Crude Oil Price – Fundamentals, Financials, etc.: *A Basic Premise for Research*

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Oil Market Developments

The Crude Oil Conundrum

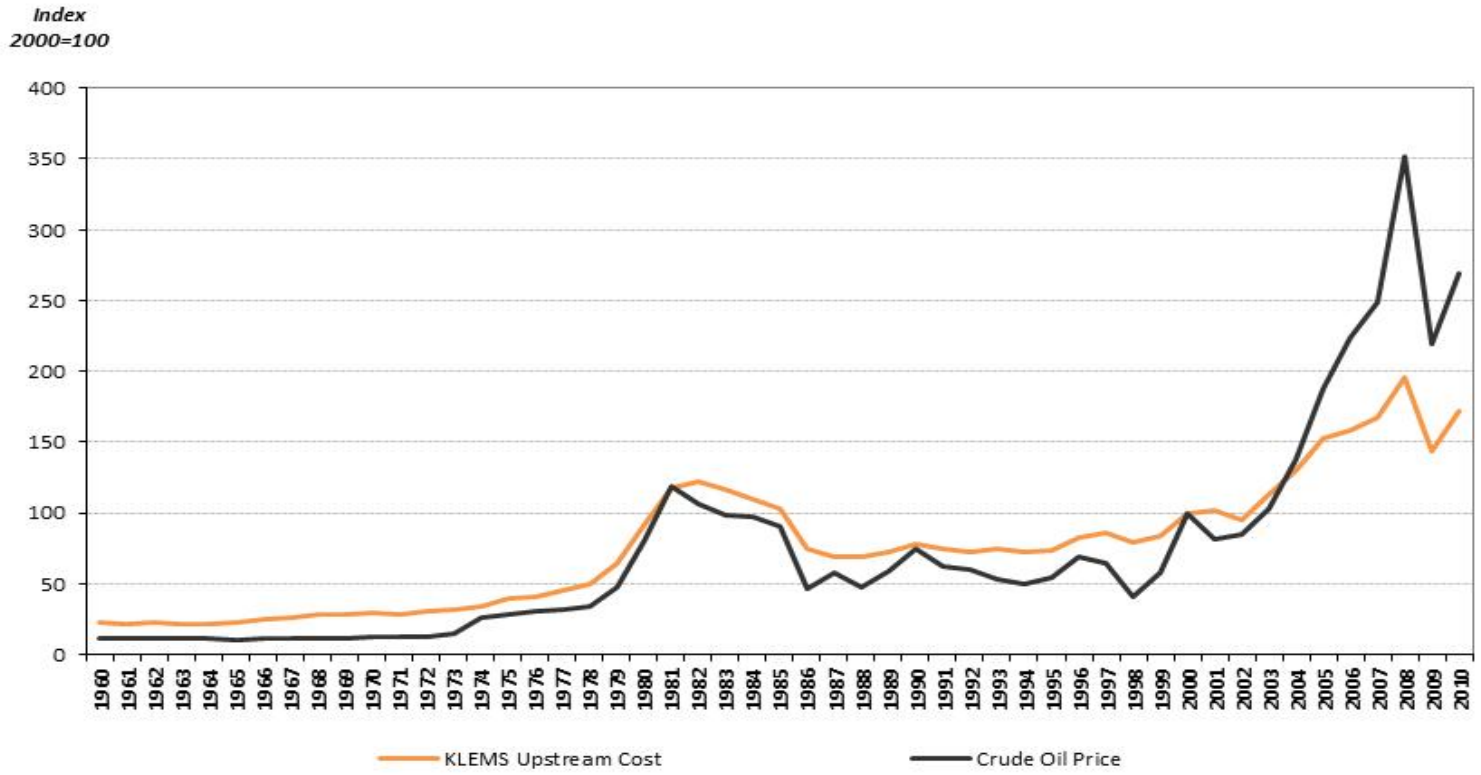
- We know crude oil supply is responding positively to high prices.
  - Major announcements in Deepwater environments in the last 10 years.
  - Unconventional oil is emerging as a major source of supply in the US.
  - These developments tend to shift the supply curve out and make it more elastic, but these are generally long run arguments.
- However, lagging investment in OPEC has reduced spare capacity. This tends to reduce the *short run* elasticity of supply, meaning shocks in the oil market will generate greater price instability.
- This is all occurring against a backdrop of rising demand from rapidly developing nations in Asia. Moreover, economic growth in the Middle East has increased demand for crude oil in the power sector, which is most pronounced in the summer months. This generally coincides with higher transportation demands in the west.
- Bottom line: a general view of overall crude oil market tightness seems to be the dominant theme in the market.
- However, signs of weakness in the global economy could be the ultimate counterweight, as it could result in weaker expected demand and international flight to the dollar.

Over the past few years many factors have been "blamed" for high oil prices…

- "Big Oil"
- Rising Costs
- National Oil Companies: Increasing control of global conventional oil resources by a smaller group of countries
  - BIPP study 2007: "The Role of the National Oil Company"
- "Peak oil"
- Demand Growth in China and India
- A Weak $ and Speculation

Investment and the Effect of Rising Costs

- *Rising costs* in the face of *price uncertainty* from 2000-2008 contributed to apparently low investment levels by "Big Oil" in the first half of the last decade (see Jaffe and Soligo (2007)).
- This can effect expectations regarding future supply availability, which in turn impacts price.



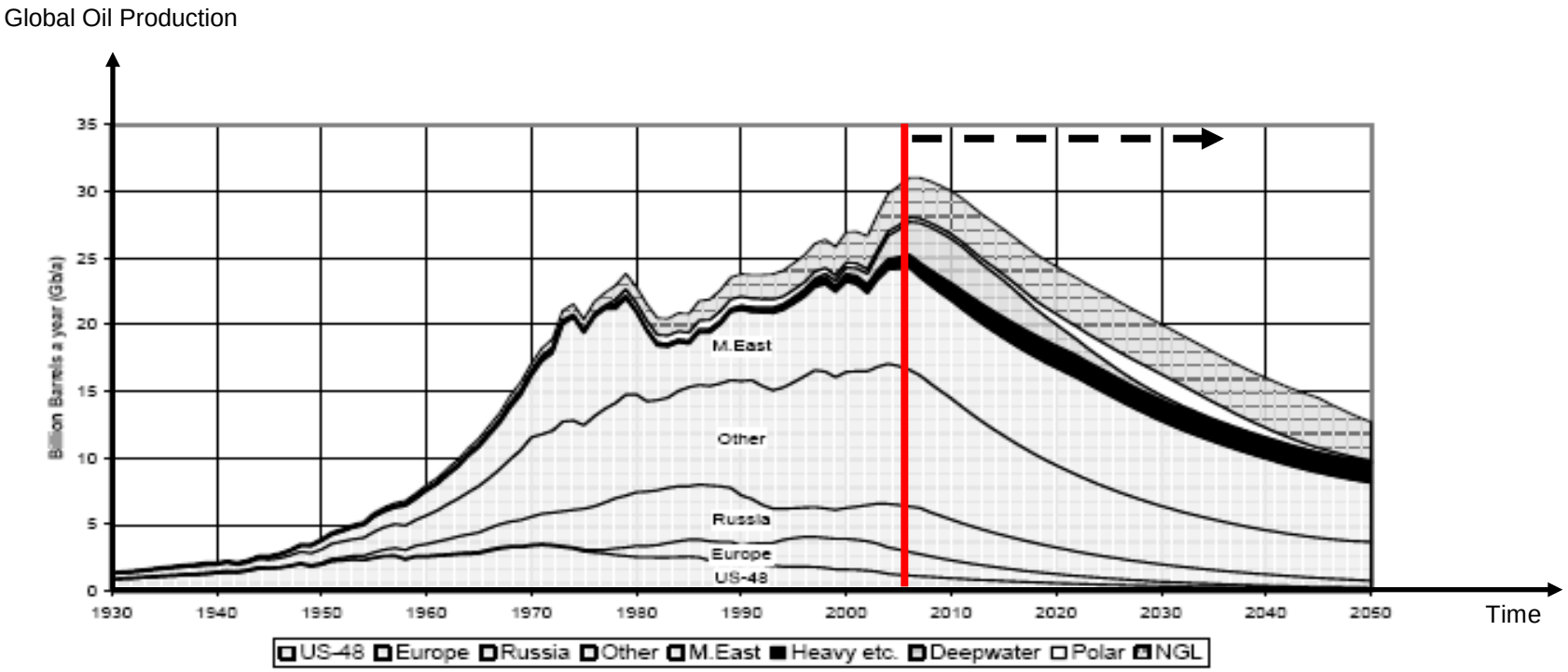
Are NOCs "efficient" firms?

- Non-commercial objectives influence the ability of national oil companies to function as many of the international integrated oil companies.
  - The word "efficient" should be used with care. NOCs may be "economically efficient" in the sense that they are maximizing some objective. However, the NOC likely faces a different objective than an IOC.
  - Theoretical modeling indicates these objectives skew the firm's observed behavior away from the unimpeded outcome (Hartley/Medlock, "A Model of the Operation and Development of a National Oil Company," *Energy Economics*, 30(5)).
- Empirical analysis indicates the relative revenue efficiency of NOCs is lower than that of IOCs. The results are robust to methodology
  - Stochastic Frontier Analysis (SFA); Data Envelopment Analysis (DEA)
  - Eller/Hartley/Medlock, "Empirical Evidence on the Operational Efficiency of National Oil Companies," *Empirical Economics*, 2010

- **Implication: higher prices are needed to maintain a given supply, much less grow production.**

"Peak Oil"

- Peak Oil theory gains mainstream traction.
- In 2007, ASPO posted a prediction of a production peak within next 5 years.
- The arguments reverberated as prices approached $100/bbl in 2007 and early 2008.



Note: Picture from the Association for the Study of Peak Oil (ASPO)

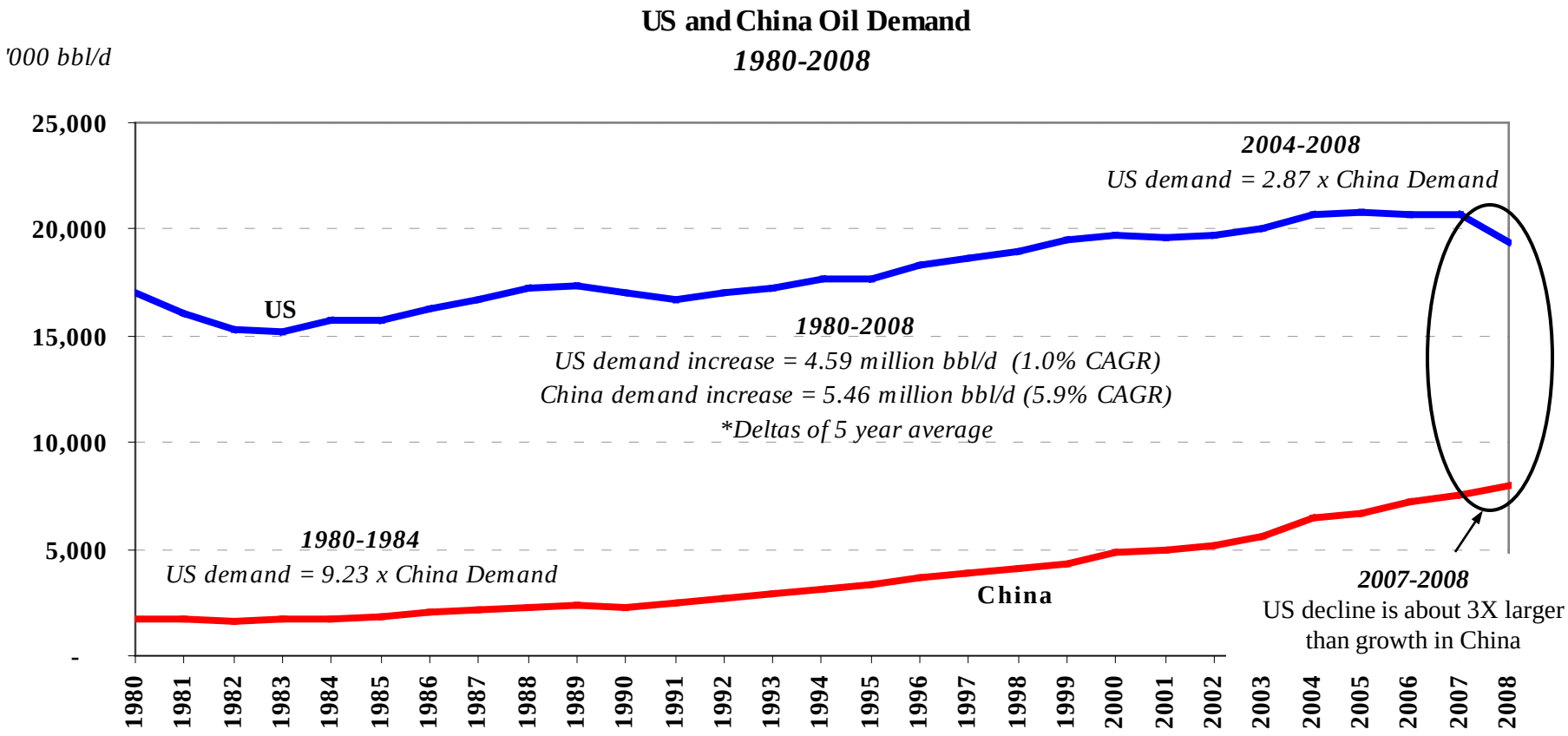
"Peak Oil" – Who is right?

- Depends on interpretation of data (is this a picture of demand or supply?)
- Common criticism: "Hubbert" curves do not have economic elements
- However, economic theory of depletable resources does not provide an answer either, only signposts
  - (1) diminishing production capacity and well productivity,
  - (2) constraints on equipment and personnel, from more drilling to sustain a given production, and
  - (3) declining exploration success.
- BUT, other factors can explain and offset the above three issues.
  - (explain) uncertainty about the location and quality of new deposits and
  - (offset) innovations that reduce development costs in more difficult environments

- **Bottom line: Uncertainty of future supply exerts a "precautionary motive" on the market.**

Demand Growth in a Mobilizing China

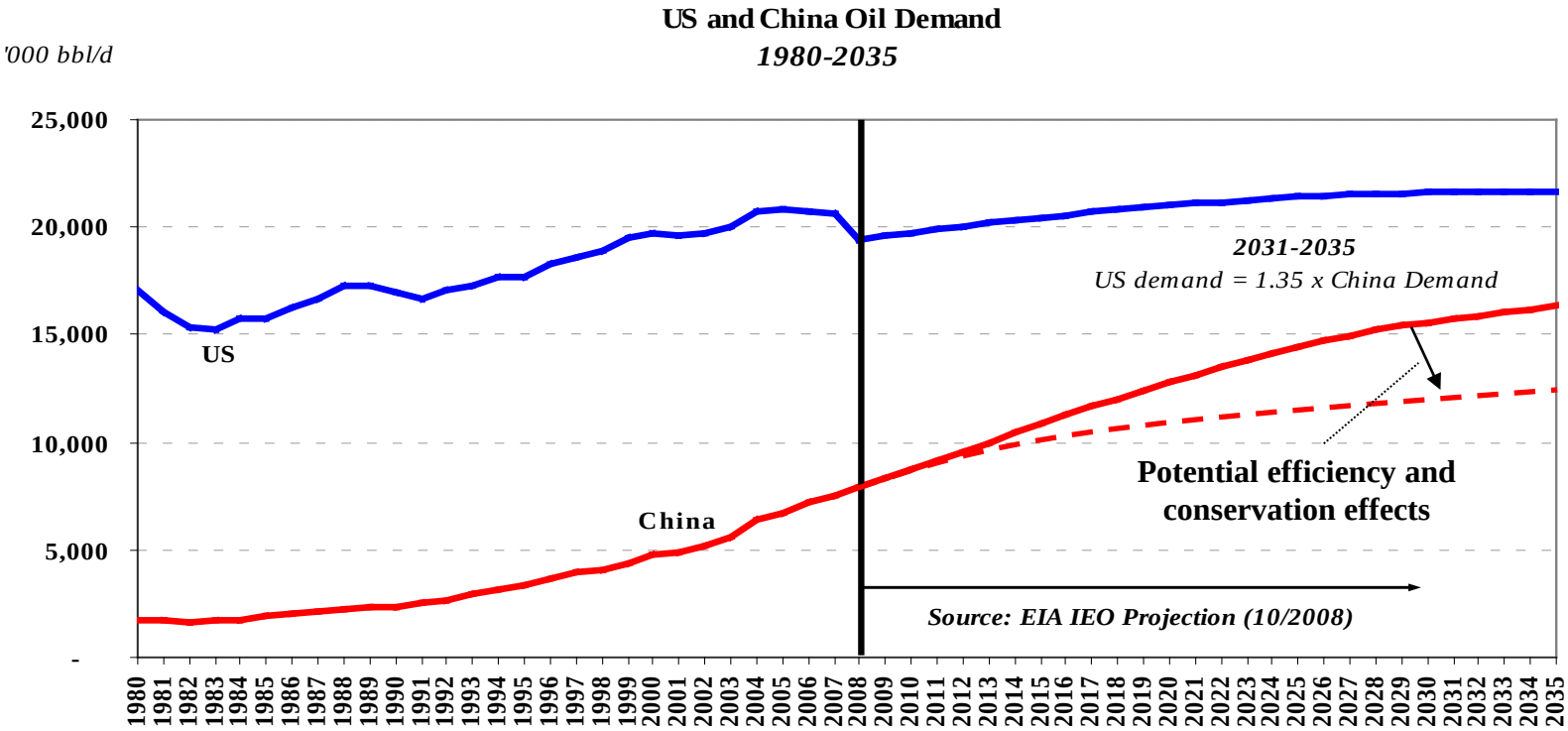
- Demand in China is growing at a rapid pace.



- Note, considering only growth rates can be misleading. We must also consider the base upon which growth is occurring. The US footprint has also grown...

Demand Growth in a Mobilizing China (cont.)

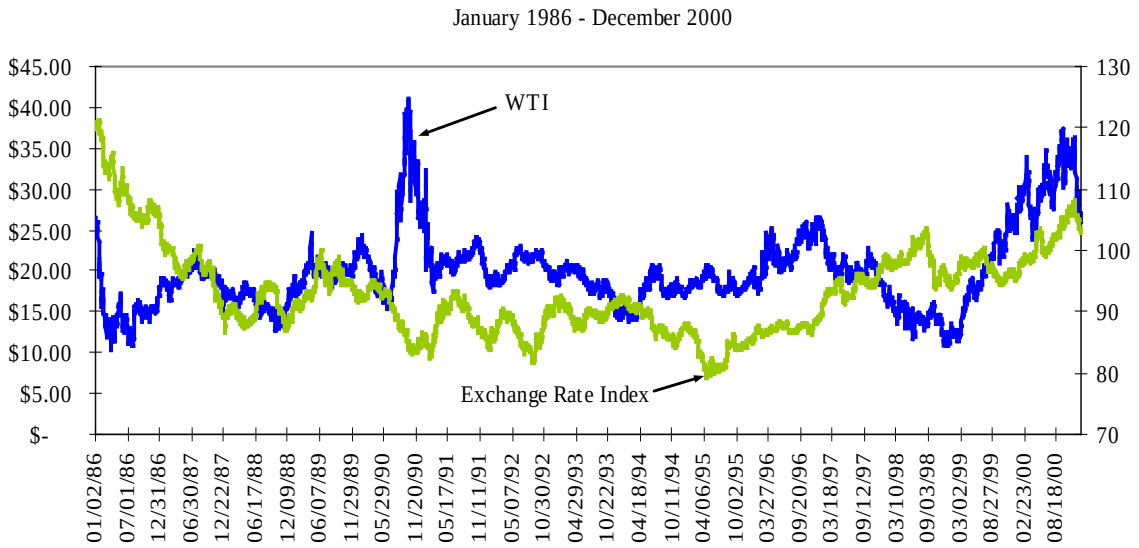
- ... but where will we be in another 28 years?
  - The forecast is credible, but we must use caution... road petroleum use in China accounts for about 1/3 of total. In US it is about 60%. The US saw flattening industrial demand, and reduced demand in all sectors except transport. Could the same thing happen in China? If so, shave the forecast by about 4.5 million bbl/d...

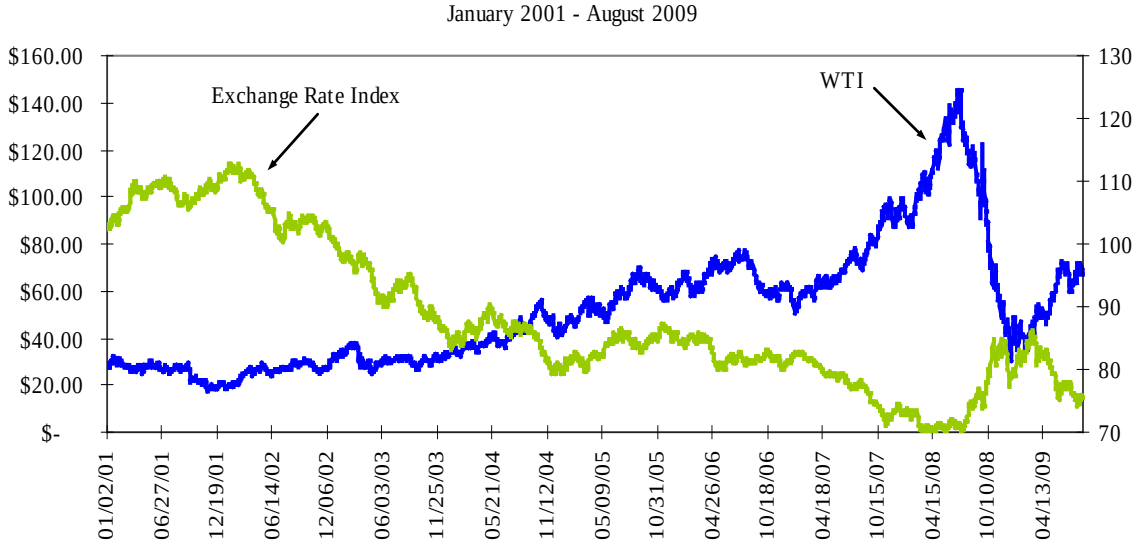


- **Bottom Line: How will we fuel mobilization in China?**

The Effect of the $

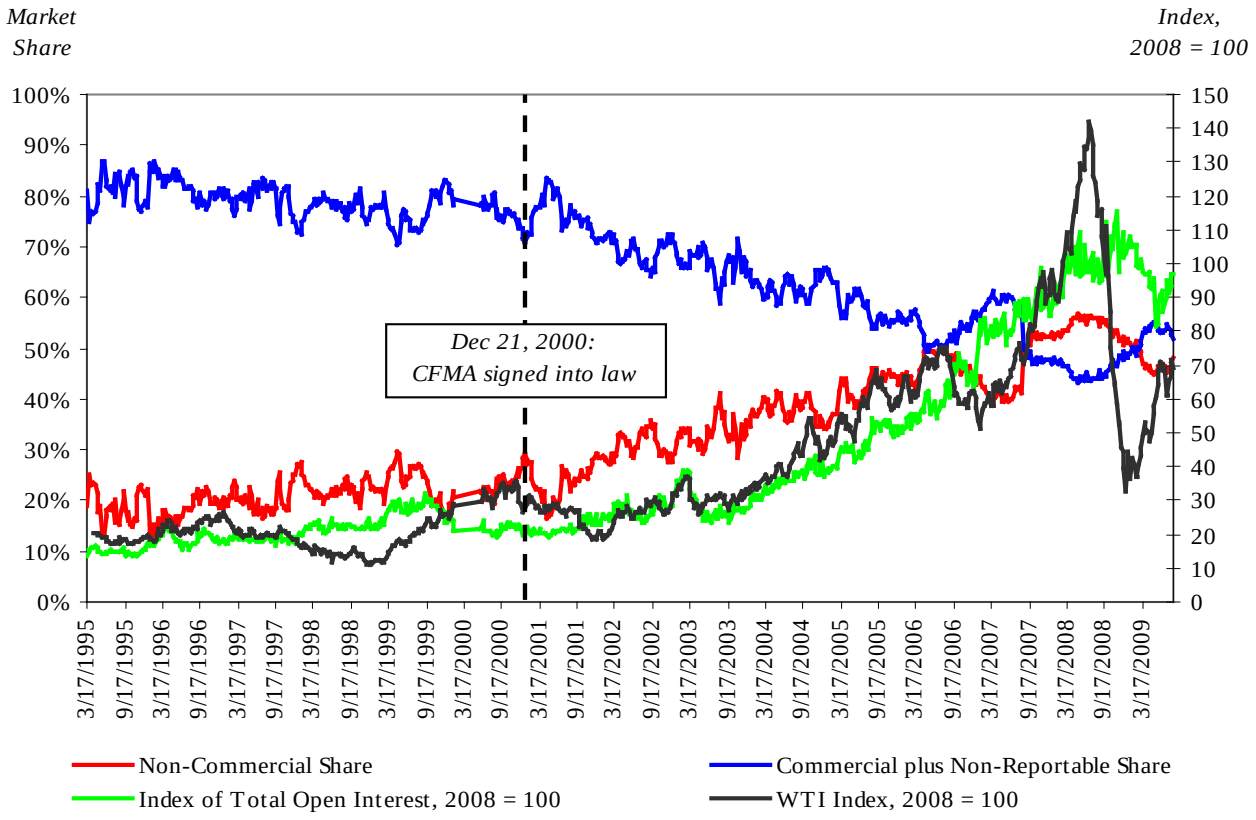
- Since Jan 2001, the correlation between the XR and the oil price is -0.82.
- From Jan 1986 to Jan 2001, the correlation is -0.08.
- Why did a strong relationship emerge for such an extended period?
  - One hypothesis asserts that it is tied to the emergence of “asset-class” investors.
  - If the concern is portfolio return, oil and the dollar can become linked via active trading.
  - Note, this also applies to other commodities.





Speculation

- Trading requires both speculators (demanders of risk) and hedgers (suppliers of risk).
- Market composition began to change dramatically shortly after the Commodity Futures Modernization Act was signed into law.
- Many have claimed that the increase in open interest by market players with no physical commercial position in the market pushed price higher.

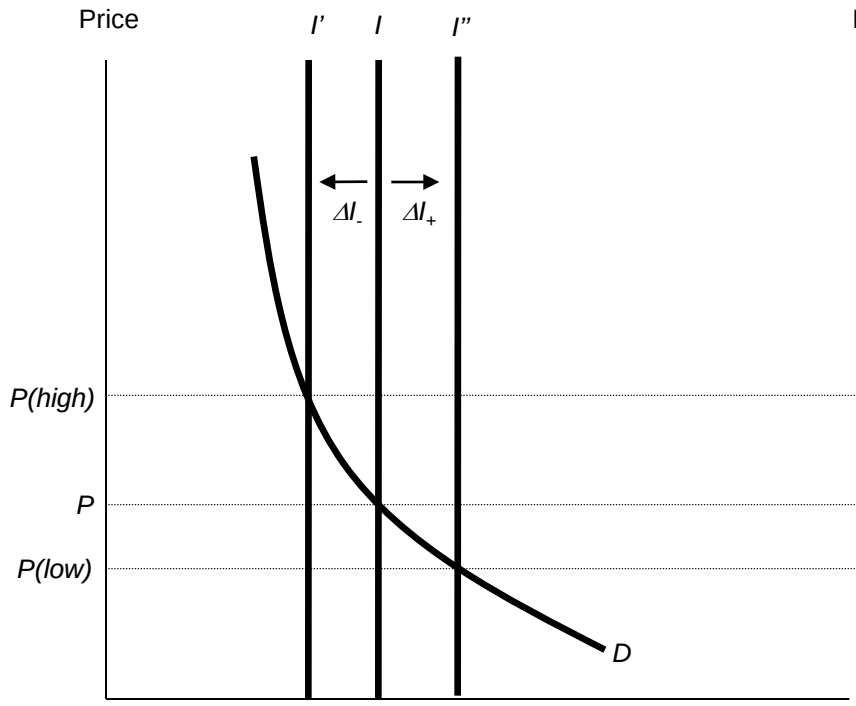


Source: CFTC COT Reports – CRUDE OIL, LIGHT SWEET - NYMEX

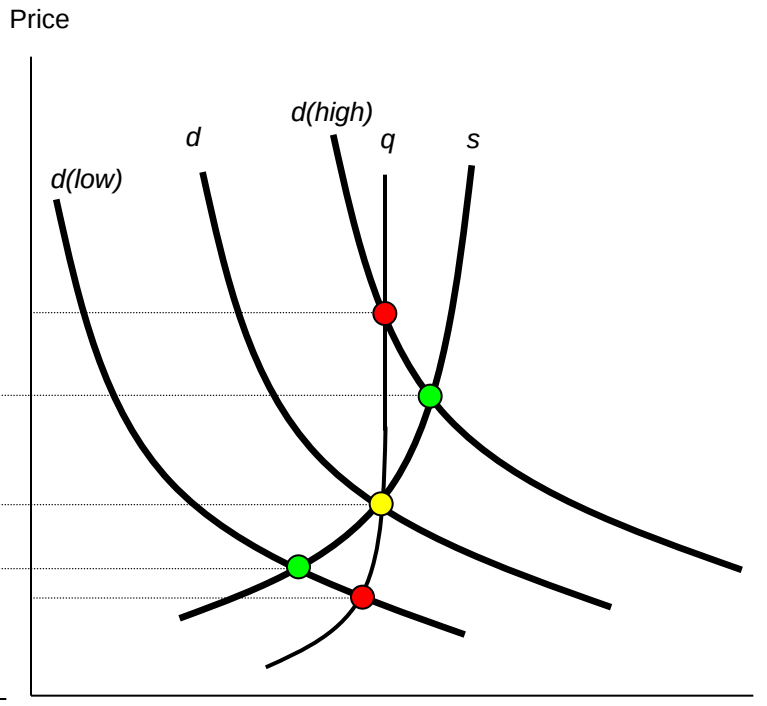
A Framework for Analysis

A Role for Both Speculators and Fundamentals: The Stock-Flow Model

- Seasonal demand fluctuation leads to price variability. Variability is dampened with access to inventories.
- A standard application in a market with a storable commodity...



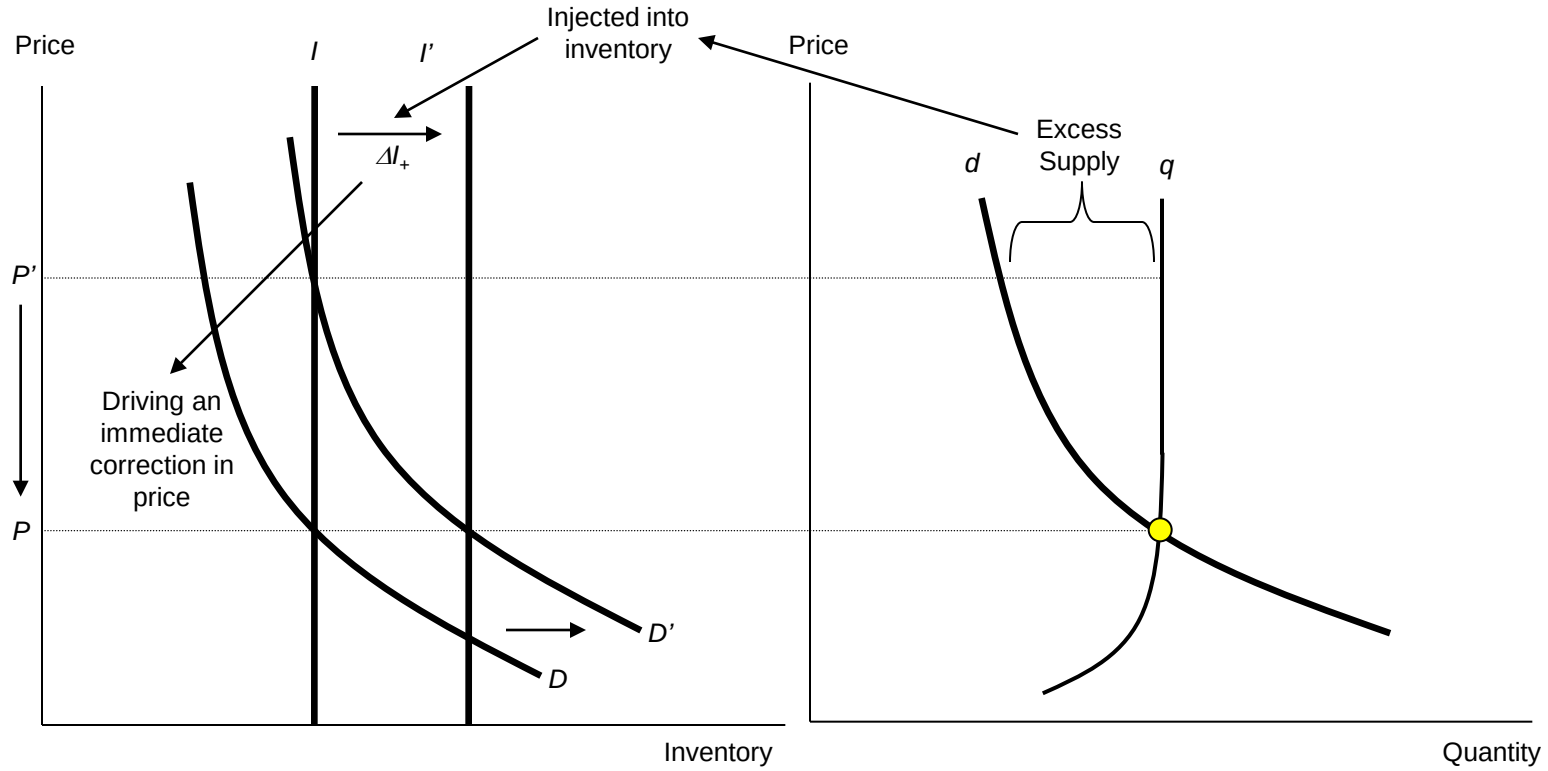
STOCK



FLOW

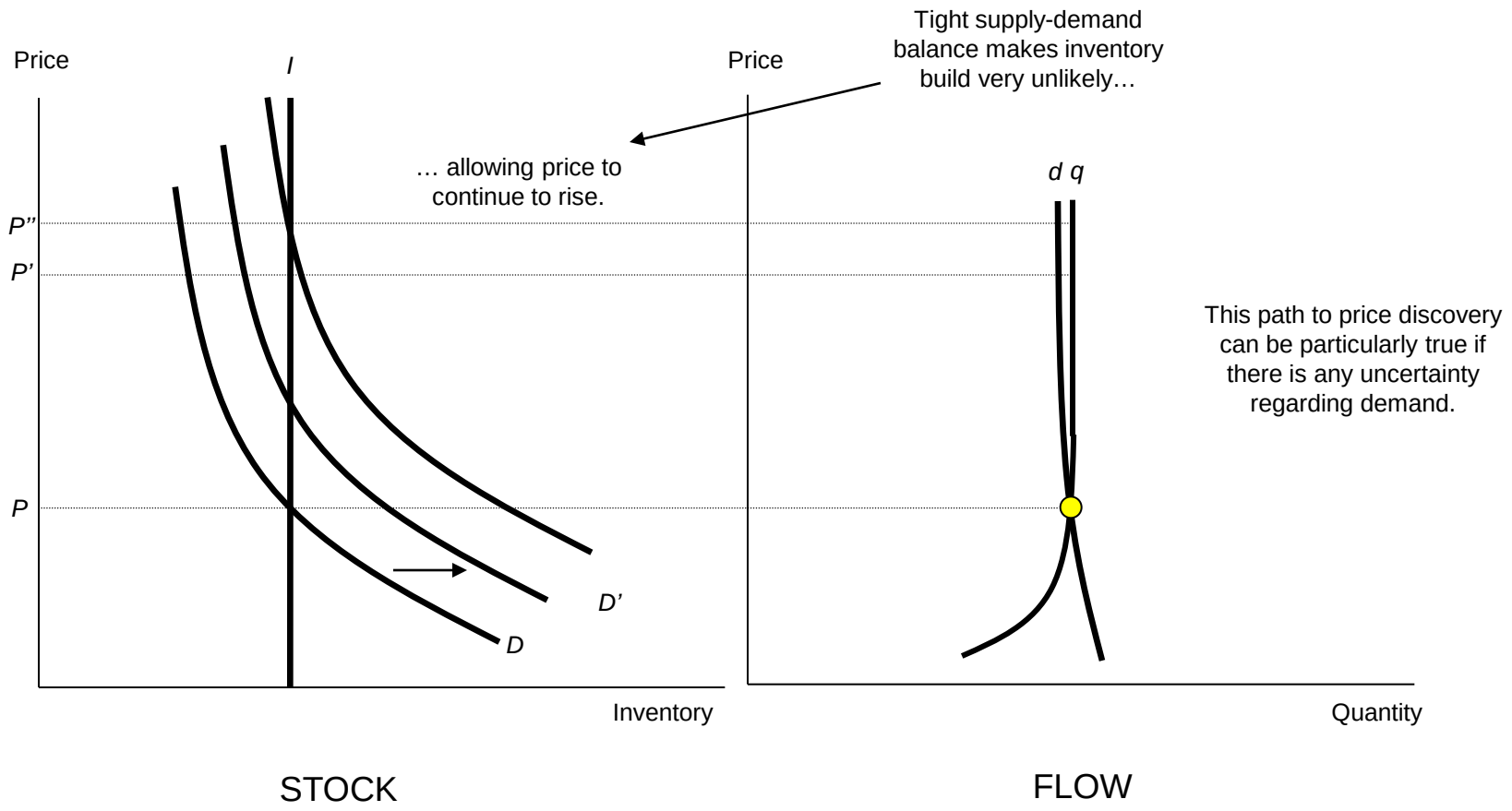
The Stock-Flow Model and Expectations

- Uncertainty about future adequacy of supply can lead to an outward shift in the demand for inventory (a precautionary motive). This should discourage demand through higher price and lead to inventory build... (This is the standard economist argument as to why speculation cannot have an impact on price.)



The Stock-Flow Model and Expectations (cont.)

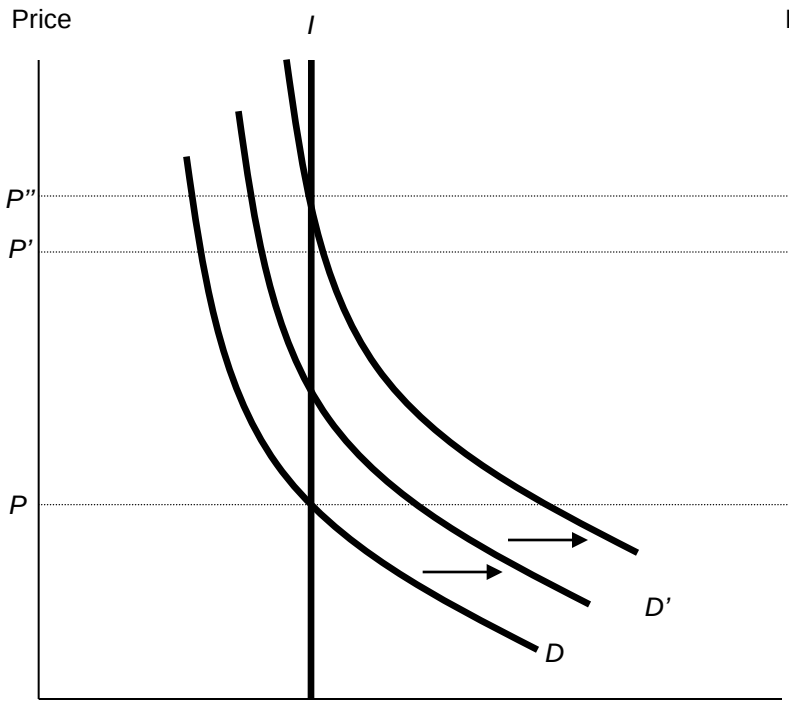
- … or should it. The same picture with *inelastic demand* indicates an inability to build inventory. This reinforces expectations about inadequacy of future supplies, leading to additional pressure and ever higher value placed on "what we have".



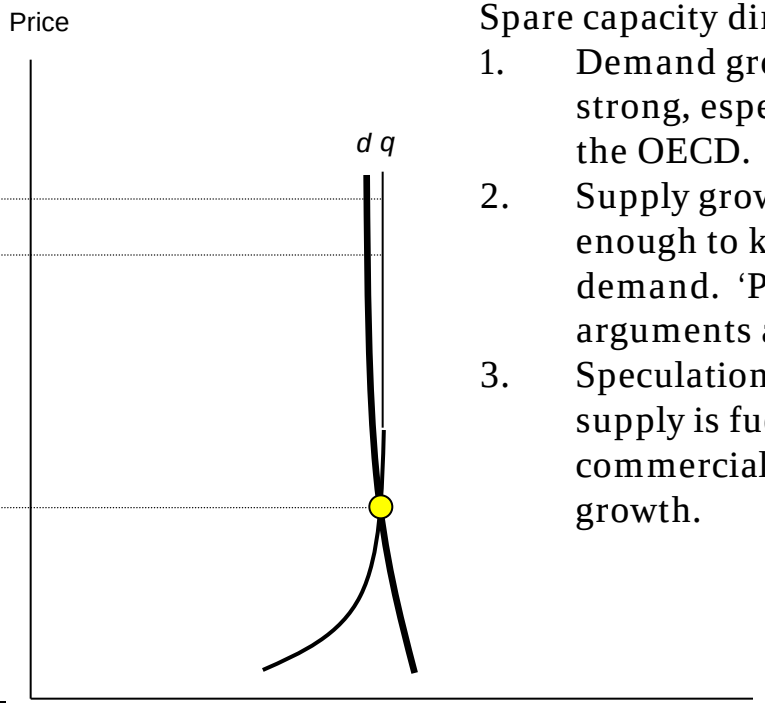
The “Stock-Flow” Model applied to the Crude Oil Market

Price goes up…

- The ability to expand production, peak oil, exchange rates, and uncertainty all play a role.
- Key point: Market fundamentals are tight, so speculation begins to exert an influence.



STOCK



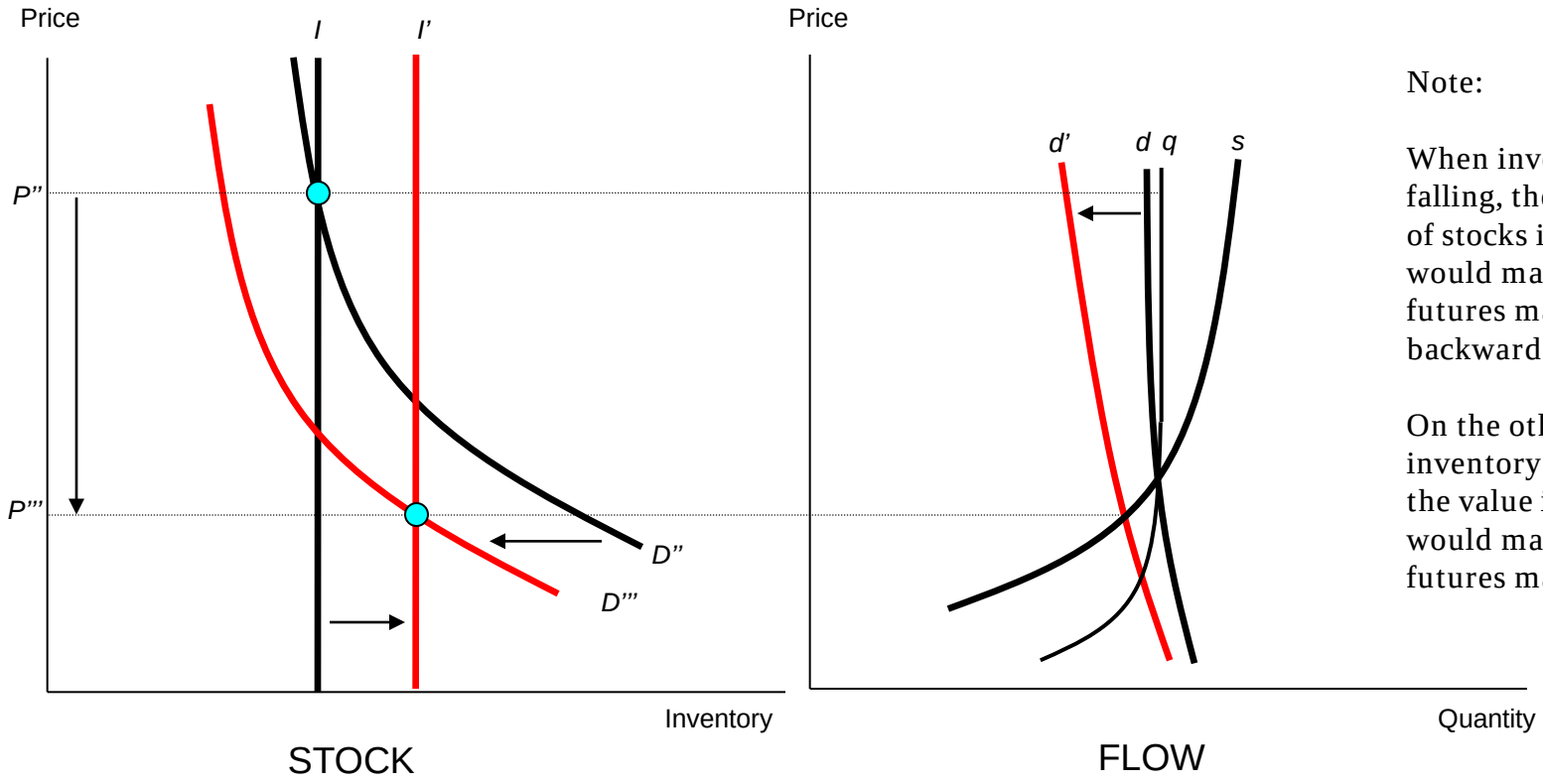
FLOW

Spare capacity diminishes as:

1. Demand growth is very strong, especially outside the OECD.
2. Supply growth is not enough to keep pace with demand. 'Peak Oil' arguments abound.
3. Speculation about available supply is fueled by a lack of commercial inventory growth.

Price comes down…

- Degradation of demand and inventory build.
  - Economic malaise pulls demand down,and adjustments to higher prices, to the extent they are sluggish, being to materialize.
  - Global economic crisis and demand *forecast* revisions ⇒ lower expectations.
  - Inventories *did* build… "oil-at-sea" numbers grew.
- OPEC can support price now by holding back capacity.



Note:

When inventory demand is falling, the perceived value of stocks is declining. This would materialize in the futures market as backwardation.

On the other hand, when inventory demand is rising, the value is also rising. This would materialize in the futures market as contango.

The Model

The Model

"Flow" Market

$$d_t = b_0 - b_1 p_t + b_2 x_t$$

$$q_t = \varphi E\left(p_{t+1}\right)^{prd} + \gamma q_{t-1}$$

"Stock" Market

$$I_t = I_{t-1} + \left(q_t - d_t\right)$$

$$D_t = a_0 - a_1 p_t + a_2 F_{t,t^*}$$

Futures Market

$$F_{t,t^*} = \left(\frac{1+u_t+\rho_t}{y_t}\right)^{t^*-t} p_t$$

where $F_{t,t^*} = p_t$ when $t^* = t$. The risk adjusted rate of interest, ρ_t, is included to reflect the fact that risk associated with the commodity must be included in the calculus. It is a forward-looking component of the expected value of the commodity in the future. So, if scarcity is an expected outcome, due to either lack of production prospects or strong demand growth, then ρ_t will increase. Note, this tends to force greater contango, as the ratio of futures to spot price, $\frac{F_{t,t^*}}{p_t}$, will increase. As such, we can write $\rho_t = \rho_0 E\left(p_{t+1}\right)$. The marginal value of storage, y_t, is a function of the demand-to-inventory ratio, such that $y_t = y_0 \frac{d_t}{I_t}$. Inserting the expressions for y_t and ρ_t into the above yields

$$F_{t,t^*} = \left(\frac{1+u_t+\rho_0 E\left(p_{t+1}\right)}{y_0 \frac{d_t}{I_t}}\right)^{t^*-t} p_t .$$

The Model (cont.)

Equilibrium

We know that $s_t = q_t - \Delta I_t = d_t$ in the flow market, so the only equilibrium condition we need to consider is the "stock" market equilibrium, which states that $I_t = D_t$ at p_t^*. This follows because the equation of motion for inventories is the "flow" market equilibrium.

$$I_{t-1} + \left(q_t - d_t\right) = a_0 - a_1 p_t + a_2 F_{t,t^*}$$

$$I_{t-1} + \varphi E\left(p_{t+1}\right)^{prd} + \gamma q_{t-1} - b_0 - b_1 x_t + b_2 p_t = a_0 - a_1 p_t + a_2 F_{t,t^*}$$

$$p_t = -\left(\frac{I_{t-1}}{a_1 + b_1}\right) - \left(\frac{\varphi E\left(p_{t+1}\right)^{prd} + \gamma q_{t-1}}{a_1 + b_1}\right) + \left(\frac{b_0 + a_0}{a_1 + b_1}\right) + \left(\frac{b_2 x_t}{a_1 + b_1}\right) + \left(\frac{a_2 F_{t,t^*}}{a_1 + b_1}\right)$$

Breaking down the equilibrium yields some insights into the manner in which price might evolve. To begin, we can re-write the long-form expression for price as

$$p_t = \underbrace{\left(\frac{b_0 + a_0}{a_1 + b_1}\right)}_{(i)} + \underbrace{\left(\frac{b_2 x_t}{a_1 + b_1}\right)}_{(ii)} - \underbrace{\left(\frac{\varphi E\left(p_{t+1}\right)^{prd} + \gamma q_{t-1}}{a_1 + b_1}\right)}_{(iii)} - \underbrace{\left(\frac{I_{t-1}}{a_1 + b_1}\right)}_{(iv)} + \underbrace{\left(\frac{a_2 F_{t,t^*}}{a_1 + b_1}\right)}_{(v)}.$$

where:

i. The minimum price we could see if all other variables took values of zero.

ii. The effect of exogenous influences of demand.

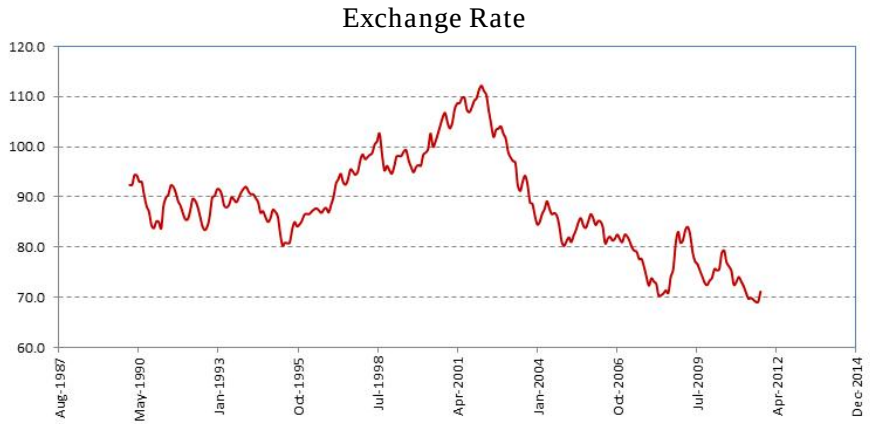
iii. The supply response impact. Notice if prices are expected to increase, then the sensitivity of supply to those expectations is critical in preventing price from rising. If $\varphi \to 0$ then the supply response is negligible and price will likely rise in response to increases in demand.

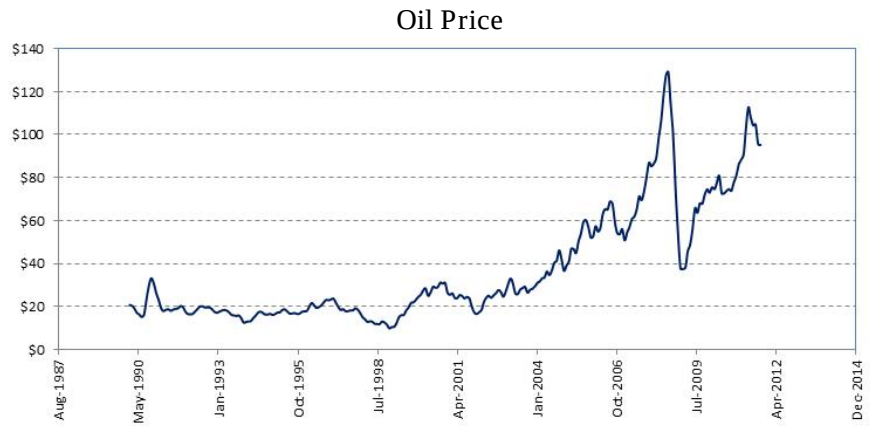
iv. The effect of inventories. This reveals that the state of the world in the prior period is important in determining price today.

v. The influence of futures markets. If $a_2 \to 0$, then the futures price has little impact on current spot price. However, if $a_2 \to \infty$, *ceteris paribus*, then the futures price will dominate current spot price formation.

The Model (cont.)

- Aim is to calibrate a model then use it to simulate possible futures.
- This will lend insight into how and why oil price volatility might increase, and the role that various factors play.
- This departs from the question of "does speculation influence price?"
  - We are asking a larger set of questions of which the query regarding speculation is one.
  - Analysis of futures data is not sufficient because (a) it ignores other factors and (b) it is a subset of all trades.
- Still need to account for exchange rate movements.





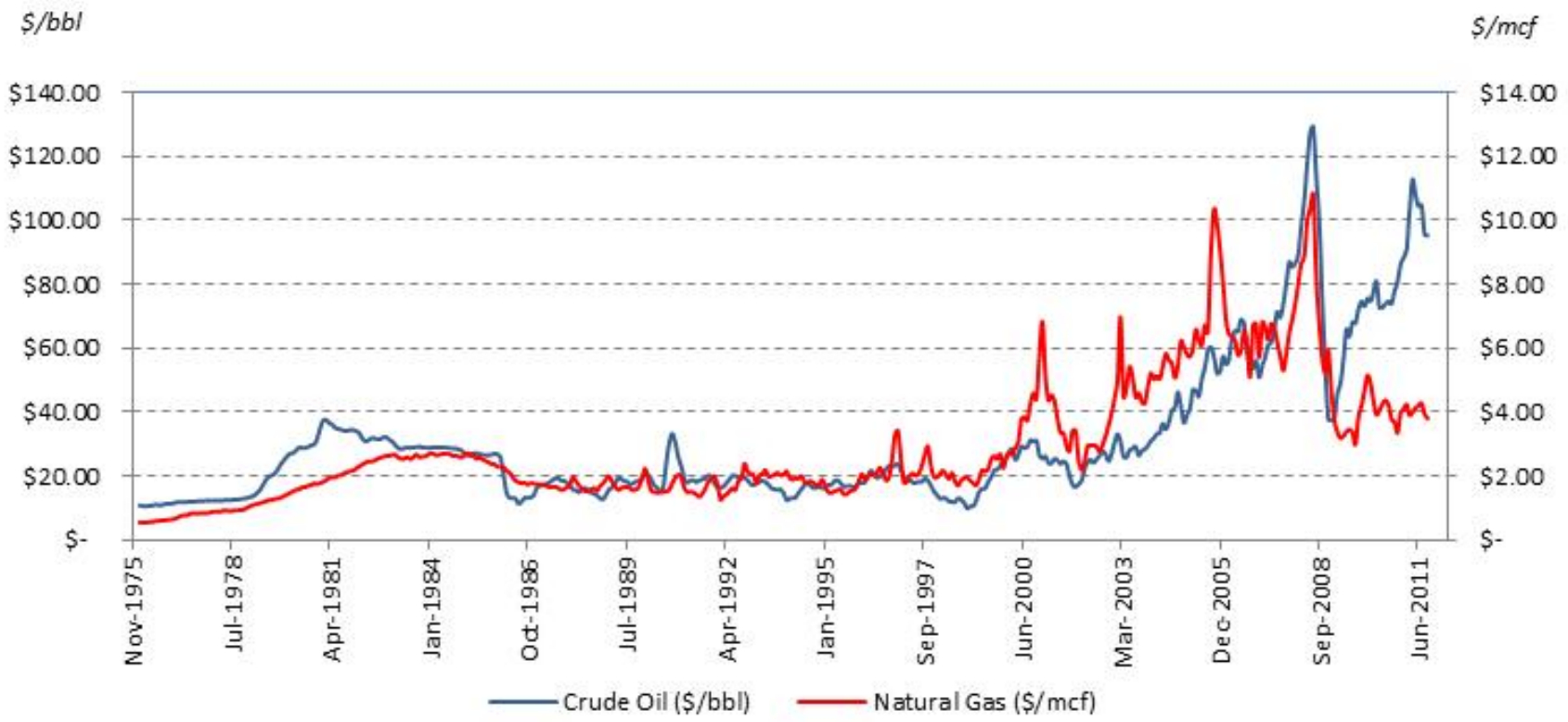
But,
what's good for the goose…

So, can we explain natural gas price?

Yes. More elastic supply and demand curves will tend to force "corrections" faster in the stock-flow framework. This can contribute to disconnects between markets when substitution opportunities are limited. Moreover, Hartley and Medlock (2011) show that the exchange rate also matters.

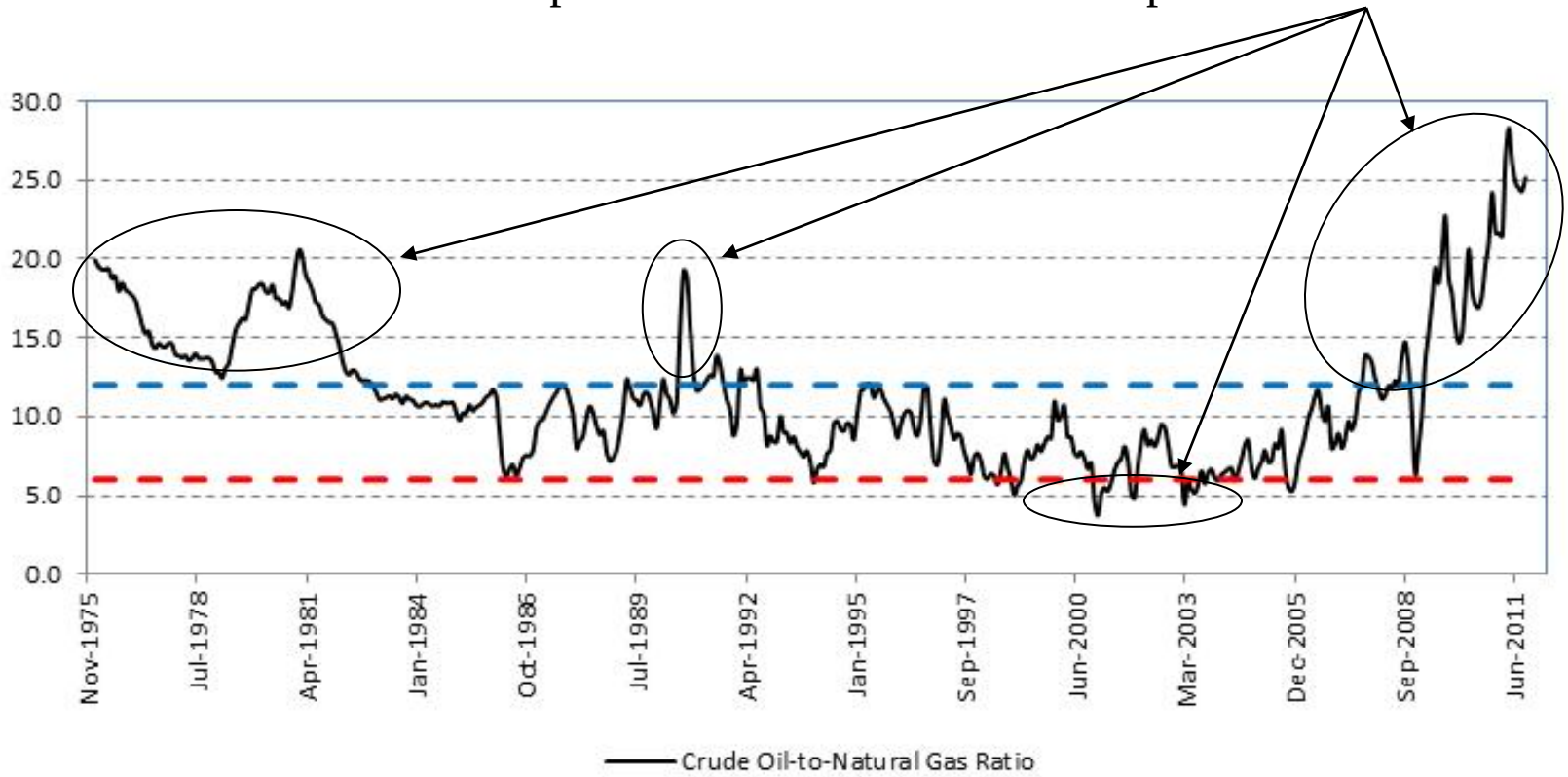
The Crude Oil-Natural Gas Price Relationship: Jan 1976 - Sept 2011

- Analyst myopia often leads to consternation when the pricing relationship changes, and, accordingly, lots of postulation as to the root cause, how long it will last, and what will cause further change.



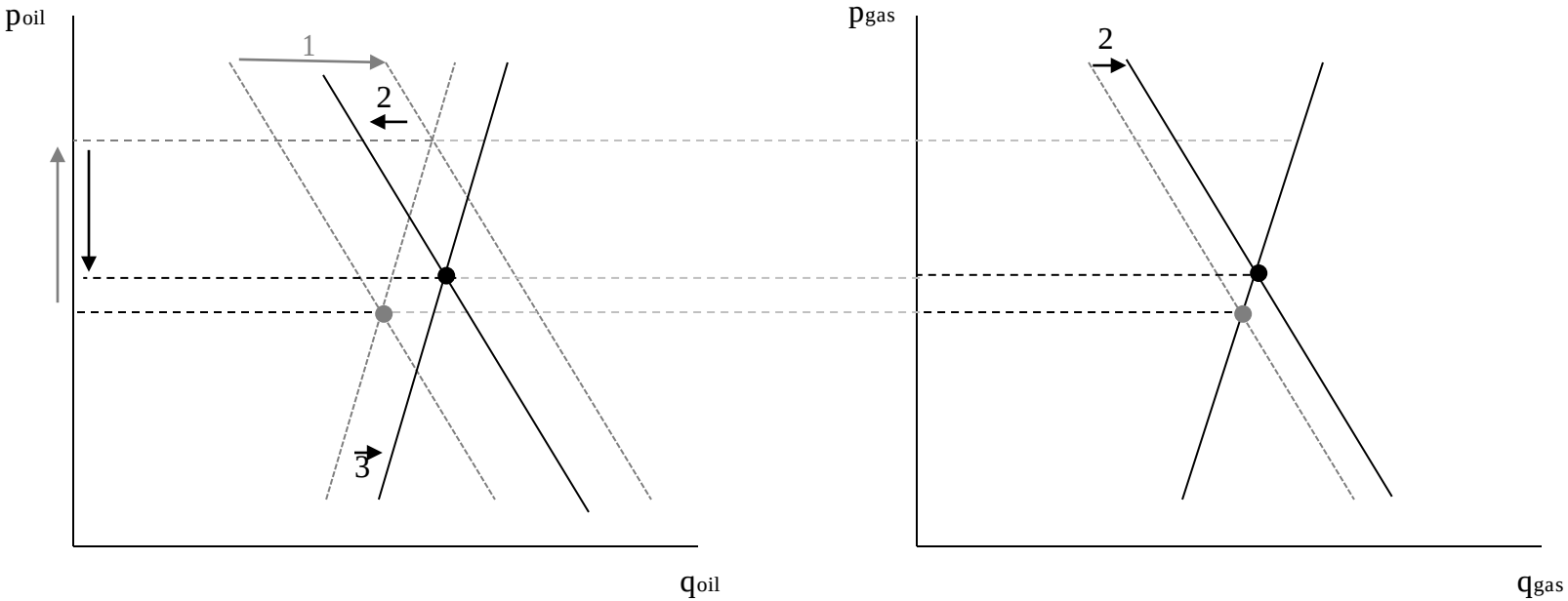
The Crude Oil-Natural Gas Price Relationship: Jan 1976 - Sept 2011 (cont.)

- The ratio of crude oil price to natural gas price has been anything but stable.
- Often, the focus is on the 1990s, giving rise to the 12:1 to 6:1 "rule-of-thumb".
- This worked fairly well from the mid-1980s to the mid-2000s, but it would be good to have a framework that helps us understand *all* relative price movements.



The Traditional Causality in Relationship

- Why should crude oil and natural gas prices even have a relationship?
  - Substitutes in end-use.
  - Co-products at the wellhead could encourage wellhead adjustments.
  - Extraction techniques are similar allowing for shifting industry focus.
- Consider the following example…
  1. Demand for oil increases
  2. Long run (capital stock adjustments) and short run fuel switching occurs as relative prices change
  3. Supply-side adjustments occur
  4. A new "equilibrium" is eventually established with both prices being higher.



In any case, shale developments in the US have made the natural gas supply curve more elastic…

- Increasing elasticity in the gas market, without similar changes in the oil market, can drive a disequilibrium.
  - Continued cost reductions in shale gas developments exacerbate the spread.
- In fact, large sustained differences can emerge if adequate fuel switching capacity is not available and supply-side adjustments are slow to occur.