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The Global Dynamics of Biofuels

POTENTIAL SUPPLY AND DEMAND FOR ETHANOL AND BIODIESEL IN THE COMING DECADE

As the world's largest producers of biofuels, the United States and Brazil have recently pledged to embark upon a joint strategy of energy cooperation to promote technology-sharing and to encourage ethanol production and consumption internationally. On February 20, the Brazil Institute of the Woodrow Wilson Center convened a conference of leading experts from both countries to assess the agricultural implications of the increased production and trade of biofuels as an alternative to hydrocarbons. The discussion led to plans for the creation of a Global Biofuels Policy Research Network to be housed at the Wilson Center in close cooperation with partner institutions. The network's research activities will focus on biofuels policy alternatives, as well as both the environmental and social impact of biofuels policies.

The energy policies that the United States and Brazil follow have implications far beyond their own borders, argued *Wallace Tyner*, a professor of agricultural economics at Purdue University. Therefore, the global consequences of energy policy alternatives must be analyzed within the international context and be conscious of market interconnections. For example, ethanol production has been subsidized in the United States since 1978. But given favorable market conditions of crude oil prices topping 70 U.S. dollars a barrel, ethanol production has now become economically viable.

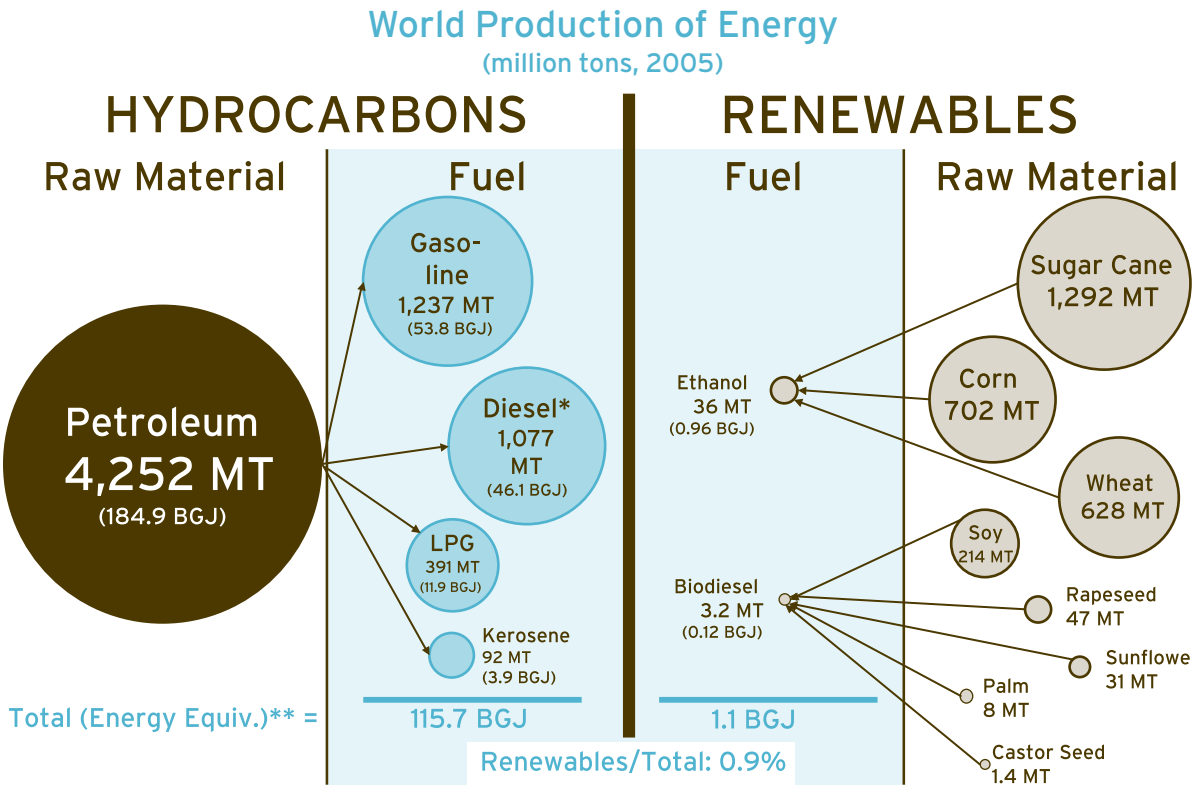
The United States produced 8 billion gallons of ethanol last year, and is set to expand its output to 11 billion in 2007. Ethanol currently constitutes approximately 3.6 percent of U.S. gasoline consumption on a volumetric basis, and 2.5 percent on an energy equivalent basis. Since January 2007, however, agricultural consequences have reduced the profitability of ethanol: the price of corn is rising. Ethanol producers are still breaking even, but the relative decline in profits has led to the postponement of new plant production and slowdown of the industry's growth.

Tyner detailed six policy alternatives for U.S. energy policy. The first is retaining the current 51 cents a gallon U.S. federal subsidy. Total ethanol subsidies are projected to reach U.S. 4 billion for 2007. The likely consequence is continued growth until rising corn prices choke off ethanol profitability—raising international food prices and upsetting both consumers and livestock producers. While the logical assumption is that higher agricultural prices would help the world's poor (around 70 percent of which rely upon agriculture), the actual impact on poverty would be far more complicated and quite difficult to estimate. Concern for higher corn prices leads to the second policy alternative, which is reducing the amount of the federal ethanol subsidy. Lowering the subsidy down to 30 cents a gallon would help lower the price of corn.

Alternatively, a third possibility is to institute a subsidy that would vary with the price of crude oil. The variable subsidy—or price floor—would only go into effect when crude oil fell below a certain price (60 dollars, perhaps). This subsidy would increase incrementally relative to how far

Written by
DANIEL BUDNY

Edited by
PAULO SOTERO



Notes: 2003 for palm, gasoine, diesel, LPG and Kerosene. *Distillated Diesel. LPG: Liquefied petroleum gases. **BGJ=Billions of Giga Joules.
Sources: FAO, Oil World, F.O. Licht, LCM, EIA. Elaboration: ICONE.

below the price floor crude oil dropped (for example, for each dollar that crude oil falls below 60, the subsidy would increase by 2.5 cents per gallon). The benefit of this approach is that it reduces government expenditures by limiting subsidies to periods when they are needed to make the industry profitable, while still providing a safety net if and when crude oil prices drop.

A fourth possible policy is the alternative fuel standard, proposed by President Bush in his State of the Union address. Such a standard would mandate the use of 35 billion gallons of ethanol as fuel by 2017—a slightly less than seven fold increase in a decade. An iron-clad fuel standard with a binding mandate would completely preclude the need for ethanol subsidies, as potential investors would be assured of its long-term viability. More effective, however, would be the fifth alternative, which consists of a combination of fuel standard and variable subsidy. With such a policy, the standard would have a variable subsidy that starts only when crude oil levels drop to low levels. A fuel standard coupled with a variable subsidy would combine the best features of both policies and effectively share the risk between the government budget and consumers.

A sixth policy alternative involves special incentives for cellulosic ethanol, which is still in the development phase and only expected to be economically viable in five to ten years. Cellulose-based ethanol, which is produced not only from crops, but from plant wastes as well, is widely seen as the most promising alternative energy source. However, the policy transition from corn to cellulose ethanol is complicated by far higher costs associated with the development process and by its risky investment climate. One way to stimulate investment in this area is a reverse auction, in which the government announces plans to purchase a set amount of cellulosic ethanol, and offers the contract to the bidder that quotes the lowest production price. This would jumpstart the industry and stimulate the private sector to begin investing.

Regarding environmental concerns and climate change, Tyner suggested implementation of a "cap and trade" system for reducing greenhouse gas emissions. Contemporary developments suggest that such a program is feasible in the near future. Both the general public and the current administration have recognized the reality of climate change and are prepared to act accordingly. In the private sector, ten U.S. agribusiness companies joined together with environmental groups to demand an efficient and consistent federal policy to handle global warming. A cap and trade system would establish and allocate greenhouse gas emissions limits that would be gradually

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reduced. In order to meet these limits, companies would be forced either to adopt more efficient technologies, or buy emission permits from other companies that can limit their own emissions at a lower cost. Such measures would benefit the ethanol industry, as alternative energies emit fewer greenhouse gases and would add market value to products like ethanol that limit pollution.

A global recession could easily lead to a drastic drop in crude oil prices, greatly diminishing the profitability of ethanol and deterring future investments in the industry. Even now, investments in alternative energy sources are risky given the lack of policy measures that insure against major oil price drops. For this reason, explained Tyner, alternative energy policies that protect against hydrocarbon price volatility, promote technological research, and stimulate investment can lead in the direction of less reliance on hydrocarbons and lower greenhouse gas emissions.

There are significant tradeoffs involved in expanding U.S. ethanol production that need to be understood and addressed prior to the wholesale adoption of biofuels, argued *Bruce Babcock*, a professor of economics and the director of the Center for Agricultural and Rural Development at Iowa State University. In order to understand whether it makes sense to embrace biofuels as a viable fuel alternative, one must take into consideration the probable agricultural and environmental repercussions, such as changes in the costs and production of crops and livestock.

By analyzing current and future ethanol plants, Babcock created economic models to determine subsequent capacity of U.S. ethanol production up to 2016, based on returns over costs. Such models can be used to analyze the projected responses of an increase in U.S. ethanol production, be they in domestic or foreign crop and livestock production, or in world commodity and retail prices. These responses are determined by key dependent variables, such as crude oil prices, policy incentives (such as the 51 cents ethanol blenders credit and the 54 cents per gallon import tariff), and demand for E85 fuelled cars (which can run on any blend of gasoline and ethanol with up to 85 percent of ethanol by volume). The United States currently consumes approximately 140 billion gallons of gasoline for fuel. If the market were to be saturated with a ten percent ethanol blend, producers would have to supply 14 billion gallons of ethanol, a plausible development given the country's present infrastructure. However, the country has no way of consuming the 25 to 30 billion gallons of ethanol that President Bush has suggested without massive investment in flex fuel technologies and infrastructure to increase the capability of cars to run on higher ethanol percentages and expand the supplemental distribution of ethanol.

The best way to spur investment in flex fuel technology and ethanol production, Babcock argued, is by ensuring that ethanol is cheaper than its alternatives. In 2006, increased demand pushed the price of a gallon of ethanol approximately 60 cents higher than the wholesale price of a gallon of unleaded gasoline. For ethanol production to remain profitable the price of ethanol must remain lower than gasoline; in 2007 ethanol did just that, and it is expected to remain below the projected price of gasoline up through 2016. The projected price of ethanol produced in Brazil is and remains lower than both the projected prices of unleaded gasoline and of U.S. produced ethanol. In fact, the price differential between Brazilian and U.S. produced ethanol was so great in 2006 that it was still cheaper to import Brazilian ethanol even after the 54 cents per gallon import tariff.

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High prices do not necessarily mean profitable ethanol production. Babcock explained that because there

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was a negative dry mill margin over total cost (i.e. ethanol plants were not recouping construction and operating costs) there has been a sharp decline in plant construction. Few new ethanol plants will be constructed in 2007 or 2008 in the United States because costs incurred would outweigh probable benefits. Nonetheless, U.S. ethanol production is set to triple by 2010 through increased productivity and capacity utilization.

Higher corn prices—due in large part to the increasing demand for ethanol—will lead to a steep increase in corn planted acreage, according to the models. The number of acres set aside for corn is set to increase 20 percent from 2006 to 2008, expanding to approximately 93 million acres. This land will come from farms previously producing soybeans (as well as conservation land), leading to a roughly 10 percent decrease in soybean planted acreage in the United States. The result will be a smaller supply of soybean and thus higher prices, paving the way for soybean producers such as Brazil and Argentina to meet the ensuing demand by greatly expanding their own production.

Babcock presented the likely consequences of a possible scenario in which the price of crude oil suddenly increases by 10 dollars per gallon. Under such a scenario the operating margins would shift from negative to positive, inducing the construction of more ethanol plants and thus increasing production capacity. The resulting drop in ethanol price would serve as an incentive to invest in flex fuel technology, increasing the percentage of ethanol mixed into gasoline. Side effects to food production and price would include: 20 percent increase in the price of corn, ten percent increase in corn acreage, eight percent increase in hog prices, 35 percent decrease in corn exports, five percent decrease in soybean acreage, and eight percent decrease in pork exports.

While 40 percent of U.S. food expenditures are on products directly impacted by feed grain prices, Babcock does not think that consumers will feel pinched as corn is increasingly used for fuel instead of feed. Pressing concerns that food prices will soar with the rise of corn-based feed prices are largely unfounded. Meat and dairy prices will rise, but food expenditures will only increase by 2.5 percent—a minor inconvenience at best for U.S. consumers.

Brazil has the oldest, most advanced and efficient ethanol programs in the world, and is eager to collaborate with other ethanol producers and increase ethanol's substitution of fossil fuels to meet global energy needs. *Marcos S. Jank*, president of the Brazilian Institute for International Trade Negotiations (ICONE) and professor of economics at the University of São Paulo, stressed the significance of an effective U.S.-Brazilian partnership in order to develop ethanol into a global commodity. The country seeks to complement the U.S. ethanol industry, not to replace domestic production. Brazil's goals include establishing common international standards, coordinating joint public and private investments, and devising a common global strategy to increase the number of producer and consumer nations.

Today, less than one percent of world fuel production comes from renewable sources, with sugar cane and corn ethanol making up, respectively, the first and second largest raw material sources of renewable fuel. The processing of sugarcane into ethanol is remarkably efficient. A standard ethanol plant yields over 182 million kwh (kilowatts/hour) from 1.4 million tons of sugarcane, of which only 40 million energy units are consumed through the process, supplying an excess of over 142 million kwh of energy that can sustain the energy needs of a city of 750,000. The benefits to sugarcane ethanol use are substantial: it is a renewable energy sources, emits low levels of carbon and pollution, and induces social development in rural areas. The main drivers pushing for the expansion of ethanol production, he explained, are environmental concerns, support for farm incomes, and energy security in the face of high oil prices.

Fuel from sugarcane produces 8.2 joules of energy per unit of fossil fuel input compared to less than 1 joule for diesel and gasoline. Fuel from corn produces approximately 1.5 joules of energy, making it far less efficient than sugarcane-based ethanol. Biodiesel from palm oil is actually the most efficient source of energy, as nine joules of energy are produced per unit of fossil fuel input. Jank noted that the two most efficient renewable sources of fuel, sugarcane and palm oil, come

Ethanol Overview in the United States and Brazil

	U.S.A.	BRAZIL
Mills in operation	97	335
Feedstock	Corn	Sugar cane
Cultivated area (million acres)	78.2	15.9
Amount designated for ethanol	15.6	7.6
FEEDSTOCK production (million tons)	267	426
Percent of feedstock for ethanol	20%	48%
Yields (tons/acre)	3.4	31.5
ETHANOL production (million gallons)	4900	4600
Ethanol productivity (gallons/acre)	321	727
Fuel ethanol as a percent of consumption	2%	40%
ETHANOL trade (million gallons)		
Imports	741	–
Exports	–	800
Cost of production (US$/gallon)	**1.14**	**0.83**
Import duty	**39%**	**0%**

Notes: 2006/07 data for Brazil and 2005/06 data for US. 2004 data for production costs. US import duty presented is the ad valorem equivalent (2004-2005 average) for non denaturized ethanol (54 cents/gallon + 2.5%).
Sources: UNICA, USDA, USITC, Ministério das Minas e Energia, World Watch Institute, RFA. Elaboration: ICONE

from tropical regions—which may provide developing countries with a sustainable development strategy. In terms of usage of raw materials for biofuel production, Brazilian sugarcane ethanol uses 48.3 percent of the raw material, while U.S. corn ethanol uses 20.4 percent. E.U. biodiesel created from oilseeds uses 20.0 percent of raw material for biofuel production.

Biofuels are becoming viable in many countries through government intervention in ethanol production, consumption, and markets. One such policy involves tax exemptions within the production chain. Another form of intervention involves establishing compulsory blends of ethanol in fuels to mandate use. Such a policy is used in Brazil and in a few states in the United States. The government can also offer subsidies for ethanol producers or provide import protection against lower-cost suppliers. The United States engages in both such policies. With the help of intervention, biofuels production is becoming more competitive with fossil fuels. Total production costs from raw material to final product of Brazilian sugarcane ethanol equal about 22 cents per liter; U.S. corn ethanol costs amount to about 35 cents and E.U. cereal ethanol about 45 cents.

World ethanol output is rapidly increasing, spurred on by Brazilian and U.S. production. In 2005, Brazil and the United States were jointly responsible for 72 percent of global supply. The United States produces 4.9 billion gallons of ethanol on 15.6 million acres of corn, while Brazil produces 4.6 billion gallons of ethanol on 7.6 million acres of sugarcane. Brazil's exports have increased sharply since 2002, with almost one half of its one billion gallons going to the United States, taking advantage of the 2003 MTBE (Methyl tert-butyl ether) ban in California, New York, and Connecticut. The international market for ethanol, however, is marked by high volatility of prices and destinations as well as by a lack of international standards.

Brazil's long history of ethanol production provides best practices to follow and obstacles to avoid for other countries looking to become efficient ethanol producers. The production of ethanol's ups and downs has followed the rise and fall of crude oil prices. The first phase of ethanol production in Brazil began shortly after the oil crisis of 1973, as oil prices quadrupled (and sugar prices happened to be quite low). In response, the Brazilian government initiated mandatory blend requirements and began to offer subsidies to domestic producers. These policies were complemented by a number of further measures in the late 1970s to encourage greater production. Fiscal incentives and tax exemptions for ethanol production were offered, E-100 fueled cars (which run only on ethanol) were introduced, and low ethanol

prices were guaranteed to the public. All gas stations in Brazil (approximately 33,000 at the end of 2006) are now ordered to offer ethanol alongside gasoline.

However, at the end of the 1980s, as oil prices plummeted, the Brazilian government cut support for ethanol production. Higher sugar prices affected production and sales of E-100 fuelled cars declined rapidly. Flux fuel vehicles weren't introduced until 2003, following the most recent rise in oil prices. There are currently 49 models of flex fuels cars which run on gas, ethanol, or any blend of gas and ethanol. Electronic sensors in flex fuel cars automatically recognize the type of fuel and properly adjust the engine combustion parameters accordingly, allowing the driver to decide his choice of fuel at the pump. Ethanol production in Brazil has grown without any subsidies (although producers still benefit from certain tax exemptions and taxes on gasoline amount to 44 percent compared to only 18 percent in the United States) and sugarcane is now a significant player in Brazil's energy matrix. Sugarcane accounts for 13.5 percent of the energy matrix and ethanol now accounts for 40 percent of the mixed gasoline/ethanol market. Today, over 80 percent of light vehicles sold in Brazil are flex fuel cars.

The main concern over sugarcane expansion in Brazil is not land availability, negative environmental repercussions, or crop displacement, but logistics: Brazil lacks ample transportation and production infrastructure for a dramatic increase in sugarcane cultivation.

MARCOS JANK

Brazil continues to invest in better technologies to improve efficiency and productivity of sugarcane ethanol. Technology is being developed to also use the bagasse and straw of sugarcane plants, and it is expected that hydrolysis of such cellulosic materials will drive future growth in ethanol production. Furthermore, the expansion of sugarcane cultivation in Brazil will have a negligible impact on the country's agriculture, as compared with the expansion of corn production in the United States. Brazil currently grows sugarcane for ethanol on 7 million acres of land out of a total 790 million acres of arable land in the country. Increased sugarcane production will not crowd out other crops, such as soybeans, corn, or oranges, Jank insisted, but will most likely expand into lands currently used as pastures (of which there are currently 440 million acres, with many acres close to existing ethanol plants).

Jank also dispelled fears that the expansion of sugarcane cultivation will encroach upon the Amazon rainforest. The Amazon region does not have the climate or soil conducive to growing sugarcane, nor does it have the technology or infrastructure in place to support cultivation and then ethanol production. Sugarcane and ethanol plants are predominantly located in the Centerwest and Northeast regions of the country. Furthermore, fears that increased sugarcane cultivation will displace soy or beef producers into the Amazon are likewise unfounded. The main concern over sugarcane expansion in Brazil is not land availability, negative environmental repercussions, or crop displacement, but logistics: Brazil lacks ample transportation and production infrastructure for a dramatic increase in sugarcane cultivation. Furthermore, Jank insists that expansion of the sugarcane crop will be based upon increased land productivity.

Brazilian entrepreneurs are investing large amounts into the sugarcane industry to increase productivity. Estimates place investments over the next six years at 14.6 billion dollars. No less than 77 new plants are currently being planned, while some of the 335 existing plants are scheduled for upgrades or expansions. The number of plants is estimated to reach 412 by 2012, increasingly with the help of foreign investors. Overall, however, the sugarcane industry is predominantly run by domestic companies. But by 2012 it is estimated that 16 plants will be foreign owned and operated, accounting for 6.5 percent of total sugar cane processing in the country (compared to approximately 4.5 percent today).

Gregory Manuel, the special advisor to the secretary and international energy coordinator at the State Department, provided a conceptual overview of the Department's interest in energy and prospects on the shape of the upcoming U.S.-Brazilian partnership. In the last year the State Department has experienced a newfound interest in energy issues, particularly the nexus of energy and foreign policy. This has come about due to geopolitical interests, economic objectives, and the environmental health agenda. Manuel described the Department's strategy as based upon a three-pronged approach encompassing scientists, policy makers, and the private sector.

Energy is being focused on three broad areas: supply, managing demand growth, and technology. The first area involves measures to increase the production of conventional and alternative energy supplies, as well as protecting existing supplies. Managing demand growth addresses the realities of global energy demand, the majority of which is coming from developing countries such as China and India. Finally, the State Department focuses on technology by looking to strengthen the research and development agenda in both absolute and relative amounts.

In regards to the U.S.-Brazilian energy collaboration, Manuel explained that the impetus behind such a partnership involves bringing collective insights, talents, know-how together with private sector competencies and technical capabilities. Joint operations would not only further the U.S. and Brazilian industries; they would also serve to benefit the world economy as well. While the areas of cooperation are still nebulous, Manuel expects the partnership to take form in the following three areas. First is the deepening of cooperation on research and development, especially in basic research. Such measures would include collaboration on the cellulosic chain to feedstock fields, as well as bioengineering of new energy crops. Second is bringing the transformational benefits of biofuels to other countries. Ethanol production brings about numerous positive developments, such as employment opportunities, slowing the process of environmental degradation, and counternarcotics benefits (as energy-producing crops gain high value they may reduce the incentive to grow narcotics-producing crops). Finally, a third area of partnership is increasing the biofuels market itself. There is an enormous benefit to creating standards and codes that will assist the development of biofuel into a global commodity. However, changes to the U.S. tariff regime on imported ethanol are not open for discussion, Manuel averred.

Emerson Kloss, a diplomat at the trade policy sector desk for agricultural issues at the Embassy of Brazil in Washington, argued that the U.S.-Brazilian partnership is one of many important joint ventures being pursued by the Brazilian government to expand the production and consumption of ethanol. Only with a truly international market for biofuels will Brazil and the United States have the structural market conditions necessary to develop and expand their own internal market and increase the participation of biofuels within their own energy matrix. Partnerships such as the U.S.-Brazilian one reflect the importance that Brazil places upon international cooperation on energy, as well as Brazil's desire to bring alternative development to poor countries by creating an international market for biofuels

GREGORY MANUEL

Numerous requests from developing nations hoping to cooperate in the field of ethanol have led to Brazil's recent reassessment of the importance of energy, as seen in departmental and ministerial restructuring efforts to better coordinate energy issues among Brazilian agencies. Current partnerships with countries in the Caribbean, Africa, and Asia seek to replicate Brazil's positive experience with the production of ethanol. Brazil's experience has provided a good source of income for rural populations and encouraged development in the country's underdeveloped Northeast. Even more promising in terms of development has been the production of biodiesels through palm oil and castor beans, although this industry is only in the initial phases and is thus relatively small in Brazil. The joint U.S.-Brazilian strategy of energy cooperation is a key step in this direction.

For more information on ethanol, please visit the Brazil Institute's *Biofuels Central*, accessible through: www.wilsoncenter.org/brazilportal

BRAZIL INSTITUTE

The Brazil Institute of the Woodrow Wilson Center was created out of the conviction that Brazil and the U.S.-Brazilian relationship deserve greater attention within the Washington policy community. Brazil's population, size, and economy, as well as its unique position as a regional leader and global player, justify this attention. In keeping with the Center's mission to bridge the worlds of scholarship and policymaking, the Brazil Institute sponsors activities on a broad range of key policy issues designed to create a Brazil "presence" in Washington.

For more information about the Brazil Institute, please visit www.wilsoncenter.org/brazil or write to brazil@wilsoncenter.org

Woodrow Wilson International Center for Scholars

THE BRAZIL INSTITUTE

Woodrow Wilson International Center for Scholars
One Woodrow Wilson Plaza
1300 Pennsylvania Avenue, NW
Washington, D.C. 20004-3027

Tel: 202-691-4087
Fax: 202-691-4076
brazil@wilsoncenter.org
www.wilsoncenter.org/brazil