The Future Supply-Demand Balance of Salt—A View of the U.S. Bureau of Mines

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ABSTRACT

Political, economic, and social events occur daily in modern society and affect the operations of industry and government. Decision makers in both sectors must confront present problems as well as anticipate future ones. As a result, projections and forecasting have become important tools of the decision making process. Forecasting the supply-demand balance of salt enables analysts in the salt industry and in the government to determine the competitive position of the company and the country, respectively, in the world market. Reliable forecasts are obtained by having an integrated data collection and interpretation system as well as a suitable method to obtain statistical projections.

INTRODUCTION

Statistics is defined as the mathematics of the collection, organization and interpretation of numerical data. The value and quality of any data are dependent on the method of collection and the reliability in the accuracy of the data. Once the quality of the data has been evaluated, some degree of confidence can be given to the interpretation of the data. How the data is interpreted will influence the forecast.

Salt is one of more than 80 mineral commodities that the Bureau of Mines forecasts end use consumption to 1990 and beyond. Although historic data on salt consumption is used to project future demand, it should be realized that forecasts do not take into account unforetold events that can influence the supply-demand situation, such as sudden changes in the economy, consumer attitudes and preferences, and natural phenomena like the weather. Forecasting short range weather conditions is difficult and often unreliable. Forecasting long range weather conditions is impossible; therefore, forecasting salt consumption to 2000 for end uses such as highway deicing, which is dependent on the weather, is unrealistic.

DATA COLLECTION

The need for procuring accurate mineral statistics was first recognized by the U.S. Geological Survey in 1880. In 1882, an annual report entitled "Mineral Resources of the United States" was published. It contained information and statistics relating to the mining and mineral industry in the United States. After the Bureau of Mines was formed in 1910, the publication eventually evolved into the Minerals Yearbook as it is recognized today.

Although the reporting of salt statistics on an annual basis began with the 1882 report, the report contained historical data back to 1797 for select salt producing states. For example, Onondaga Salt Springs in New York produced 25,474 bushels of salt in 1797 (equal to 713 short tons), and during the same year, salt production in Kanawha County, West Virginia was reported to be 150 pounds per day. Historical data provides a time series for showing trends and for the basis of forecasting.

A canvass form is the easiest method for collecting mineral data. Although data collection through canvassing is a laborious and time consuming process, the quality of the information is only as good as the effort put into the process. Salt statistics are surveyed annually by the Bureau of Mines. In 1983, 44 companies operated 83 salt-producing plants in 15 states and provided the Bureau with information for each type of salt concerning quantities and values of salt sold or used, end use consumption, destination of shipments by state, imports for consumption by end use and other important information.

Changes in the canvass forms have occurred through the years to reflect the needs of the salt industry, the government and the public. The original surveys were mainly interested in production data; however, the canvass was expanded in 1941 to include end use consumption data. This change helped market analysts identify the growth potential in certain sectors. In 1970, the form was again modified to include imports of salt by end use, and in 1981, the term "evaporated salt" was changed to show the differentiation between solar evaporated salt and vacuum pan-open pan mechanically evaporated salt. Modification in the salt canvass forms are ongoing and will continue to be in order to respond to the changes and needs of industry and government.

DATA INTERPRETATION

After the data has been collected, it must be interpreted, or analyzed, to ensure accuracy and quality. A series of data often may reveal a particular trend in the data set. A trained analyst generally can identify irregularities in the data and can evaluate the meanings of these trends. For example, as noted in Table 1, the domestic population and consumption of salt generally followed a positive trend for the 100-year period 1880 to 1980, during which time the population increased 4½ times and per capita consumption rose eightfold. The growth in per capita consumption reflected the changes in the uses and quantities of salt as industrialization evolved and as population increased. In 1880, the major uses of salt were mainly for flavoring and food preservation, while in later years, salt would be used in the production of many inorganic chemicals, metal, rubber, petroleum, and used to deice roads.

While the population continued to rise between 1970 and 1980, actual consumption declined. This decrease was attributed to the beginning of public awareness and concern regarding the adverse effects that salt had on the environment (excessive road deicing affects local vegetation), on human health (hypertension linked to high-sodium diets), and on property (metal corrosion on vehicles, roads and bridges). Also, the energy crises in the early and late 1970s resulted in the closure of several energy-intensive operations, such as in the synthetic soda ash industry, which consumed large quantities of salt.

TABLE 1

Historical U.S. Per Capita Consumption of Salt

Year	Population (Millions)	Consumption (Million Short Tons)	Per Capita Consumption (Pounds)
1880	50.2	1.3	52
1890	62.9	1.2	39
1900	76.1	3.1	82
1910	92.4	4.3	94
1920	106.5	6.9	128
1930	123.1	8.0	131
1940	132.6	10.2	155
1950	152.3	16.4	216
1960	180.7	26.1	289
1970	204.9	49.0	478
1980	223.0	44.8	402

1880–1980 = 100 years
Population grew 4.5 times
Per capita consumption grew 8 times

FORECASTING METHODOLOGY

Collecting data is meaningless unless something useful can be done with the data. Although compiling data into a table may be useful for documenting historical information, the data can also be used to produce supply and demand forecasts. A supply and demand forecast is a statistical estimate of the future availability and need of a particular commodity or service. After the data has been collected and the quality has been evaluated, a statistical analysis and a contingency analysis can be performed.

Statistical Analysis

The foundation for projecting domestic salt consumption by the Bureau of Mines is based on a computerized end use analysis system using the least-squares, or regression, analysis method that produces a statistical projection. The system estimates the fundamental regression equations and the related coefficients of determination (known as R^2). The results present information regarding which macroeconomic indicator best interprets the historical pattern of end use consumption, and consequently which estimated relationship should be used as a basis for generating end use statistical projections.

A statistical projection is obtained by correlating historical end use data with various macroeconomic indicators, such as U.S. population, gross national product (GNP), and several indices of U.S. industrial production activity. As shown in Appendix 1, the Bureau of Mines presently uses 71 macroeconomic variables compiled and published by the Department of Commerce, Bureau of the Census and the Federal Reserve Board (FRB). The majority of the indicators are the FRB indices of industrial production which are measures of activity in the industrial sector of the economy. The Census Bureau's "Censuses of Manufactures and Mineral Industries" report and the "Annual Survey of Manufactures" report, data made available by certain trade associations, and other industry sources, are used to compile the raw data for the industrial production indices. These indices are a ratio of the previous, current and subsequent monthly, quarterly, and annual raw data for each industrial sector, and the 1967 raw data, which is the Federal comparison base year (in which the index is equal to 100).

When using regression analysis for statistical projections, it is assumed that the previous empirical relationship will continue in the future and forms a forecast base for deriving a range of high and low forecasts. If the past relationship is not expected to continue in the future, then contingency analysis is applied to each end use separate from the statistical projection.

Contingency Analysis

A contingency analysis produces a contingency forecast and is used whenever the statistical projection indicates that the coefficient of determination is too low to be statistically significant, generally less than 0.70 (1.0 coefficient of determination signifies perfect correlation), or when the analyst has reason to believe that certain current or anticipated events may alter future trends. This type of analysis is highly subjective and judgmental, and varies from commodity to commodity and for the various end uses of a commodity. The contingency forecast is based mainly on the historical data pertaining to the end use of a commodity, and the events or developments that could have an impact on the future use of a commodity. These developments include:

- new technical achievements
- unprecedented price changes
- competition from substitutes or alternatives
- environmental restrictions
- changes in supply
- consumer attitudes or preferences.

In the Bureau of Mines' forecasting methodology, a contingency analysis of end use demand includes three forecast scenarios: a high range forecast is selected to reflect optimistic assumptions regarding that particular use of the commodity; a low range forecast is generated to indicate more conservative assumptions that may eventuate; and a probable forecast is formulated to show which is the most likely assumption to occur based on present knowledge and an appraisal of developments.

SALT FORECASTS

Twenty-one years of historical salt consumption data by end use were used to forecast demand to 1990 and 2000 using the statistical demand projection system previously discussed; however, total primary production and total primary demand were projected to 2000 by simple linear regression, as shown in the computer-generated Figure 1. As indicated in Figure 1, total domestic demand for salt historically exceeds total production. This is attributed to the long-term reliance on imported salt, mainly due to favorable economic considerations rather than domestic supply problems.

Table 2 lists the various macroeconomic indicators with their corresponding coefficients of determination that correlated best with the data. Also included are the statistical projections obtained previously from the 1980 Mineral Facts and Problems chapter on salt. As noted, most of the coefficients of determination in both analyses were less than the optimum 0.70 needed to signify strong correlation.

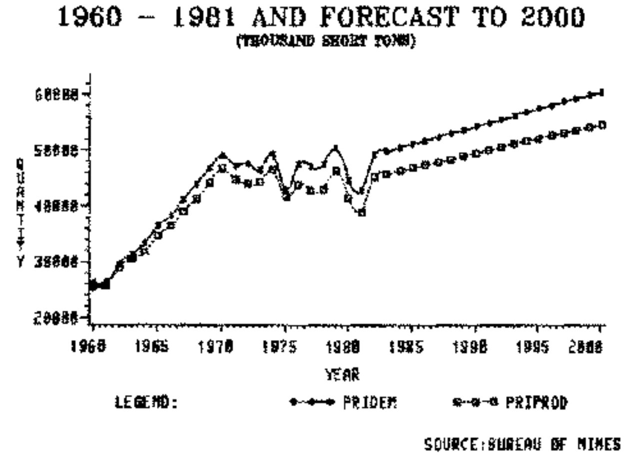

Figure 1. U.S. Primary Demand and Production of Salt.

Statistical Analysis Problems—and Answers

An investigation to determine the reasons why successive statistical analyses produced unreliable projections revealed that the problems were primarily in the benchmarking of the economic indicators rather than in the data or the forecasting methodology.

The Federal Reserve Board monitors 235 industrial sectors that produce goods and materials (expanded to 260 in 1984) and generates a macroeconomic indicator for each, many on a monthly basis. Because of the difficulty in canvassing complete industrial sectors to obtain monthly production data in order to publish a monthly Industrial Production (IP) Index, the FRB uses monthly reports of kilowatt-hours consumed (obtained through the Federal Reserve System) and man-hour data (obtained through the Bureau of Labor Statistics) to track the sectors where actual product output is not available.

About 60% of the 235 macroeconomic indicators are based on the actual quantities of goods and materials produced (output indicators) and 40% are from energy and employment data (input indicators), which are used to generate "Production Adjustment Factors" that approximate output quantities. Therefore, more than half of all indicators are actual productivity measures of the domestic manufacturing industry and the remainder are adjusted. Of the 71 macroeconomic indicators that the Bureau of Mines uses (out of a total of 235), 61% are categorized as output and 39% are input (see Appendix 1).

The FRB uses the quinquennial "Censuses of Manufactures" publications (1967, 1972 and 1977) to update, revise and benchmark the output indicators. The input indicators are also benchmarked at this time with actual product data for those industries which, for the previous five years, were tracked using only kilowatt-hours and man-hours as the sources of data. As a result, the Production Adjustment Factors usually do not correlate with the

TABLE 2

Statistical Analysis of Salt (Data in Thousand Short Tons)

			Current Analysis		Previous Analysis**	
End Use	**Best Macroeconomic Indicator**	**Best R^2**	**Base Year 1981**	**Statistical Projection**	**Base Year 1978**	**Statistical Projection 2000**
Alkalies and chlorine	petroleum products	.62	22,722	32,629*	24,511	58,000
Other chemicals	agriculture chemicals	.10	1,133	864*	1,159	0*
Deicing	total production	.70	8,257	24,581	10,690	21,000
Paper products	population	.38	247	273*	221	470*
Food products	gross private investment	.33	2,203	3,580*	2,815	3,800
Agriculture	total production	.69	1,788	3,144*	1,851	2,900
Metal production	metal cans	.82	294	676	346	790
Rubber	tires	.02	102	153*	96	180*
Petroleum	rubber and plastic products	.66	837	1,268*	451	620*
Textiles and dyeing	synthetic materials	.14	220	149*	182	120*
Water treatment	paints	.80	1,006	1,838	890	1,500
Other	new construction	.10	3,371	5,783*	4,261	6,500*
Total			42,180	- - -	47,473	- - -

*have R^2 less than 0.70

**from 1980 Mineral Facts and Problems

newly benchmarked input indicators, thereby creating problems when attempting to use input indicators in forecasting. The FRB states:

> "Compilation of current monthly IP series for the period since 1973 involves various problems of extrapolation. These problems are generally less serious, however, for series based on monthly physical product data, which account for nearly one half of total IP, than for IP series based on monthly measures of input such as kilowatt-hours or man-hours."[1]

The macroeconomic indicators used to produce the statistical analyses shown in Table 2 were benchmarked using the 1972 Censuses of Manufactures report, which was prior to the energy crisis in 1973. Because of increased fuel costs, most industries strived to conserve energy while maintaining productivity. This change in energy consumption biased the indicators in which kilowatt-hours were being used to track that particular industrial sector. Likewise, the two economic recessions in the past decade have affected employment, especially in industries that have converted to automation or robotics. Although productivity may have been maintained, man-hours as a tracking tool has affected the input indicators.

In summary, it is this author's opinion that if the indicators used in Table 2 were benchmarked using the 1977 Censuses of Manufactures data, although unavailable at the time, the statistical projections and coefficients of determination would have been better.

Contingency Analysis and Forecasts

As stated earlier, a contingency analysis may be used whenever the reliability in the statistical analysis is uncertain. Figures 2 through 4 graphically show the historical and projected trends of the major and minor end uses of salt to 2000. The following contingency analyses for selected end uses take into account the recent technical and social events which may alter the future demand for salt.

Chloralkali—the major end use of salt. Over one half of the annual domestic demand for salt is for the production of chloralkali chemicals, namely, chlorine, caustic soda and soda ash. Figure 2 shows the historical demand for

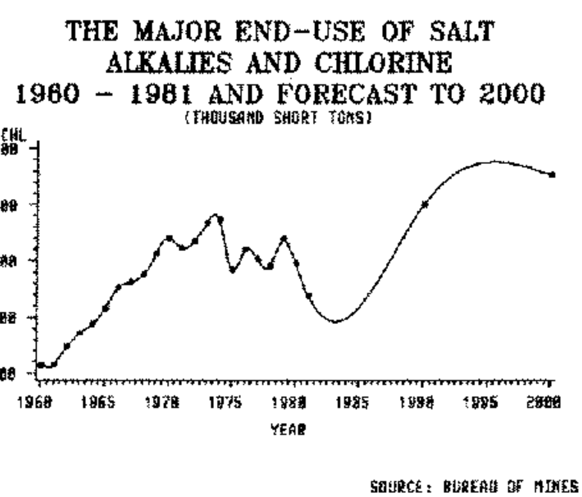

Figure 2. Chloralkali Forecast.

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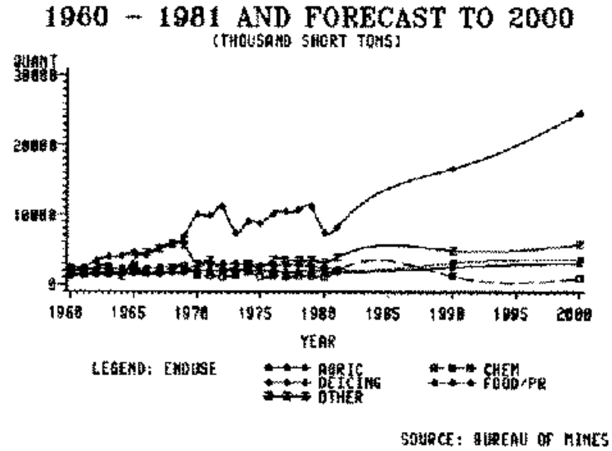

Figure 3. Forecasts of Other Major End Uses of Salt.

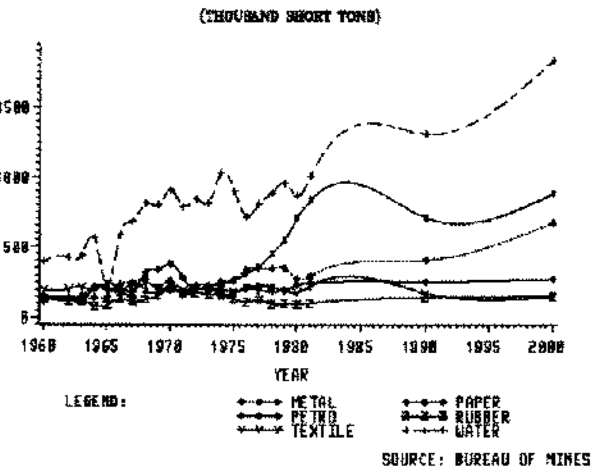

Figure 4. Forecasts of Minor End Uses of Salt.

salt in this sector. Because of its significant contribution to total demand, it is not surprising that the trend of lows and highs as noted in Figure 2 resemble the overall demand trends seen in Figure 1. Sharp declines after 1973 and 1979 show the effect of increased energy costs that plagued the energy-intensive chloralkali industry, and therefore salt consumption. Through changes in chloralkali production technology and an increase in chloralkali-based products, such as polyvinyl chloride, the future demand in this major industry is anticipated to be strong, possibly reaching more than 30 million tons in 2000. Chloralkali will continue to be the largest salt-consuming sector.

Deicing. The severity and duration of icy conditions in winter are the main factors that control this sector, the second largest in terms of total salt consumption, as shown in Figure 3. Although there are occasional periods of mild winter weather that reduce the demand for deicing salt, it is expected that normal to severe weather will tend to be the pattern in the future, thereby increasing the future need for salt for deicing purposes.

Food products. It is expected that salt consumption in this end use will grow in proportion with the population, despite the current public concern regarding the alleged adverse effect of high sodium intake in the diet. From a present base of 2.2 million tons, salt for food applications should reach 2.8 million tons by 2000.

Agriculture. Salt demand for livestock and poultry nutrition is dependent on the demand for meat and meat products. This sector should parallel the growth of population and the need for meat as a source of protein. High cholesterol levels in the blood may alter the demand for salt for agricultural purposes.

CONCLUSIONS

Reliable statistical projections of the future demand for salt require a sound forecasting methodology. This methodology is based on correlating accurate end use data with updated macroeconomic indicators and evaluating the results against any developments that may affect that commodity or end use. Although the statistical analyses presented in this paper proved to be unreliable because of questionable influences of the indicators, contingency analyses made by an expert analyst can provide meaningful insight to otherwise meaningless results.

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APPENDIX 1

Macroeconomic Indicators

	Average Annual Growth Rate, %	
	1983–90	1983–2000
Indicators		
Gross National Product (GNP) (Billion 1972 dollars)	3.3	2.9
U.S. Population (Million persons)	0.9	0.8
Gross Private Domestic Investment (Billion 1972 dollars)	5.9	4.4
New Construction Activity (Billion 1972 dollars)	2.7	2.0
FRB Indexes of Production (1967 = 100)		
Total Production*	4.0	3.2
Oil & Gas Extraction	−0.1	−0.1
Oil & Gas Drilling	1.7	0.9
Food & Products*	2.5	2.0
Grain Mill Products	2.9	2.4
Textile Mill Products*	2.9	2.0
Paper & Products	2.6	1.8
Converted Paper Products	2.8	2.2
Chemicals & Products*	4.7	3.8
Basic Chemicals*	4.1	3.3
Alkalies & Chlorine	3.2	2.6
Synthetic Materials	6.1	4.7
Synthetic Rubber	4.2	2.3
Drugs & Medicines*	4.8	4.7
Soaps & Toiletries*	3.9	2.7
Paints	2.7	2.3
Agricultural Chemicals*	4.5	2.2
Fertilizer Materials*	2.2	1.8
Petroleum Products*	1.0	0.6
Rubber & Plastic Products*	6.3	4.8
Tires	2.1	2.0
Rubber, Excluding Tires*	3.5	2.9
Plastic Products NEC*	7.4	5.5
Leather & Products*	−0.6	−1.4
Ordnance*	6.7	3.4
Lumber & Products*	2.3	1.5
Furniture & Fixtures*	3.4	2.7
Stone, Clay & Glass*	4.1	2.8
Pressed & Blown Glass	4.0	3.0
Cement	2.8	2.1
Primary Metals	4.7	3.2
Iron & Steel	5.4	3.4
Basic Steel & Mill Products	5.0	3.2
Consumer Durable Steel	6.3	4.0
Equipment Steel	5.3	3.4
Construction Steel	4.2	2.7
Nonferrous Metals	3.8	3.0
Copper Mill Products	4.1	3.4
Construction Aluminum Products	3.9	3.2
Fabricated Metal Products*	4.7	3.7
Metal Cans*	2.3	1.6
Hardware, Plumbing, & Structural Metal*	4.3	3.6
Hardware, Tools, & Cutlery*	5.2	4.2
Structural Metal Products*	4.1	3.3
Other Fabricated Metal Products*	5.2	4.0
Nonelectrical Machinery*	5.8	4.5
Engines & Equipment*	4.5	4.5
Construction & Allied Equipment*	6.8	5.1
Metalworking Machinery*	5.8	4.4
Special & General Industrial Machinery*	4.8	3.6
Office, Service, & Misc. Equipment*	6.1	4.6
Electrical Machinery*	6.4	5.0
Major Electrical Equipment & Parts*	5.2	4.1
Household Appliances*	4.7	3.4
Television & Radio Sets	3.8	1.9
Communications Equipment*	6.7	5.0
Electronic Components*	8.7	7.6
Miscellaneous Electrical Supplies*	6.5	4.8
Transportation Equipment*	4.6	3.2
Motor Vehicles & Parts	4.8	3.4
Automobiles	4.7	2.6
Trucks & Buses	9.0	6.9
Truck Trailers	8.2	5.2
Motor Vehicle Parts*	2.9	2.2
Aircraft & Parts*	4.3	3.1
Ships & Boats*	4.3	3.0
Railroad Equipment	13.6	7.9
Mobile Homes	−1.0	−1.2
Instruments*	4.3	3.6
Equipment Instruments & Parts*	5.1	4.4
Consumer Instruments & Products*	3.0	2.3

*FRB Indexes of Production which are tracked monthly using measures of input (Kilowatt-hours or man-hours). Undenoted indexes are tracked using actual measures of output.