# THE TRUTH ABOUT ENERGY PRICES *AND* VOLATILITY

## – THE ROLE OF FOUR STRUCTURAL CHANGES –

**(September 2005)**

***Author's Note:*** *In our February and May 2004* ***PROFILE*** *reports, we published two essays setting forth in-depth arguments as to why energy prices would soon rise sharply and steadily. They did, and for the reasons we identified. The present essay reviews our earlier arguments which have become increasingly salient. We also explain the true sources of energy price volatility from first principles.*

*—H. W. Brock*

The fate of future oil prices will prove to be *critically* important for world economic growth, for trade deficits, for currencies, and for interest rates in the years to come. Do not be fooled by the fact that the recent oil shock has wreaked less damage than expected. A scenario with oil rising to well over $100 is quite likely in the intermediate-term future. So are scenarios in which sufficient energy is not available at all, *regardless* of price (recall the 1973 embargo). In either event, the impact on the economy and on global politics will be very significant.

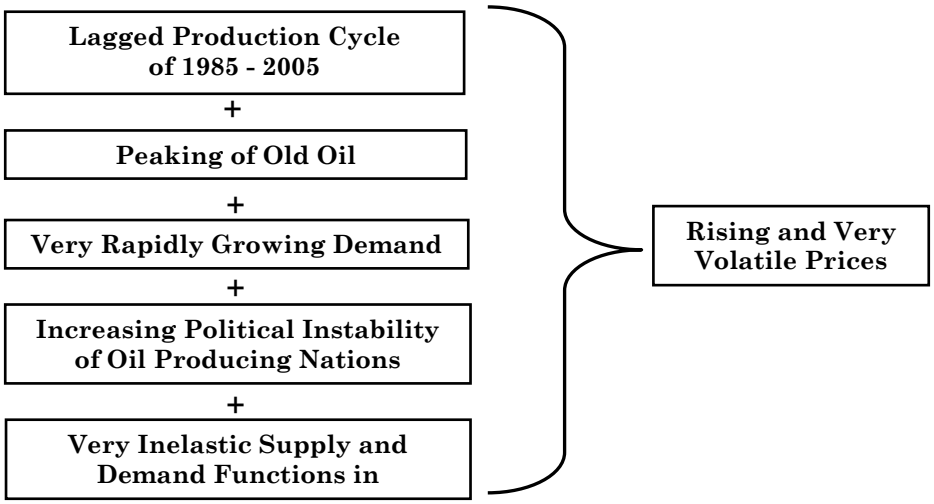
Because of the global importance of oil prices, sentiments about this topic run deep. For every analyst who vociferously expects prices to rise much higher, there is another who is sure that prices will fall back down to $25 per barrel—their correct long-term level.

As readers of these ***PROFILE*** reports know, we published two essays early in 2004 predicting that oil prices would soon rise sharply in the short run, and that prospects for the longer run were highly disturbing. We offered five main reasons for our predictions (see Figure 1): **(i)** the lagged consequences of a down-cycle in exploration and production during the 1985–2000 regime of falling real prices; **(ii)** the peaking of "old" oil production; **(iii)** rapidly growing demand, given the astonishing rise of the Chindian economies; **(iv)** increasing political instability in oil producing regions—instability that will sharply raise producers' risk premiums; and **(v)** the price inelasticity of both supply and demand for oil in the short-to-medium run. As we saw matters at the start of 2004, the threat to future oil prices lay in the *intersection* of these five developments.

The first of the two SED chapters was authored by Matthew Simmons, the Houston investment banker who just published *Twilight in the Desert,* an intriguing and disturbing prognosis of Saudi Arabia's energy future that stands conventional wisdom on its head.

Thus far, our analysis (and Simmons's) seems to have been right for the right reasons. In particular, when most observers were predicting a fall in prices back to $30 based upon some optimistic inventory trends early this year, we cautioned in a June 16 email to clients that inventory adjustments would no longer play the important role they used to play in pricing energy. This also has proven to be correct as developments this past summer have made clear (recall our August 16 email on this matter).

**FIGURE 1: THE CRUX OF THE OIL CRISIS**




Nonetheless, a few readers of these reports have taken strong issue with our assessment of future oil prices. Let us summarize several criticisms directed at our research:

> "Woody, I am surprised and disappointed by your analysis. It smacks of the gloom and doom of the Club of Rome report in the mid-1970s that predicted $100 oil by 2000—a report now ridiculed around the world! You have been so right about the lagged productivity gains accruing from the IT revolution … You have stressed Mordecai Kurz's general equilibrium theory in which structural changes of a technological variety play an important role throughout history. And you have reinforced this perspective by publishing the writings of Paul Romer and others on the subject of "endogenous" growth theory.
>
> In this regard, you have taught us renewed respect for the need to fully deregulate markets and let technology rip. When this occurs, there are no "shortages", and widely predicted price spikes (e.g., the Club of Rome's predictions) rarely occur. Given all this, how can you downplay the potential role of market-induced technological innovation at this particular juncture in history? Surely remarkable technological changes will solve future energy crises by radically reducing energy demand per unit of GDP (e.g., conservation and increased efficiency) *and* by creating substitutes for fossil fuels *and* by increasing the supply of oil proper.
>
> Finally, your analysis fails to confront the fact that real energy prices have been stable or falling for over one hundred years. What makes you think this trend will reverse?"

**Rebuttal:** Our analysis is in fact completely consistent with advanced economic theory, and we *do* in fact agree with the principal thrust of this argument. Specifically, technology will indeed as always come to the rescue, and oil prices will probably continue to decline *asymptotically* as the

twenty-first century progresses. The problem is that the road from today to this long-run asymptotic limit is not an interstate highway, but a very curvy country lane. The journey to the asymptote of lower very-long-run prices will be punctuated by periods in which prices *rise* much more than expected (e.g., 1971–1981 and probably 2004–2020), and *fall* much more than expected (e.g., 1963–1972 and 1985–2000).

**Technology to the Rescue:** Why do we expect the *current* regime to be one of higher (and extremely volatile) prices? Why are we not betting on technology and substitution to save the day in the shorter run? To begin with, note that new technologies and new substitutes will only come into being if prices *have been high* for a good while in the first place. It is *lagged* high prices that typically stimulate both conservation and innovation. But why will prices be high in the first place? The answer lies in the intersecting developments shown in Figure 1, and the collision of the forces of supply and demand that they portend.

Having discussed most of these developments in the past, we shall only update our views given developments during the past year.

**The Production Down-Cycle of 1985 to 2000:** As regards the down-cycle of production during the period 1985 to 2000, the International Energy Institute has confirmed that Big Oil went to sleep, and now needs to spend up to $10 trillion to cope with what lies ahead over the next one to two decades. It is telling that no such plans are on the drawing board.

Why did Big Oil curtail its level of exploration and development late in the century? Because the real price of oil fell by 65% between 1985 and 2000, and because the volatility of oil prices exploded (see below). In short, the industry acted perfectly rationally.

**"Peaking":** As for the peaking phenomena, much new evidence of the magnitude of this problem has come to light. Indeed, for the first time, both OPEC and Saudi Arabia have admitted that, because of peaking and soaring demand, "we cannot produce enough new oil to cope with the demand that lies ahead." For example, it was long assumed that the House of Saud would remain the world's backstop supplier, assuming that suitable investments were made to bring long-term production up to 20 or even 25 million barrels from 10.5 million today. Many observers now doubt that we will ever witness 15 million, and Simmons believes that we may not see 12 million.

Additional evidence about the forthcoming crisis in Saudi production just appeared in the cover story of the Sunday *New York Times Magazine* this past August 21. In it, perhaps the most knowledgeable person in the world about Saudi oil agreed with the pessimists and forecasted a major world oil shortage. He is Dr. Sadad al-Husseini, until last year head of exploration and production for Aramco itself. All in all, the consensus about the future of Saudi Arabia's output is finally changing and becoming more realistic.

Above and beyond this, we have witnessed the sharp downward revision in the reserves of Shell and many other producers that stem in part from realism about peaking. The consensus was shocked and remains largely unaware that more is to come.

**Global Politics:** On the political front, the explosion of the Iraq insurgency has kept oil production in Iraq at about 2.5 million barrels per day, down from the nearly 5 million that the provisional government had forecast only two years ago. This is just a taste of things to come as insurgencies proliferate elsewhere. Then there is the prospective fate of the House of Saud, and the ever more strident determination of Iran to do anything possible to stymie "the West." Indeed, Iran only one month ago stated outright that it would curtail oil supplies to the West if the allied governments press too hard on the matter of nuclear weapons development within Iran. And Iran is not the only country that will be able to make *credible* threats of this kind.

Additionally, China has been doing inside deals with the governments of Venezuela, the Sudan, Iran and other thugocracies. These deals will altogether *preempt* future oil supplies from the global market. Finally, political protests in late August virtually shut down Ecuadorian production which fell from 210,000 barrels per day to less than 27,000. This is yet another omen of instabilities ahead, as is the turmoil in many of the former "republics" of the Soviet Union. As we have stressed before, the end of the Cold War will prove to have been very destabilizing for the global energy industry, much more than is generally appreciated.

**Volatility and Inelasticity:** While visiting Australia a few weeks ago, the author turned on the BBC news early one morning and caught a thirty minute discussion on oil prices by a panel of six experts. The extraordinary volatility of oil prices was the theme that kept emerging during the discussion. Nobody could explain this, and one expert concluded that, "we probably need a sorcerer to make sense of volatility."

This is not the case. As we have pointed out in the past, and will do so again in the future, the key to understanding oil price volatility lies in understanding that *both* the supply and the demand of oil and gas are *price-inelastic* in the short-to-medium term. And as shown in Figure 2 below, the steeper (more inelastic) the two functions are, the more price will rise (or fall) for any given shift in market conditions indicated by a shift in the location of either function.

> *More formally, if you think of shifts in the two functions as being driven by random shocks, then it can be shown mathematically that the variance of price will be a very sharply increasing function of the steepnesses of the two functions. Please see the legend of Figure 2 for a more detailed analysis of this <u>fundamentally</u> important point, and note in particular the coefficient of the last expression where the Greek parameters represent the two steepnesses.*[1]

Most everyone can understand why the demand function is inelastic: given the lack of substitutes with which to "fill up my car or heat my house," consumers have no option but to say, "Fill her up whatever the price!" In the long run, the demand curve will be much more flat since substitutes will be available, and more oil will have finally been found.

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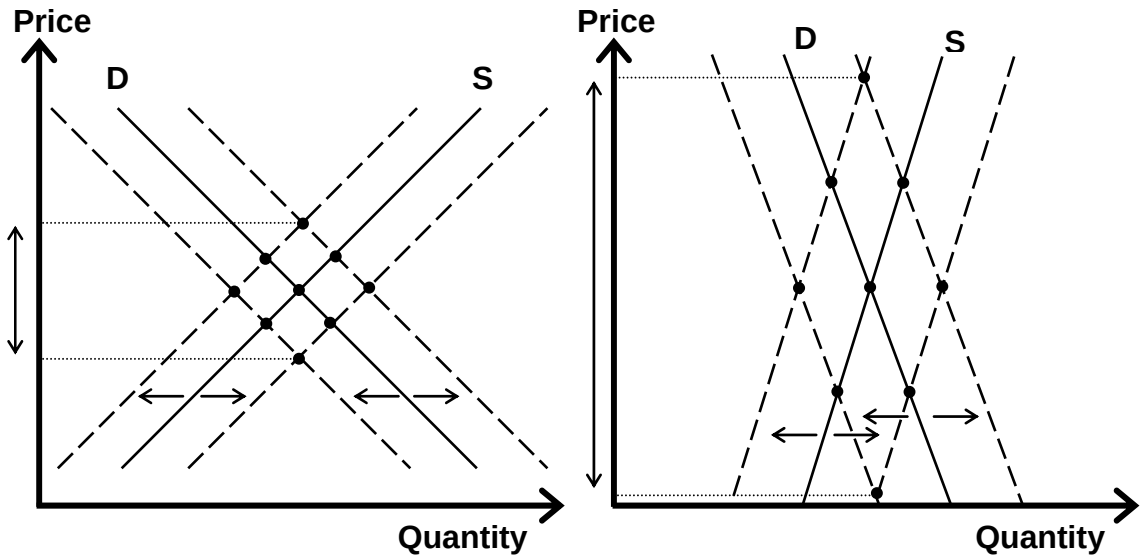
[1] I am indebted to John O'Leary of Harvard University for this derivation.

## FIGURE 2: THE TRUTH ABOUT OIL PRICE VOLATILITY
### – PRICE RISK AS A FUNCTION OF ELASTICITY –




## A. The Deterministic Case

Let supply and demand be linear as above. The prices associated with a given level of supply and with a given level of demand will be

$$p = \lambda\, s + q_s \qquad\qquad p = \mu\, d + q_d$$

Setting supply equal to demand, we get the equilibrium price

$$p^* = \frac{\mu\, q_s - \lambda\, q_d}{\mu - \lambda}$$

### B. Price Volatility from Stochastic Supply and Demand

Suppose now that supply and demand are subject to shocks given by random variables $\tilde{S}$ and $\tilde{D}$ with known variances and covariance. The relation of price to supply and of price to demand shall now be

$$p = \lambda\, (s - \tilde{S}) + q_s \qquad\qquad p = \mu\, (d - \tilde{D}) + q_d$$

The equilibrium price will be as follows

$$p^* = \frac{\mu\, \lambda\, (\tilde{D} - \tilde{S})}{\mu - \lambda} + \frac{\mu\, q_s - \lambda\, q_d}{\mu - \lambda}$$

Employing the results of elementary probability theory, we find that the variance of price depends only on the variances of $\tilde{S}$ and $\tilde{D}$, their covariance, and the slopes of the supply and demand curves. Note the mathematical form of the coefficient and how it *blows up* as both functions become more price inelastic.

$$\mathrm{Var}[\, p^* \,] = \left(\frac{\mu\, \lambda}{\mu - \lambda}\right)^2 \mathrm{Var}[\, \tilde{D} - \tilde{S} \,] = \left(\frac{\mu\, \lambda}{\mu - \lambda}\right)^2 (\, \mathrm{Var}[\, \tilde{D} \,] + \mathrm{Var}[\, \tilde{S} \,] - 2\, \mathrm{Cov}[\, \tilde{D}\, ,\, \tilde{S} \,] \,)$$

But the supply curve must also be price inelastic to explain the level of volatility we observe. Why will it be? After all, if the price of oil falls a lot, won't rational producers *cut* production a lot, resulting in a fairly price-elastic function? Yes, they will, if they are good capitalists attempting to cover marginal costs. But this will *not* be the case if the producers are third world nations that seek to maximize the revenue needed with which to bribe 4,300 Saudi princes, or Venezuelan workers whose living standards have collapsed under President Chavez, etc.

> *Mathematically, if you are a revenue maximizer, and prices fall for whatever reason, you will seek to increase production, not decrease it, in order to maintain revenue. For* ***Revenue = Price x Quantity.*** *One result can be a steep downward sloping supply curve that, in the presence of a steep downward sloping demand curve, can amplify price volatility hugely. This is the crucial point that is never cited in analysis of volatility. Instead, commentators conclude that the real culprit must lie in the secret strategies of hedge funds!*

To conclude, our analysis of oil is consistent with an extension of classical economic theory that takes into account political factors, long lagged responses, and mistakes in the inability of forecasters to foresee structural changes such as the rise of Chindian demand. Indeed, this analysis is consistent with the kind of general-equilibrium-with-mistakes model that Mordecai Kurz developed in the 1990s. When this analysis is coupled with the inelastic supply and demand functions unique to the oil industry, the result are those long-cycles and high volatility levels of energy prices that we have been living with for so long and will continue to live with.

Readers interested in a view much more optimistic than our own should refer to the writing and website of the well-known Cambridge energy analyst Daniel Yergin. He believes that the current cycle is just another cycle, and that new technology and new production (e.g., Russia) will once again come to the rescue. At some level, Yergin is correct, of course. But his short-run forecasts have proved problematic in the past: one reason why is his failure to invoke the logic of the supply-*and*-demand inelasticity shown above.

**Caveat:** Our analysis is completely consistent with the likelihood that from time to time prices will fall way back *down*, to say $20. A recession in China, or a rapid fall-off in tourism due to terrorist attacks on commercial airliners could easily precipitate such a drop. The reason lies in the short-term price inelasticity of supply and demand. *This amplifies the adjustment process in both directions.* In this regard, recall that a spate of cheating by OPEC members (Iran in particular) caused prices to plummet from over $30 to under $10 in the winter of 1986, and that oil fell again to $10 only seven years ago during a spurt of overproduction in the midst of the Asian financial crisis.