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The Four Reasons for the Collapse in Oil Prices
– And Prospects for Future Prices –

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The Four Reasons for the Collapse in Oil Prices

– And Prospects for Future Prices –

The world was as shocked by the collapse in oil prices as it was by the precipitous rise in the value of the Swiss franc. Both are examples of price changes begging to be explained. In this ***PROFILE***, we restrict ourselves to the case of oil prices. Part 1 discusses the four reasons not only why oil prices dropped, but also why they dropped as far as they did. It is the *magnitude* of the price fall that is counter-intuitive. The trader Anuraag Shah of Tusker Capital made a fortune betting on a declining oil prices, but never expected a price of $45. He aptly summarized global astonishment in three well-chosen words: “It’s bloody nuts!” Actually, no it isn’t, as we shall see.

In Part 2 we discuss the short and long term prospects for oil prices. In our view, making sense of future prices requires an understanding of the two developments that explain why prices fell as far as they have, discussed in Part 1.B. Finally, Part 3 discusses a new methodology for forecasting commodity prices in general, not simply oil. This methodology not only makes improved forecasting possible, but also permits the concept of “event risk” to be properly understood and quantified. Since event risk will be the major source of price risk in the future, this should prove useful.

1.A. The Two Obvious Reasons for Lower Oil Prices

Everyone acknowledges that two developments jointly explain why oil prices should and did drop. *First*, supply has been increasing—partly because of increased US output, and because of increased “cheating” by members of the OPEC cartel. *Second*, global demand growth has slowed markedly. Global GDP growth is currently a dismal 2.9%. But it could and should be 6% had governments around the world adopted the right policies.

Why growth is stagnant both in the West and in the emerging world, and should be stagnant, was discussed at length in two of our 2014 ***PROFILES.*** We emphasized how unimportant monetary policy is to sustaining high growth, as opposed to incentive structure policy which is the key to sustained growth (South versus North Korea between 1960-2015 is the ultimate case study here). We also discussed the pernicious impact of rampant corruption on growth.

What everyone acknowledges about the role of increased supply and decreased demand driving down prices is true. Yet this simple story fails to explain the *magnitude* of the oil price decline. The story here is more counter-intuitive.

1.B. The Two Deeper Explanations
– Price Inelasticity, and the Game-Theoretic Logic of Cartel Pricing –

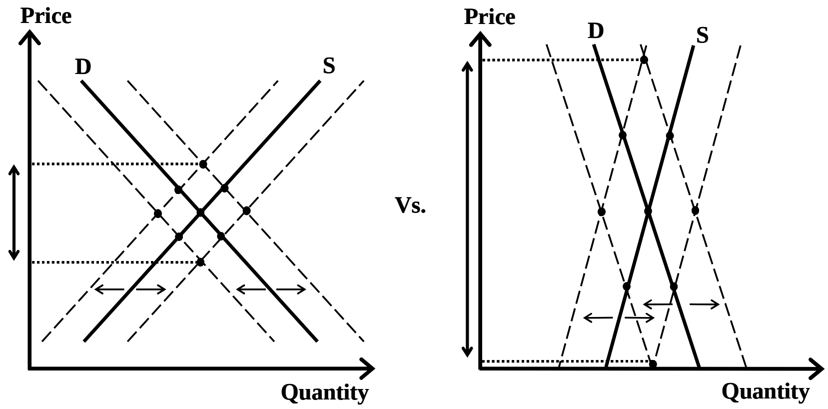
To understand this magnitude, we first discuss the role of the price elasticity of oil. Oil is quite unique amongst commodities in that it possesses very price-inelastic supply *and* demand functions (curves). It is this property that largely explains the unexpectedly large change in prices that has occurred many times in the past forty years. We now explain why this is so important, and also why the supply and demand curves both have this property. Longstanding readers of our reports will recall our discussion of this point in reports published in the 1980s and 1990s. But many readers will not be familiar with these arguments so a brief review should be helpful.

The Role of Price Inelasticity of Both Supply and Demand

The price elasticity of supply and/or demand defines how much quantity (demanded or supplied) changes in response to a given change in price. "Highly inelastic" means that, for a given change in price, the resulting impact on the quantity supplied or demanded will be very slight. [Highly elastic implies the reverse.] Visually, when price is plotted on the vertical axis, and quantity on the horizontal axis, then highly inelastic supply and/or demand will be represented by *steeply sloped* supply and/or demand curves.

The fundamental theorem here is that the price of a commodity will increase *non-linearly* the steeper *both* curves are. There is considerable confusion about this point. For example, we are all aware that oil demand is price inelastic. This is often cited as a reason why oil prices can be very "volatile." But this is incorrect. Crazy price movements of the kind we have just experienced require that *both* the supply and demand curves be very steep. This is seen graphically (and our result is proven) in Figure 1 where we show how comparable shocks to supply and demand cause vastly greater price variation (the vertical axis) when *both* lines are steep versus when they are not. [By "comparable shocks" we mean horizontal shifts of equal magnitude in both the supply and demand curves.]

FIGURE 1: THE TRUTH ABOUT COMMODITY 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

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

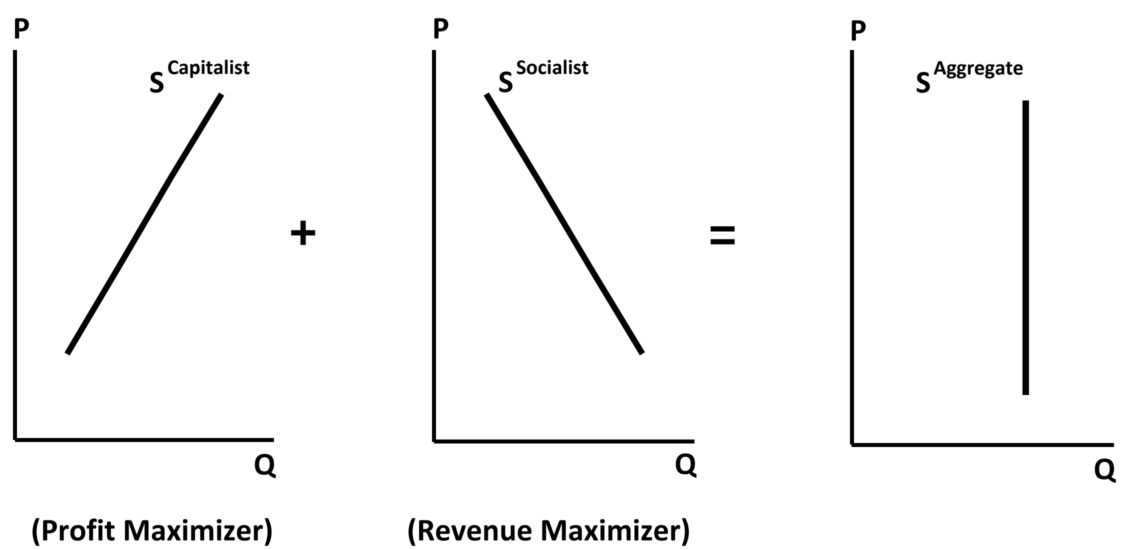
Employing the results of elementary probability theory, we find that the variance of price depends only on the variances of $\tilde{S}$ and $\tilde{D}$, their covariance, and the slopes of the supply and demand curves. Note the mathematical form of the coefficient and how it *blows up* as both functions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

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

Why are the Demand and Supply Curves for Oil so Steep? The case of demand is well understood. To a large extent, oil is a "necessity" for which there is no short-term substitute. Suppose the price of oil goes from $2 per gallon at the pump to $4. I can of course buy a new car for $30,000 that gets double the mileage per gallon as my existing car. Were I to do so, my expenditure on oil would not rise. But I would be in debt, and possibly broke. No thank you: I will keep my car, hope that prices will fall back, and simply "fill-'er'-up" as always. For I *have* to get to work. Period. This is price inelasticity of demand. The situation is quite different in the long run (five years or more) when capital substitution can be both possible and profitable, and it makes sense to sell my current gas guzzler, unless prices fall back down to $2.

It is the steepness of the oil *supply* curve that is counter-intuitive and poorly understood. The reason for that is seen in Figure 2.

FIGURE 2: MYSTERY OF THE STEEP SUPPLY CURVE



What matters to global oil prices on the supply side is that the *aggregate* supply curve is defined as the horizontal sum of the "capitalist" and "socialist" supply curves. Capitalists are profit maximizers like Shell Oil. Thus, when price falls, they close marginal wells, and vice versa when prices rise, so that they exhibit upward-sloping supply curves, just as textbooks tell us. But the rulers of such socialist thugocracies as Russia, Iran, Venezuela, and other such regimes are not capitalists who focus on profit. Rather these leaders focus on the REVENUE they need to pay off those who oppose them, and to pay subsidies to their "people" to curry favor with them.

When price falls, revenue can only be maintained by producing more—not less. This is what gives rise to the backward-bending "socialist" supply curve of Figure 2.

Cartel Pricing and its Game-Theoretic Logic

The second reason for the precipitous drop in oil prices lies in the collapse of the OPEC cartel, an event that the market has not fully appreciated. Cartels are rarely successful in maintaining the discipline amongst members needed for the cartel to set and maintain a given target price. In the past sixty years, two cartels were successful for many decades, but neither is any longer. First, there was the de Beers diamond cartel—really a monopoly of the legendary Oppenheimer family of South Africa. This began to collapse some twenty-five years ago due to developments in Australia and Russia.

Second, there was OPEC which began to flex its muscles under the Shah of Iran in 1973. Prior to this time, US oil prices were largely set by the Texas Railroad Commission. Overnight, OPEC drove oil from $3 to over $9. The cartel was run with an iron fist by Saudi Arabia's Sheikh Yamani. If someone cheated on their cartel quota by overproducing, as Iran did in 1985, Yamani would make them pay. In this case he started pumping an extra two million barrels daily within Saudi Arabia, which drove the price down much further than the $25 he had targeted. Indeed, the price fell to below $10. At the World Economic Forum in Davos in 1990, Yamani told the author he had not been familiar with the price inelasticity logic of Figure 1 above, which we explained to him in depth. As a result, he hugely underestimated the price impact of an extra two million barrels.

The Compound Bargaining Game: A satisfactory analysis of cartel behavior is very difficult, and requires a game-theoretic perspective. This is because a cartel is essential a *compound bargaining game*. First, there is the bargaining game played by the cartel members *within* the cartel itself (members of OPEC), and second there is the bargaining game *between* the cartel and the rest of the market.

Intra-Cartel Bargaining: A cartel is best able to control output and price **(i)** when there is a 'swing producer' like Saudi Arabia within the cartel with the unilateral ability to both increase or decrease supply as global conditions demand; **(ii)** when the swing producer has the power to inflict heavy costs on cartel quota cheaters without severely hurting itself in doing so; and **(iii)** when the interests of all cartel members are *homogenous*, that is, when all members primarily care about the benefits of stable and high prices and nothing else.

Extra-Cartel Bargaining: In this case, a cartel's power is greatest **(i)** when the cartel as a whole can inflict maximal damage to non-cartel members at an affordable cost to itself; **(ii)** when the cartel has no major external enemies that it wishes to hurt via lower oil prices, despite the cost to itself of doing so; and **(iii)** when the cartel has a large share of the total oil market. While there are many more quite technical considerations, these are the main six points concerning the compound bargaining game.

The Cartel Status Today: From the standpoint of intra-cartel bargaining, conditions **(i)** and **(ii)** remain in place. Saudi Arabia still can play the role of swing man within the cartel, and can dramatically increase or decrease production at little costs to itself. However condition **(iii)** may well spell the end of the cartel. Religious (and thus political) conflicts have split the cartel into Sunni and Shiite camps. In particular, Saudi Arabia and Iran hate each other, and this is one reason the Saudis have driven oil prices much lower by refusing to cut production when they easily could have done, and did in the past. Iran is not rich—as Saudi Arabia is—and can ill afford the reduced petrol revenue that high Saudi production levels contribute to.

As for extra-cartel bargaining, condition **(i)** is in trouble since there are now a number of weak cartel members who cannot afford lower oil prices. The lower prices go, the more these members will be incentivized to cheat on their quotas, or simply to exit the cartel. Condition **(ii)** is a problem insofar as Saudi Arabia and the emirates wish to hurt Russia a lot, and also wish to drive down soaring US production. Lower prices achieve both goals. Condition **(iii)** is also in trouble since OPEC's share of the total market is falling, in large measure because of US energy independence. What matters is that these new developments increase the pain to the cartel of acting so as to stop price declines. They also weaken the ability of an **x%** reduction in cartel output to stabilize or increase oil prices to the extent such a cut would have done in decades gone by. Today, a reduction of **2x%** or even **3x%** is needed. Because of all these developments, the OPEC Cartel as we know it has ceased to exist.

2. The Future of Oil Prices, Short and Long Term

Looking forward, what can be said about future oil prices? First, significant price changes due to supply/demand price inelasticity will continue to occur. Second, the bargaining game realities just discussed will either bring about the end of OPEC, or weaken its role in the global market it once controlled. Which outcome is more likely depends upon the rate of decline of the cartel's *gain-to-pain ratio* when it acts.

Demand Side: On the demand side, demand will be primarily driven by the level of aggregate global growth. Given the failure of policy makers in the West to understand the need for incentive structure reforms, or to implement such reforms due to political cowardice, and given the likelihood that rampant corruption will continue to weaken growth in the so-called "emerging world," prospects for strong demand growth are slight. The likelihood that the advent of non-renewable energy sources will reduce the demand for hydrocarbons still further will be reduced due to ongoing low oil prices.

Supply Side: On the supply side, there is good and bad news for the oil industry. First, without OPEC either wishing or able to play its traditional role of stabilizing prices, many producers will attempt to maximize revenue by producing as much oil as they can. This, of course, is the fatal "non-cooperative" equilibrium point of the famous Prisoner's Dilemma game: *what is individually rational for each producer is in fact collectively ruinous.* Along with stagnant demand growth, such behavior will probably insure low prices in the $30–$50 range for at least five years. A strong global recovery would of course undermine this outcome, and the boon to consumers of lower oil prices may play a role in generating stronger-than-expected economic growth.

The real risk here lies in the damage to oil industry infrastructure that will result from maximizing short-term output. Profits will be insufficient for producers to cover depreciation, and future supply could thus be constrained. What has been true of Venezuela in this regard could be true of a dozen other major oil producers. Thus when global demand rebounds, say in five years, global supply will be deficient. If this is the case, the supply/demand story in conjunction with the price inelasticity story could cause a stunning increase in oil prices to $120 or even much higher.

3. How to Forecast Commodity Prices and Properly Assess "Event Risk"

We first discuss the orthodox way in which to forecast commodity prices. Next, we highlight its deficiencies. Finally, we introduce a completely novel approach introduced by the author several decades ago. This last approach has the virtue of making possible a meaningful assessment of event risk, something which orthodox forecasting models cannot do.

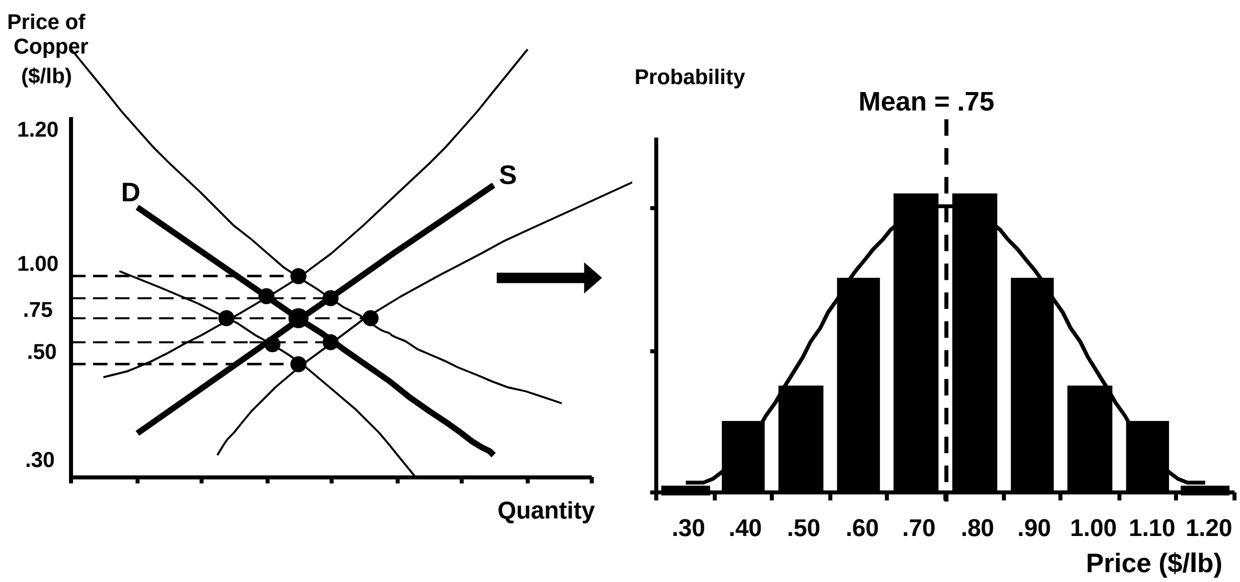
The Orthodox Regression Model: The standard approach to commodity price forecasting has been to econometrically estimate the so-called "structural form" model of the market in question consisting of its supply curve and its demand function. Figure 3 summarizes this conventional approach to price forecasting. It shows statistical confidence levels around the mean supply and demand curves. Next, using the resulting equations, an analyst solves for the so-called "reduced form" of this model by equating supply and demand and solving for price.

The result is an equation that expresses price as a function of the various "state variables" (or drivers) that have been found to be statistically significant. Associated with each such driver will be its regression weight indicating its relative impact on price. By simply plugging in likely future values for the state variables, this equation yields a mean point forecast of price conditional upon these assumed state variable values. The standard deviation of the error term associated with the regression analysis will provide a first-order risk assessment of the commodity price risk. The result will be a bloodless forecast and risk assessment based *solely* upon historical data.

Enhanced Classical Regression Model: Suppose the analyst wishes to extend the foregoing analysis to a more full-bodied risk assessment incorporating his/her *personal* views as to market conditions at some future date. In particular, suppose he has subjective beliefs (probabilities) about the likelihood of the future values of those state variables that drive the market. For example, he has strong beliefs about the joint probability distribution of future GDP *and* mining capacity *and* the state of new technology. Suppose moreover that his subjective probabilities do *not* correspond to the statistical means and variances of such variables derivable from historical data. What can he do to arrive at a meaningful forecast *and* risk assessment of price?

FIGURE 3: COMMODITY PRICE FORECASTING
– "Event Risk" Not Assessed at all –

A Classical Regression Forecast



The answer is straightforward. Using the historically-estimated reduced-form model, he can insert his own subjective probabilistic forecast of the future values of the state variables into the equation, and then solve for the probability distribution of price consistent with this subjective estimate of the probability of future states. If his boss presses him for an optimal "point forecast" of future price consistent with his subjective views, he should use the *mean* of this resulting price forecast. Interestingly, forecasts and risk assessments of this kind are very rarely carried out, even though they are not difficult to undertake.

> **Two Limitations:** While such a forecast would embody his subjective beliefs about the likelihood of future states of the world, the *weights* attached to the state variables in the reduced form equation are classical regression weights estimated entirely from historical data. Yet in today's non-stationary world, these weights will clearly change over time—*often dramatically.* Additionally, the classical framework

does not permit him to incorporate *new* state variables for which there may exist no historical data at all—and hence no required regression weights.

The Arrow-Bayes Forecasting Model: Faced with difficult commodity-price forecasting problems of precisely this kind several decades ago, the author developed a much more powerful commodity-price forecasting model suitable for environments where "things really do change," and thus where considerable subjective uncertainty exists about the future. This model is known as the Arrow-Bayes model, and it can be shown to be a conceptual and mathematical generalization of the classical models discussed above. It was inspired by Kenneth Arrow's concept of commodity prices being "contingent upon future states of the world."

The new model's principal innovation was to permit a *direct* linkage between the discrete "chunky" events that characterize many commodity-price shocks, and prices themselves. Two examples of such discrete events might be: **(i)** war breaks out in Iraq, and world output drops by two million barrels per day, or **(ii)** a new government is elected in Chile that nationalizes the nation's copper industry. More specifically, the theory permits a *direct* linkage between the (subjective) probability of such future events and the resulting probability distribution of future prices. No historical data is presupposed at all by this model, although some such data almost always exists and should be used as appropriate.

Note: For hedge-fund managers interested in "event risk" bets, the following discussion should be particularly relevant since the goal of this new model was to permit event risk to be properly assessed *and explicitly linked to future prices*.

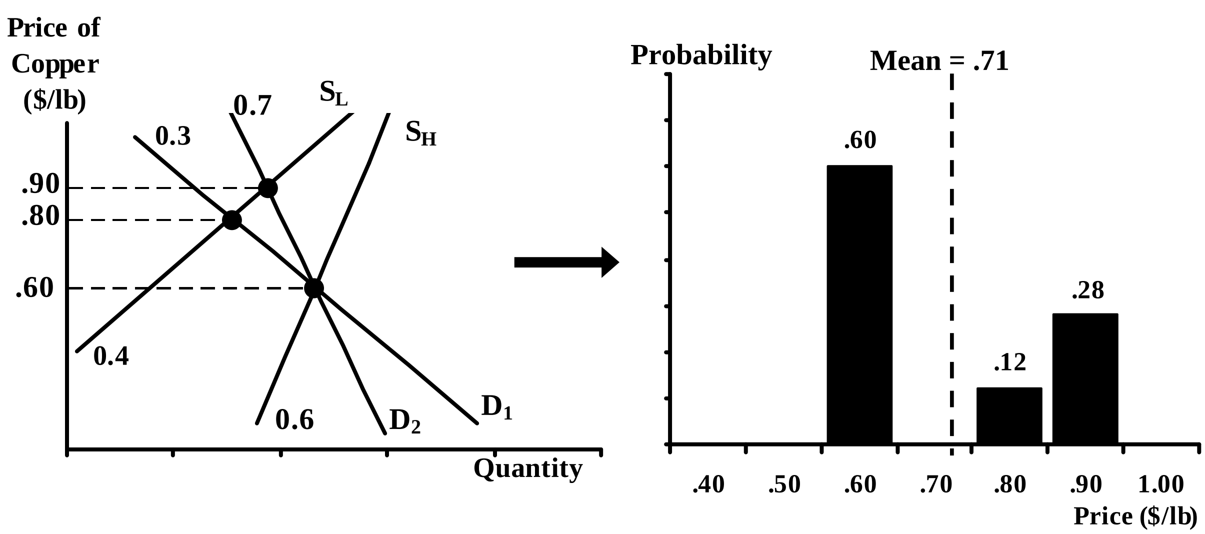
Figure 4 exhibits the essential nature of this model from an early 1980s study by the author of the global copper market. There are two sets of future "events" or "states" that matter: those impacting future supply, and those impacting future demand. A particular supply (demand) function is associated with each such event. The probability of the induced supply (demand) function is thus the probability of the associated event. This is the essential point: *probabilities of <u>events</u> are attached to entire supply and demand <u>functions</u>.* In the case illustrated in the figure, we consider *two* supply states and *two* demand states, and the pairs of "contingent" functions they induce are labeled with the probability of occurrence of these states.

We have also assumed that the supply and demand events are *probabilistically independent,* and happily this is often true in commodity-price analysis. [If they are not independent, a slightly more complex analysis can be introduced with no problem.] As a result, the probability of *each* of the three possible market equilibria shown, and hence of the three possible prices shown is simply the *arithmetic product* of the probabilities of the curves intersecting at that point. For example, the probability of a $0.80 copper price is shown in the right-hand histogram at **.12**, and this is the product of the probability of the first demand curve (namely **.3**) times that of the low supply curve (namely **.4**) on the left-side.

In the special case of the $**.**60 price, we have conflated two market equilibria into one: For one supply curve intersects *two* demand curves at this same price point. Thus, the probability of obtaining the associated price of $**.**60 is the *sum* of **(.3 x .6) + (.7 x .6) = .60**, as shown.

FIGURE 4. COMMODITY PRICE FORECASTING
– "Event Risk" Assessed Correctly –

An Arrow-Bayes Forecast



Source: From a study of the world copper market carried out by H.W. Brock in 1982 for Conzinc Rio Tinto.

Note the resulting forecast appearing in the histogram to the right: It has a well-defined mean value of $.71 should someone demand a point forecast. *Yet this mean is highly uninformative.* It tells virtually nothing about the true price risk involved. What matters here is the distribution itself, and it is very informative.

Note how the classical approach sketched in Figure 3 is incapable of generating any such distribution. The traditional historically-based methodology usually (but not always) constrains the analysis to generate a normal or log-normal or beta distribution, or whatever. Also in the classical case, there is no intuitive link between the big "events" being bet upon and the resulting probability of price—the latter being of course the ultimate "event" of all!

Finally, note the importance for the resulting probability forecast of shifts in the *slopes* of the supply/demand functions—slopes that can change a lot in different states of the world. Such shifts are hugely important for commodity-price forecasting and risk analysis. Moreover, they cannot be handled in a natural manner via classical statistical methods.

Readers interested in a much more in-depth analysis of the issues raised above are referred to the reference cited below.[1] In commenting on this essay, Kenneth Arrow wrote:

> *Brock (Chapter 18) shows how the Bayesian analysis in terms of states of nature can be used to estimate distributions of future prices. He correctly holds that in behavior under uncertainty, single-valued expectations are insufficient. Further, economic analysis makes prices derivative from more fundamental supply and demand factors. Hence, a true Bayesian distribution of future prices must be a transformation of the joint distribution of these basic factors.*

[1] "Arrow-Bayes Equilibria: A New Theory of Price Forecasting," by Horace W. Brock, appearing in *Arrow and the Ascent of Modern Economic Theory*, ed. George Feiwel, pp. 559-596, New York University Press, 1987.

