The Brazilian Bio-ethanol Experience

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Outline

- Introduction
- History of the Brazilian Alcohol Program
- Main results
- Public policies
- Sales on neat ethanol / flex-fuel cars
- Cost reduction
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Introduction - some figures

- **Worldwide Brazil is the largest sugarcane producer.**
- **The Brazilian Alcohol Program (PROALCOOL) still is the largest biomass commercial program in the world.**
- **Tradition on ethanol use as automotive fuel in Brazil: (i) from 1920–1928, different levels of anhydrous ethanol in gasoline, (ii) 1931, gasohol (5% ethanol in the fuel mix), (iii) 1941, gasohol (10% ethanol in gasoline).**

The first phase (1975-1979)

- **The Brazilian Alcohol Program (PROALCOOL) was established in 1975 with the purpose of producing anhydrous ethanol to be blended with gasoline. At that time Brazil was strongly dependent on imported oil (80%) and gasoline was the main oil derivative. The creation of PROALCOOL was also influenced (a second reason) by the frequent problems faced by sugarcane entrepreneurs due to the excess of sugar production and strong variations of its international prices.**

The second phase (1979-1985)

- **With the second oil chock, in 1979, the Brazilian Government has decided to enlarge the Program, supporting large-scale production of hydrated ethanol to be used as neat fuel.**
- **While during the first phase of the Program ethanol production was accomplished by new distilleries annexed to the existing sugar mills, during the early years of the second phase many autonomous distilleries were built.**

The second phase (1979-1985)

- **During the second phase, the installed capacity of ethanol production has reached 16 billion liters of ethanol per year (the same existing capacity nowadays).**
- **About 10 billion US dollars were invested by private companies, but a strong financial support by Federal Government was given (e.g., loans with very low interest rates).**

The third phase (1985-1991)

- **Despite its success, oppositions to the Program were reinforced due to the decline of international oil prices and to the heavy subsidies given to inefficient alcohol producers.**
- **Furthermore, despite efforts towards restructuring of oil refineries, large surplus of gasoline existed at that time.**
- **Up to 1988, lower taxes for ethanol neat cars (E100).**

The fourth phase (1991-onwards)

- **The fourth phase has started with an ethanol supply shortage that deeply impacted the supplier's credibility, leading to a drop in sales of neat ethanol cars.**
- **Since then, Brazilian Government has removed its support to the Program. Sales of pure alcohol vehicles, that have reached 92-96 per cent during the eighties, were continuously reduced.**
- **Deregulation of the ethanol market has started in 1997.**

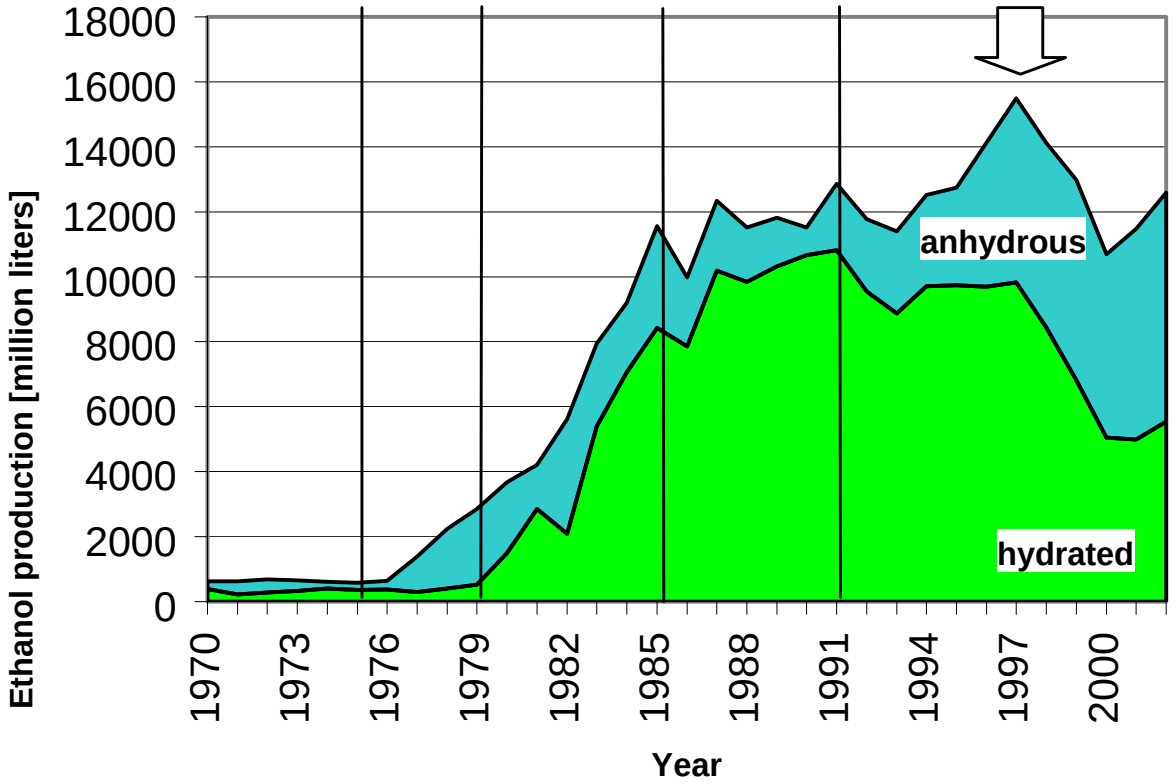
Evaluation of main results

- **Despite some difficulties, the Program has been very successful regarding its primary goals: (i) reduction of oil imports, (ii) stabilization of the sugar market, (iii) enhancement of Brazilian competitiveness on the sugar market, and creation (at low cost) of hundreds of thousands of jobs.**
- **Among its results, those related with environment and sustainability should be highlighted: (i) a very positive energy balance (output/fossil input = 8.3 to 10.2), (ii) complete replacement of tetraethyl lead,**

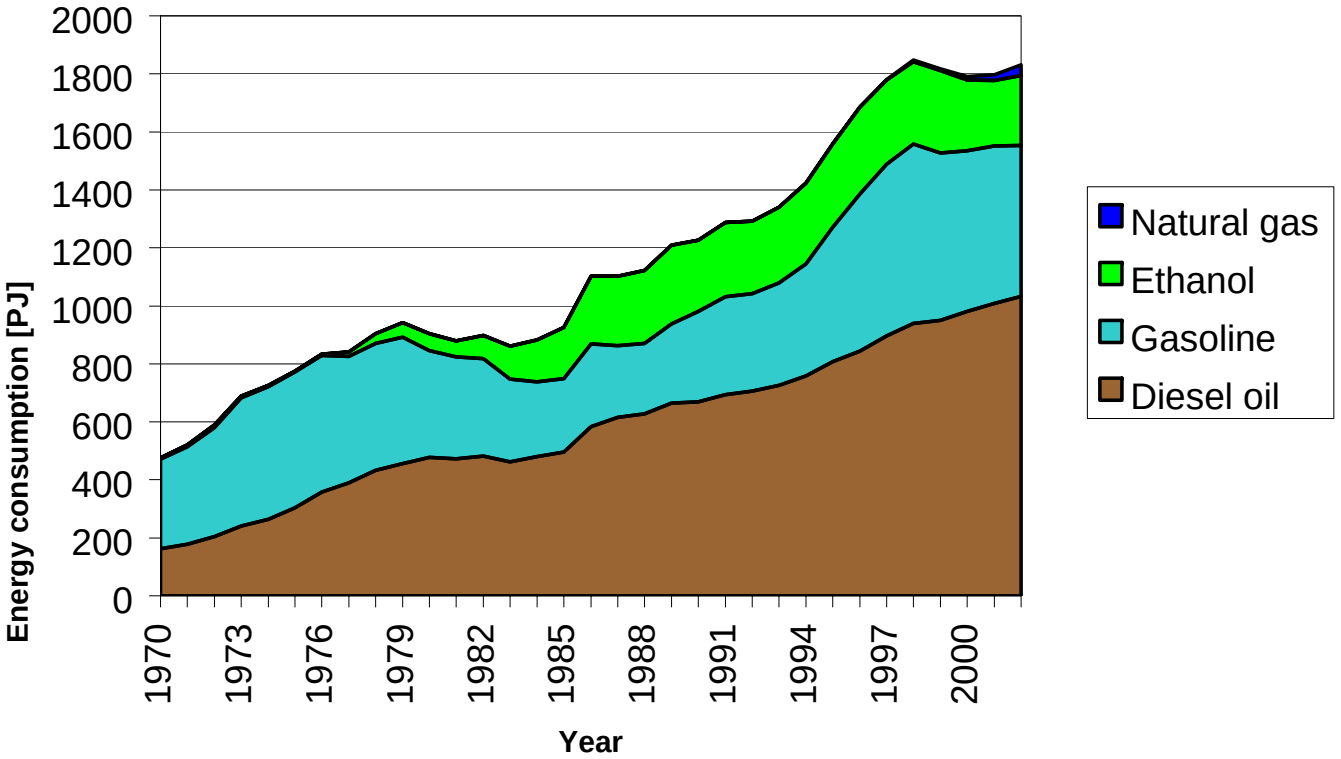
Evaluation of main results

- **(continuing) (iii) substantial reduction of GHG emissions (estimated as equivalent to 20 per cent of all emissions caused by fossil fuels in Brazil), (iv) substantial reduction on emissions of sulfur oxides, carbon oxide and particulates and (v) reduction on toxicity and reactivity of volatile organic compounds. However, the benefits of ethanol use regarding CO, HC and NO_x emissions were reduced after the advent of the three-way catalyst converters, the same happening regarding evaporative emissions due to the use of canisters.**

Evolution of ethanol production

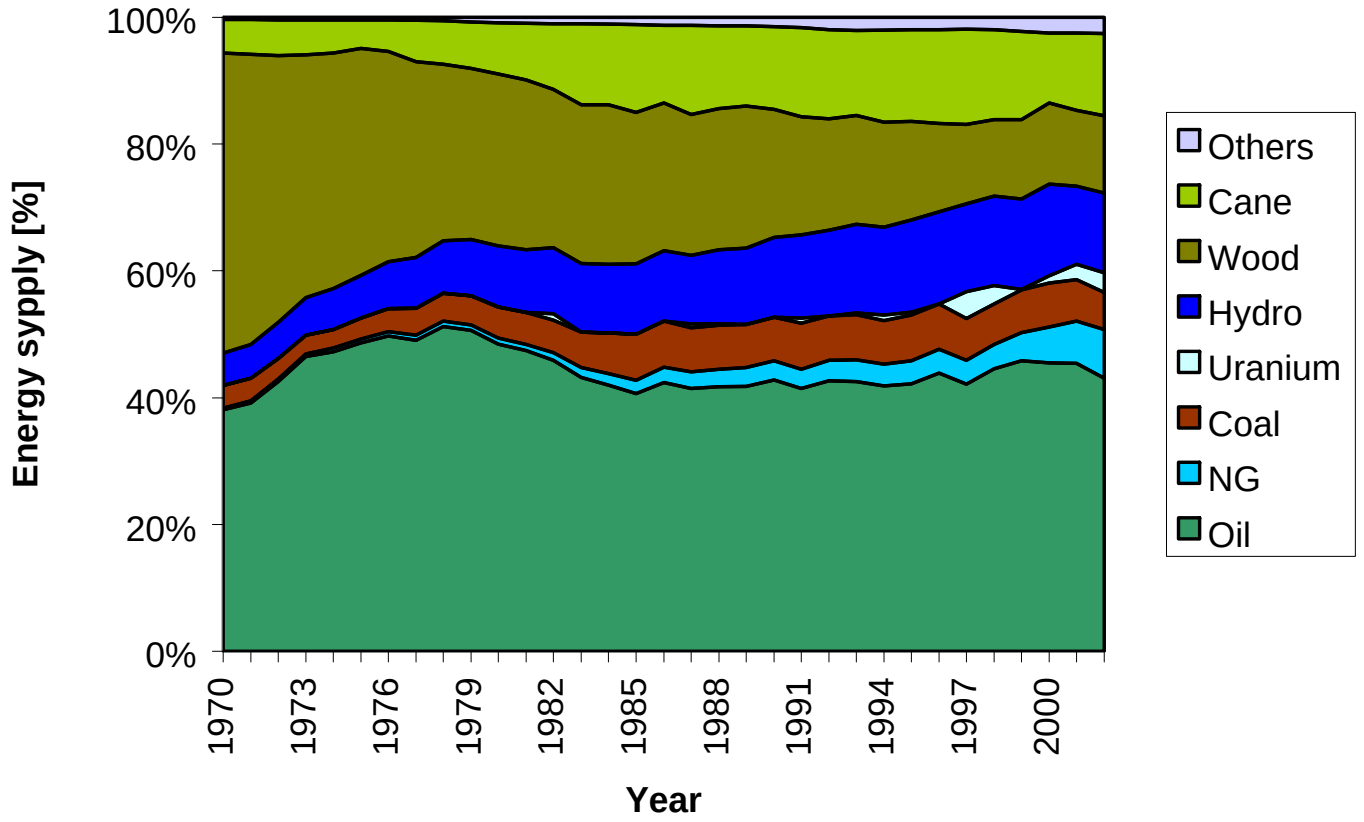


Ethanol contribution - road transport



Ethanol has contributed with up to 50% of the energy consumption regarding automotive transport (30% in 2002). Natural gas is a new low price option for consumers.

Sugarcane share on energy matrix



In 2002, sugarcane (ethanol + sugarcane bagasse) share in the energy matrix was 13%.

Ethanol's public policies up to 1988

- **Sugar and ethanol parity on payment for producers (it was indiferent to produce sugar or ethanol). Production control based on quotas.**
- **Ethanol and gasoline parity (on consumption basis) at the pump station. Prices for fuels established by the government.**
- **The Brazilian oil company (PETROBRAS) bought all ethanol. Price's support was given to ethanol's producers. Sugar exported by the government.**
- **Annual crop plan done by the government.**

Ethanol's public policies 1988-onwards

- **From 1988-1997: no more parity for producers and consumers, no more production control, no more control on fuel's price, no more action from PETROBRAS, no more control on sugar's price, no more sugar exported by the government, no more special taxes for neat ethanol cars.**
- **From 1998-onwards: no more established prices by the government to ethanol and sugarcane, no more price's support to hydrated ethanol, no more government participation on ethanol sales.**

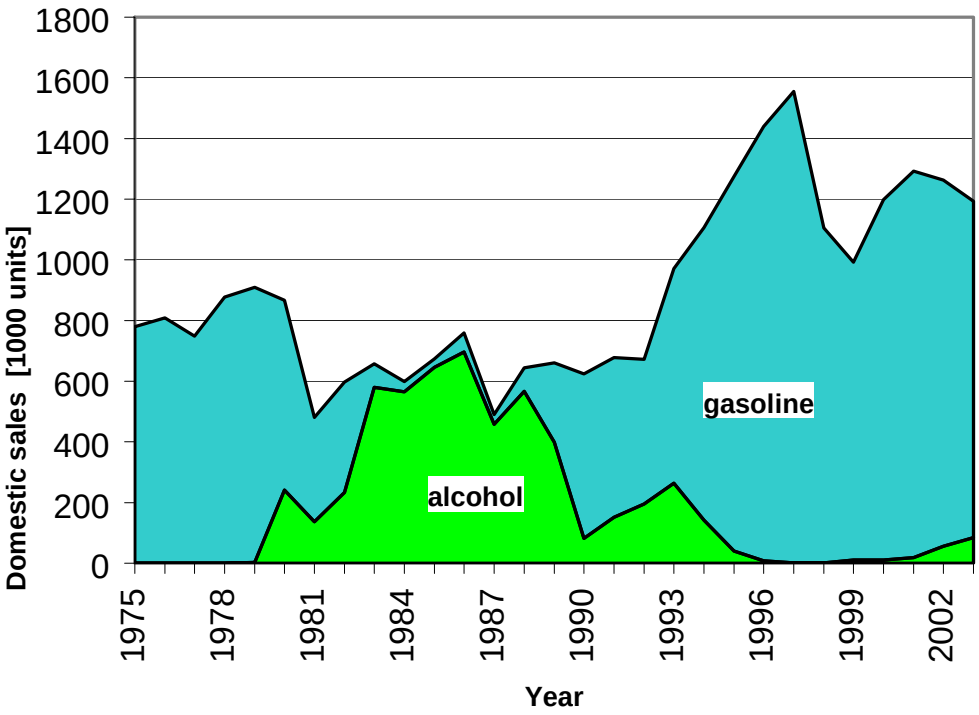
Ethanol's public policies 1988-onwards

- **Federal Government still regulates the blend of anhydrous ethanol in gasoline. The share varies between 20 and 26% (volume basis - E20 to E26) according to the balance between ethanol demand and supply. When the international sugar market has good prices, less ethanol is produced and its share on the fuel blend is reduced. Sometimes, imports of alcohol were also necessary to match the fuel's demand.**

Ethanol's public policies 1988-onwards

- **Since the 1990s, producers have explored a strategy to induce more flexibility into the industry, shifting the production to alcohol or sugar according to market opportunities. This has been possible due, at one hand, to the high competitiveness of Brazilian producers in the international sugar market and, at the other, to the their power to force regulations concerned with the ethanol market (percentage of ethanol in the fuel mix).**

Sales of new E100 cars



- Sales of neat ethanol cars have represented 96% and dropped to almost 0%.
- Due to low prices of ethanol vis-à-vis gasoline, and with the advent of flex-fuel engines (2003), sales of ethanol cars are risen again.
- E100 cars = 16% of sales in 2004.

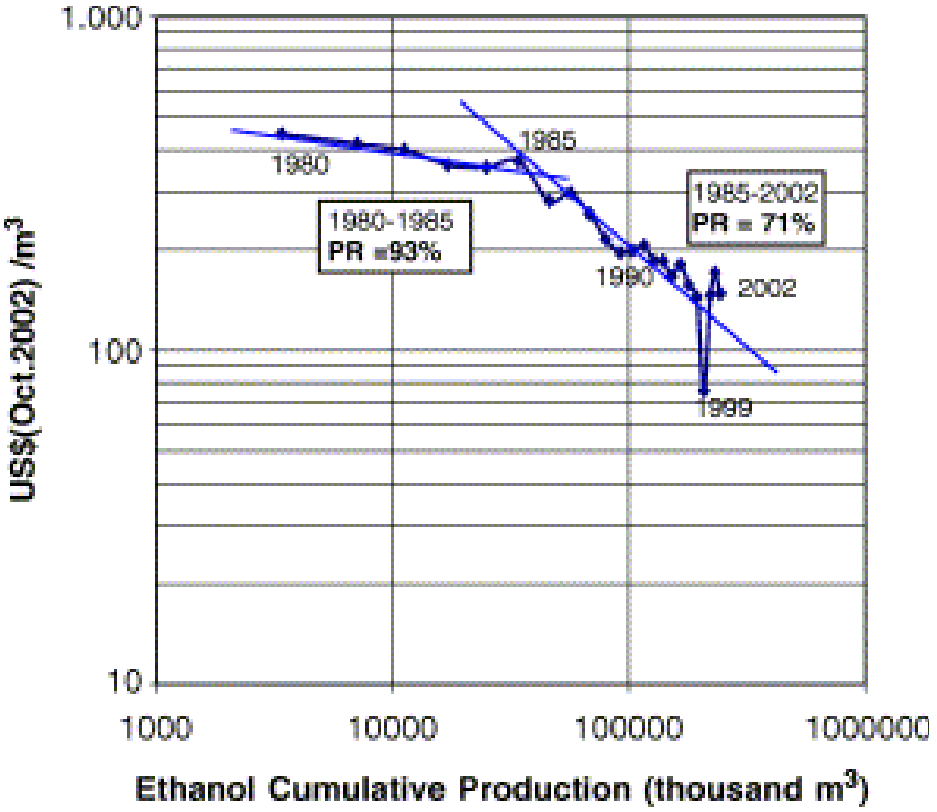
Innovations and cost reduction

- **Due to innovations both on the agriculture and on the industry sides, productivity has been improved and costs have fallen. To give a figure of comparison it should be noticed that average production yields were 3,900 liters/ha.year in the early 1980s and have reached 5,600 liters/ha.year in 2001. In the most efficient units, yields are up to 6,500 liters/ha.year.**
- **Technological development, increases on the scale of production and the deregulation itself (more competition among producers) are factors that explain the tendency for cost reduction.**

Innovations and cost reduction

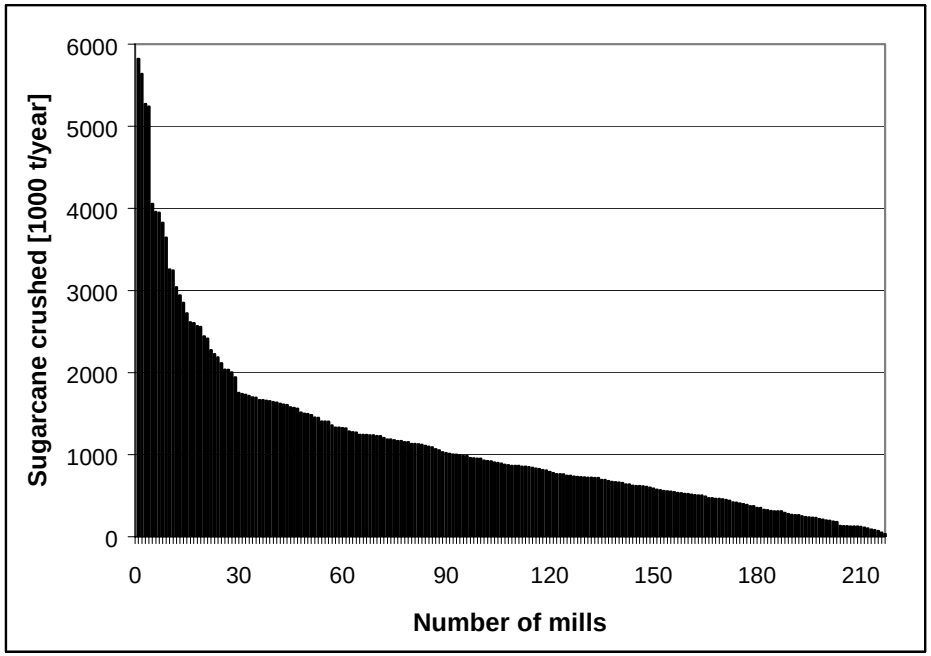
- **Regarding ethanol costs, it was estimated in 2001 that the production cost of one liter of hydrated ethanol in mills of good productivity was 0.18 US$. This cost is right now estimated as 0.15 US$/liter.**
- **Just the widespread adoption of yet existing – and commercial – technologies would result in a reduction of ethanol production costs of about 13% in the next 5-6 years, i.e., to about 0.13-0.15 US$/liter.**
- **The production of hydrated ethanol in SE Brazil is nowadays competitive with gasoline as long as oil prices is down to 25 US$/barrel.**

Cost reduction



- **Learning curve based on prices paid to producers (as "proxy").**
- **The progress ratio in the period 1985-2002 is estimated as 0.71.**
- **Source: Goldemberg *et al.* (2003)**

Mill's size (crushing capacity)



- **There are more than 300 hundreds mills in Brazil.**
- **The production in C-S region covers about 85% of the total production.**
- **The figure concerns to 217 mills in the C-S region (harvest season 2001-2002).**

Vale do Rosário

In the harvest season 2001-2002: 4.1 million tons crushed, 146.2 million liters of ethanol, 365.8 million kg of sugar + other products (electricity included ~ 7% of the incomes).

International market

- **At 2000, world production of alcohol was estimated as about 34 billion liters. Brazil has produced 12.5 billion liters, followed by the United States (6.5 billion liters), China (3 billion liters), European Union (2 billion liters), India (1.7 billion liters) and Russia (1.3 billion liters).**
- **The international trade of alcohol was estimated at the same year as 3.6 billion liters per year, mainly for industrial purposes and for beverage production.**

International market

- **There is some optimism regarding the enlargement of the alcohol market as some countries are interested to start to use alcohol-gasoline blends.**
- **Brazil has adequate conditions to become an exporter of bio-energy products (e.g., adequate weather conditions, reasonable availability of land, no constraint regarding labor, has technology and know-how).**
- **Producers are interested to export ethanol, but trade barriers are difficult to be overcame.**

Final remarks

- **Ethanol industry is well established in Brazil. Just the production of anhydrous ethanol, for blend with gasoline, assures a market of about 8-10 billion liters.**
- **With cost reduction of ethanol, consumers are more interested in E100 cars (ethanol's price is about 40% of gasoline's price). Flex-fuel cars are a new option in the market, and very successful so far.**
- **Deregulation has given good results, reducing tensions between actors and pushing for cost reductions.**