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Bioenergy and the Rise of Sugarcane-Based Ethanol in Brazil

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Introduction

> "This is something that, every time I think about it, I imagine how could human kind become dependent on something that is going to finish some day? This is stupidity. I can't understand why. How could, in less than 50 years, because it was in the first half of the 20th century, the whole human kind became dependent on something that is going to be eliminated….Each country can (now) have its own 'oil deposits.'"
> (Hon. R. Rodrigues, Minister of Agriculture, Brazil 2006.)

Brazil's rise to be the world's preeminent bioenergy producer provides three important lessons. The first lesson is about the complex task for developing countries balancing government intervention with market forces as they try to develop an industry. The second is how critical research and development (R&D) is for lowering costs to allow for market entry of an infant industry. The third is about the new challenges for bioenergy as it increasingly competes with the food industry for the same raw materials.

The Industry

Increases in petroleum prices and demand are creating pressure to develop new sources of renewable energies. Biofuel will represent 30% of the global energy used by 2020 compared with only 2% today (International Energy Agency, 2005). In 2004, the global ethanol market was US$30-40 billion, of which $4 billion involved international trade. Brazil, China, India, Malaysia and South Africa, the United States (US), and the European Union (EU) are important players in the burgeoning global market. Brazil is one of the world's most competitive biofuels producers because of its comparative advantage in producing ethanol and soybeans. The US, the 2nd leading ethanol producer in the world, has variable costs of production of corn-based ethanol of US$0.96 per gallon. Fixed costs range from US$1.05 to US$3.00 per gallon. While in Brazil the total cost of production was approximately US$1.10 per gallon during the 2005 crop year, with variable costs of US$.89 per gallon and fixed costs of US$.21 per gallon. In early 2006, the wholesale price paid to the mills for anhydrous ethanol was US$2.05 per gallon, while the retail price at the time for ethanol-gasoline blends was US$3.41 (including taxes).

Total world ethanol production (all grades) in 2005 was 12.2 billion of gallons, with 70% of this total produced by the US and Brazil (Figure 1). Other significant producers are China, the EU, and India. Production in the

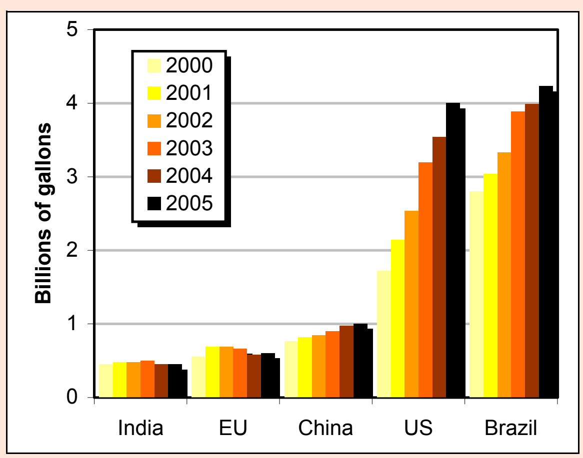

Figure 1. Leading ethanol producing nations, 2000 – 2005.
Sources: Renewable Fuels Association. Ethanol Industry Outlook 2006. Available online: http://www.ethanolrfa.org/.
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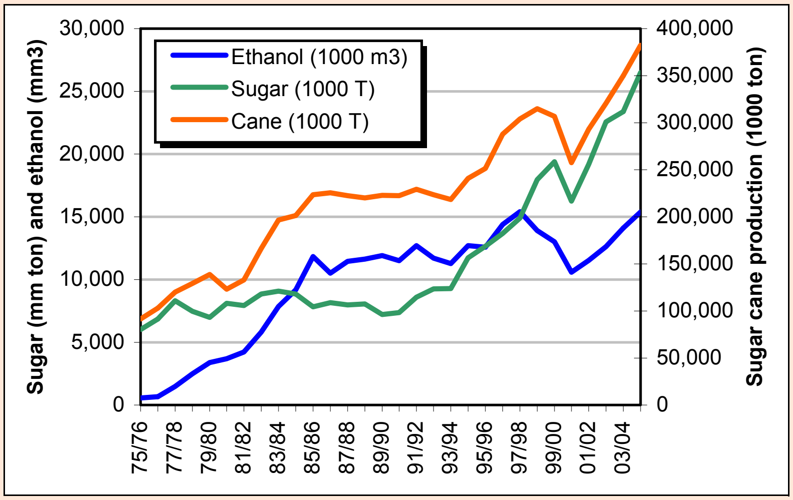

Figure 2. Sugarcane, sugar, and ethanol production in Brazil, 1975/76-2004/05.
Source: UNICA, União da Agroindústria Canavieira de São Paulo. (2006). Estatísticas. Available online: http://www.unica.com.br.

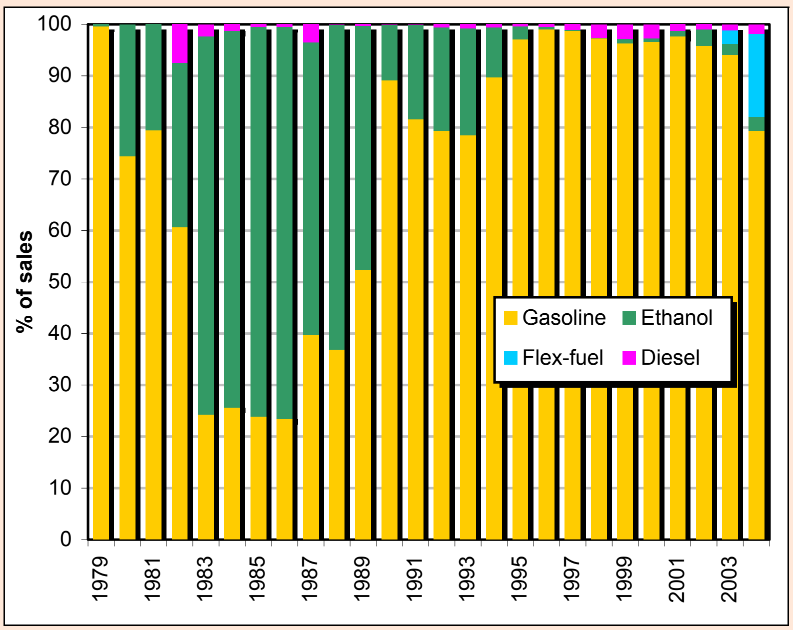

Figure 3. Fuel type of Brazilian car sales (1979-2004).
Source: ANFAVEA, Associação Nacional dos Fabricantes de Veículos Automotores. (2006). Available online: http://www.anfavea.com.br/.

US started to grow rapidly in the mid 1990s, while expansion in Brazil has been most active since 2000 (Figure 2). Between 2000 and 2005, world production has grown at a rate of 13% per year. In 2004/05, Brazil was the world's largest producer of sugarcane, sugar, and ethanol with 34%, 19%, and 37%, respectively, of world production. Today, real ethanol prices in Brazil are less than one-third of what they were in 1975.

In 2004, over 350,000 flex-fuel cars were sold in Brazil (ANFAVEA, 2006) (Figure 3). This amounted to 16.1% of the market, a 500% increase from 2003. In 2005, flex-fuel car sales jumped again to approximately 800,000, or 38% of the cars sold.

In 2005, the EU started to require a 2% blend of ethanol in their gasoline. This proportion will increase to 5.75% by 2010. Sweden, an importer of Brazilian ethanol, now offers consumers a 20% tax break to purchase flex-fuel cars, special parking privileges, and no congestion charge for urban flex-fuel drivers. New laws to be passed in Japan will require that 3% of ethanol will be added to the gasoline. This means that a new market of 0.45 billion gallons/year will be created if this Japanese law is passed. Germany intends to add 2% in its gasoline. Negotiations are also evolving with China for ethanol exports from Brazil.

This tremendous export potential has stimulated investment in infrastructure for transporting ethanol from the production areas to major ports in Brazil. A US$200 million ethanol pipeline from the interior of the State of Sao Paulo to Rio de Janeiro (1,000 miles) is currently under construction for export purposes by the Brazilian oil company, Petrobras.

There are currently around 330 operating mills producing ethanol, with another 89 planned (Unica, 2006). In Brazil during the 2005 crop year, more than half of the total sugarcane production was used for ethanol production. Use of 10% ethanol blends reduces greenhouse gas emissions by 12-19% compared with conventional gasoline and reduces tailpipe carbon monoxide emissions by as much as 30% (Wang, Saricks, & Santini, 1999). Since 2002, regular gasoline has contained 25% anhydrous ethanol, but in March, 2006 the percentage was decreased to 20% due to short supplies and strong domestic demand.

All agribusiness exports, including ethanol and sugar have grown significantly as Brazil liberalized its trade policy. Brazil exports more than 50% of its sugar, oranges, coffee, and soybeans. Ethanol exports have increased rapidly to over 15% of production. For many nations, the size and stability of domestic consumption has been critical in the development of export markets. The rise of the ethanol industry in Brazil may be due to the reverse. Its long history as a leading sugar producer and exporter has lead to the development of a dynamic domestic cane-based ethanol industry. A new found domestic demand for ethanol complements the scale and global competitiveness of Brazil's sugar industry. This gives the sugar complex a solid domestic and international market foundation by which to grow and develop.

In March 2006, the country's fuel blenders (e.g., BR (Petrobras), Shell, Exxon, Ipiranga) had to cut the ethanol content to 20% of its blended fuel because of ethanol shortages. Sugar prices were at their highest levels in five years, as was the ratio between sugar and ethanol prices. The competition for inputs between energy and food sectors is wonderful news for processors as they now are able to sell into either of two very high demand markets, sugar and ethanol. But, the competition raises important public policy issues if energy demand limits critical food or feedstuffs.

Supply is responding, but mostly in the eastern part of the country. Poor transportation and infrastructure, longer distances to export terminals, and smaller local markets in the Center-West region make investment less appealing. The State of Sao Paulo though is in a unique situation to benefit from the country's commitment to ethanol. It has a long history of being a leader in sugarcane production, fuel processing, and automobile manufacturing. Special sugarcane varieties have been developed and perform well in Sao Paulo's climate. The topography is conducive to mechanized harvesting. Finally, Sao Paulo benefits from some of the best infrastructure in the country. Because of the tremendous interest to build mills in Sao Paulo, the value of land has risen considerably. A 1.5mmt sugar mill will need around 27,000 hectares of sugarcane no more than 40 kilometers from the mill. In the western part of the State of Sao Paulo, land in June 2002 was selling for US$1,350/hectare. By June 2005, land was selling for US$3,070/hectare.

Brazilian consumers have added to the problem of short supply as they have aggressively purchased the flex-fuel cars. Consumers only buy ethanol if the pump price is 30% below gasoline blends. For the first quarter of 2006, retail pump prices for ethanol and gasoline approached parity in Sao Paulo, forcing some consumers back to gasoline. Technology allows consumers to be very astute about their purchases and adapt consumption very quickly. The challenge is for the distribution system to match the dynamics of the market.

History

The first investment in ethanol dates back to the 1920s. The Instituto do Açúcar e do Álcool (IAA) was established in the 1930s and state intervention regulated sugarcane activity in Brazil until the 1980s. Ethanol production though was a minor activity in Brazil until the 1970s when the sharp rise in oil prices threatened the military dictatorship's ability to rule. At the time 90% of the gasoline was imported, causing fuel shortages, inflation, current account deficits, and diminished hard currency reserves. By 1975, sugar prices fell sharply in the international market. At the same time, oil importing countries suffered from significant price hikes (from US$2.91/barrel in September 1973 to US$12.45/barrel by March 1974). Brazilian imports and balance of payments accounts were strongly impacted by this oil price increase, leading the government to launch the Proalcool program at the end of 1975. The purpose of the new program was to stimulate domestic fuel ethanol supply obtained from cane biomass by means of aggressive market intervention through quotas, marketing orders, price setting, and subsidized interest rates.

The second oil shock in 1979 brought about new Proalcool activities focused on demand expansion for hydrated ethanol. A system of tax exemptions for buyers of ethanol cars and consumer pricing fixing that pegged ethanol to gasoline prices were put in place. Additional activities integrated ethanol production for the first time into its energy planning process. Brazil's National Energy Commission expanded the ethanol production target to 3.8 billion gallons as a result of growing domestic needs.

Throughout much of Latin America sweeping market-based reforms, called the Washington Consensus, occurred in the mid 1980s as a result of the deteriorating financial state and hyperinflation that had overrun the region. In Brazil, government spending controls were needed because of the high level of accumulated national debt. The need for ethanol became less compelling as oil prices declined.

In 1987 Petrobras, the state-owned oil and gasoline company, was no longer obliged to buy all the fuel ethanol produced by the sector. In 1988, the Brazilian Constitution fundamentally changed the State's economic planning role from being normative to indicative. In 1990 the IAA, the public institution through which government intervention had been executed for about 60 years, was eliminated (MP - Medida Provisória no. 151, March 15, 1990). In 1993, the government passed a law in which all gasoline marketed in Brazil would be blended with 20% to 25% of ethanol.

Sugarcane prices, including freight to mills and distilleries, and all ethanol prices were deregulated and determined by market forces starting January 1, 1997 (Portaria no. 64, March 1996). Producers are now paid through a formula based on the sugarcane's end use, either sugar or ethanol. The Organização dos Plantadores de Cana do Estado de Sao Paulo – ORPLANA (producers) and the União da Agroindústria Canavieira de São Paulo – UNICA (mills) agreed in 1999 on a voluntary, non-profit sugarcane payment system called CONSECANA-SP (Conselho dos Productores de Cana-de-Acucar, Acucar e Alcool do Esatdo de Sao Paulo-Consecana).

In 1997, the Cane, Sugar, and Ethanol Official Harvest Plan was published for the last time by the Brazilian government (Portaria no. 46, May 1997). The 40% tariff quotas for sugar exports were eliminated and market-based prices for anhydrous ethanol became effective May 1, 1997. By 1999, price deregulation for cane and hydrated ethanol was also in place. In 2003, the Brazilian automobile industry launched the first flex-fuel car. Consumers now could decide the mix proportion at every fill-up: pure gasoline, pure ethanol, or a blend. The tax rate at the retail level in January 2006 for pure gasoline was 52.12%. This was 58% higher than the tax on pure hydrated ethanol. The anhydrous ethanol, which is used to blend with gasoline, is untaxed. Thus, the gasoline blended with 13% or more anhydrous benefits from a lower tax level when compared to hydrated ethanol. An 80:20 blend would have an effective tax rate of 22%.

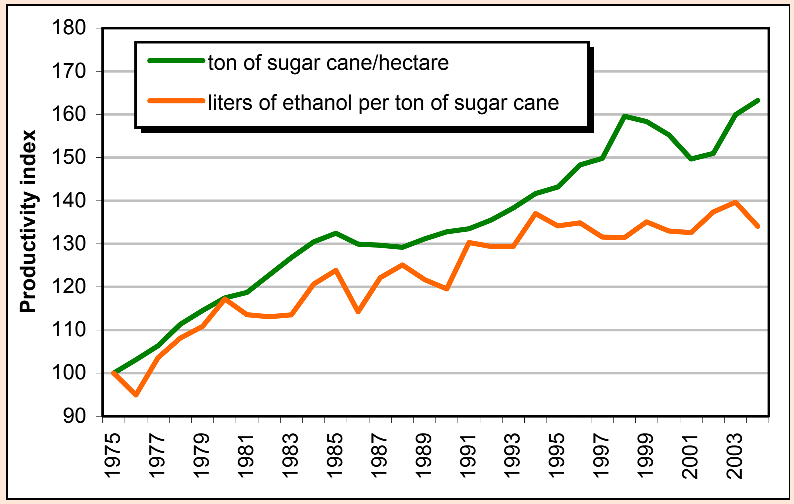

Figure 4. Sugarcane and ethanol productivity in Brazil, 1975-2004.
1975=100. Source: Centro de Tecnologia Canavieira, 2006 and authors' calculations.

R&D Investment

The sustained capacity to improve and diversify its production by investing in R&D is one of the most important factors underlying the success and growth of Brazil's sugar/ethanol complex. Sugarcane productivity has risen steadily at a 2.3% growth rate between 1975 and 2004. Yields are now over 80 tons/hectare. Industrial productivity growth is not as brisk, increasing on average 1.17% since 1975.

This growth rate is the result of new variety development, biological pest control introduction, improved management, and greater soil selectively. These efforts were initiated by the Sao Paulo state government's the Instituto Agronômico de Campinas (IAC) and Instituto Biológico. By 1970, Copersucar, a private cooperative of sugar and cane producers, created a Center for Technological Research. This research center was instrumental in the expansion of sugarcane production and the industrial development of the sector. In 1971 the federal government created the Programa Nacional de Melhoramento da Cana-de-Açúcar (Planalsucar) with a particular focus on the development of new sugarcane varieties. Planalsucar was created to reduce the technology growth rate difference between industry and production within the Brazilian cane sector (Figure 4). With industry developing faster, an agricultural production lag could eventually result in bottlenecks for sugar and ethanol producers. In the 1990s though, the Brazilian government decided to close Planalsucar, as part of its adjustment plan to reduce the size and role of government.

Copersucar (now the Center for Sugarcane Technology (Centro de Tecnologia Canavieira)) invested about 1% of its total revenue back into research related to sugarcane and its final products through the 1980s and 1990s. The State of Sao Paulo made substantial investments in basic research and molecular genetics (ONSA - SUCEST genome project) and a US$8 million investment in a sugarcane breeding improvement project (FAPESP – Fundação de Amparo a Pesquisa do Estado de São Paulo). Work with transgenic sugarcane is also being conducted, but the legislation necessary for greater commercialization has not been evolving at the same pace as the research.

Government's Current Role

The government's current role is not only much smaller, but quite different as well. Most of the government's efforts today are to ensure that the transformation to a market-driven sector proceeds smoothly and to help improve the industry's environmental performance.

Some minor traditional interventionist policies remain. For example, cane producers in the North-Northeastern (NNE) states are still paid a subsidy (R$5.7 or 19%) to offset their higher cost of production. This transfer is maintained to equalize costs and slow migration to the Center-South (CS) states.

Government indirectly affects cane, sugar, and ethanol prices received by producers through excise taxes. The ICMS (Imposto sobre Circulação de Mercadorias e Serviços) tax is an interstate tax that varies by state and serves to generate state revenue. ICMS taxes are levied when production and utilization occur in different states. Excise tax differences cause illegal tax avoidance as sales are "booked" to a low tax state (e.g., Minas Gerais), but actually sold in a higher tax state (Sao Paulo). As a result, states have an incentive to homogenize their excise tax rates to keep sales "in-state."

The IPI (Imposto sobre Produtos Industrializados) is a federal excise tax applied to industrialized products. It is currently set at 5% of sugar prices received by producers and has not been considered a factor that causes resource reallocation between regions or states.

Two new market-oriented institutions are CIMA (Conselho Interministerial do Açúcar e do Álcool) established in August 1997 and ANP (Agência Nacional do Petróleo) established in August 1997. CIMA involves representatives from ten federal government secretaries who monitor and evaluate the deregulation process as the sector moves to a free market. ANP serves as overseer of the new oil derivatives market.

The most active area for the government has to do with regulating the industry's environmental impact and helping the industry develop energy co-products from waste material (bagasse). Activities that are controlled include: sugarcane field burning; bagasse (post-processing residual material) management; soil quality; herbicides and insecticides storage and usage; liquid waste application for fertilizer, forest preservation, surface and ground water quality, ethanol storage; water usage; sugarcane transport (weight and volume); and noise pollution.

One of the most harmful environmental effects from sugarcane production is the burning of fields to facilitate manual harvesting. Burning is conducted prior to harvesting to eliminate pests and remove weeds. This makes movement through the field safer and easier, but produces significant quantities of greenhouse gases, ash, and other airborne particulates. Absolute elimination of burning has proven difficult so a schedule was established to gradually reduce the burning over the next 20 years in Sao Paulo, the largest production region. In 2000, additional steps were taken to eliminate burning and shift practices over to mechanized harvesting (Law no. 10.547, March 5, 2000). The new law specifically established where burning was prohibited and mechanization in turn would be used; about 55% of production. It also established rules where burning would be allowed; 45% of production. Burning is still permitted where the ground is sloped 12% or more, making mechanized harvesting impossible; or where small landholders were involved and had no other means of harvesting.

Two controversial outcomes of these environmental policies are the immediate unemployment of over 100,000 of the nation's 1.2 million seasonal sugarcane workers and the creation of incentives for producers to relocate their farms to avoid regulation. The loss of jobs is important because the sugarcane workers are some of the most at-risk elements of rural Brazil. Politically it is difficult for Brazil's president, Luiz Inacio Lula da Silva, who came to office as a very strong advocate for the country's disenfranchised workers.

The sugarcane harvest area in Brazil is around 5.2 million hectares (UNICA, 2006) and employs 1.2 million workers (Parra, 2005). With the new burning law, approximately 2.9 million hectares (55% of total cane acreage) will be mechanically harvested. Each combine harvests around 1,300 hectares per year and replaces 60 seasonal workers. This means that the 2,231 combines will displace about 134,000 workers, or 11% of the sector's labor force.

Production migration too is of great concern because land is plentiful in Brazil and regulatory oversight is weak. So, environmental regulation may be having the perverse effect of increasing pollution in the short run as production expands in new regions where environmental regulations are weak and monitoring is difficult.

The Brazilian energy sector is undergoing a restructuring process due to deregulation that has evolved since the beginning of the 1990s. One important implication for the sugarcane sector came about in September 1996, when Decree no. 2003 allowed independent producers to commercialize co-generated electric energy.

In the Brazilian sugarcane sector, the energy generated by bagasse burning is used for cane processing. However, many sugar mills, particularly in Sao Paulo, have the capacity to produce energy above their own needs that can be sold in the market. An analysis presented by the Secretaria de Energia of Sao Paulo suggests that approximately 28% of the sugarcane weight in the form of bagasse can be transformed into ethanol (Souza and Burnquist, 2000; Queiroz, and Ribeiro, 2002). The processing of one ton of sugarcane produces about 260kg of bagasse, with 13% dry fiber and 50% average moisture. About 5kg of steam is obtained from each kg of burned fiber. The current price paid for energy obtained from this source is low relative to the cost of new construction.

The current installed capacity to produce co-generated energy by the sugarcane sector in the Brazilian Southeast is estimated at 619MW with another 205MW of expansion capacity. This would be enough power to provide electricity to 700,000, or 2% of the State's residential needs. The overall energy generation by the sugarcane sector represents a total of 995MW, which corresponds to only 1.32% of the overall installed energy capacity in the country. An important advantage for the energy supplied by the sugarcane sector is that its seasonal production matches the countries' needs. During the "dry" months (June - August) sugarcane production and processing is at its peak when water reservoirs are at their lowest levels and the nation's hydro-electric system is least efficient. There is the potential using existing technology to produce 4.02GW if value added taxes (ICMS) could be reduced and electricity prices were allowed to approach market levels (Eletrobras, 2004).

Conclusion

The opening quotation by Brazil's agricultural minister, Mr. Rodrigues, captures the enthusiasm and commitment to bioenergy. Investment and expansion will continue as supply tries to catch up with demand. Brazil's leading airplane manufacturer, Embraer is reported to be exploring the use of ethanol as a substitute for jet fuel. Brazil's global strategy is focused on building basic demand in Asia and Europe. Enticing customers in Asia to switch to ethanol would give significant credibility to the fuel. It would help entice other large sugar producers, both within and outside of Brazil, to shift their mills over to ethanol processing. Also of importance are potential new opportunities for low-latitude underdeveloped countries to expand exports.

For More Information

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A complete set of references is available from the authors upon request.

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