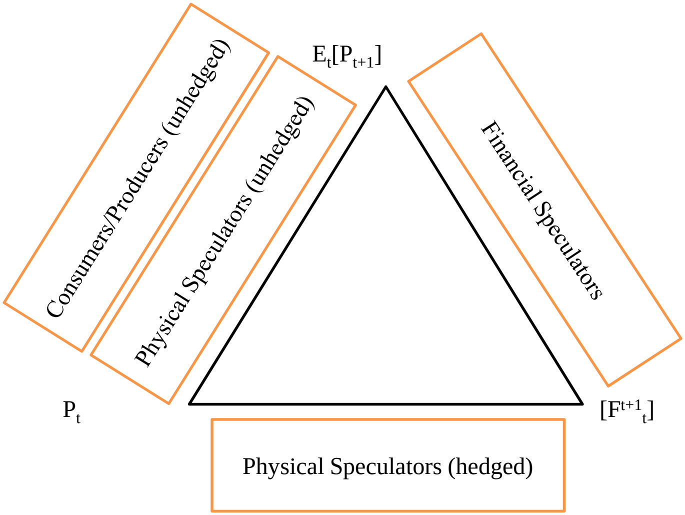
Söderlind, P. (2009).
Why disagreement may not matter (much) for asset prices.
Finance Research Letters, 6(2):73–82.

Explaining the CTFC data



Direction of arrow indicates to whom oil is being sold to for future delivery. The CTFC **net long** data is the red minus the pink arrow (number of barrels). This can vastly exceed the number of barrels which are actually changing hands, as they can be settled eg. by taking the opposite position on another futures contract on the same settlement date. The difference in futures prices is then a profit or loss.

Spreads and Players



The Convenience Yield

In logs

$$\overbrace{\underbrace{f_1^0}_{\text{Futures price}} - \underbrace{p_0}_{\text{Spot price}} + \underbrace{cy_t}_{\text{Convenience yield}} - \underbrace{c_t}_{\text{storage costs}}}^{\text{total return on hedged physical oil}}$$

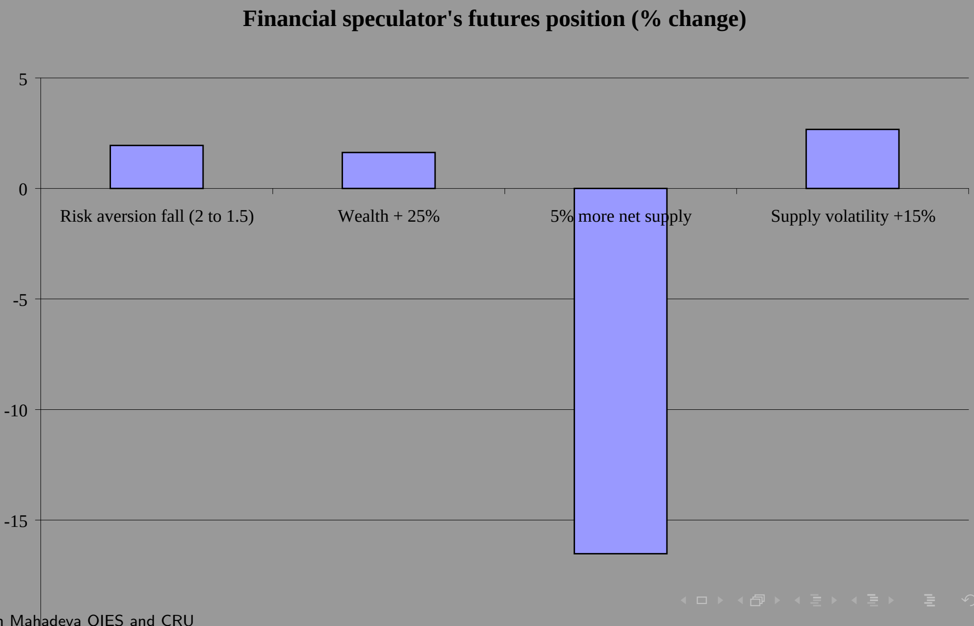
$$= \overbrace{\underbrace{r_t}_{\text{risk-free rate}}}^{\text{opportunity cost}}$$

$$\Rightarrow p_0 - f_1^0 + r_t + c_t = cy_t$$

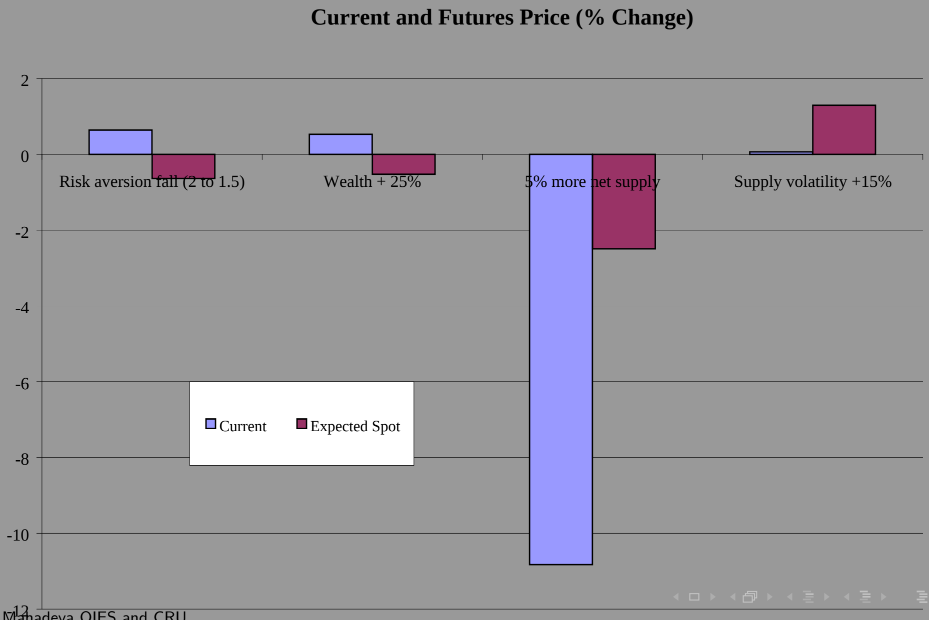
$$\text{But as } cy_t = f\left(\frac{\text{Inventory}}{\text{Demand}}\right)$$

$$\Rightarrow p_0 - f_1^0 + r_t + c_t = f\left(\frac{\text{Inventory}}{\text{Demand}}\right) \quad (15)$$

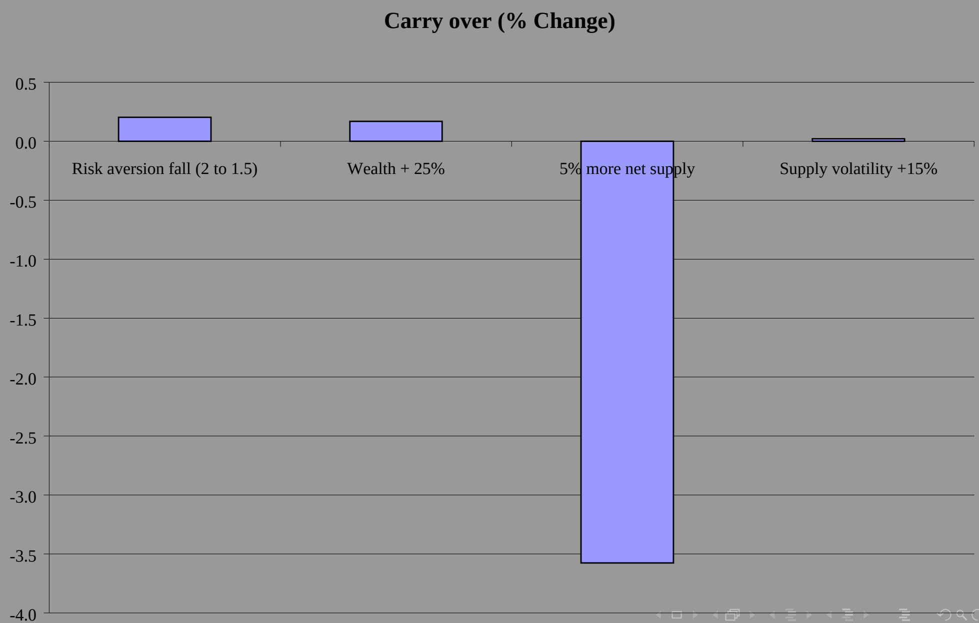
Results — Financial participation



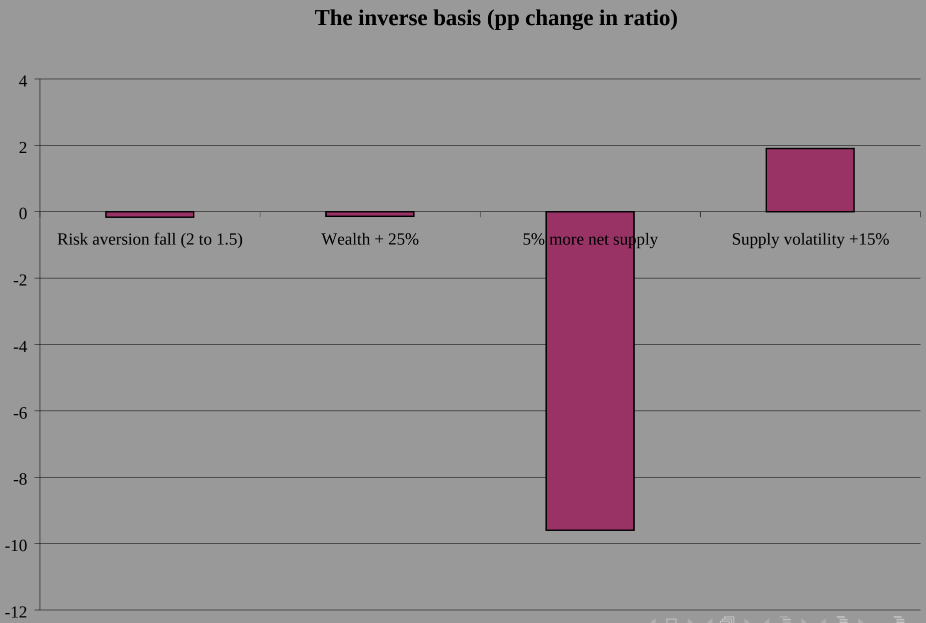
Results — Price levels



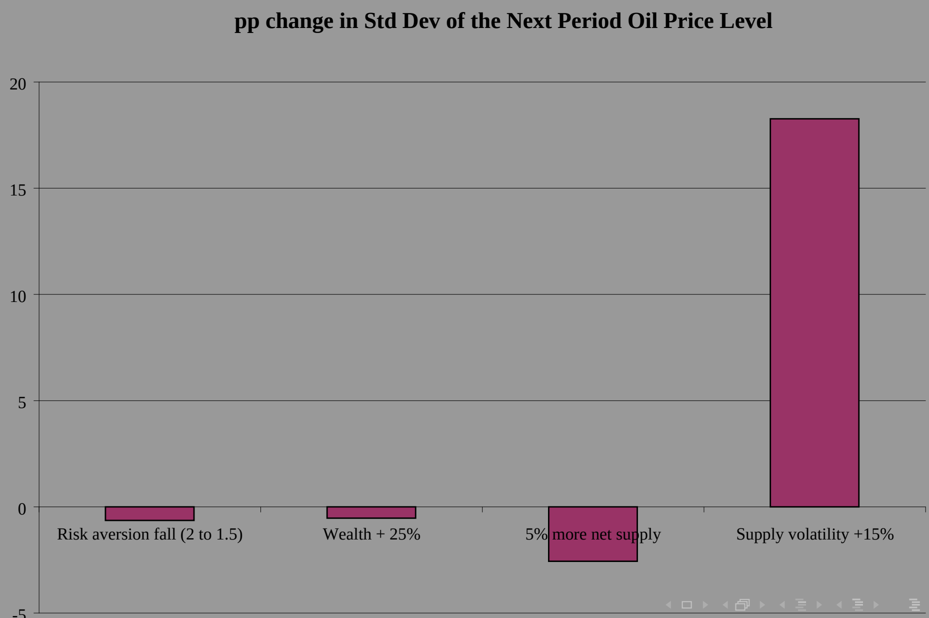
Results — Carry over



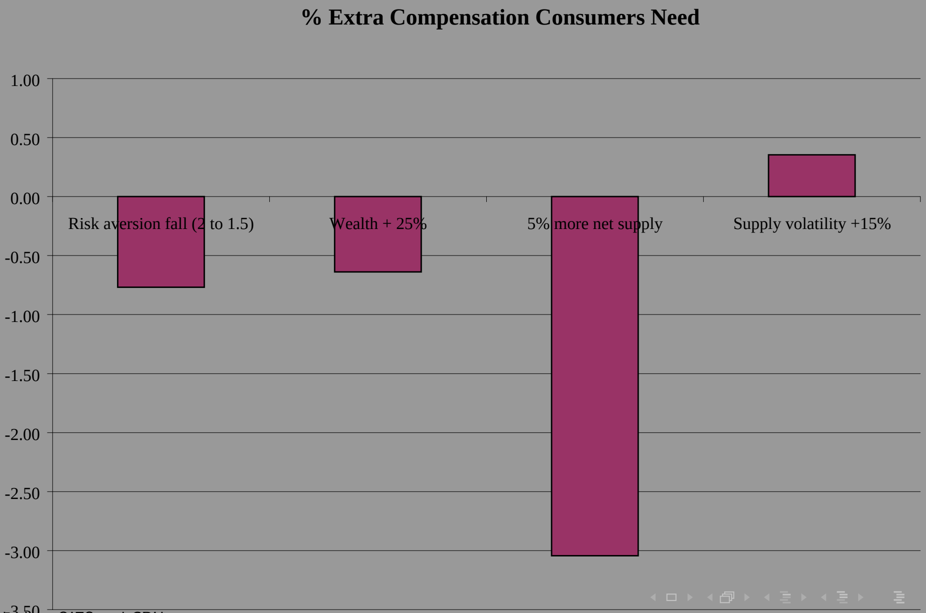
Results — Spreads



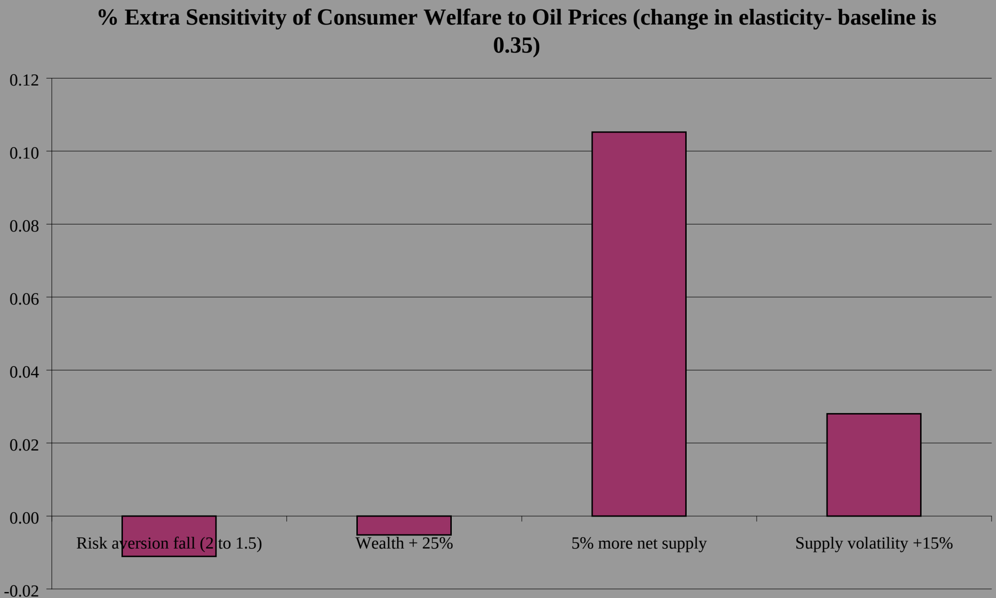
Results — Price uncertainty



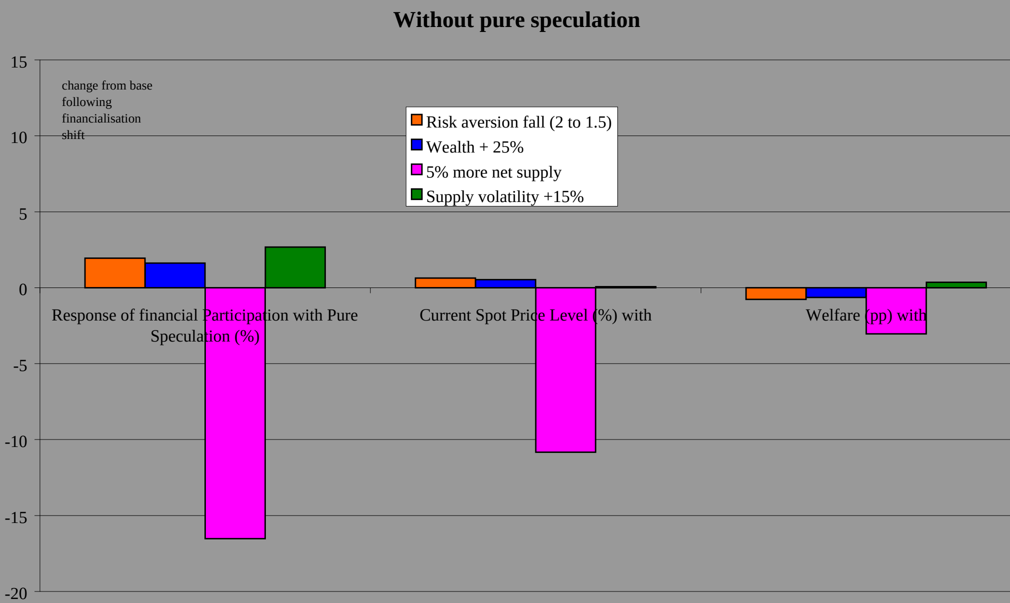
Results — Welfare



Results — Welfare exposure

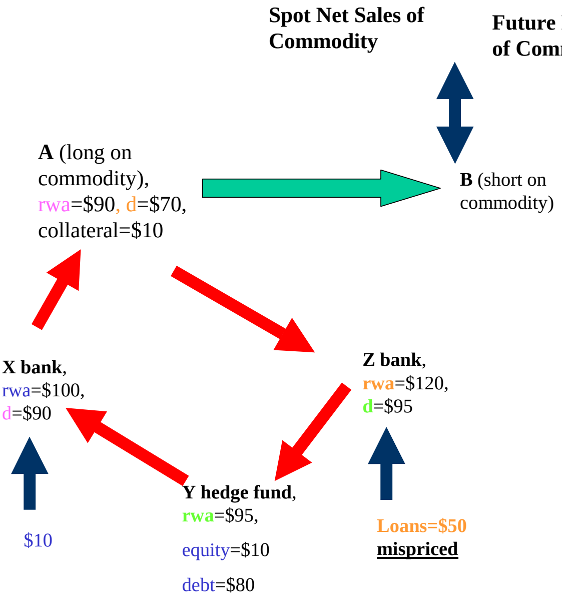


Results — without pure speculation



Results — with pure speculation

Financial System I



The diagram shows how mispricing in underlying assets in one part of the financial system can create mispricing in commodity spreads in principle

This can be due to inadequacies in microprudential; macroprudential and/or collateral policies.

Key question: **Are some commodity spreads more sensitive than others to shocks in the financial system? Why?**