About The Model

In this analysis, a monthly vector autoregression model was constructed using the prices of lumber futures, and indexes of lumber prices, wholesale construction materials prices, consumer housing prices, and consumer shelter prices from January 1976 to December 1992. The Bureau of Labor Statistics supplied the monthly producer price index values for lumber and construction materials and the consumer price indexes for housing and shelter for urban consumers.

The lumber futures price was the closing price of the contract nearest to expiration, except during the delivery month, when the contract of next nearest expiration was used. This may have introduced some seasonal variations, but such variations and other time-dependent influences are accounted for in the model.

To see how the markets react to each other, and to produce the results reported here, a one-time 10-percent increase was simulated in futures prices and in lumber prices. The model is linear, so results from the 10-percent change can be multiplied by 2 to observe the effects of a 20-percent change and by -1 to see the ef- of a 10-percent price decrease.

	Response to price change				
	Lumber	Futures	Materials	Housing	Shelter
			Percent		
Lumber price increase (10 percent)	—	16.0	4.8	5.4	5.0
Futures price increase (10 percent)	3.8	—	2.2	2.6	1.0

Radical Change 'n Market Structure?

n gene lumber prices have not al- 'ays b as variable as they have dur- ig the last 2 years. Prior to 1991, the verage annual change in lumber prices 'as 6 percent. To explain the recent rise the level and variability of prices, ana- sts cite cutbacks and uncertainty in the mber supply, environmental concerns, d the increase in demand for lumber as economic recovery lifts housing mand.

with all models, if the fundamental ucture of the market has undergone a ical break with the past, the results uld have limited applicability to the current situation. But despite increased volatility, the structure of lumber markets appears to be unchanged. The restraints on timber supplies over the past couple of years are not much different in character from the intermittent restraints on supplies caused by other impacts, such as railroad and mill workers' strikes. Prices fluctuated sharply during those events as well, but the markets continued to balance available supplies with demand.

Lumber remains a basic commodity traded in an auction-like setting, with many buyers and sellers linked by an efficient information network.

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Renewable Fuels Association

Technology Lowers Ethanol Costs

In the last 10 years, technological innovation in the ethanol production process has reduced costs dramatically. Energy is the largest operating cost in ethanol production, and reduction in energy use has accounted for most of the cost savings. A shift to larger plants and the adoption of energy-saving innovations have reduced the energy required to produce a gallon of ethanol by nearly two-thirds.

The use of improved strains of yeast for fermentation has also contributed to cost reductions. These innovations have collectively lowered the cost of producing a gallon of ethanol from \$1.35-\$1.45 per gallon in 1980 to less than \$1.25 in 1992, a 34-percent decline in inflation-adjusted terms.

Similar cost reductions will be achieved in the next 10 to 15 years if a host of new innovations can be successfully integrated into production facilities. These innovations are the product of recent advances in scientific fields as diverse as

Regulatory Environment Will Affect Ethanol's Future

Ethanol-blended gasoline currently receives a 5.4-cent-per-gallon excise tax exemption for 10-percent blends. Coupled with this Federal support are various state and local incentive schemes that provide additional support. The Federal support, without which the production of ethanol would be largely uneconomical, is in effect until the year 2000.

Major increases in short-run production, however, may be related to the outcome of regulatory interpretation and legislation. The new Clean Air Act (CAA) requires the nine highest ranking ozone nonattainment areas to sell reformulated gasolines beginning in January 1995. The recent EPA supplemental notice of proposed rulemaking on reformulation would offer an incentive for adding renewable oxygenates such as ethanol-blended gasoline. Rules for the reformulated gasoline program are under review and open for comment; finalization has not yet occurred. Two ethanol producers have announced a moratorium on the construction of new plants pending the outcome of the rulemaking.

Ethanol is also playing a strong role in a Federal Oxygenated Fuels program which began in November 1992. The CAA mandated the Oxygenated Fuels program for 39 urban areas which are either moderate or serious CO nonattainment areas.

The ethanol ethers, ethyl tertiary butyl ether (ETBE) and tertiary amyl methyl ether (TAME), could also play a potentially important role in a reformulated gasoline program. Unlike 10-percent ethanol blends, ethanol and methanol ethers help reduce emissions of volatile organic compounds. Ethanol ethers have the additional advantage of being produced from a renewable resource.

genetic engineering and materials science. For example, genetically altered yeasts that tolerate high concentrations of ethanol can lower energy costs.

impact of scientific advances is not limited to innovations in production facilities. Farm practices that raise corn yields, and lower input costs, could mean lower prices for corn, the primary feedstock in ethanol production. In addition, development of high-value uses for by-products of ethanol production will also generate additional revenue.

Innovations at The Plant Level

Ethanol plants are achieving a high level of control over the production process through the use of membranes—thin sheets of semiporous material that selectively filter desired substances from the production stream. One experimental design would allow water and ethanol to penetrate a membrane while trapping the starch and yeast in the fermenter. With the yeast retained, fermentation can proceed continuously at a fraction of the conventional batch rate of 40-50 hours. Coupled with energy-efficient distillation, continuous fermentation with membranes could considerably reduce equipment requirements of plants constructed in the next few years.

Membranes also are likely to be used in the saccharification stage, in which corn starch is converted to sugar for fermentation. Enzymes and starch are retained, while glucose and water are allowed to pass through. By reducing saccharification time in a wet-milling plant to 10-15 hours and reducing enzyme requirements by a factor of 10, this process could shrink operating costs by 1.2-1.5 cents per gallon of ethanol.

The development of low-cost reliable membranes may allow many plants to recover high-value by-products and to lower operating costs at many points in the production process. The energy and equipment needed to dry the by-products could be significantly reduced by running liquid components through a microfiltration unit to separate excess water. By-products such as lactic acid may then be recovered and concentrated through a system of membranes. Higher value, low-volume by-products, such as citric acid or sorbitol, may also be extracted as more sophisticated membrane technology becomes available.

Improving the fermenting organism is another method of lowering operating costs. The development of yeasts that can function in higher ethanol concentrations could lower the energy costs of distilling alcohol by 0.8 to 1.2 cents per gallon of ethanol. In the longer run, a wholly different fermentation organism may replace yeast. In laboratory testing, the bacterium *Z. mobilis* has speeded fermentation, raised alcohol yields slightly, and allowed fermentation at higher temperatures.

Although these organisms are likely to reduce the cost of refining ethanol from corn starch, the greatest potential for biological improvements lies with the development of new organisms that can convert biomass other than corn into ethanol. For example, converting the hull and other fiber portions of the corn kernel into ethanol could raise yields from 2.6 to nearly 3 gallons per bushel. Organisms have been developed that are capable of converting most organic material into ethanol and other products.

Alternative Feedstocks Soon Feasible?

The relatively high cost of corn, limited markets for corn ethanol by-products such as corn gluten feed and dried grains and solubles, and competition for land suitable for corn cultivation are likely to limit massive increases in the production of ethanol from corn. Doubling of ethanol production from corn would require approximately 350 million additional bushels of corn each year, put upward pressure on the price of corn, and double the supply of by-products. Ethanol made from other food crops, such as potatoes and sugarcane, would also be expensive because of their high value as human food products.

Production of ethanol on a large enough scale to substitute for gasoline is likely to come from other forms of available biomass. Among the lower cost—and more abundant—forms of biomass are agricultural residues, waste streams from agricultural processing, municipal solid wastes, yard and wood wastes, recycled newspapers, and crops grown expressly for their energy content.

Conversion of waste materials and agricultural residues into ethanol could produc[illegible] to 3.8 quad of energy each year (1 quad = 10^{15} Btu). Crops grown expressly for energy content on excess cropland could produce 11.4 quad of energy annually, according to a 1991 article in *Science*. Together these sources of energy would account for half the total annual consumption of energy in the U.S. transportation sector.

The technology for converting most biomass into ethanol has until recently been unproven and too costly for commercial-scale ventures. Although simple sugars are ultimately fermented to form ethanol from both corn and biomass feedstocks, the sugars in biomass are more tightly bound in long chains, and some simple sugars are different from the sugars in corn.

A pair of recent advances has largely overcome these problems. First, a process that uses enzymes to break down the bonds between chains of sugar has been well tested, and research has now shifted to producing these enzymes inexpensively. Second, genes that instruct other organisms to ferment different sugars have been introduced into *E. coli*. The resulting organism is capable of fermenting a variety of sugars with high productivity and with fermentation yields that match those of common yeast strains.

In the long term, biomass-derived ethanol may begin to complement ethanol derived from corn. The conversion of biomass into ethanol would greatly increase the supply and variety of feedstocks available for ethanol production. Operating and capital costs for biomass conversion plants are estimated to be comparable to costs at corn conversion plants, and the cost of biomass feedstock, especially waste materials, can be distinctly lower. Technical barriers to economical biomass conversion, however, still exist, and lower cost levels may be achieved only after pilot plants are constructed and the production process is refined.

Read More About It

The research results cited in this article are discussed in detail in a report by USDA's Economic Research Service—"Emerging Technologies in Ethanol Production," ERS Report No. AIB-663, January 1993 ($9 per copy). Additional ERS analysis on the effects of increased ethanol production on agriculture can be found in "Ethanol and Agriculture," May 1993 (ERS Report No. 667, $6 per copy).

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Further Cost Savings Needed

Ethanol fuel supplements imported oil with a domestic renewable resource that provides some environmental benefits. The use of ethanol as a fuel for vehicles in the U.S. has grown from insignificance in 1977 to nearly 900 million gallons in 1991. An ethanol industry has emerged through a combination of government support and new technologies, which enabled large-scale production of ethanol from domestic resources.

Growing consumer acceptance of ethanol-blended fuels, incentives to gasoline blenders, and decreasing costs of production were responsible for the swift rise in ethanol production. In a climate of fiscal restraint and competition from other alternative fuels, however, the continued growth of ethanol production will depend on the introduction of a new set of cost-saving innovations into the production process.

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