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Natural Gas Price Forecasting: One Explanation for Upward Bias

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ABSTRACT

The paper asks why historical gas price forecasts have been consistently too high for the last decade, poses one likely explanation, and suggests an alternative approach that might produce better forecasts. The accuracy of fuel price forecasting, in general, is important because forecasts play a significant role in the production and planning decisions of most major industries. As well, the issue of environmental pollution raises questions about fuel choice. The economics of natural gas will be determined in these and other applications by projections for natural gas prices. We demonstrate that published forecasts have consistently projected substantial growth in price while actual growth has been mild. Next, we propose that forecasts may have been based on a view of gas supply which presupposed that the industry would operate under a short run supply constraint. This explanation also sheds light on poor forecasts which were based on "linkage" or the theory that gas prices parallel those of oil because gas and oil compete in the same markets. Finally, we propose that forecasts should be based on a view of gas supply which accounts for the effects of technological change on offsetting the cost-increasing effects of depletion. This perspective is fundamentally one of long run gas supply.

INTRODUCTION

Fuel price forecasts play an important role in the production and planning decisions of most major industries. Price forecasts are critical in the electric power industry where capital intensive investment decisions turn on the price trajectories for various fuel choices over an extended planning horizon. As well, the issue of environmental pollution raises questions about fuel choice. Natural gas could provide an alternative means for complying with environmental restrictions in the United States under the Clear Air Act. The economic's of natural gas will be determined in these and other applications by projections for natural gas prices.

For the last decade, most major gas price forecasts have consistently projected substantial growth in price while actual growth has been mild. Given the increased importance of projecting fuel prices, we are troubled by the dismal record of U.S. natural gas price forecasting. This paper accomplishes three objectives. First, we demonstrate that the major U.S. gas price forecasting services have consistently over-projected gas prices for at least the last ten years. Survey results of published forecasts performed by the major forecasting services over the last decade are compared to actual prices in graphical form to illustrate this point.

Second, we identify and discuss one possible explanation for why over-forecasting during the early 1980's occurred — namely that forecasts were based on a view of gas supply which presupposed that the industry would operate under a short run supply constraint. This explanation also sheds light on forecasting on the basis of "linkage" or the theory that gas prices parallel those of oil because gas and oil compete in the same markets. Linkage represents a theoretical substitution response in which increases in the price of oil stimulate the demand for gas and, hence, push up gas prices. Large increases in the price of gas, however, will occur only under constrained market conditions. Furthermore, recent evidence indicates that the link between oil and gas prices has been broken (Petroleum Economist 1990). Thus, forecasts which continue to peg gas prices to those of oil will probably be wrong.

Third, we present a theoretical framework in which price behavior can be more accurately viewed and predicted. We propose that forecasts should be based on a view of gas supply which accounts for the effects of technological change on offsetting the cost-increasing effects of depletion. This perspective is fundamentally one of long run gas supply. In applying the theories of short and long run supply to the natural gas markets, we draw upon work developed by Tilton (1985) in the area of metals demand (Tilton, J. 1985).

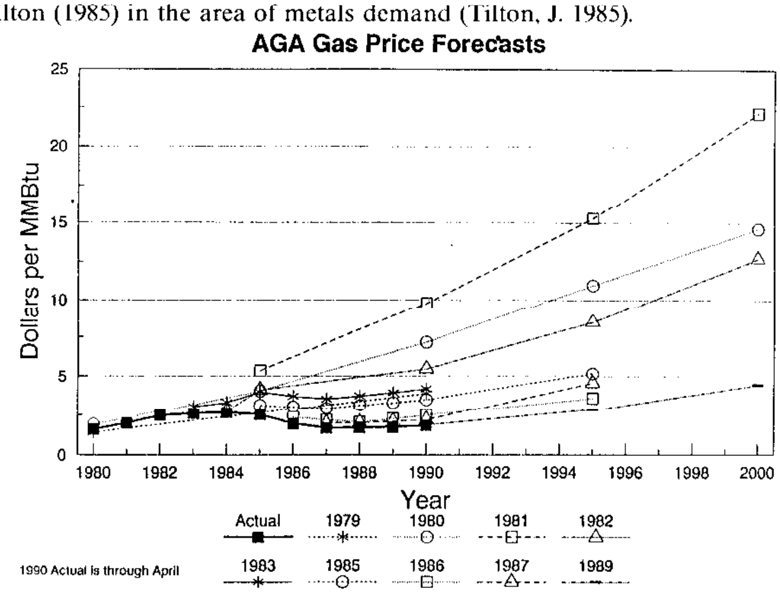

Figure 1. AGA gas price forecasts

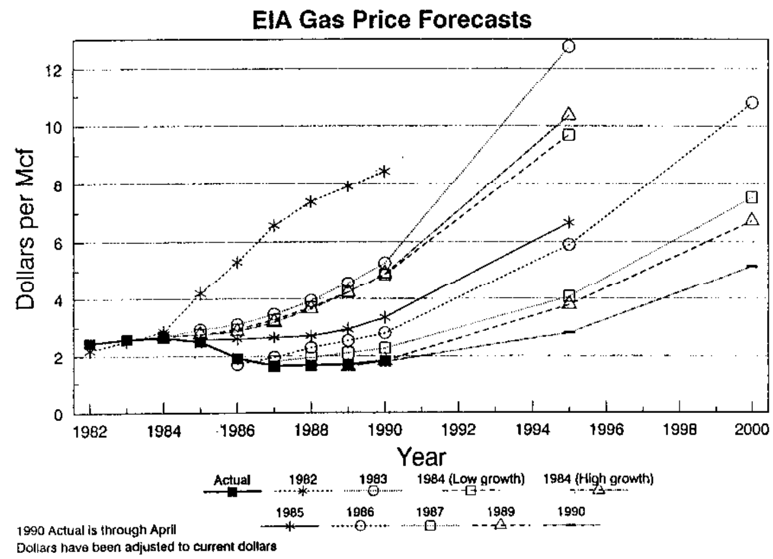

Figure 2. EIA gas price forecasts

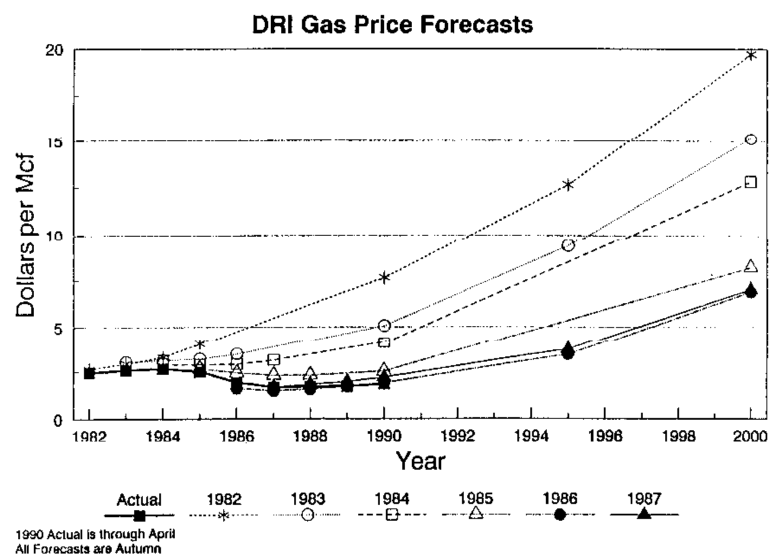

Figure 3. DRI gas price forecasts

SOME EVIDENCE

Price Projections by the Leading Forecasters

We reviewed twenty-eight major published forecasts of average U.S. natural gas prices performed by the American Gas Association (AGA), the Energy Information Administration (EIA), Data Resources, Inc. (DRI) and Wharton Econometric Forecasting Associates (WEFA) between 1979 and 1989. Figures 1 through 4 compare forecasts with actual prices (in nominal terms) over the period. Two observations can be made about the relationship between surveyed forecasts and actual prices. First, the accuracy of the forecast improves as the time between the year in which the forecast was performed and the forecast year decreases. Two, most of the forecasts predict prices substantially in excess of actual prices.

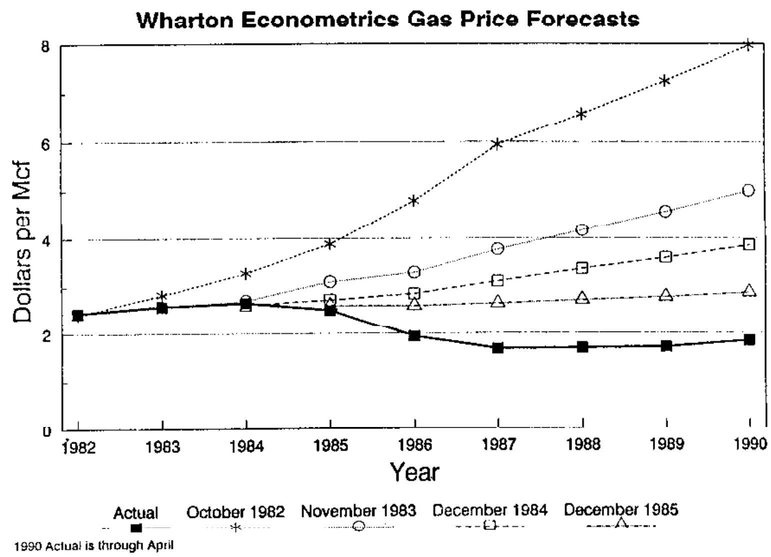

Figure 4. Wharton Econometrics gas price forecasts

What the History of Gas Prices Shows

Both regulatory and non-regulatory or market factors have determined wellhead gas prices since 1976. Monthly wellhead gas price data over the period January 1976 to July 1990 was used in this study. Between 1979 and 1984, for example, the wellhead price of regulated gas sales was subject to a price ceiling and a uniform rate of increase under the Natural Gas Policy Act (NGPA) of

1978. After January 1985, however, the amount of gas subject to such control was sharply reduced. This reflects a higher proportion of gas sold competitively rather than to pipelines at regulated rates.

Thus, the distinct decrease in prices beginning in 1985 is accounted for by the transition from a system of regulated to market-determined prices. While the break in 1985 can be visually observed with relative ease, it is not at all apparent from inspection that a transition period exists, much less the duration of such a period. More exact methods are required to determine the length of the transition period.

Three distinct phases in the series of gas prices over the period can be distinguished. These phases include: (1) the "NGPA Period" (January 1979 to December 1984); (2) the "Transition Period" (January 1985 to October 1986); and (3) the post-Transition or "Market Period" (November 1986 to July 1990). Regression analysis was used to estimate the cumulative average growth rate in gas price over the periods discussed above, and an exponential growth trend model was used to estimate the cumulative monthly growth rate. The result was adjusted to obtain an annual rate. Overall, the average annual rate of increase in nominal wellhead prices during the period January 1976 to July 1990 was 6.77 percent. The average annual growth rate during the NGPA period was 16.42 percent.

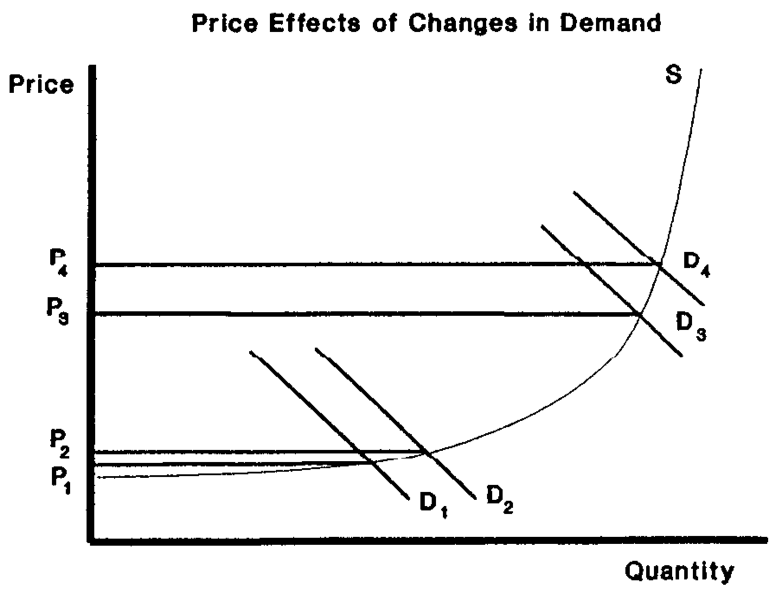

Figure 5. Price effects of changes in demand

A similar analysis was used to identify the duration of the Transition Period and following Market Period. In this case, an exponential growth trend model was used to estimate monthly growth rates beginning in January 1985. The sample size was increased month-by-month in order to determine any change in growth rate which might signal the end of the transition period. The Transition Period is characterized by a large negative growth rate, followed by very mild negative growth in prices in the Market Period. The Transition Period spans the twenty-two month period from January 1985 to October 1986. Average annual growth in gas price during this period was -26.70 percent. Average annual growth in prices in the Market Period was -.49 percent.

It is clear from even a cursory review of gas prices that the artificially high prices of the NGPA Period are of little value for predicting future gas prices in the new market system. While excising the NGPA period from the series of gas prices might solve the problem, such action leaves forecasters with relatively little data upon which to base future predictions. This solution also fails to address the factors underlying the over-forecasting problem which occurred during the early 1980's. In the next section, we propose a framework for addressing this problem.

THE PROBLEM — DIFFERING VIEWS OF GAS SUPPLY

Overview of Gas Supply

Price forecasts derived from underlying models of the natural gas market will necessarily be determined by the interaction of supply and demand. This is a critical concept in our discussion of short and long run industry supply to follow. In our analysis, demand is assumed to be exogenous (i.e., determined outside a hypothetical model system). Thus, the responsiveness of price to exogenous increases (or decreases) in demand will depend on the location of demand along the supply curve. This situation is shown in figure 5. For example, an increase in demand from D_1 to D_2 along the portion of the supply curve where there exists excess capacity (i.e., where supply is relatively elastic) will result in a modest (if any) increase in price from P_1 to P_2. Conversely, if the industry is operating along the inelastic portion of the supply curve, increases in demand from D_3 to D_4 will result in a relatively large increase in price from P_3 to P_4. The inelastic portion of the curve represents a constraint, either on operating capacity in the short run or on the known stock of the resource in the long run. These constraints and price behaviour under each scenario are examined more closely in the following sections.

A Short Run View of Gas Supply

If forecasts performed during the NGPA period predicted growth rates equal to those mandated by the legislation, then the over-forecasting problem could be reasonably dismissed on the basis that forecasters had no (or disregarded) information on when decontrol would occur. Several forecast growth rates, however, exceeded those mandated by the legislation. This assertion is based on comparisons between the rate of growth in gas price over the NGPA Period and the growth rates projected by the surveyed forecasts. These forecasts may have been based on expectations regarding the response of gas prices to market conditions when controls were lifted. The price "fly-ups" which were predicted to follow decontrol could have occurred only if a particular set of market conditions existed. The failure of prices to respond in the forecast manner reveals important information about market conditions as they existed after decontrol.

Over-forecasts of gas prices during the early 1980's might be due to a view of gas supply which presupposed that the industry was operating (and would continue to operate over the forecast period) under a capacity constraint. This constraint characterizes the short run industry supply of gas. Such a short run view of supply would lead to price increases such as those predicted by major forecasts surveyed in this study.

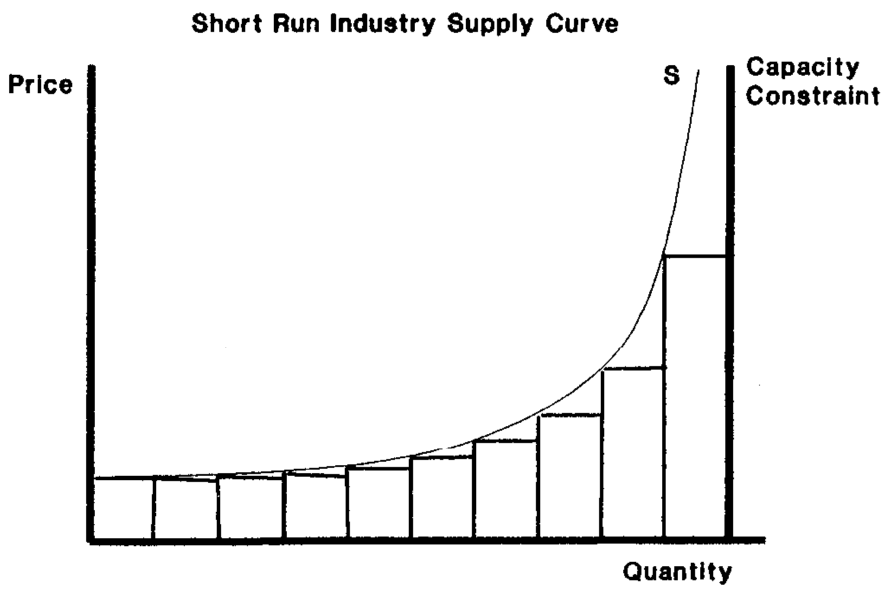

Figure 6. Short run industry supply curve

In the short run, producers have time to change only their level of output but not their capacity. The short run industry supply of gas is depicted in Figure 6 as a fixed, upward-sloping supply curve constrained by industry capacity. The short run industry supply curve consists, essentially, of current productive capacity arrayed in order of increasing short run marginal production cost. Tilton (op. cit., p. 399) specifies cost in the short run as average variable production cost. Average variable production costs provide a proxy for short run marginal production costs, given that the latter are considerably more difficult to estimate. Productive capacity is specified, for the purposes here, as total number of operating wells in the U.S. Thus, producing wells with lower marginal production costs form the relatively elastic portion of the supply curve and wells with higher marginal production costs form the inelastic portion of the curve.

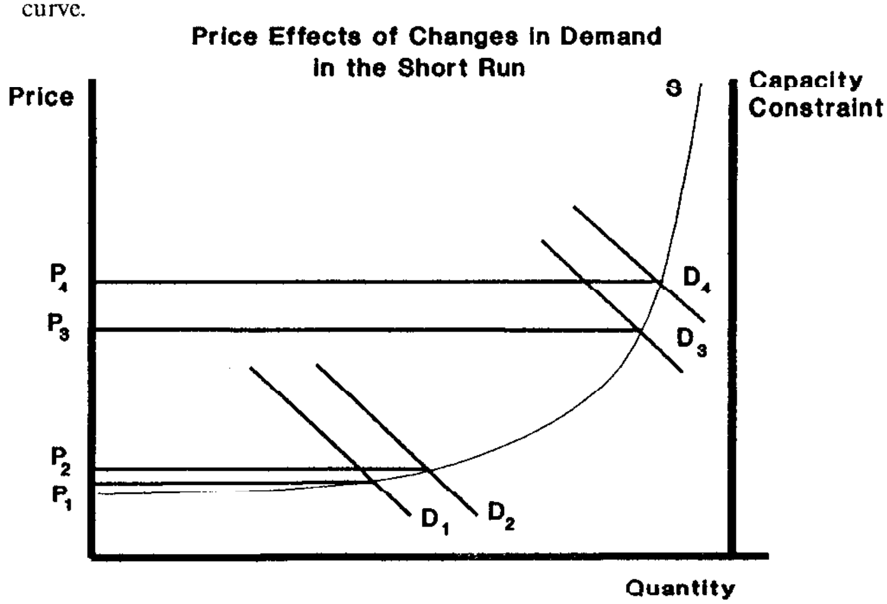

Figure 7. Price effects of changes in demand in the short run

The responsiveness of price to exogenous increases in demand under short run supply conditions is shown in Figure 7. For example, an increase in demand from D_1 to D_2 along the portion of the supply curve where there exists excess capacity (i.e., where supply is relatively elastic) will result in a modest (if any) increase in price from P_1 to P_2. Conversely, if the industry is operating close to capacity, increases in demand from D_3 to D_4 will result in a relatively large increase in price from P_3 to P_4.

Consistently high gas price forecasts may be explained by a view of gas supply which assumed that the industry would be operating along the relatively inelastic portion of the supply curve. Under these assumptions, forecasters would have expected the demand for natural gas to be in the inelastic range. If this constrained view of short run supply did underlie price forecasts, then anticipated demand increases would lead to the increases in prices which were predicted by the major forecasters. The proprietary nature of models which major forecasting services use precludes any knowledge about the form of such models (e.g., structural or non-structual). Any reference to models which underlie major forecasts, therefore, is pure speculation. The behavior of prices after decontrol, however, is inconsistent with a short run gas supply scenario.

Linkage

Industry practitioners and energy policy makers have adhered for many years to the theory that oil prices tend to tug gas prices along. Thus, many forecasters predict that gas will move in tandem with crude oil prices. This view, which we refer to as "linkage", has been and continues to be a leading theory which underlies gas price forecasting. See, for example, Klann, Susan Steiger, et al., "On the Threshold", Oil and Gas Investor, November 1989, 9(4), pp.50-63.

Linkage is accounted for by the substitutability of residual fuel oil and gas in dual fuelled industrial and electric utility applications. To the extent that increases in the price of oil may stimulate the demand for natural gas, the resulting responsiveness of natural gas price (i.e., the magnitude of price changes) will depend almost entirely on current gas market conditions. Thus, according to its proponents, linkage is the driving force behind shifts in the demand for natural gas along the short run industry supply curve.

For example, if increases in demand occur along the elastic portion of the short run supply curve (see Figure 7), the resulting price increase will be slight. Conversely, if increases in demand occur along the inelastic portion of the short run supply curve, the resulting price increase will be greater. The mild increases in gas prices observed over the past several years, however, cannot be explained by linkage. Thus, forecasting and attendant policy making based on the linkage theory has proven wrong and is likely to prove erroneous in the future. The Natural Gas Policy Act of 1978 (NGPA) is a good example of the use of linkage as a basis for forecasting gas price. The protectionist policies embodied in the NGPA were designed, in large part, to protect consumers from large projected gas price increases expected to result from increases in crude oil prices. Under these assumptions, price ceilings on certain types of gas and uniform price increases on regulated sales to gas pipelines were legislated. The authors of the NGPA, however, crafted the legislation using oil price projections that proved to be wrong.

The behaviour of oil prices in the wake of the Iraqi invasion of Kuwait in August 1990 provides a unique opportunity to assess the short run behavior described above. While oil prices soared with the threat of Middle East conflict in early August of 1990, natural gas prices failed to respond in kind. In fact, the $1.33 per MMBtu median spot price of natural gas for September 1990 — four weeks after the invasion — was only three cents higher than the $1.30 per MMBtu spot price recorded for August 1990 and eight cents lower than the $1.41 per MMBtu spot price recorded for September 1989. See, for example, monthly spot market prices reported by Fosters Natural Gas Report. Indeed, the failure of gas prices to respond to an increase in the price of oil in the short run indicates that excess capacity in the market exists. In other words, the natural gas industry currently operates along the elastic portion of short run supply. Therefore, any upward pressure on gas demand would not result in a substantial price increase.

In sum, the predictions of major forecasters over the past several years are more in keeping with a constrained view of short run industry supply. The history of gas prices over the past fourteen years — including periods of both market and non-market price determination — are not supported by this short run supply scenario.

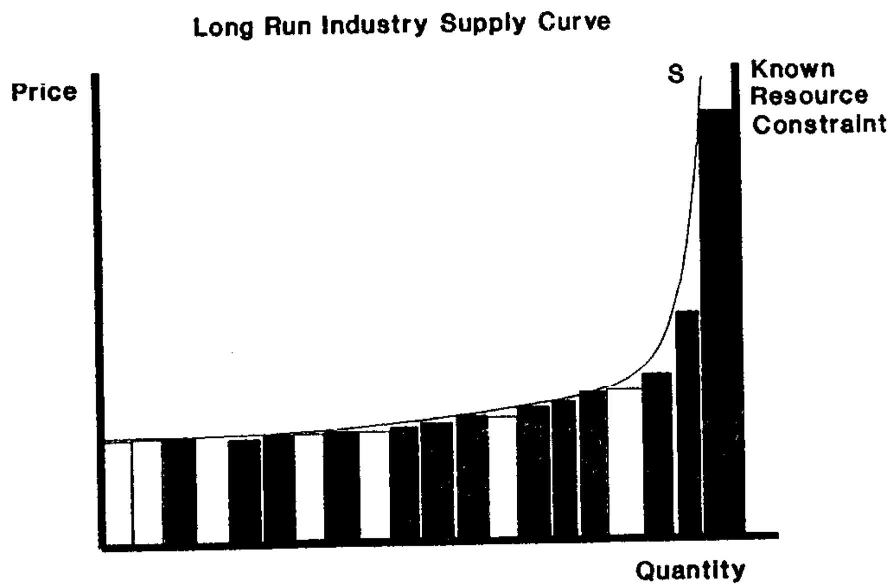

Figure 8. Long run industry supply curve

A POSSIBLE SOLUTION — INCORPORATING TECHNOLOGICAL CHANGE IN FORECASTS

To some extent, we can better explain the actual behavior of gas prices during the period following decontrol by viewing the long run characteristics of market supply. In contrast to the short run, the long run reflects a period of time in which producers can expand the capacity of existing operations. In the long run, producers can develop previously uneconomic resources and explore for new resources. The relevant constraint on long run supply, then, is the total amount of gas known to exist in the resource base. (Tilton, op. cit., p. 398.)

As shown in Figure 8, the long run supply curve consists of producing wells and known but undeveloped resources (i.e., future wells given by the shaded areas) arrayed in order of increasing long run marginal cost. Tilton (op. cit., p. 413) specifies cost in the long run as average total production cost. Average total production costs provide a proxy for long run marginal costs, given that the latter are considerably more difficult to estimate. When viewed at a point in time, the portion of the curve over which supply is relatively elastic represents the effect of technological improvement on the development of new wells. Advances in technology lower the cost of recovering portions of the resource base. Under older technology, these reserves may not have been recoverable. As well, technological improvement permits both exploration and exploitation of new reserves. Over time, such improvements are reflected in downward shifts in the supply curve.

The controlled nature of gas prices during the NGPA period (1976 to 1984), of course, precludes the applicability of the long run theory of gas supply. The relatively stable behaviour of wellhead prices during the period in which market forces determined prices, however, may be better explained by the effect of technology on lowering the costs of exploration and development. Unfortunately, the market period is still relatively new, providing us with very little price data over which to observe the hypothesized stability. The next step in the development and empirical testing of this theory is the estimation of a long run supply curve. This topic is taken up in ongoing work by the authors. As a first step in this direction, the next section summarizes recent technological developments in the gas industry.

TECHNOLOGICAL CHANGE IN THE NATURAL GAS INDUSTRY

Specific Developments

We have suggested that the long run behaviour of natural gas prices is due, in large part, to the effects of technological change on offsetting the cost-increasing effects of depletion. In this section, we document support for such a theory in the technical literature. For example,

> In recent years, advances in the fields of geosciences and drilling technology have resulted in notable additions of the global hydrocarbon resource base .... However, these changes have not been recognized

> (emphasis added) by many energy analysts and are neglected in resource estimates or long-term energy projections. Although technological advances are not confined to any particular area or type of fuel, there is a growing body of evidence that in all probability, the balances will tilt in favour of natural gas. (Rogner, H-H 1988).

A review of the technical literature brings to light evidence which suggests that both drilling technology and geological knowledge in the natural gas industry have improved over the last decade. The advent of horizontal drilling, for example, has changed the timing and method of extraction. For example, "... innovative oil men are using this development (horizontal drilling) to produce oil at current prices rather than simply waiting for the market to improve before initiating development." (*Oil and Gas Journal*, September 24, 1990, pp. 70-79). The American Gas Association cites horizontal drilling along with other technologies as responsible for greatly improved natural gas exploration and development results. Finally, "No single technology is responsible for these emerging trends ... . Typically, many diverse technologies have combined to improve capability or efficiency of the E&P process." (*Foster Report* No. 1792, September 28, 1990, p. 20). Evidence of lowered extraction costs is reflected in reported recovery costs. For example, nominal recovery costs per foot for all depths under 20,000 feet were lower or about the same in 1988 as in 1976 and substantially lower for all depths in 1988 than 1981 (US Energy Information Agency, 1990).

The effects of better knowledge on enhacing exploitation of already known fields is discussed in a recent Argonne National Laboratory consensus study (Argonne National Laboratory, 1988). As well, a Rand Corporation study indicates that after the 1973 crisis, "western exploration and development boomed in all major e..ergy sources supported by rapid technological innovation that was quickly diffused worldwide (Gustafson, 1989). Finally, expansion of the base of geological information and improvements in drilling results has been made possible by modern information management techniques (satellite surveys, computer data processing, etc.).

Advances in recovery technology, coupled with better information on existing fields, have led to increases in reserve estimates. The Argonne National Laboratory study at Appendix 2: "Reserve Growth on Nonassociated Gas Reservoirs" by the Bureau of Economic Geology and at Appendix 4: "Gas Recovery Technologies" documents, in some detail, the process by which such factors act to increase economically recoverable resources from known and already partially depleted natural gas reserves. Least expensive discoveries of new reserves are often in developed areas "America's Oil, Look Again," *The Economist*, June 3, 1989, pp. 70-71. This article is apparently based, in part, on the American Association of Petroleum Geologists' report cited below. In addition, information acquired through exploration in heavily exploited areas makes possible new discoveries. Similar observations are made for oil reserves. The American Association of Petroleum Geologists recently reports that:

> The average size of future new field discoveries will be orders of magnitude smaller than those experienced during the early part of the century when giant fields were being discovered, but the drilling boom of the 1970's and 1980's showed that reserve volumes can be added directly in proportion to drilling activity. The drilling boom also demonstrated the potential for substantial reserves growth in already discovered fields through in-fill and step-out drilling and through improved recovery methods (AAPG 1989).

TABLE I. Estimated proved[1] world reserves of natural gas[2] annually as of January 1 (trillions of cubic feet)

Year	United States	Total Western Hemisphere[3]	Middle East	Africa	Asia-Pacific	Western Europe	Total Free World	Communist Nations	Total World
1967	289.3	398.9	215.1	158.2	32.5	87.7	892.4	150.9	1,043.3
1977	216.0	362.3	535.9	209.1	120.0	140.9	1,368.2	954.5	2,322.7
1987	191.6	475.1	925.3	201.4	198.6	229.7	2,036.4	1,595.8	3,632.2
1988	187.2	511.4	1,084.0	248.6	224.8	218.2	2,287.5	1,510.0	3,797.5
1989	187.2	518.4	1,182.1	253.3	240.7	200.1	2,394.6	1,560.7	3,955.3

1 "Proved" means recoverable with existing technology in place, and is more narrow than the definition used in Table 1 by the Argonne National Laboratory.
2 Table adapted from American Petroleum Institute Basic Petroleum Data Book, Petroleum Industry Statistics, Vol. IX, No. 2, Section XIII, Table 1, May 1989. They cite their sources as:
1967-1980: United States: American Gas Association, Committee on Natural Gas Reserves.
1981-1988: United States: Department of Energy; Rest of the World: The Oil & Gas Journal, "Worldwide Report" issues.
1989: The Oil and Gas Journal, "Worldwide Report" issue.
3 Includes Latin America and Canada.

The Reserve Picture

A look at U.S. and world reserves of natural gas indicates that the technological trends described above have acted to increase the amount of economically recoverable gas. Table 1 shows that world reserves of natural gas recoverable under existing operating conditions have increased four-fold from 1967 to the present. On a world scale, then, gas reserves are certainly rising, not falling.

Total reserves recoverable with present operating conditions is, however, much less than total recoverable reserves. The Argonne National Laboratory of the United States Department of Energy estimated present total, technically recoverable U.S. reserves at 1,118 Tcf, 1,059 Tcf of which are located in the lower 48 states (see Table 2). ANL, op. cit., p.2. Amounts estimated to be recoverable at $3.00 or less per thousand cubic feet equal 595 Tcf (of which 583 Tcf are in the lower 48 states) while another 176 Tcf (174 Tcf in the lower 48 states) are recoverable at costs from $3.00 per MMBtu to $5.00 per MMBtu. It appears from these data that most domestic U.S. reserves are located in the lower 48 states and are recoverable at costs under $3.00 per MMBtu, (1 Mcf of natural gas has approximately 1 MMBtu heat content).

TABLE II. Argonne National Laboratory Consensus Study

Economically Recoverable Reserves with Presently Known Technology

	Reserves	
	Total U.S.	Lower 48 States
	(Tcf)	
	(1)	(2)
At $3 per MMBtu or less	595	583
At $3 to $5 per MMBtu	176	174
Total Under $5	771	757
Total Reserve	1,118	1,059

Source: Argonne National Laboratory, *An Assessment of the Natural Gas Resource Base of the United States,* May 1988.

A number of gas industry observers have suggested that the current annual rate at which reserves are replaced is equal to or higher than annual takes. Even if this is not true, however, there may be considerable reserves at present take rates. It is useful, in assessing the reserve picture, to assume that annual U.S. consumption is approximately 20 trillion cubic feet (Tcf). Actual present consumption in the United States was as low as 16.2 Tcf in 1986, declining from about 19.9 Tcf in 1980 (*International Energy Annual*, Department of Energy, Energy Information Administration, 1987, p.96). At this rate of consumption in the U.S., we expect that from a production standpoint, a 30 year supply is available at prices at or below $3.00. When the long term effects of reserve replacement and technological advance are considered, such a period of moderately priced natural gas may be considerably extended. That is, the evidence briefly surveyed above suggests that the industry is located along the elastic portion of the long run supply curve.

CONCLUSIONS

We began this paper with comments on the importance of energy price forecasting — gas price forecasting, in particular — in planning and production decisions. When an entire class of forecasts proves to be consistently incorrect, then, there is ample reason for concern. We have proposed and investigated a likely cause of the over-forecasting problem in the natural gas industry — that historical long term forecasts have been based on a short run view of gas supply. This is true particularly for the price fly-ups predicted for the period directly following decontrol in the U.S. Decreases in gas prices following decontrol in 1985, however, may be better explained by a long run supply scenario in which technological change offsets the cost increasing effect of resource depletion. Clearly, a more detailed look at long run gas supply is the next logical step in investigating the proposals presented here.

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