

Current status of the Brazilian ethanol program: Report on Hiroshima University-IDEC's mission to Brazil.

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Abstract

This article reports the results of a research mission of the Graduate School for International Development and Cooperation (IDEC) faculty to Brazil in September 2009. The purpose of the mission was to strengthen the understanding about the relation between ethanol policy, the local development and current importance of ethanol program as strategy to emission mitigation in Brazil. Relevant notes on discussions carried out with specialists from government and private organizations are presented and afterwards jointly evaluated by the mission's participants. Among the main results it was observed a consensus on the necessary increment of sugarcane crops and ethanol production in Brazil in order to attend both domestic and international demands. Several evidences of diversification on the usage of ethanol indicate that demand for the fuel will keep the growing consumption records observed over the last decade what also generates concerns on the supplying capacity and the policies regarding the land usage and sugarcane cultivation. A subsection dedicated to post-mission research activities are presented followed by general conclusions and recommendations for further researches.

1. Introduction

The Brazilian ethanol program is an emblematic initiative toward the diversification of fuel mix for transportation purpose. In a matter of few years the country was able to adapt a colonial culture into a fuel that would reshape the energy sector in Brazil (Leite, 2009). Figures for 2009 place the energy by products of sugarcane (co-generated electricity from bagasse and ethanol) as the second main source of energy source in Brazil answering for 19% of total energy consumed in the country (EPE, 2010). For reference, this amount equals the total energy consumption by the transport sector in Italy in 2008 (IEA, 2010).

The remarkable achievement observed to Brazil is particularly relevant in a transitory context of fuel mix diversification world widely. Constraints related to environmental concerns and a general doubt about the sustainability of the current fossil fuel regime have enacted multiple initiatives toward less energy intensive systems and in favor of lower carbon energy sources.

In Brazil, ethanol is also the leading strategy for greenhouse gases (GHG) emission mitigation from energy combustion (MCT, 2008). Studies based on life cycle assessment for Brazilian ethanol offer some evidences of how sugarcane based ethanol can potentially answer for reduction in carbon from transportation sector. For instance, Macedo (1998), based on an emission balance method and life cycle coefficients, concluded that the usage of co-generated electricity from sugarcane bagasse and ethanol, two main energy by-products of sugarcane, would allow net savings in CO₂ (equivalent) emissions, due to ethanol and bagasse substitution for fossil fuels in an order of 46.7 million tons CO₂ (equivalent)/year, i.e. nearly 20% of all CO₂ emissions from fuels in Brazil (Macedo, 1998).

Given the expected benefits of ethanol, policy makers and entrepreneurs share the understanding that ethanol could be potentially converted into an international commodity. Projections in this sense are also popular between scholars. For example, Leite et al. (2009) suggest that by expanding the sugarcane-derived ethanol with existing technology it would be necessary 21 million hectares of land to displace 5% of projected gasoline use worldwide by 2025. Authors complement that it is less than 7% of current Brazilian agricultural land and equivalent to current soybean land use. Such figures would be more modest if new production technologies were introduced.

These and others issues were object of extensive discussion in a research mission done by the Graduate School for International Development and Cooperation (IDEC) faculty to Brazil between 18 and 23 September 2009. This article reports the main subjects discussed in several meetings with researchers, business leaders, government officer and specialists from innumerable Brazilian and international institutions. Furthermore, this article provides additional remarks on after-mission research activities including an overview of 3 recently published papers addressing the complex issue of ethanol demand in Brazil in both national and regional levels and a debate about the theme of ethanol innovation in the country.

This article is organized in 3 sections. After this introductory section, the section 2 highlights the purpose and planning of the mission to Brazil. In section 3 it is presented a summary of main discussions with experts from specialists. A subsection of section 3 is dedicated to describe the visit to the Sao Martinho ethanol facility in the state of Goias, Brazil. In section 4 it is presented a summary of main lessons and achievements. A brief discussion of after-mission research activities is included in section 4. Finally, in section 5 it is presented the remarkable conclusions of the mission.

2. Planning, Profiles and Progresses of the mission to Brazil

One of research interest of the Development Policy Division of the IDEC is related to energy policies and its association with development and environmental issues. Renewable energies in general and biofuels in particular have received particular attention due to the relevance of the theme as an inductor for local development in a lower carbon context. Experiences in this direction include Dhakal et al. (2002), Wu et al. (2005), Wu et al. (2006), Taniguchi and Kaneko (2009), Kaneko et al. (2010), De Freitas and Kaneko (2011a), De Freitas and Kaneko (2011b), De Freitas and Kaneko (2011c), De Freitas and Kaneko (2011d), Komatsu et al. (2011).

Therefore, the mission to Brazil is part of the research activities of IDEC faculty members and students. The purpose was to understand the relation between ethanol policy, the local development and the importance of ethanol program as strategy to emission mitigation. Additionally, the mission aimed to promote academic ties and to collect research and teaching materials.

The planning of the mission to Brazil started with the contact with key organizations related to ethanol and sugarcane industry in Brazil. Three main institutions were originally contacted. The first was the Brazilian Sugarcane Industry Association (UNICA). UNICA is the largest organization in Brazil representing the sugarcane sector. It was created in 1997, following a consolidation process including regional organizations from the State of Sao Paulo after government deregulation of the sugar and ethanol sectors. UNICA members respond for more than 50% of all ethanol produced in Brazil and 60% of

overall sugar production in 2008. (UNICA, 2011a). UNICA has an extensive network of representation offices including representatives in key markets of North America, Europe and Asia.

The second institution contacted was the Ministry of Industry, Development and International Trade (MDIC). The ministry invited experts from both the federal and state level government offices both the Federal and State level specialists from government.

Finally the Japanese embassy was contacted. Through the Embassy contacts it was possible to meet Japanese specialists from diplomatic mission and the Japan International Cooperation Agency (JICA). The embassy also made the bridge to Brazilian alumni including energy and biofuels specialists of several research institutes in Brazil. Following Figure 1 summarizes the key organizations contacted along the planning of the mission to Brazil.

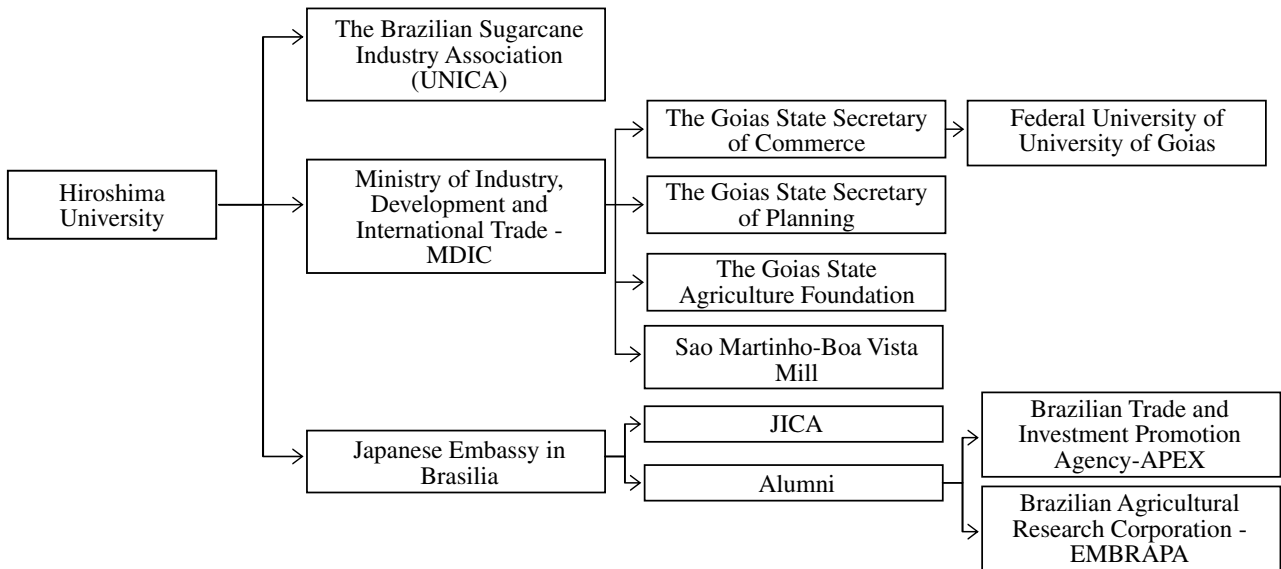


Figure 1. Network making

The final schedule of the mission's main events is summarized in the Figure 2. The summary of the discussions carried along the meetings are provided in the subsections 2.1. to 2.5. In section 2.6. we report the group impressions on the visit to an ethanol distillery.

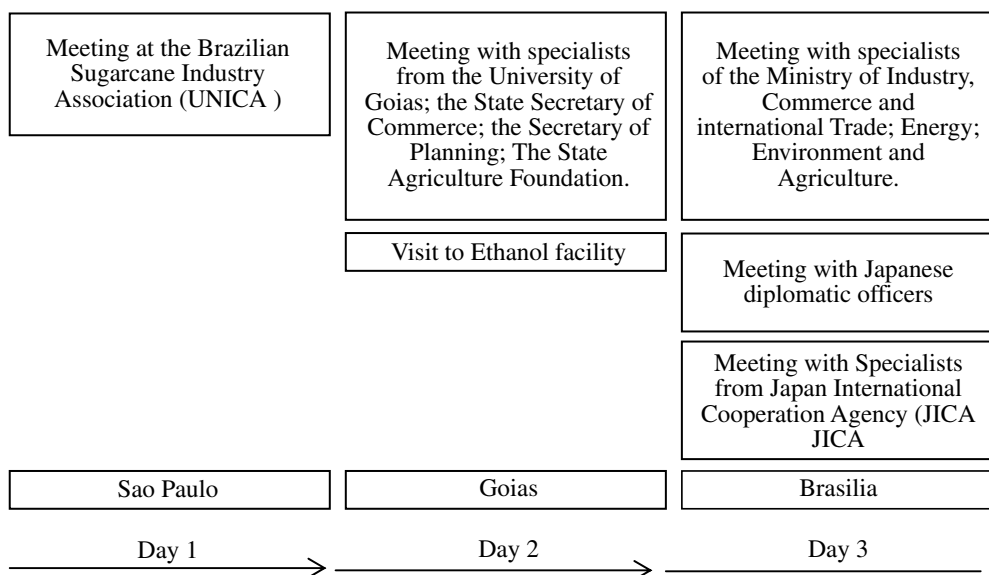


Figure 2. Mission schedule main events.

Activities in Brazil started in Sao Paulo city, capital of the Sao Paulo State. In São Paulo, we had a day meeting with representatives of UNICA. After, the group moved to Goias State. In Goiania, capital of the Goias State the group met 15 specialists from private and public organizations. In the city of Quirinopolis, also in the Goias State, the group had a half day visit to a major ethanol facility. Last day was in Brasilia, Capital of Brazil, where we had meetings with Federal Government representatives and Japanese diplomatic mission and JICA researchers. Figure 3 indicates the States of Brazil the mission visited.



Figure 3. Visited localities in Brazil.

Dislocations between Brasilia, Goiania and Quirinopolis were done by road. Otherwise, the group moved by airplane.

2.1 Meeting with the Sugarcane Industry Association - UNICA

UNICA is the largest organization in Brazil representing sugar, ethanol and bioelectricity producers in Brazil. It was created in 1997, following a consolidation process involving regional organizations in the State of São Paulo after government deregulation of the sugar and ethanol sectors. UNICA members answer for more than 50% of all ethanol produced in Brazil and 60% of overall sugar production (UNICA, 2009).

The organization is managed by a Board of Directors composed of representatives of member organizations, and a full-time group of experienced executives, specialists and technical consultants whose expertise covers relevant areas such as the environment, technology, energy, international trade, corporate social responsibility, legislation, economics and communications. In 2007 UNICA launched its first international office in Washington, D.C., and after expanding to Europe and Asia.

The UNICA Mission is to play a leading role in the consolidation of the Brazilian sugarcane industry as a modern agroindustry complex equipped to compete sustainably, in Brazil and around the world, as suppliers of ethanol, sugar and bioelectricity. Among main priorities of UNICA are included the consolidation of ethanol as a globally traded commodity, to promote demand of ethanol as a clean, renewable transport fuel, to expand use of ethanol to other relevant sectors, to foment large-scale production of bioelectricity for Brazil's domestic market, to assist member companies in becoming sustainability benchmarks, to disseminate solid, credible scientific data about the competitiveness and sustainability of sugarcane ethanol (UNICA, 2009).

To reach the objectives UNICA relies on several strategies. It includes, supporting best practices in the sugarcane

industry, in a competitive, free market environment, the promotion of the global expansion of ethanol production and use, to encourage the continuous advancement of sustainability throughout the sugarcane industry, to play a leading role in negotiations to eliminate trade-distorting barriers against sugar and ethanol, to promote bioelectricity as a reliable alternative to fossil fuels, to support research into new technologies and uses for ethanol, particularly refineries.

UNICA demonstrates an accurate understanding about the emissions from sugarcane industry and uses the evidences to defend the ethanol as a lower carbon fuel. This strategy also serves as argument for decentralization of energy production in Brazil in alternative to centralized energy generation facilities. References from UNICA specialist indicates that all sugar and ethanol mills in Brazil are self-sufficient in electricity due to the production of vapor through the burning of sugarcane bagasse in boilers. Furthermore, some mills are able to commercialize energy surplus to distribution grids.

Figures from UNICA present the cogenerated electricity from sugarcane industry as a potential source of energy for the country. Another remarkable reference is the expectation that all biomass residuals of sugar and ethanol production by the 2017/18 harvest Brazil would be able to produce an electricity surplus of approximately 10,000 MW, an amount equivalent to a power plant the size of Itaipú, the largest hydropower plant in Brazil. In São Paulo State alone, cane reserves would produce 4,800 MW by the 2017/18 harvest, about 20% more than what is currently being generated by the entire São Paulo Energy Company complex.

UNICA representatives also gave a full update on new advancements in Flex Fuel Technology. Update references for 2009 estimates that for every 100 light vehicles sold in Brazil, 88 uses flex fuel technology. Specialists also informed about noticeable gains in efficiency for new models of flex fuel vehicles. Gains in efficiency from first generation of flex fuel vehicles to 2009 models were around 8% indicating that combustion of ethanol has been improved in flex fuel models.

By the time of the visit to UNICA there was the launch of the first motorbike with flex fuel technology. The motorbike produced by Honda costs around US\$ 150 more than the gasoline version and savings in fuel economy is expected to cover the costs. Specialists remind that this difference in price is part of the transition between technologies and prices will be equivalent when competition is installed in the market. Other coming applications for sugarcane industry include usage of the fuel for civil aviation and as input for bioplastic industry.

2.2 Meeting with specialists of the Federal University of Goiás, the Goiás State Secretary of Commerce, the Goiás Secretary of Planning, the Goiás State Agriculture Foundation.

By the time of the visit to Brazil, the Goiás State figured as the 4th largest producers of sugarcane in the country (UNICA, 2011c). According to Goiás experts' presentation, projections for 2010 put the State in a 2nd position evidencing the extraordinary investment and coordinated policy efforts in the region. One reason for expansion of the sugarcane industry in Goiás is the fiscal incentives to ethanol production and several state coordinated initiatives turned to attract investments in the sector.

The government of Goiás understands that one of vocations of the State is in the development of the agroindustry and feedstock sector and extending the industry of ethanol is a major target for next years. One important mechanism to boost the production of ethanol in the State in a relatively short time span is by employing technology intensive culture developed in partnership with private a public research centers in the region. In this extent the Federal University of Goiás (UFG) has played important role. One example shared with IDEC mission was the recent updates in the development of new genetic modified breeds of sugarcane adapted to the land and climate conditions of Goiás.

2.3 Meeting with specialists from the Ministry of Industry, Development and International Trade, Ministry of Mining and Energy, Ministry of Environment and Ministry of Agriculture, Feedstock and Supply.

Meeting with federal government interlocutors allowed an integrated view of policies related to biofuels in Brazil. Aspects of investment attraction were emphasized reflecting a pragmatic view of government officials in developing the ethanol industry in Brazil, including the attraction of foreigner investors. The relation between Federal and State level was presented with examples of successful projects, including foreigner investments in new business frontiers in the country side.

Specialists from several ministries offered a general framework of current policies in the sector of biofuels. The ethanol was object of most discussion while biodiesel figured in a secondary position. Opportunities for both inflow and outflow of international trade and investments in Brazil and from Brazilian industry were presented in detail. Specifically about the capacity of Brazilian industry to supply international market with technology and know how it was presented examples from many industrial sectors including equipment for plantation, harvest, handling and transport of sugarcane, technology for sugar and ethanol mills, including technology for co-generation of electricity, the Flex Fuel system and vehicles and wide variety of services from technical assistance, project engineering, logistics and carbon credits and consultancy projects in CDM.

The issue of agribusiness was exposed with several data collected and aggregated into research and teaching materials. A full description of different biomass and the possible areas where biofuels could be developed were presented. Detailed presentation on the national energy balance with projections for 10 years were presented displaying biofuels and co-generated electricity from sugarcane bagasse with a major share.

Guarantee in fuel supply is a concern also shared by government representatives. Discussion about this topic also included some references to the regulation of the sector, including about prices and stability in supply. Government however manifested positively about the capacity of the country in sustains domestic supply while increasing exports of ethanol. A main argument for such positive perspective is the actual mature status of national ethanol industry and the presence of regulatory governance in the sector.

2.4 Japanese Embassy in Brasilia.

Japan has one embassy in Brasilia and five consulate offices in Brazil. Diplomatic representations in the country are distributed according to the cultural and business linkages between Japan and Brazil. Therefore consulates are located in Curitiba, Rio de Janeiro, Belem, Recife and Manaus.

Cultural ties were established with the massive immigration of Japanese to Brazil starting in 1909 when 165 families arrived in the port of Santos, Sao Paulo State. Migration to the Amazon area started 80 years ago. Nowadays the north region, where the consulates of Manaus and Belem are located, concentrate some of most important industrial park of Japanese organization outside Japan with 30 companies corresponding to around 20% of total investment in the Industrial Park of Manaus.

It is at the Japanese vehicle factory Honda, located at the Manaus industrial park, that motorbikes with flex-fuel engine are produced. With this new motorbike model Honda becomes the world's first manufacturer to produce a motorcycle equipped with flexible-fuel technology.

2.5 Japan International Cooperation Agency - JICA.

Meeting with JICA researchers started with a panorama of JICA's strategic interests in Brazil. Among discussed themes it was provided an explanation on the South-South selected anchor countries from developing and transition world operates as reference for linkage with other markets. The conceptualization of the South-South cooperation is part of the JICA strategic adaptation that aims to use soft power and negotiation capacity of selected anchor countries to extend the Japanese relation between nations. An example is the usage of Brazil a hub for third part cooperation projects by JICA's in Latin America and Africa.

The importance of JICA was explained in the context of international cooperation. Presented figures by researchers show that JICA has the second largest budget amongst international cooperation organizations, after the world Bank. Regarding the investments in Brazil across the time it was recognized that Brazil displays a rapid economic growth of Brazil and gradually has received less investments projects by JICA. Investments have therefore been addressed to developing nations in issues as health, agriculture, water resources and governance.

In this new framework JICA projects in Brazil were reformulated. Some current experiences included projects related to environment issues in the Amazon, themes of social development in infrastructure and agriculture in the poorest regions of Brazil and cooperation projects in agriculture and health with African and Latin America nations.

2.6 Sao Martinho, Boa Vista Distillery.

The Sao Martinho is the largest sugar and ethanol conglomerate in Brazil (UNICA, 2011d). History of Sao Martinho started back in the 19th century in the country side of Sao Paulo state where it was first installed the group's first sugarcane mill, in 1914. In 1937, the growth grew up progressively becoming by the mid 1940's the world's largest sugarcane processing companies (Sao Martinho, 2011).

Expansion in the ethanol demand motivated by the Brazilian Ethanol Program (Proalcool) allowed Sao Martinho to diversify their production. Additional units for ethanol and mix ethanol-sugar facilities were incorporated to the group as well as biotechnology business units (Sao Martinho, 2011). In 2006, the Group processed around 9.7 million tons of sugarcane, producing 597 thousand tons of sugar and 440 million liters of Ethanol (Sao Martinho, 2011).

The IDEC mission visited the Boa Vista Mill, a subsidiary of Sao Martinho Group located in Quirinopolis, at the country side of the Goias State. Information from the institutional website of the Sao Martinho's Group place the Boa Vista Mill as one of most modern distillery in the world with crushing capacity of 3.4 million tons of cane in the 2010/2011 harvest (Sao Martinho, 2011).

The facility is an example of industrial arrangement that allows the mutual production of ethanol and sugarcane. Fundamentally this type of business model allows the producer to shift production between main sugarcane by products sugar or ethanol or even mixed of these products. According to the manager Director of the Boa Vista Mill, the plant is the first Brazilian mill that combines 100% mechanized harvesting (without burning) and electrically-driven grinders, which are more versatile than those driven by steam turbines and used in the majority of the units around country. The unit is installed in an area of 1.7 million square meters and has 23 thousand meters of constructed area (Sao Martinho, 2011).

Most process at the Boa Vista Mill is managed from the Industrial Operations Center, a command room that operates round the clock showing the real-time status of processes in progress at the mill. The system allows to remotely managing all the production processes such as extraction and treatment of cane juice, fermentation, distillation, storage, generation of steam, electric power and compressed air, water and effluents treatment, among others.

The Boa Vista unit is being developed in several stages and by the time of the visit the operations were concentrated on ethanol production. Three types of ethanol is produced in the plant, the hydrous ethanol, used as fuel by ethanol cars, and the anhydrous ethanol, which is added to gasoline to be used as fuel by gasoline cars. The industrial Ethanol is used mainly as input to other industries including paints, cosmetics and foods and beverages.

Innumerous energy and non-energy by-products of sugarcane are produced by Sao Martinho. Some examples include several types of sugars, the Ribonucleic Acid Sodium Salt, exported and used in the pharmaceutical and food industries as raw material and flavor intensifier, the several types of yeast used to feed animals, fusel oil, used as solvent and in the manufacturing of explosives and ethanol and sugarcane bagasse, used in the generation of electricity and steam.

The sugarcane bagasse was particularly interest to our observation. Along the visit to the factory installations and we could track the full process of cogenerated electricity from the sugarcane crop in the field to the boilers where the electricity is produced. After full implementation the high-pressure boilers at the Boa Vista Mill will have capacity to generate 65 MW by 2010, while trading a 41 MW surplus.

Sao Martinho group has a robust program for diversification of product mix and expansion toward the foreign markets. One example of recent efforts is the commercial agreement with the Japanese company Mitsubishi and the Boa Vista subsidiary of Sao Martinho Group. Through this agreement Mitsubishi committed to buy 30% of total Boa Vista's ethanol production yearly (Sao Martinho, 2008).

3. Discussion and lessons.

The visit to Brazil provides a mosaic of information with rich research possibilities. Remarkable lessons include the professionalization of the ethanol industry in Brazil with high productive facilities and technology intensive processes. Second, from the talks with specialists form different organization we observed a progressive interest in diversifying the usage of ethanol to other purposes that is not only to automobile transportation. From the perspective of ethanol producers, the diversification of sugarcane usage is expected to attract more investments and provide higher revenues, from industry and government point of view it means an expansion in the taxes revenues, the increase of employment in rural areas and the and expansion of the agriculture frontier. Private organizations, including Japanese industry and investors, are joining the rush in the ethanol industry investing in new technologies for production and usage of ethanol.

A major concern regarding the successive records in demand increment is related to the capacity of increasing production in the same rate of demand. By the time of the visit to Brazil this expectation was embodied in an atmosphere of optimism however recent news (UNICA, 2011b) have posed doubts in the supply capacity being one of the reasons the mild in investments post 2008 world economic crisis.

Surprisingly, environment issues were not discussed in most talks. Interlocutors presented a broad view of ethanol as a cleaner alternative to gasoline however our impression is that in Brazil environmental issues are not between the main appeals of ethanol diffusion. Two notes in this issue are particularly interesting. The first regards the land usage for sugarcane production. To achieve the increasing demand for ethanol interlocutors have systematically mentioned the substitution of pasture lands by sugarcane crops. Figures presented by different specialists show a general consensus that in Brazil the expansion of sugarcane crops in the southeast and Midwest regions will happen by displacing pasture "area". Important references have reported this scenario as feasible (Goldemberg et al., 2008; Leite et al., 2009) Critics of pasture land substitutions have in general observed a pushing effect from old pasture to new pasture lands, in general towards protected forest areas (Schlesinger, 2010; Rathmann et al., 2010) Egeskog et al. (2011) defends the creation of integrated ethanol/dairy production systems that could ultimately increase net income of farmers while reducing land conversion pressure by increasing land-use efficiency in feedstock production.

Despite of uncertainties related to land usage we observed that trends in the ethanol industry are accompanied of innumerable environment friendly results. The usage of vinasse, a toxic by product of the ethanol production, as input to fertilizer to sugarcane crops and the massive usage of sugarcane bagasse to energy generation are particularly remarkable. The vinasse is the main effluent of ethanol production coming from sugar-cane, a substance with high concentrations of potassium, calcium, magnesium, sulfur and nitrogen with potential polluting characteristics. However the treatment of this residual has the potential to convert it into lower pollutant fertilizers.

During the visit to the ethanol facility we observed in locus the usage of bagasse to electricity generation. The process itself is an extraordinary recycling system that effectively supplies energy to the whole industrial complex. Technical director of the plant informed about the importance of the boilers pressure capacity as a main component of the efficiency process.

Despite of the importance of bagasse as energy by product the exceeding bagasse is noticeable. The bagasse surplus together with sugarcane straw conserves high energy content properties with potential capacity to be integrated into the ethanol production process. However, this technology is still under development being remarkable the recent efforts with bioethanol production via enzymatic hydrolysis of cellulosic biomass (Bon and Ferrara, 2007; Soccol et al., 2010).

The strategic importance of ethanol in Brazil is also object of public companies interest. A remarkable step in this trend is the growth of the national oil company (Petrobras) as a player in the ethanol production market (IPEA, 2010). The expanding weight of the State in the ethanol industry is evaluated by government as an attempt to regulate prices in the sector currently under the control of private organizations (Portal Brasil, 2011; Cortes, 2011).

4. Post-mission research achievements.

Several research activities were conducted taking into consideration several lessons from the visit to Brazil. Two main researches are noticeable. First deals with the complex issue of ethanol demand in Brazil. The second approaches the theme of innovation.

The ethanol demand research resulted in two papers. The first article by De Freitas and Kaneko (2011a) analyzes the characteristics of ethanol demand in the context of fuel mix diversification in Brazil. The paper provides an historical review of national demand for ethanol until the current status when ethanol is the most important gasoline additive and alternative fuel consumed in Brazil and is responsible there for profound changes in the dynamics of fuel consumption. The diffusion of flex-fuel vehicles is part component of the new advances in ethanol expansion and is a central component of the increasing demand for ethanol in Brazil.

This study develops a demand model for the period after the introduction of the flex-fuel technology and uses a cointegration approach and autoregressive distributed lag bounds tests over the period 2003-2010. The evidences confirm that during the last decade, ethanol has strengthened its position as both an independent fuel and a substitute for gasoline. There is also evidence that growth in the Brazilian automobile fleet based on flex-fuel technology is a major driving factor of long-run ethanol demand. Further, the dynamics of gasohol (mandatory blend of gasoline and ethanol) and ethanol prices operate in a symmetric manner over ethanol demand, thereby evidencing the increasing substitutability between these alternative fuels.

The second paper by De Freitas and Kaneko (2011b) is also related to the ethanol demand but in a regional perspective. This is a new approach on an issue generally ignored by most analysts on fuel demand in Brazil. By considering the ethanol demand in regional level it was possible to take into account the peculiarities of the developed center-south and the developing north-northeast regions.

Regional ethanol demand is evaluated based on a set of market variables that include ethanol price, consumer's income, vehicle stock and prices of substitute fuels; i.e., gasoline and natural gas. A panel cointegration analysis with monthly observations from January 2003 to April 2010 is employed to estimate the long-run demand elasticity. The results reveal that the demand for ethanol in Brazil differs between regions. While in the center-south region the price elasticity for both ethanol and alternative fuels is high, consumption in the north-northeast is more sensitive to changes in the stock of the ethanol-powered fleet and income. These, among other evidences, suggest that the pattern of ethanol demand in the center-south region most closely resembles that in developed nations, while the pattern of demand in the north-northeast most closely resembles that in developing nations. Following Figure 4 summarizes several estimations for ethanol demand with respect to ethanol price, cross gasohol price, fleet growth and income.

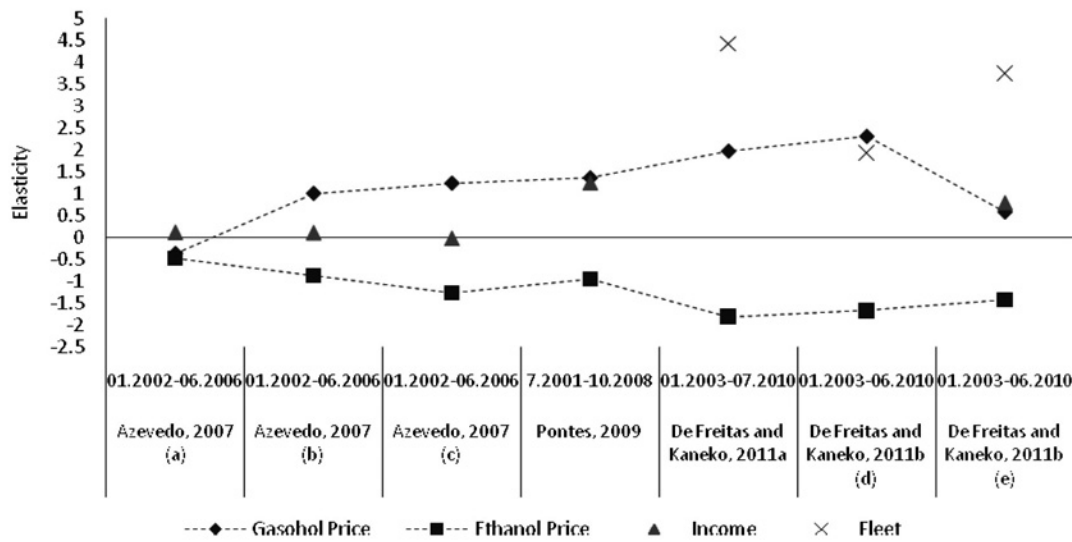


Figure 4. Long-term ethanol demand elasticity from several studies.

Notes: Azevedo (2007) (a) refers to estimations for ethanol estimation in national level; Azevedo (2007) (b) refers to estimations for ethanol estimation in regional level- southeast region; Azevedo (2007) (c) refers to estimation to ethanol demand to the Northeast region; Pontes (2009) estimates ethanol demand in National level; de Freitas and Kaneko (2011a) refers to ethanol demand estimation in National Level; De Freitas and Kaneko (2011b) (d) refers to ethanol demand estimation to the Center-South region; De Freitas and Kaneko (2011b) (e) refers to ethanol demand estimation to the North-Northeast region.

Regarding the theme of innovation in ethanol it is recorded one main achievement so far. In De Freitas and Kaneko (2011c) it is provided a first evaluation on the causal relation between ethanol innovation and the market characteristics of fuels in Brazil. Analyses are based on records of ethanol-related patents (Figure 5), volume of fuel consumption and prices for the period 1975-2008. Empirical evidence is based on a multivariate Granger causality test within a Vector Error Correction Model framework.

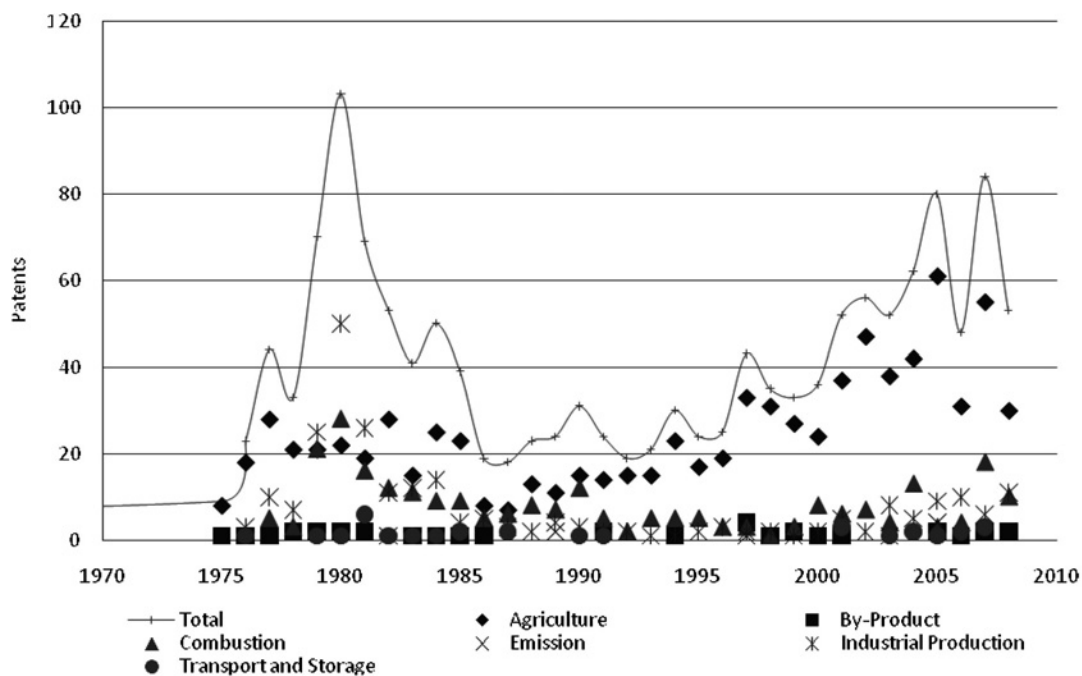


Figure 5. Patents records to ethanol in Brazil.

Source: authors analysis based on INPI (2010) database.

The results of this study demonstrate a potential causal relation between ethanol innovation and ethanol consumption, evidencing a unidirectional relation from ethanol consumption to patent registers in the studied period. Such a relation indicates that increments in ethanol consumption can potentially stimulate innovation in the sector. By contrast, a cross-effect with the gasoline price seems to have a neutral impact on the number of patents registered, whereas the ethanol price has an indirect effect on innovation, given the primary relation between the ethanol price and demand. Several questions are raised regarding the yet to be determined factors driving innovation in the sector. A study focused on nonmarket aspects, including policy factors, such as subsidies, or international technology spillovers, would potentially elucidate several unanswered questions concerning ethanol innovation in Brazil. Following Figure 4 resumes the classification for ethanol patents in Brazil for the period 1975-2009. Results of this study are currently under revision process by Ecological Economics Journal editors.

5. Conclusions and further research

This article reports the results of a research mission of IDEC faculty to Brazil in September 2009. Relevant notes on remarkable themes discussed with specialist from government and private organizations are presented. Results point out a general trend towards the increasing of sugarcane and ethanol production in Brazil in order to attend both domestic and international demands. Several evidences of diversification on the usage of ethanol indicate that demand for the fuel will continue to grow in the next years raising some concerns about the pattern of sugarcane crops extension.

Environmental issues were not extensively discussed by interlocutors evidencing that environmental issues are not a robust component of ethanol discussion in Brazil. In general, interlocutors emphasized the lower carbon content of ethanol relatively to gasoline. The issue of land occupation to sugarcane production was debated in several occasions being clear the intension of producers to increment areas of sugarcane plantation by replacing unused pasture lands or increasing sugarcane productivity in the field. The observed trend is that ethanol production originally concentrated in the Southeast region, particularly in the State of Sao Paulo, is gradually migrating to Midwest lands, including the Goias State where we visit an ethanol distillery.

Finally, domestic technology development underlies some of most outstanding progresses in sugarcane productivity growth in Brazil. Interlocutors from different organizations pointed out the role of genetic adapted seeds that allows healthy plants and adapted to different soils and climate conditions.

Our evaluation is that ethanol demand is a topic of major importance. In order to better explore this theme we developed several post-mission researches. Results evidence that ethanol demand in Brazil is in large degree associated to the growth in the flex fuel fleet. The pattern of consumption however differs between regions indicating that distinction by regions could produce important policy implications, including the possible impact in regional competitiveness. It was also observed that increment in ethanol demand is an important inductor for innovation in the sector.

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Disclaimer

This study represents the views of the authors and does not reflect the opinions of the Graduate School for International Development and Cooperation - IDEC, Hiroshima University, or any other visited specialists and institutions in Brazil.

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