

## **Interdependent international relations and the expansion of the production and consumption of biofuels: the case of Brazilian ethanol**

### **Problem statement**

One of the biggest challenges to be faced by countries in the near future is the search for sustainable energy matrices. The definition of the energy matrix of a country or region is not limited to the availability of natural resources, but also refers to the availability of alternative energy, advanced technology, production capacity for power generation and the policy decisions and social forces existing within the country or region.

Ethanol is currently the main liquid biofuel produced in the world. Recent increases in the demand and production of ethanol can be partially attributed to the historically high levels reached by international oil prices, the issues of energy security and climate change. This, besides leading ethanol and other energy sources to gain space on the international scene, has created incentives for the use of alternative sources of energy and the reduction global dependence on fossil fuels (Serra, Zilberman, and Gil, 2011).

The United States and Brazil are the leading producers of ethanol. In 2009, global ethanol production was equivalent to 30.1 billion tons, of which corn-based ethanol from the U.S. and sugar cane-based ethanol from Brazil account for 87.8% (OECD, 2011).

Studies indicate that ethanol from sugar cane is one of the most technologically efficient, economically viable and, currently, is a profitable non-subsidized biofuel (OECD, 2011; LEAL and WALTER, 2010; GAUDER, GRAEFF-HÖNNINGER and CLAUPEIN, 2011; FURTADO, SCANDIFFIO and CORTEZ, 2011). The expansion of the global market for bioenergy is seen as a promising alternative for some countries, especially the potential producers and suppliers of raw material, as is the case in Brazil.

A pioneer in ethanol production, Brazil has stood out as from 1970 when the oil crisis motivated the government to create the National Alcohol Program (PROALCOOL) in order to find a replacement for gasoline in cars and reduce oil imports which were consuming half the total foreign exchange earned from exports. The Alcohol Program created a market for ethanol and production and increased rapidly (FURTADO, SCANDIFFIO and CORTEZ, 2011).

In Brazil, the use of ethanol as a biofuel is common and vehicles can use it in its pure form or blended with gasoline, where it is up to 25% of the mixture. Besides being the only country where cars can use 100% ethanol as fuel, technological advances in the auto industry have led to the introduction of 'flex cars' and enabled an increase in consumption. Flex cars can use can be fuelled by ethanol and/or gasoline in any proportion, and are sales leaders, representing 82% of sales of light vehicles. Of the Brazilian fleet of light vehicles, 40% can be supplied by both ethanol and gasoline (ANFAVEA, 2011).

Other countries like the United States, India, Sweden (and 18 other European countries), Canada, China, Japan and Thailand implement renewable energy policies and blend ethanol with gasoline (MUSSATO et al. 2010). And the global trend is that a substantial part of the gasoline will be substituted by ethanol, which will cause an increase in ethanol production from different sources of raw materials, and most notably from sugar cane.

In the United States, the main factors that have led to the expressive growth of the corn-based ethanol industry are the blending targets for ethanol in gasoline established within the Renewable Fuels Standard (RFS) and high oil prices. Subsidies that currently exist for U.S. refineries that blend corn-based ethanol in gasoline will expire on 31 December 2011 and will not be renewed.

In the case of the European Union, the main destination of Brazilian ethanol, the regulatory guideline on renewable fuels is called Directive 2009/28/CE. This Directive states that by 2020, 20% of the total energy consumption should be met by renewable sources in the European Union and that renewable energy sources should constitute a minimum of 10% in the transportation sector in each member country. The directive also sets a series of sustainability criteria for biofuel production that must be followed by suppliers both from inside and outside the European Union, so that a sugarcane mill in Brazil must meet the same criteria regarding sustainability required of a company installed in the European Union. It is worth noting that Europe is a major producer of ethanol from sugar beet.

Both the U.S. and the EU, however, have raised protectionist barriers to limit the entry of Brazilian ethanol into their territories, with high import tariffs that disrupt competition and destabilize the economic sustainability of ethanol.

Although the global production and consumption of ethanol are expected to increase, the growing interdependence of markets and nations, producers and consumers of biofuels have led the actors involved in this sector to seek and develop mechanisms that help develop the sector. Therefore, the identification and analysis of such interdependencies can be part of efforts to overcome difficulties and possible restrictions to the expansion of production and use of biofuels.

From among the different conceptual and methodological alternatives that can be applied to the study of this process of interdependence between the political and economic agents, this paper explores the theory of Complex Interdependence proposed by Robert Keohane and Joseph Samuel Nye Junior (2001) and Games Theory from John von Neumann and Oskar Morgenstern (1944). Keohane and Nye Junior's (2001) theoretical model seeks to explain the dynamics of world politics after the Cold War, and helps to understand the relationships between states and transnational actors. According to the authors, interdependence means mutual dependence and in the case of international relations refers to situations of mutual effect between countries or actors in other

countries. These effects are usually related to the economic, geographical, political and social structures of a country (KEOHANE and NYE JUNIOR, 2001).

In this sense, the game is a formal representation of a situation where a number of players interact in a setting of strategic interdependence, that is, the welfare of each one depends on not only its own actions but also the actions of the other actors involved. Thus, the action of each actor, in general, will depend on the expectation that each one maintains regarding the strategies and actions that other players will adopt (VON NEUMANN and MORGENSTERN, 1944). Thus, game theory seeks to understand and clarify how the players (be they organizations, countries, nations, etc.) take their decisions, or make their choices in a situation of strategic interaction.

## **Objectives**

This study aims to analyze the international relations of interdependence between Brazil and other, real or potential, ethanol biofuel producing and consuming countries and their implications for the ethanol supply chains in Brazil. The specific objectives of this paper are to characterize the use of ethanol in the Brazilian and world energy matrices; identify the interdependent relationships between countries; and propose a simulation model based on games theory where those countries that are interdependent in the ethanol sector are considered player nations and the possibility of resolving possible conflicts and barriers to the expansion of production and consumption of ethanol by different countries is explored.

## **Procedures**

By applying complex interdependence as the key analytical theory and focusing on the review of international relations as well as on game theory, three relational dimensions were defined to identify the interdependencies between ethanol producing and consuming countries: political, economic and social relations.

A total of 80 printed and electronic documents were collected between the years 2002 and 2011, in 44 ethanol producing and consumer countries. The search for documents in those countries was conducted in the databases of the Brazilian Ministry of Foreign Affairs and national and international resolutions, regulations and certification organizations. Documents related to international cooperation and agreements in the ethanol sector between Brazil and other producing countries and consuming countries are also reviewed

The documents were stored and classified in QDA Miner software. To extract the knowledge from textual bases, an analytical framework was developed based on the dimensions, codes (signs) and keywords. Afterwards, the documents were analyzed and coded with their respective labels. Applying the analytical framework of the software, graphical representations

elaborated from the relative frequency of the occurrences of each code in the political, economic and social relations were produced.

Finally, simulations will be carried out using game theory, in order to identify the decisions and strategies used by the ethanol producing and consuming countries with the aim of exploring possible resolutions to potential conflicts and barriers to the expansion of production and consumption of ethanol by different countries.

### **(Preliminary) Results and concluding remarks**

The preliminary results of the research show that most of the Brazilian international acts concerning the biofuel industry were signed after 2005, when the Kyoto Protocol came into effect. In the international agenda, one of the priorities is to ensure a secure supply of energy at stable and moderate prices, gradually replacing fossil fuels with renewable sources of energy.

International relations between current or potential ethanol producing countries became perceivable closer as they aimed to ensure a reduction in greenhouse gas emissions, increased biofuel production, the development of Research & Development (R & D), the qualification of technical staff and specialized work force, among others. The study identified international cooperation as one of the means of managing the interdependence among countries, and thus acquire technical assistance, technology transfer, and disseminate socio-economic and environmental benefits of ethanol in other countries.

The Regulations adopted by some countries were also identified. In the United States biofuels cannot be produced from biomass originating from protected forest or environmental area. In the European countries, biofuels cannot be produced from raw materials obtained from land with high biodiversity or a high carbon stock. In Brazil ethanol cannot be produced in the country's most sensitive biomes, or from the expansion of sugarcane plantations that advance into native vegetation. In Sao Paulo state measures have been taken to reduce the burning of the cane straw by using mechanization.

Through the game theory simulation model a strong relationship of interdependence was noted within the political, economic and social needs of countries with an interest in the ethanol industry. Analysis of the different relations in each player within the system revealed that the asymmetrical relations of sensitivity and vulnerability become sources of power in a system such as international relations. Examples seen in the international acts were the concern of countries with the tariff and non-tariff barriers imposed on international trade and the concern to make ethanol a global commodity, although they are issues subject to dependence on technical, political and economic factors.

This research identified leadership roles among the countries. Brazil as the second largest ethanol producer in the world, second only to the United States, has one of the cleanest energy matrixes in the world, in which almost 50% of the energy comes from renewable sources. From the technological point of view the country is more advanced in the production and use of ethanol from sugar cane as fuel. In this sense, the country has worked not only to increase its production from sugarcane for fuel purposes, but also to transfer its experience and technology so that other tropical countries that have land, labor and intense solar radiation, can become producers and exporters of ethanol, so expanding and diversifying its supply in the world market.

A recent Memorandum of Understanding was signed by Brazil, South Africa, China, United States, India and the EU (large producers and consumers of biofuels) that allowed the creation of the International Biofuels Forum at the headquarters of the United Nations will discuss the increase efficiency in the production, distribution and consumption of biofuels on a global scale; preserving the environment, food production; and boosting the development of ethanol in a global market.

Finally, it should be noted that the OECD has advised members of the World Trade Organization (WTO) to increase efforts to reduce barriers to imports of biofuels and so allow the entry of developing countries that have ecological and climate systems more suited to its production.

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