

A Comparison of Natural Gas Spot Price Linear Regression Forecasting Models

Problem Statement

The market for natural gas in the United States is predominantly influenced by the heating season demand. Natural gas prices in the U.S. fluctuate from highs in the winter heating season to lows during the summer. These prices fluctuate daily in response to factors of which present air temperature is a key member but does not appear to be the only factor. If these fluctuations could be predicted with greater precision, efficiency gains could be realized. This paper seeks to analyze which variables influence natural gas prices and develop an equation which will predict the price of natural gas one month in the future during the heating season.

Hypothesis

The U.S. Dept. of Energy, Energy Information Agency, (EIA) has developed a number of energy commodity models. One of these models seeks to predict the future spot price of natural gas at the wellhead. This model takes the explanatory variables to be the one month lagged spot price, deviations of natural gas in storage from the historical average, and deviations in ambient air temperatures from their historical average. This model is a reduced form equation that uses historical time series data to explain spot price fluctuations. Forecasting models often represent a tradeoff in information versus model structure. The addition of other variables may for example explain a historical period relatively well, yet the addition of these variables may not necessarily improve the forecasting ability of the model. In some cases it is quite difficult to obtain accurate forecasts and in others the addition of new variables introduces multicollinearity and other econometric problems. At any rate, forecasting models typically use fewer regressors in an attempt to minimize mean squared error. The EIA spot price model for natural gas uses two variables and the lagged value for spot price as the foundation of its model, which brings into question the potential bias in the EIA estimator due to the omission of other relevant variables. This paper proposes that other variables can be added to the EIA spot price model that can improve upon the explanatory power during the historical period and improve upon its forecasting properties.

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Overview of the Market and Industry of Natural Gas

The market for natural gas is normally categorized as comprising four separate markets: residential, commercial, industrial, and electric generating utilities. These markets have quite different consumption patterns and prices. The demand for natural gas is a derived demand. It is "derived" in the sense that it is an essential fuel for heating, cooking, electric generation, and it also serves as a feedstock for industrial uses such as fertilizer production. The objective functions of consumers, commercial, industrial and electric generation utilities help determine in a very real sense the demand for natural gas. The supply depends on natural gas stockpiles, pipeline capacity and existing well production. The variables on both the demand and supply side help to determine the prices of gas in the market at any given time. In addition financial markets also play a role and expectations today may well affect price a month in the future.

The residential consumption pattern appears to be directly proportional to heating load. Heating load is primarily dependent on weather conditions. Heating load relates most directly with air temperature but is also related to local wind velocity and to a lesser extent with the duration of low temperatures. The consumption pattern for the commercial and to a lesser extent the industrial markets are also related to heating load. Figures 1 and 2 display the consumption patterns for these four markets.

The origins of industrial consumption are more complicated. It is dependent on a variety of factors which vary with what portion of the country and what industry is examined. The prosperity of the U.S. economy is one factor which appears to affect industrial demand. Another factor in industrial demand is heating load which accounts for the consistent winter time peaks. Industrial electrical generation is a third major factor in the rapidly increasing rate of industrial natural gas consumption. The de-regulated environment for electric generation has fostered the creation of companies which purchase or build electric generating facilities which sell electricity for profit to the local electric utilities. These companies often purchase generating facilities from electric utilities. This generation is then re-classified as industrial instead of electric utility, even though the electricity produced from the same amount of natural gas is sold to the same electric utility.

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An additional factor in the increased industrial (as well as electric generating utility) consumption of natural gas is the trend to use natural gas for a larger percentage of base loaded operating electric generating units. This trend has two driving forces. Most of the new large scale generating units being built today make use of new high efficiency combined cycle units that utilize new gas driven turbine technology.

The second cause for this trend is the increasingly stringent federal Clean Air regulations. The cost to modify existing coal fired generating units to meet Clean Air requirements is often much more expensive than the cost to bring natural gas pipelines to their door and to make minor modifications needed to run on natural gas.

The consumption pattern for electric generating utilities is quite opposite from the other three markets in that the peak period for consumption is during the summer months when the heating load is non-existent. Since natural gas prices are lower during the summer, the fuel is in plentiful supply, and it burns with the least pollution emissions, electric generation companies will choose to burn natural gas. The boilers and turbines which burn natural gas during the summer are usually designed to burn #2 oil as well. During the winter these machines are often switched to #2 oil.

The price of natural gas for each market is markedly different as displayed in Figure 3. The price for residential gas is the most expensive and has had consistent peaks during the summer months. These pricing peaks are attributed to the fact that natural gas local distribution companies charge more per standard cubic foot (scf) of natural gas for low consumption but less per scf at higher consumption rates. Since the consumption use of residential customers is so low during the summer they pay the higher rates for low consumption. A key factor in the consistently higher rates of residential gas prices each month is that residential customers pay a on-demand charge as part of their cost of gas. This gives them the right to continuous, "firm" gas service. Some commercial and most industrial and electric generating utilities purchase gas on an "interruptible" basis. Their contract for gas service gives them lower price rates for which they agree to allow the local distribution gas company to interrupt their service under a set of pre-negotiated conditions. Another factor in these lower rates is that these three markets have higher consumption rates

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Historical Perspective

The use of gas as a fuel for light and heating has been commonplace since the 1840's. Many of the large cities in the United States have distribution networks which have piping sections that were installed over 100 years ago and have been in continuous service since their installation. The original source of gas was coal and oil. Industrial facilities were built which manufactured gas from coal and oil. During the 1930's the use of natural gas began to replace manufactured gas as the source of gaseous fuel. The gas industry was a heavily regulated industry from the time of the Great Depression of the 1930's to the end of the 1970's. The gas industry was perceived as a natural monopoly and as such, needed to be regulated.

The natural gas industry is usually categorized as being composed of three different activities:

- a) Production from the wellhead where the natural gas is released from the earth and collected by a system of field piping and gas cleansing devices which are used to refine the natural gas to a commercially consumable product.
- b) Transmission from the well gathering fields to areas of customer concentration
- c) Distribution to customers in a concentrated area.

Regulations were imposed which required that companies only engage in one of these three activities, production, transmission or distribution. The four types of consumers: residential, commercial, industrial, and electric utility were restricted to obtaining gas from only one source, their local distribution gas company.

This regulated system appears to have worked fairly well for several decades. It allowed the market for natural gas to expand so that it became a common fuel in all three markets. The use of gas as a source of energy increased from 16% in 1949 to 32% in 1971. At the beginning of this period of regulation the gas industry was made up of isolated piping networks located in cities which were large enough to finance the construction of gas manufacturing stations. During this regulatory period the gas industry continued its evolution from a manufactured gas industry to a natural gas industry. Production fields expanded and transmission pipelines were built from the wellheads in and around Texas to the large urban markets throughout the United States.

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The regulatory bodies passed rules which governed the manner in which the local distribution companies could purchase gas. Gas was purchased not as a commodity but as a bundle of services covering the removal from the earth, transmission and storage. Transmission companies were regulated as to the pipelines they could build and the prices they could charge to transport gas. Transmission pipelines could only be licensed for construction when a new production field showed sufficient capacity for twenty years production and long term commitments for the purchase of this gas were established. Only two types of bundles of services were offered the distribution companies: Firm deliveries or Interruptible deliveries. Prices for these bundles of services were regulated.

The use of gas was widespread throughout the U.S., however the manner in which the regulatory environment had allowed the gas industry to develop caused fundamental weaknesses. The system of rigid price controls in all three areas of gas activity and in all four markets could not function in a world of rapidly changing prices that had come to pass during the early 1970's. The price that natural gas production companies were allowed to charge didn't provide enough economic benefit to perform enough well exploration to bring in enough new generating wells to keep up with demand. One of the regulatory responses was to institute a moratorium on natural gas customer growth. Another weakness that came to be recognized was the physical structure of the transmission piping network. There were not a lot of interconnecting transmission pipelines between the major customer areas nor between the transmission lines themselves. This prevented areas with excess transmission piping capacity from providing gas to other areas of the U.S. which had insufficient capacity during heating season peaks.

The natural gas industry underwent a dramatic transformation from the late 1970's to the early 1990's. This transformation came as a result of the de-regulation of major portions of the natural gas industry. The cornerstone of this de-regulation was the issuance of FERC Order 636 which allowed open access of natural gas transmission pipelines and allowed the unbundling of the ownership and transportation of gas. With open access and unbundling a distribution company for natural gas could make a contract with any number of gas production companies to transport gas to the area of usage. The de-regulation of the 1980's stimulated the construction of a wider network of transmission pipelines which by 1995 had created a