



Diapason Capital Markets Report

Special Report

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The case for higher crude oil prices by 2012-13: Part 1

The structure of growth and supply constraints will force prices higher — then lower

No commodity has affected the global economy more than crude oil. No commodity has a more direct impact on every world citizen. No commodity exerts more influence on the world financial system's function and stability than oil. Given the importance of oil to the world economy, one would think the process that determines oil prices would be well understood.

One would clearly expect officials of all of the world's major energy economies to be fully conversant in market processes. One also expects competition authorities, especially the U.S. Federal Trade Commission, to have a strong working knowledge of market process.

One also expects investment banks, which put at risk large amounts of capital trading crude oil, to be able to forecast the price crude oil in a systematic way. Sadly, none of these expectations are close to being fulfilled.

We believe that crude oil prices are close to being launched and would take a semi-parabolic trajectory up to next year or so, in 2012-2013 time frame. But in order for this hypothesis to be realized, there needs to be a structural underpinning of oil prices going forward -- a trend that is defined mainly by the interaction of market players (users and suppliers of crude oil) influenced in a large part by the perceived future scarcity of crude oil supplies relative to future demand. That is what we intend to show in this report.

The economics of exhaustible resources

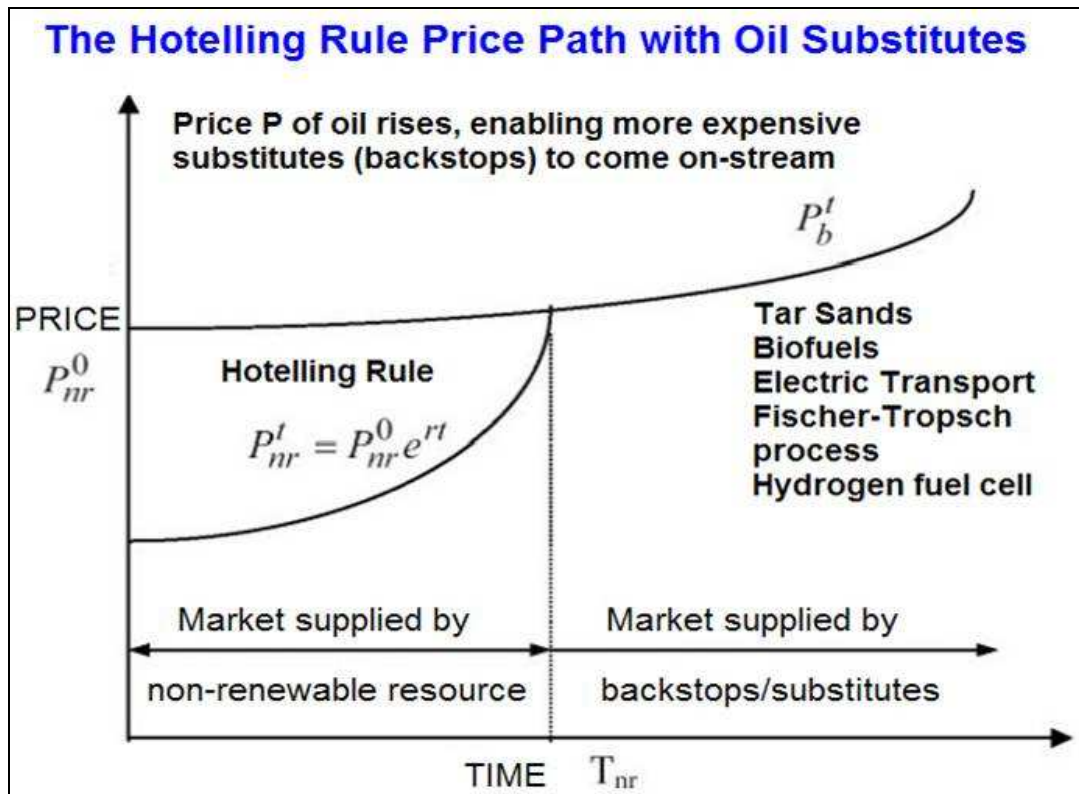
Understanding what causes crude oil prices to do what they often do start with the theory and terms of the economics of exhaustible resources. The literature on the subject is quite extensive but had to be organized and annotated (e.g. Dave Cohen, 2008). Harold Hotelling (1931) defined the classical economic theory of the long-term pricing of non-renewable resources like conventional oil. The theory states that the price of a depleting resource like conventional oil should rise over time at the interest rate because its value should increase as the stocks (reserves) are exhausted. According to Hotelling, the scarcity rent for an exhaustible resource must rise over time at the rate of discount, which is taken in Hotelling to be equal to the interest rate (r).

Scarcity Rent is the rent that accrues to the owner of a natural resource just because it is scarce. The context of the term in this report is that it would be more efficient for the owner of any oil reservoir to “store” the oil directly by just leaving it in the ground, waiting to produce it until the price has risen. The equation shows that the owners of the oil reservoir will receive sufficient compensation for surrendering use of the non-reproducible resource which leaves them indifferent between producing today and producing in the future.

The Hotelling rule forms the basis of the economic theory of non-renewable resources, and generations of economists have used it to forecast future trends of commodity prices. It is simple, elegant, well-justified within general macroeconomic theory, but have taken some hard knocks after crude oil prices collapsed by 67 percent in 2008. The theory also had problems explaining the decline in the real price of oil between 1957 and 1967, and the sharp declines between 1982 and 1986.

Tobias Kronenberg (2008) said that empirical analyses show that the Hotelling rule does not hold in reality. Others have also come to firmly reject the Hotelling approach. Ferdinand Banks (2004), for instance, insists that the Hubbert curve approach, which is named after the geophysicist M. King Hubbert (1956), who used it to predict with some precision the peak in US oil production, is more appropriate in modelling crude oil prices. *(There is extensive literature dealing with Hubbert’s method, e.g., J.H. Laherrère (2000) and A.R. Brandt (2007), so we will not discuss it here, as it is beyond the scope of this paper).*

The problem with the Hotelling theory was that it did very little to incorporate the issue of exhaustibility of a resource. There had been a tendency for oil to be priced as if it were soybeans, a renewable crop, or iron, for which reserves are vast and therefore not a concern. That oil is not priced as a depleting resource has consequences. The simple Hotelling rule lays out a path by which so-called backstops (substitutes) for oil are enabled as the price rises over time (see chart on the next page). Other economists have since then extended Hotelling’s model to take the factor of exhaustibility more fully into account.



The Hotelling theory extended

The main proponent of the Hotelling theory extensions was Neha Khanna (2003). Kanna's version was a more sophisticated theory of non-renewable resource depletion which linked the marginal extraction cost directly to cumulative production or the remaining stock of the resource. These are referred to as “reserve dependent costs” in the literature. In this case, each unit of the resource extracted today is not only unavailable in the next period, but also increases future extraction costs by lowering the remaining reserves.

The opportunity or user cost of extracting a finite stock of resources is now two fold: foregone interest income and higher extraction costs. In this case, the scarcity rent does not rise at the interest rate, but at the interest rate less the percentage increase in cost due to a marginal reduction in remaining reserves. The resultant costs figures are significantly higher relative to those obtained from the simple Hotelling model.

One of the Kanna extensions also changed the basic Hotelling's assumption of constant demand for the non-renewable resource over time, which was not realistic. Typically one would expect an increase in the market demand over time due to a growth in population as well as per capita income. Graphically, this would lead to a rightward shift of the demand curve from one period to the next. This has profound implications.

This simple extension of the basic model introduces an element of realism into the model in two important ways. **First**, it reflects a realistic situation for non-renewable resources, such as crude oil, which have witnessed a rapid growth in their total demand. **Second**, regardless of whether the marginal extraction cost is falling or rising over time, the resulting equilibrium production trajectory may initially increase before eventually declining to exhaustion as illustrated in for both monopoly and competitive market structures -- which was exactly what was seen in the past ten years, confounding calls for imminent peak in global oil production.

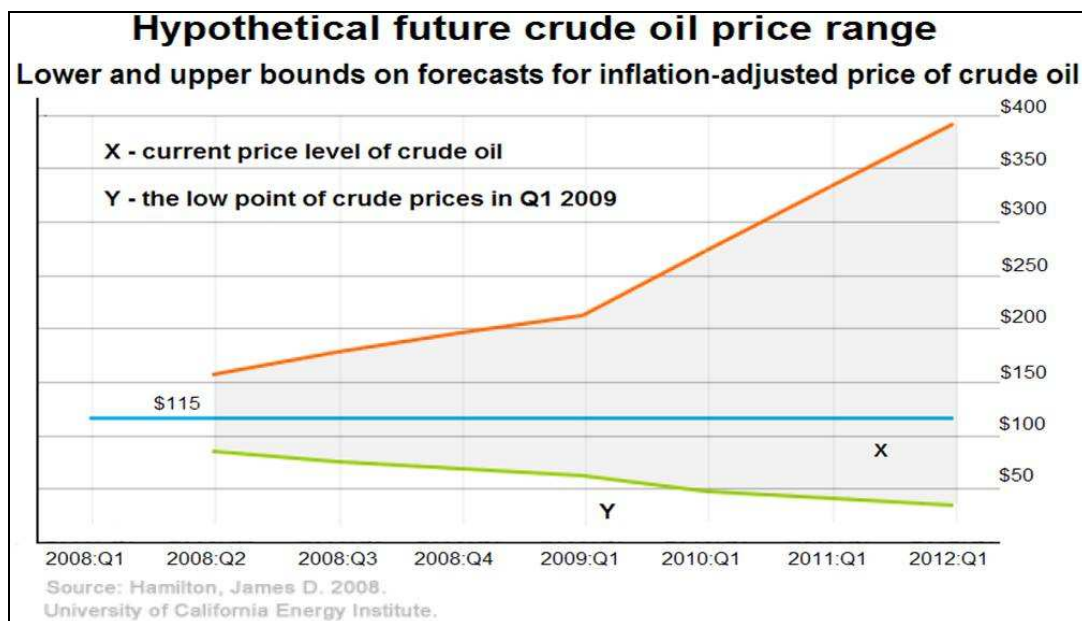
Statistical approach to crude oil forecasting

Another approach to forecasting crude oil prices was undertaken by Professor James Hamilton (2008). His statistical approach pretends there's no such thing as supply and demand fundamentals like rising demand in China or dwindling supplies from the North Sea. The exercise simply viewed the oil price as a numerical time series.

Hamilton concludes that historical oil prices exhibit "a random walk without drift" in his statistical analysis. Hamilton finds that the [historical] standard deviation in oil prices from quarter-to-quarter was 15.28%. Hence, if we start a quarter with \$115 oil, prices in the next quarter may average between \$85 and \$156 per barrel. In a year, they could range between \$62 and \$212. In four years, they might be anywhere between \$34 and \$391.

Jerry Taylor and Peter Van Doren of the libertarian Cato Institute also argue that in principle oil prices are unpredictable, not only in the short-term but in the long run as well. They said, "There is simply no reason to believe that mere mortals can foretell oil prices or petroleum market shares in the future, absent some sort of time machine". In other words, crude oil prices hew to the "Random Walk Theory", so there is no point in even trying to forecast it.

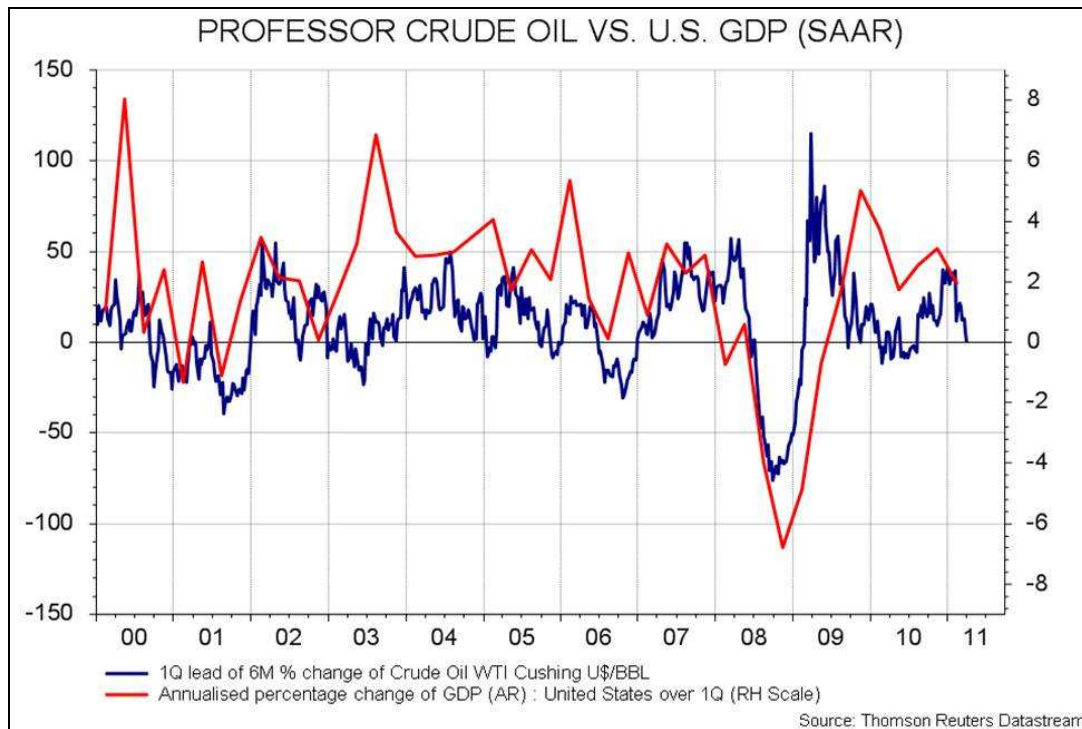
Taylor and Van Doren, based on derived data from Hamilton's work, created a chart to demonstrate that future oil prices can vary over a very wide range very quickly from some initial price point (see chart below). Even worse, the "best" predictor of future oil prices is said to be the current oil price -- a mainstay theorem of the Random Walk Theory. Since the current oil price is also a "lousy" predictor, there is simply no way to forecast future oil prices, they claimed.



Although a purely statistical take on historical oil prices displays no discernible pattern, commodity prices do not exist in a vacuum. So what do we think about the chances that the oil price will randomly walk itself up to \$120/barrel in the next 2 or 3 quarters? The chance is balanced in such a way the odds are close to 50-50, based on this theory, as our calculations show. It essentially underlines the futility of using Random Walk in crude oil forecasting.

Taylor and Van Doren approvingly cite Hamilton's observation that "neither nominal U.S. interest rates nor real U.S. GDP growth rates can predict oil price movements." Based on our experience, it would be surprising if any single variable could be used to forecast the oil price. Oil consumption is interwoven into everything that people do, from growing food to manufacturing computers to going shopping. Moreover, insofar as GDP growth is concerned, it is more likely for crude oil prices to influence GDP growth rates, rather than the other way around.

In other words, although GDP growth may be a primary factor generating demand for crude oil, its influence is more diffuse, unlike the sharp and abrupt impact higher crude oil prices can have on GDP growth, when they have risen beyond a certain "tipping" point.



"Flow" supply vs. "flow" demand method

The oil price breached \$100 almost five months ago because the world's economies were demanding lots of the stuff (at that time). However, there was a problem in the perception that supply could not meet demand as the Middle East and North Africa had just erupted into what is now called "a spring of discontent". Hence, prices rose sharply, despite relatively ample supplies. Subsequently, with the recent slowdown of the global economy, the oil price has fallen by \$25 so far, even though demand did not really fall proportionately to the actual decline in price.

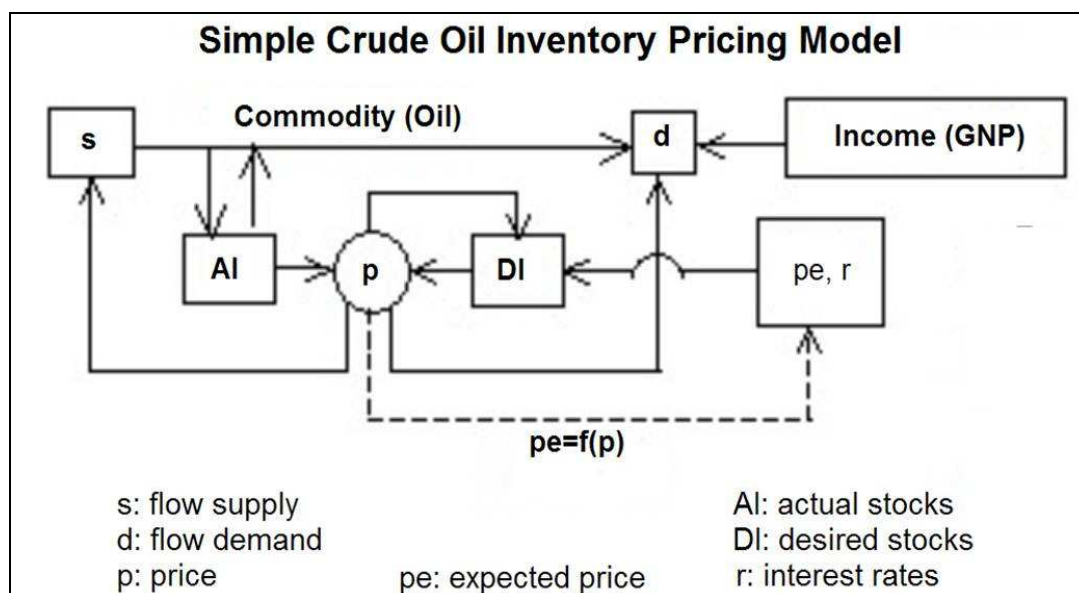
So saying that the relative movements of the oil price are driven by supply & demand fundamentals is not really at all the same as saying that April's \$115 high price was entirely justified by those fundamentals.

In the same way, today's \$90 lower (WTI) price can not be entirely justified by those same set of fundamentals if there is a fixed relationship between actual demand and actual supply available (of which there is none). Obviously, there is a certain asymmetry in the "supply-demand" equation, and that is important to understand because short-term oil prices can a lot of times be explained in great detail by that asymmetry.

The steadily rising oil price that we have witnessed of late is basically explained by the relation between 'flow' supply and 'flow' demand -- and with or without speculation the result would be almost the same. What has happened is that 'normal' demand is tending to outrun 'normal' supply, causing a fundamental supply-demand imbalance that is independent of speculative activities. This keeps inventories below the desired level, and leads to the earlier rather than later production of a certain quantity of oil. This concept was modelled by Professor Ferdinand Banks (2009) which clarified the role of inventories in crude oil price-setting.

The influence inventories have on crude oil price

Professor Banks started off with oil inventories (i.e. oil stocks) as a stock concept -- they are defined in, e.g., barrels, and measured at a certain point in time, but they lack a time dimension. The model is explained in the chart below.



Here are the key takeaway points in Professor Bank's model:

- It is a servomechanism negative feedback model that works like a thermostat. "Price is formed by the relation of actual stocks (AI) to desired stocks (DI), with the flows playing a secondary (but important) role. The equilibrium expression is $AI = DI$, and when this situation prevails, $s = d$, and price is constant (i.e. $\dot{p} = 0$)! Put another way, a stock equilibrium implies a flow equilibrium, while a flow equilibrium does not imply a stock equilibrium".

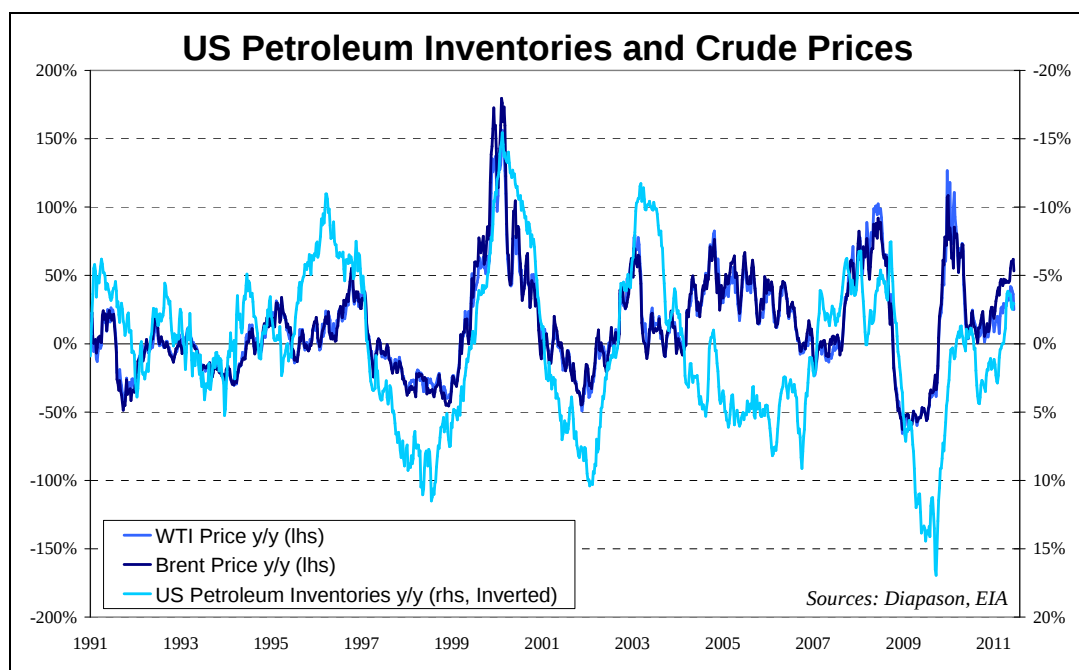
-- Oil market fundamentals determine stock levels, which sets price, which influences flows.

-- As an example, the 2008 EIA data before the crash fits well with the model. As stocks fell well below the average historical range in June and July, the average monthly price rose to \$134. Thereafter, stocks have risen toward the top of the range, causing the price to plummet.

-- Expectations ultimately drive the price because of their influence on desired stocks.

Theoretical niceties that capture expectations about price keep academic economists busy, but what are they really modelling? Here we approach what we can call the Central Mystery of oil pricing. What is modelled is the collective behavior over time of all the traders of physical and paper oil with an active interest in futures contracts, including the all-important front month.

Traders evaluate inventory levels against expectations on Wednesday after the EIA data is released, but they are drawing off projections into the future, apparently the same projections they make as on all other days.



Market sentiment is key in the short-term

We speak casually of a "bearish" or "bullish" mood in the market because traders move as a herd. The professional traders, the ones who make money, lead the pack, while the amateurs take up the rear. Group psychology runs the show. Proof? Consider Hurricane Ike's effect on oil prices back in September 2008 when commodity prices were declining sharply. As Ike bore down on the Texas coast on Friday September 12th, the DOE announced that "95.9 percent of the Gulf of Mexico's 1.3 million barrels per day of oil production" was shut-in. On that day oil briefly fell below \$100/barrel for the first time since April 2nd, but closed up 31 cents at \$101.18. By Sunday, when it was apparent that the damage had fallen short of expectations, oil

resumed its bearish run.

It is patently absurd for oil prices to fall with over 1.2 million barrels per day shut-in, but there you have it. Traders will tell you that "on any given day, expectations determine the price". But what sets expectations? Expectations are set by the prevailing mood of traders, also known as the dominant market sentiment. A dominant sentiment can trump the fundamentals of supply and demand in the short-term when the conditions are right.

No amount of infrastructure damage or shut-in oil was going to reverse the downward trend at that time (in Sept 2008), unlike in 2005 when two powerful hurricanes caused a sudden spike in the price even though the amount of shut-in oil was about the same. A bullish sentiment ruled the market during those years. The prevailing sentiment follows from the psychology of groups. When the oil price is rising, and a bullish mood is established, it will invariably rise faster and higher than the fundamentals dictate. When it is falling, in a bearish mood, it will fall faster and lower than it normally should.

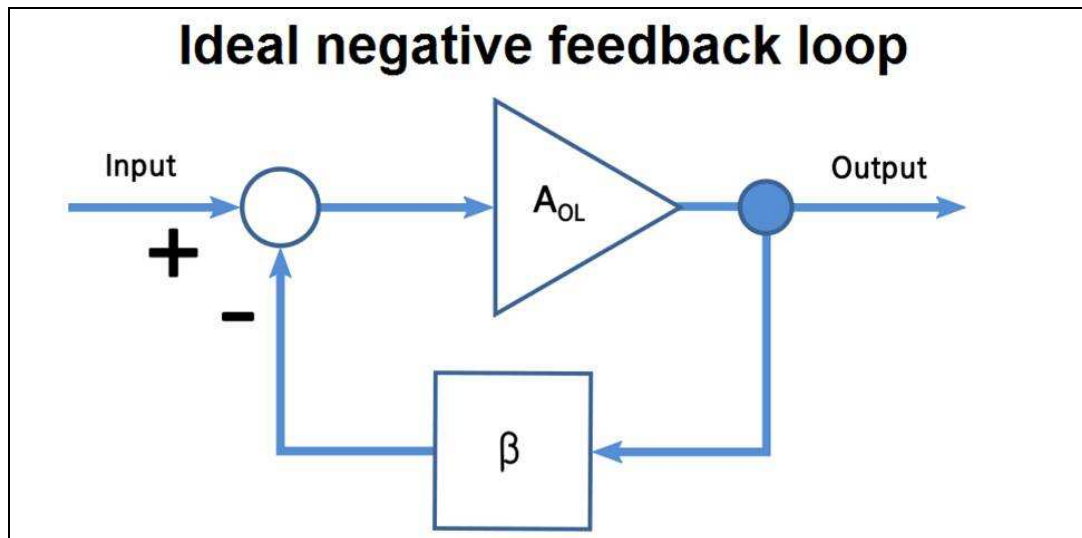
The negative feedback loop (servomechanism) method

So far we have shown three approaches to crude oil price forecasting. Now we look at a method that is unconventional but may serve as groundwork for a systematic projection crude oil price evolution. It provides one plausible alternative to Hotelling's work. It also takes a large dollop from Ferdinand Bank's work as regards the servomechanism negative feedback loop element ("underdamped, second-order dynamic system") in his equations.

This method takes the fundamental economic interaction of players and factors, but projects the crude oil price evolution along lines that are displayed by a typical unstable oscillatory response of a second-order system when the damping ratio is negative (analogous to principles utilized by homeostasis found in biological systems.)

Negative feedback occurs when the output of a system acts to oppose changes to the input of the system, with the result that the changes or output are attenuated or damped.

Negative feedback is used to describe the act of reversing any discrepancy between desired and actual output. If the overall feedback of the system is negative, then the system will tend to be stable. But with delays in implementing the dampening, counter-intuitive results are obtained sometimes (as is frequently encountered with dynamical systems) and the output intensifies, instead of being attenuated, and inadequate damping will result in a runaway feedback process. That is, a vicious cycle has become manifest, and the output tends to perpetuate until the correct and appropriate fix is implemented.



Recent example of feedback loop

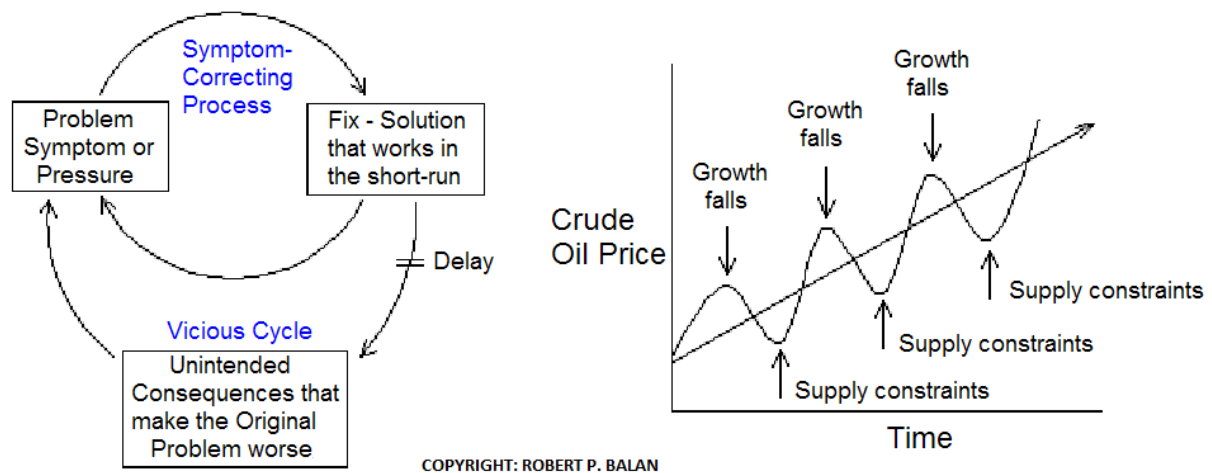
We saw an example of negative feedback loop recently with the decline in consumer spending after crude oil and gasoline prices rose sharply at the start of the year. Apparently, crude oil prices hitting \$115 almost five months ago curtailed spending, which curtailed economic activity in turn, and subsequently helped bring down crude oil prices due to reduction in demand for energy.

The economic system that is dependent on oil is a dynamical process and is very complex and no linear model can readily explain what we have been witnessing in terms of oil prices and economic activity (the general so-called "health of the economy"). As such it is often useless to look for a linear chain of cause and effect. However, in the case of crude oil pricing, the underlying truth of all the wide gyrations in prices would have been the increasing scarcity of crude oil. Crude oil is depleting and will become so expensive, both in monetary and energy terms, to extract that production rates will begin to decline and less oil will flow over time.

However, this does not necessarily mean that crude oil prices will be developing along a straight line trajectory sloping upwards. Yes, the bias will likely be to the upside, but the price will start to oscillate widely. The overshoot of the oscillation peaks and troughs defined by this upwards sloping line will tend to reach extreme variances until proper steps are taken to ameliorate the primary deficiency, after which prices settle down into an equilibrium which will necessarily be defined by economic growth and supply constraints.

The diagrams below present schematics of what the general pricing process flow will look like, and its impact on crude oil pricing displayed on a time-price series. The interaction will take a typical second-order sinusoidal response with an upwards bias imparted by scarcity rent and market perception of impending global crude oil reserve depletion. More detailed discussions and flowcharts are presented in subsequent pages to enable us to understand the behavior of crude oil pricing at micro and macro scale.

The oscillations caused by growth and supply constraints

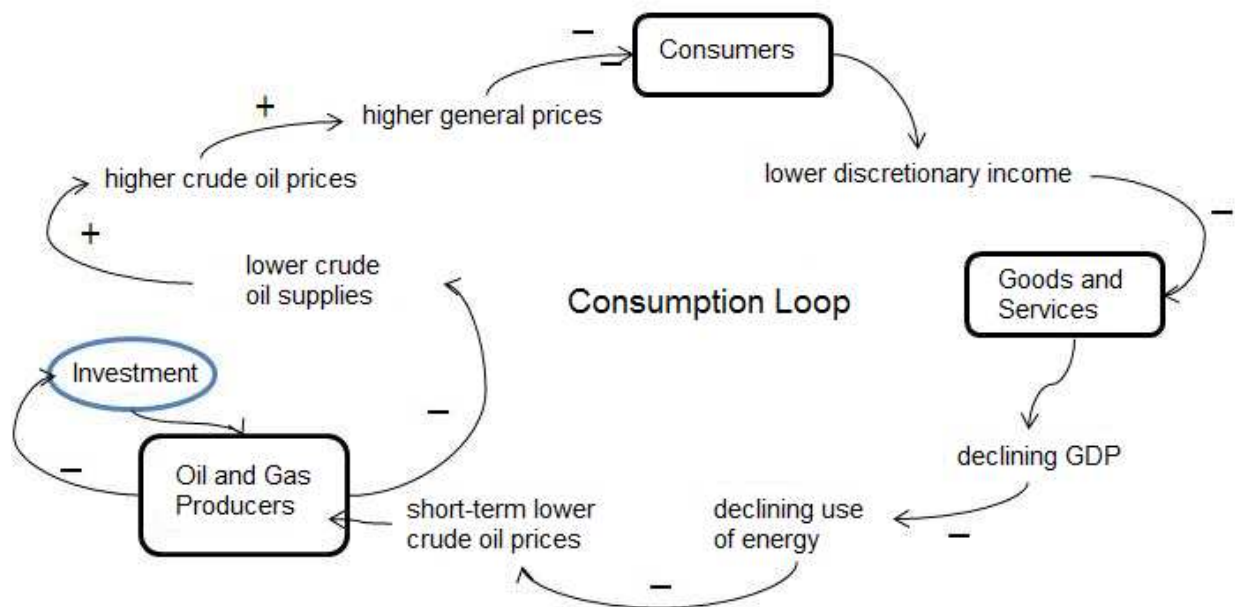


Dynamical systems, Feedback, Mutual Causations

Real life dynamic systems are dominated by complex feedback loops, most of which operate over different scales of time. This latter fact is very hard to represent in typical systems dynamics models since the latter tend to provide only one size of time increment (Δt) for a time step and to represent much longer time scale phenomena. It is necessary to use extremely small time constants in the equations – and hope the precision is appropriate – and run the model for excessively many iterations. Margaret Walls (1992) surveyed the literature on empirical crude oil modelling; one such dynamical model has been recently proposed by George Mobus (2010).

It is the mixture of short and long time scale phenomena with mutual feedback that cause system variables to behave seemingly erratically. In an attempt to try and grasp what is happening in the oil industry at a macro scale, it is necessary to employ two approaches to linking the many variables involved in the oil markets and the general economy in causal diagrams that might help shed some light on the interactions and subsequent seemingly unpredictable behavior of the whole system.

The first method is to show the large scale feedback loops in two domains: the consumer economy, and the debt-based (financial) economy to show the relations between the variables. We start with a simple loop diagram to show the long-term feedback between oil supply fluctuations, prices, effects on consumers and the economy, and how these eventually feedback to cause an opposite effect on supplies.



The graph above shows the oscillatory-like behavior which results from long-term feedback through the consumer-based economic system to counter the direction of oil supplies and prices.

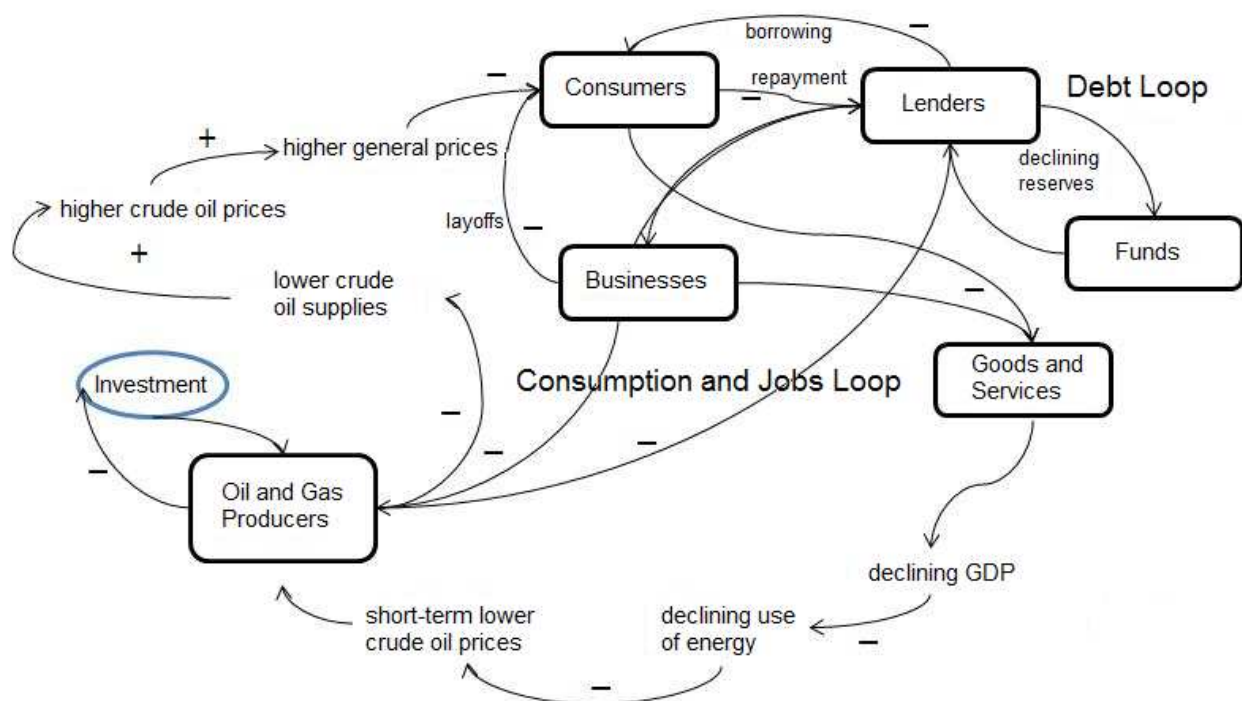
This feedback loop is surprisingly very similar to the phenomenon of homeostasis found in biological systems. Lowering supplies, possibly from diminishing extraction rates put upward pressure on oil prices, but that has an impact on consumers' discretionary spending

The second method is to put together a systems dynamic model which attempts to combine several short and long-term loops that may help explain the seeming dichotomy between peak oil and peak demand and why the price system doesn't seem to operate in the classic, and direct, economic supply-demand fashion we would expect.

Consumers buy less stuff resulting in a softening of the economy. But that, in turn, means less work and hence less energy consumption. Lower demand puts downward pressure on prices causing producers to reduce their short-term production. And that, in time, drives the price of oil back upward. The time constants for this loop are probably measured in weeks or months with the severity of the swings based on shorter-term factors like regional oil stock shortages.

For example, one could add a smaller loop to the above diagram in which oil investors (speculators?) monitor the supply on a weekly or even daily basis and try to anticipate the future with bids they think will make them a profit in the future. This, aside from often being inaccurate, at best, acts as an amplifier that drives the swings upward and downward more than simple supply/demand pressures would do.

A somewhat more complicated picture emerges when we include the business world as consumers of energy and suppliers of jobs, and the banking role played in lending operating and investment funds to both consumers and businesses. The graph below shows these additional factors and how they may affect the overall cycle.

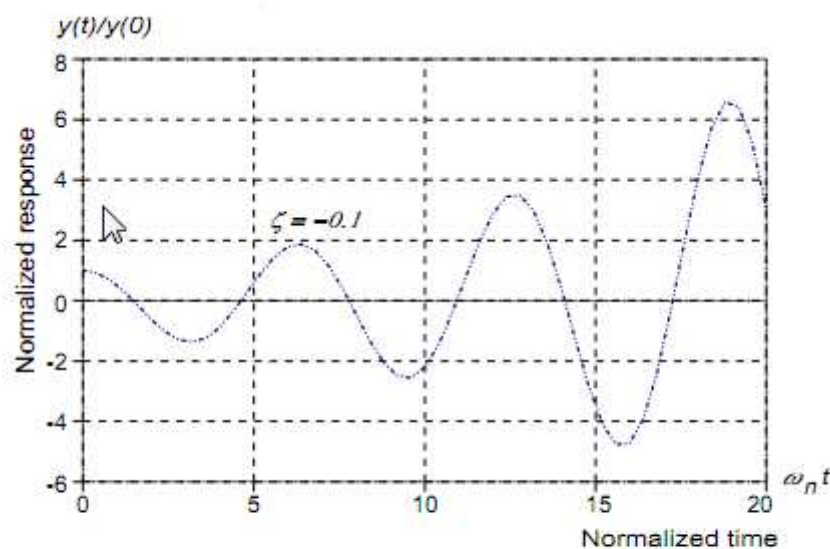


The graph above shows how businesses and consumers (who are also workers) may borrow money from lending institutions to cover operating and capital costs with the intent of paying back the loans when work picks up. Due to the long-term average declining supply of oil, however, less work can be done making it difficult for both borrowers to service their debts. This additional negative feedback loop adds more difficulty to the supply loop since oil producers must rely on debt financing to expand their extraction efforts.

Oil supplies, relative to demand, are determined by the extraction rate supported by global producers. In the short-run, producers (like Saudi Arabia) can up or down modulate their flow rates in order to adjust the supplies on a short time scale. However, in the long term, producers need to invest more capital and exploration costs to hopefully expand their production. They will do so only if for some period of time there appears to be a comfortable floor price for oil. They perform analysis of their returns on investment (ROI) just as any other business would to see if the investment today would pay off at some future (perhaps ten years off) time. In both graphs above, the blue oval represents this investment time delay which introduces even more uncertainty into the problem.

However, there is one undeniable fact that can be shown to, in the long run, continue to drive supply relative to demand lower, and keep upward pressure on prices -- and that is the peaking and subsequent decline of oil extraction.

The tendency for prices to inch upward acts like a speed governor damping demand and continuing to push the economy downward as less work gets done. Workers who lose their jobs, furthermore, will be buying less and thus acting to keep a consumption-based economy subdued (or go into recession or worse), which causes prices to decline. Moreover, inadequate backstops for crude oil, and inefficient allocation of existing resources will tend to magnify the swings in prices. The variability of a time series of crude oil prices in such a condition will intensify, instead of being attenuated, and the frequency response will widen with time, as the graph below suggests, illustrating a runaway feedback process.



A typical unstable oscillatory response of a second-order system when the damping ratio ζ is negative.

Note: illustration taken from web.mit.edu/FirstSecondOrder.pdf

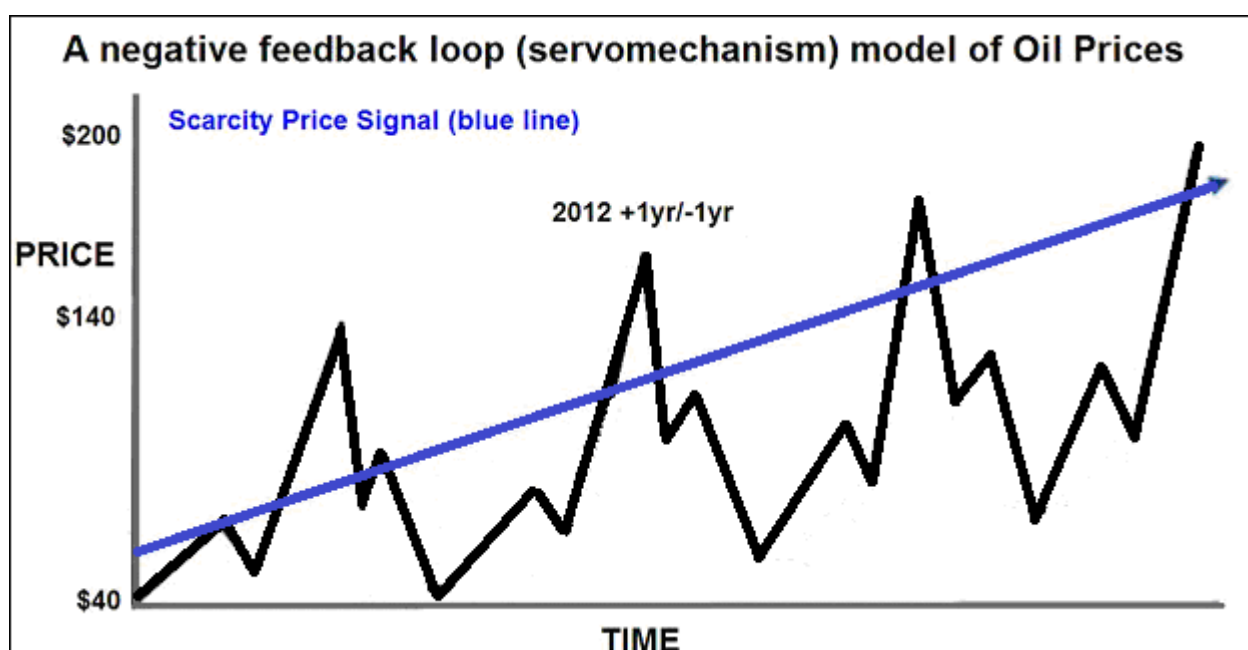
The illustration in the graph above shows the theoretical sinusoidal frequency response of an underdamped second-order dynamic system which intensify, as in a microphone feedback.

\$147/barrel was too expensive; \$33/barrel was too cheap

A negative feedback loop in crude oil pricing operates between two constraints — industrial energy needs and consumer purchasing power. This is actually one of the most bedeviling problems for oil producers and oil investors -- when is it too cheap to keep producing, and when it is too expensive to sell. The events of the past two years gave us hard boundaries: \$147/barrel was too expensive, and \$33/barrel was too cheap. But those numbers aren't terribly useful numbers in the real world.

We now know that \$147 was extra-inflated in September 2008 by too much money sloshing into the commodities sector, and \$33 was extra-deflated by the fear and confusion that dominated all markets in December 2008, as the global economy teeters into what looked like a repeat of the Great Depression. It's likely that tighter regulation of the oil futures market will tamp down the former, and the latter will not be seen again so long as the world banking system continues to beg, borrow, and steal its way to stability and "full faith and credit."

The next few months or quarters will provide more insight into the dynamic constraints in this regard as the global economy recovers in fits and starts — constrained by consumer deleveraging and energy supply barriers which threaten to become more acute as the global economy expands at a tremendous pace relative to those seen in previous decades.



A graphical and stylized presentation of price action properties derived from a negative runaway feedback model is shown in the chart above.

The chart above displays some real-world attributes of oil pricing and long-term fundamentals, namely:

- It does not impute rationality to the market, i.e. it does not treat oil like a non-renewable resource. It reflects the moodiness and short-sightedness of markets
- It embodies a negative feedback loop (servomechanism)
- It reflects the growing ability of emerging economies (after some decoupling) to drive up oil prices over time as supply falters and demand remains inelastic (the peaks) while incorporating the consequences of future price spikes (the valleys)

The first price spike (and decline) in the chart was mostly caused by a global economic financial crisis which has been 20-odd years in the making. Very high oil prices were likely the straw that finally broke the camel's back. Subsequent spikes may be predominantly caused by the oil price itself and other assorted disasters like the long-forecast crash of the U.S. dollar.

This article is not an attempt to predict the level of future oil prices. Future oil prices levels can not be forecast with much accuracy. What we tried to do here is to try getting a handle on future oil price changes, their timing and their direction, and it promises to be a volatile set. And the volatility looks likely to become even more pronounced as the world consumes more and more of the proven reserves of energy.

The trend over the next few years will almost certainly to be on the upside, with a temporary peak expected in H1 2012, then another higher structural peak in H1 2013, and a likely subsequent price crash over the next year or two thereafter, as predicted by the model. We expect this sequence to be replicated henceforth over the next few years, until the global economy produces sufficient backstops for crude oil or learns how to live with less oil, or finds an efficient way to allocate the remaining oil resources.

Another issue discussed is whether the price level itself does or does not tell us future crude oil prices. It does not. Nonetheless, we now know that the \$35 oil price in February 2009 was not right as we looked down the road at that time to a period when the global economy rises like a Phoenix from the ashes. We also know now that \$115/barrel price seen five months ago came close to the threshold of what the global economy can bear at its present, parlous state.

Due to the nature of oil pricing, and the negative feedback loop characteristics of crude oil price setting, we may be bound for a long, very volatile period punctuated by periodically rising crude oil prices, and periodically collapsing prices, until the global economy learns how to come to grips properly with depleting crude oil resources.

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