Lack of commitment of Brazilian federal institutions to ethanol competitiveness

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Abstract: Brazil is regarded as pioneer in developing a market for sugarcane ethanol, to a large extent due to initiatives of federal government in setting up this sector in the past by a heavy use of public policies to provide a fair environment for the development of a complete production chain of ethanol. The aim of this paper is to present the level of commitment of Brazilian federal institutions to ethanol market by means of public policies, especially those related to second-generation technology which is a crucial ingredient for the long-term development in the ethanol industry because of its technological impacts. For this purpose, this paper assesses the actions taken and decisions made by Brazilian federal institutions aiming the production and competitiveness of sugarcane ethanol based on the concept of sectorial system of innovation and production (SSIP).

Keywords: ethanol; sugarcane; biofuels; public policies; sectorial system.


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1 Introduction

This paper analyses public policies enacted by Brazilian federal institutions aiming to increase production of ethanol and to stimulate its use after the year 2003, when the fleet of flex-fuel cars increased significantly in the country and concerns about environment spread throughout the world. Since then, car manufacturers have supplied Brazilian
market with flex-fuel vehicles running by petrol gas or ethanol or by a mixture of them, giving the consumers options according to their relative prices.

At the same time, environmental issues not only were brought to the agenda of international fora but also started to influence public policies searching for solutions to negative side effects caused by the use of fossil fuel. However, despite high expectations raised by new investment projects on biofuels production, Brazilian policies ended up being mostly less effective in the light of the challenges that ethanol market will definitely face in the future. Although leading companies have prepared to increase productivity, the sector as a whole was badly affected by gasoline price oscillations, distorting demand behaviour and leading to instabilities in fuel market. Besides, this erratic price behaviour has caused a lack of definition about the proportion of sugarcane used for ethanol or sugar production. Overall, these determining conditions of ethanol production in Brazil are influenced by the fact that this fuel is not yet a commodity like sugar, minerals and oil, whose prices are established in global markets. Giving this, we argue that after the process of deregulation undergone by the sugar–alcohol segment in the 1990s in Brazil, private firms became incapable of operating in such a changeable environment of unstable prices and insufficient technological innovation, in the light of a growing world competition between fossil and renewable fuels.

Brazil is regarded as pioneer in developing a market for sugarcane ethanol through initiatives of federal government implementing policies, mostly in the early 1970s, to create a favourable environment for the development of a complete production chain of ethanol. In those circumstances, and given the high level of sugarcane supply, the role of State in fomenting ethanol was crucial to reduce uncertainties and to attract investors to ethanol production, as a promising alternative. However, different from such a context in which ethanol was taken by Brazilian government as strategic for the country’s economy, in recent years that commitment began to falter, and the previous intention of being free from expensive foreign oil supply, vanished.

Having this evolution in mind, the aim of this paper is to show that Brazilian federal institutions have not been committed to ethanol, mainly after 2003, and its implications for the activity’s development. The main focus of this analysis is the second-generation technology, a crucial ingredient for the development ethanol industry in the long run, especially because of its positive technological externalities. Taking into account the progress of last generation technologies to process ethanol from lignocellulosic biomass (second-generation ethanol), already taking place, Brazilian federal government could have a more prominent role within the Sectoral System of Innovation and Production (SSIP) of ethanol by implementing strategic policies in line with that development. Moreover, by being on the frontier of knowledge and technological development, production of second-generation ethanol can enhance the sugar–ethanol segment and it can induce transformations in the economy as a whole. Not only it pushes scientific and productive development forward, but also creates demand for skilled workers and opens new opportunities in related economic activities with lower level of greenhouse gas emission.

2 Theoretical background and methodological approach

On the basis of the concept of Sectoral System of Innovation and Production (SSIP) as theoretical guidance for this analysis, public policies¹ are seen as structural components
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of a system surrounding the production of ethanol in Brazil. The notion of SSIP is appropriate for analysing public policies designed to promote production and innovation in those segments based on natural resources, such as that of ethanol. Bearing this in mind, it is possible to identify the boundaries between the components of that system, including government actions to promote technological innovation and productive and organisational changes resulting in a cooperative and also competitive environment (Rosario, 2008). Therefore, the focus of this analysis goes beyond the dynamics of innovation in the sectorial system, comprising incentives for improving production processes and wider spillovers that result in higher competitiveness in the ethanol sector.

According to Malerba (2002, 2003), the interpretation of SSIP must take into account market and non-market relations behind the notion of sectorial structure, which goes beyond the industrial structure through a multi-dimensional, integrated and dynamic perception of a sector. The actors of a system can be individuals or organisations involved with different learning processes, organisational structures, beliefs, purposes and behaviours, and they can interact by means of communication, exchange, joint operations, competition and hierarchical relationships. From this standpoint, a system can also encompass institutional actors whose actions affect both innovative ability of a firm and subsequently process of economic development (Nelson, 2006).

Three groups of actors can be detected in the SSIP of ethanol. The first involves supplying companies and producers, the second consists of entrepreneurial agents, scientists and consumers and the third comprises institutional actors not directly linked to the production system, such as universities, financial institutions, technical associations and governmental agencies (Figure 1) (Malerba, 2002).

Figure 1  Actors of the SSIP

Government and its agencies have an important role in designing and enacting policies towards the whole sector. On the basis of Nelson (2006), support to research and development (R&D) in sectorial systems can be provided by three types of programs or actions through governmental agencies. The first one disseminates knowledge in certain scientific fields in the long run, the second is carried out by agencies with the purpose of meeting needs of new equipment and R&D and the third is focused on short-term requirements of an industrial segment or a group of clients. Thus, actions and decisions taken by government through its organisations and agencies are essential to a sectorial system, given that public policies can affect the performance of a large range of sectors and the overall process of local and national economic development. Institutional actors like universities, financial institutions, local authorities and governmental agencies are
essential components of SSIP, whose actions and strategies shape its structure and its process of technological innovation and dissemination. Accordingly, this paper is focused on actors responsible for public policies targeting competitiveness of ethanol production system and its spillovers, with emphasis on the period after 2003.

However, in order to understand the role of federal government in supporting ethanol industry in Brazil, it is important to stretch back to the mid-70s when ethanol market was deeply shaped by federal government intervention, opening a successful alternative route to the historical reliance on fossil fuel. By then, as Brazilian economy relied heavily on foreign sources of oil, its frequent price increases had a direct impact on inflation and foreign exchange reserves. It was in such a context that government detected ethanol as a possibility to mitigate those problems and also to create favourable conditions for the country’s energetic sovereignty, launching in 1975 the National Alcohol Program. By that, government expected to improve economic conditions in the hinterland, to stimulate national technologies and equipment, raising the level of employment and income (Michellon et al., 2008). Therefore, the governmental support had a crucial role in such a context, both reducing the existing uncertainties and opening up a market for biofuel (Shikida, 1998).

In the following years, however, ethanol industry went through market instabilities and difficulties to develop new technological tools required in the production of second-generation ethanol. Simultaneously, although being an important factor in the SSIP of ethanol, government has, to a large extent, neglected its role, taking rather a hesitant position. Yet, if this market is considered strategic in a long-term view for the country, Brazilian government can act providing the necessary conditions for a dynamic process of innovation in this activity in order to impact its surroundings and the economy as a whole, as it did in the past when biofuel market was created.

Although largely seen as less competitive in economic terms, given its higher costs, when compared to fossil fuel, ethanol has become very important for Brazilian economy and a greener option, given its capability to reduce the greenhouse gas emissions. For the US Environmental Protection Agency (EPA), Brazilian sugarcane first-generation ethanol is highly advanced, mainly due to the reduction of emissions by up to 50% along its life cycle (US Congress, 2007). As for the second-generation biofuel the reduction is of 60%, which demands high technology in order to process lignocellulosic biomass, including, for example, vegetable residues, sugarcane bagasse, switchgrass, sorghum and algae (Coyle, 2010).

Furthermore, actions by the Brazilian State were indispensable for biofuels in the past and now they continue to be in the light of competition between fossil and biofuels, given different cost structures that private companies have in their exploitation of fossil fuels market. Such a difference is highly affected by permanent price oscillations of oil in the international context. Hence, if restrictions to gas emissions are not adopted, subsidies will still be necessary for biofuels to become viable and competitive (Alic, 2013). On the contrary, government support remains important until investors start believing that prices and demand for biofuels are immune from political decisions to favour more pollutant options, which have historically been supplied by stronger markets. That is why public policies aiming long-term economic development are so important. Therefore, being less competitive than fossil fuels, biofuels, inevitably, still depend on public policies to create favourable conditions for their markets to prosper.

The engagement of State has taken place not only in Brazil but also in the USA, where, since the late 70s, government has stimulated production of ethanol by means of
different pieces of law with the purpose of becoming less dependent on fossil fuels. Subsidies were given for production and consumption of corn ethanol from 1978 until 2011, largely due to a strong lobby in the federal congress as well as governments of producing states. Production of ethanol has been widely regarded as important based on principles of national sovereignty by controlling new sources of energy (Tyner, 2008; DOE, 2011; Yacobuci, 2012). Besides, concerns about environmental sustainability, already in the official agenda, became more prominent when were connected with technological development and trade relations. Therefore, investments on technology and knowledge were decisive factors pushing the country to a competitive position in this economic activity. In the light of these events, attention could be drawn to public policies and to the actual actions of State to deal with the issues related to ethanol in Brazil.

3 Components of ethanol SSIP in Brazil

As already mentioned, Brazilian State has been crucial for the development of the ethanol sectorial system since PROALCOOL was launched in 1975, fostering a domestic market of ethanol as well as R&D programs focused on biofuels. That was the beginning of a sectorial system to produce ethanol, when a public institutional apparatus was heavily committed to stimulating this activity (Pedro, 2008; Maia, 2009; Varrichio, 2012). However, despite being a milestone in the evolution of energy policy and having triggered off the progress of ethanol in Brazil, PROACOOL was dismantled in the 1990s as the State stepped back from its initial role, causing its sectorial system to be deeply disfigured. This was one of the main reasons why this system became deficient in its organisation, interaction and governance in the 1990s and afterwards (Baccarin, 2007; Michelon and Santos, 2008; Batista and Alves, 2011). By giving up on its central role in sugar and ethanol markets, government deeply caused the activity to undergo greater instabilities, jeopardising future developments in terms of sustainability and technological innovation (Pedro, 2008; Furtado et al., 2011). The retreat of federal government aggravated the economic conditions to produce ethanol by eliminating guarantees that large-scale production of ethanol would be more profitable than sugar production (Baccarin et al., 2009). Overall, government gave a veiled hint that biofuels were not relevant to reduce dependence on fossil fuels after 1990s, that is, the biofuels sector was not considered as an economic opportunity to explore its scientific and technological dynamics.

To analyse the actions implemented by Brazilian federal government in the sugar–alcohol segment after 2003, it is necessary to display the composition of the SSIP as well as to assess the level of commitment to ethanol as an alternative among renewable fuels shown in plans and decisions made. On the basis of Pedro (2008), Maia (2009), Souza and Hasenclever (2008), Furtado et al. (2011), Varrichio (2012) and Souza (2013) the sectorial system of ethanol in Brazil can be described by interactions between the following components:

a mills and distilleries
b equipment supplying companies
c research companies on biotechnology
d research institutions and laboratories
universities

funding agencies and credit institutions

government organisations, including departments and regulation offices
distributors and consumers.

It is important for this analysis to point out the extent of actions and instruments implemented by federal government, its goals and trajectories, and if the ethanol sector has been prepared to face new industrial and technological challenges, particularly those related to second-generation ethanol. This is where opportunities lie for a successful strategy to increase production more efficiently, including a better use of raw material (Embrapa, 2008; Bomtempo and Chaves, 2014). The prospects of ethanol production and consumption are hinged on new technological routes, such as those emerging from the second-generation biofuels. As mentioned by Furtado et al. (2010), in order for decreasing returns not to set in, the process of technological innovation in agriculture must be raised, so that the country can transform productive advantage into an effective scientific and technological leadership.

Although first-generation ethanol is produced by means of traditional process, obtained from sugarcane instead of residual biomass, its potential competitiveness in the next years will depend on the development of a production system based on lignocellulosic biomass. First-generation biofuels are those currently most consumed, consisted of ethanol (made from sugarcane and corn) and biodiesel (obtained from grains and plants/animals by-products) (Sims et al., 2008; Hofstrand, 2009). Second-generation biofuels correspond to those which are produced from cellulose, hemicellulose or lignin of organic materials, that is lignocellulosic materials comprising those three components. The main examples are cellulosic ethanol, obtained from waists and straws of sugarcane and corn, and biodiesel/synthetic biofuels that are similar to those obtained from fossil sources (IEA, 2010; Higam and Singh, 2011).

To analyse actions and instruments implemented in Brazilian SSIP of ethanol, emphasis is given here to the sphere of federal government and to all polices and decisions focused on the ethanol sector, mainly second-generation biofuels. Emphasis will thus be given to those departments of federal government directly or indirectly involved with SSIP of ethanol, once the guidelines are designed at federal departments and passed on to lower tier institutions, according to decisions made at the higher ones in the government hierarchy. Therefore, in the light of orientation shaping the policies adopted in recent years, it is possible to detect the significance of ethanol as a strategic segment for Brazilian government.

In his analysis about the governance of the innovation system of ethanol, Pedro (2008) places on the macro-level those federal institutions acting on regulation, R&D and innovation and setting public policies, such as Department of Agriculture, Cattle and Distribution (MAPA), Department of Mining and Energy (MME), Department of Science, Technology and Innovation (MCTI), Department of Development, Industry and Foreign Trade (MDIC) and Department of Education and Culture (MEC). At a lower level and attached to those departments, other institutions need to be taken into account to grasp the dynamics of the ethanol SSIP (Figure 2).
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4 Federal policies and actions to foster ethanol in Brazil

There are a broad range of opportunities associated with the technological dynamics surrounding the sectorial system of production and innovation of ethanol, specifically that of second generation (CGEE, 2009; Bomtempo, 2010; Cortez, 2010; Goldemberg, 2011). Thus, it is important to verify if this view has become a main goal of public policies for renewable biofuels focused on increasing competitiveness in a broad sense.

The reason why supporting this sector and its technological progress can cause positive impacts on economic development is that ethanol is based on renewable sources and it can be added to gasoline or used by flex fuel vehicles. Therefore, besides diminishing dependence on fossil sources, ethanol consumption can reduce emissions of greenhouse gases by 50%, compared to fossil fuel. In the case of second-generation ethanol, it can reach more than 60% in reduction of emissions (US Congress, 2007). Furthermore, if favourable conditions are provided to technological development in this segment, the country as a whole will have the opportunity to evolve more rapidly towards a stage in which biofuel is produced from lignocellulosic biomass. To expand the production of second-generation ethanol, supporting policies can help the production of biofuels become more competitive. As mentioned above, public support is crucial for this sector to become more competitive than the already settled fossil fuels production chain. That is, federal government plays a crucial role in mitigating risks through supporting strategic research projects and economic incentives to this sector. This is what has most frequently happened in the USA, where a strong presence of federal government and second rank institutions provide support to ethanol market and technological developments (Fuller, 2014; Yacobucci, 2012; CBO, 2012; Stubbs, 2010; DOE, 2010). Conversely, in Brazil, as shown below, the engagement of federal government is only eventual, to foster technological progress for ethanol.
By doing so, supporting policies will be able to transform a natural resource-based activity into a dynamic one, and consequently boost economic development due to productive and technological externalities (CNPEM, 2013; Furtado et al., 2011; Cortes, 2010; Bomtempo, 2010; CGEE, 2009). Competitiveness of Brazilian ethanol has derived from technological progress in sugarcane production, including genetic improvement, mechanisation, biological control of pests and recycling of residues. From these mechanisms emerged an institutional infrastructure of scientific research, responsible for generating more productive and resistant varieties (Bastos, 2007). That is, State has been an important agent, by means of public policies, reinforcing existing capabilities among private companies and governmental institutions as well.

Once around 65% of production cost is related to raw material (Rosillo-Calle, 2010), progress achieved by research can boost productivity, which will certainly be embodied in the processing of cellulosic ethanol, as this is obtained from sugarcane residues. In the end, this can be an opportunity for the country to be in a competitive position in the world market of biofuels. Given this scenario, our objective is to observe how it has been the commitment of federal public policies in a way that Brazil can take advantage of the already existing competitive conditions of the ethanol SSIP.

In other words, federal government is in a position to stimulate positive spillovers beyond the sector itself, improving the quality of human resources, attracting investments in supplying activities like machinery and equipment, reducing the dependence on fossil fuel and increasing foreign trade. There is a specific literature discussing development perspectives for countries whose economies are deeply based on natural resources whose exploitation can allow them to leap to a new economic and social status (Pérez, 2010; Marin et al., 2009; Marin and Smith, 2010; Marin and Benavente, 2011; Katz et al., 2011). Our argument concerning the Brazilian SSIP of ethanol follows that approach and suggests that coordinated actions by federal government can invigorate the SSIP of ethanol in a way to profit from the opportunities emerging from second-generation biofuels.

Figure 3 shows how the guidelines established by the federal government trickle down to actions taken by institutions working on research, development and innovation (R&D&I), credit, control, regulation, trade promotion, weather surveillance and geographic zoning. At this point, it is important to stress the issue connecting public policies with production of second-generation ethanol, given its technological intensity and its higher potential for demand and for scientific and technological investments. Thus, which guidelines set by federal government can be more responsive to the transformations required by higher competitiveness and multiplying effects of ethanol production?

This question is discussed below in the light of policies implemented by federal departments and related institutions involved with ethanol market in 2000s. After revolving official documentation and websites, we could rank the actions and policies according to each program or subject, what allowed us to assess the level of government’s commitment to ethanol.

The role of MAPA concerning ethanol is that of just gathering information about the activity and monitoring its evolution, although its involvement with fiscal benefits and subvention to the Northeast region must be mentioned. So, MAPA has just played a consulting role and provided technical support, like monitoring and indicating areas suitable for sugarcane crops. For EMBRAPA, ethanol, including the second-generation one, has become an important issue, after a specific branch was set up, the EMBRAPA
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Agroenergia (Table 1). However, no significant result has yet been achieved, thus indicating the criticism about the low priority EMBRAPA has given to sugarcane and biomass ethanol in its operations. This criticism emerged amid a debate in Brazil over its engagement in activities not belonging to its core mission. EMBRAPA, for instance, has a long history in fostering knowledge and technologies to agriculture, especially soybeans crops, but not to sugarcane. In the past, there were institutions like PLANALSUCAR which had a significant involvement in sugarcane-related activities, which was dismantled in the 1990s when federal government withdrew from this sector.

Figure 3  Federal guidelines for specific areas that affect ethanol competitiveness

<table>
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<tr>
<th>Actions/Policies</th>
<th>Short description</th>
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<tbody>
<tr>
<td>CIMA</td>
<td>Council that sets rules for ethanol and sugar production, including the proportion of ethanol blended with gasoline</td>
</tr>
<tr>
<td>Sectoral chamber</td>
<td>It organises meetings of representatives, though with no decision power</td>
</tr>
<tr>
<td>ZAECana</td>
<td>It defines the extension location of cropping areas for sugarcane and also monitors harvests all over the country</td>
</tr>
<tr>
<td>SAPCana</td>
<td>It monitors harvests all over the country</td>
</tr>
<tr>
<td>Grants</td>
<td>It can provide subsidies to compensate losses caused by severe draughts in the Northeast region</td>
</tr>
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</table>

Linked institution

‘EMBRAPA Agroenergia’ is a branch of the EMBRAPA that conducts researches in many areas related to agriculture, focusing on issues related to biomass-energy

This was the first effective engagement by federal government in agroenergy, happened in 2007, providing supports for researches on second-generation ethanol

Source:  Own elaboration based on official documents and websites

Actions taken by MME to promote ethanol have been concentrated on regulatory aspects (Table 2). The release of debenture emission to the ethanol segment is an innovative action to mitigate financial problems of various companies, increasing its attractiveness.
for investment. Such actions reveal the strategic position of ethanol in the management of national fuel supply, though oil products are still having more attention. ANP has become responsible for regulation and supervision of ethanol domestic supply in Brazil including its quality, though this does not mean complete control. Currently, there are no mechanisms to assure that commitments of government towards the sector are attained, once market behaviour is, to a large extent, affected by the oscillations of sugar price, by uncertainties about the prospects of ethanol, and by the priority given by the government to gasoline.3 Despite the interest of ANP in ethanol, its capacity to offer an ‘institutional safeguard’ to investors in this market cannot be delivered by the existing regulatory and controlling mechanisms alone.

Table 2  Department of Mining and Energy – MME

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<tr>
<th>Actions/Policies</th>
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<tbody>
<tr>
<td>Definition of guidelines about Energy Policy</td>
<td>National Council of Energy Policy (CNPE) also sets guidelines for the use of ethanol based on the national energy matrix</td>
</tr>
<tr>
<td>Authorisation for debenture issuing</td>
<td>Issue of debentures approved in order to clear debts and increase investment in the ethanol sector</td>
</tr>
<tr>
<td>Plan for the use of biomass</td>
<td>The use of biomass has only come up in discussions about electric energy generation, without any concerns about its use to enlarge ethanol production</td>
</tr>
</tbody>
</table>

Linked institutions

ANP

National agency to supervise market of oil and other fuels. Ethanol market has become part of its assignments recently. In 2005, production and distribution of ethanol were put under responsibility of ANP. ANP has not been able to improve the conditions of production and distribution of ethanol, neither to reduce consumption oscillations.

PETROBRAS

Petrobras is the largest company in Brazil and the most responsible for exploration, refining, marketing and transportation of oil products in Brazil. Recently, it has been playing an important role in the ethanol market, but with association with other partners of Petrobras Biocombustíveis. Creation of Petrobras Biofuels in 2008. Petrobras became involved with ethanol after buying shares of companies already in the business, but its initial focus was on biodiesel. Partnerships have been set up but recently have been restricted to the company’s research centre. PETROBRAS has a high capacity to invest and to boost research in the field of cellulosic ethanol.

Source: Own elaboration based on official documents and websites

The involvement of PETROBRAS with biofuels due to concerns about the matter raised in 2006, resulted in the creation of Petrobras Biocombustíveis (a branch for biofuels) only in 2008 (Table 2). Ethanol only became an important portfolio, particularly after its association with other companies to produce ethanol. This has also been a common behaviour among petrochemical companies working in fossil fuel market. According to Alic (2013), large global companies are investing in biofuels as a strategy to protect their assets, and also to stake a claim in a segment other than fossil fuels. Likewise, Oberling et al. (2012) examine the interest of companies such as Shell, Petrobras, ExxonMobil and
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BP in both first- and second-generation biofuels, so that they will be leading players in such a market in the future. As for PETROBRAS, even though biofuels are not a priority, not employing its financial capacity and qualified human resources, some research on cellulosic ethanol has been carried out. However, unless federal government takes first- and second-generation ethanol into the agenda, PETROBRAS will keep it as a second priority as compared to oil. This argument is based on the strategies adopted by the company related to its core business in recent time, that is, the exploration of oil in deep-water and refining/distribution of fossil fuels.

Overall, ethanol lost ground in recent years mostly due to reduction of oil price in international market, thus making the former less competitive than gasoline (Baccarin, 2007). This price mechanism has been the main problem for Brazilian ethanol. If oil price rises consumption of ethanol in domestic market increases, but if oil supply grows, as shown after pre-salt reserves were detected in the Brazilian deep ocean, its price falls, making ethanol less competitive.

MCTI has strongly supported ethanol through its subordinate organisations, transferring financial resources to research and development (Table 3). However, as mentioned above, despite renewable energy being regarded as a strategic area under the PACTI (so far, one of the biggest federal program created to grant funding for innovative projects in many areas), those financial resources held by the Sectorial Funds and passed on to Ethanol Program did not reach a level of priority compared to other programs like National Program for Production and Consumption of Biodiesel. Between 2006 and 2013, only US$ 13 million out of US$ 1.1 billion held by PACTI, were spent on Ethanol Program. Meanwhile, Biodiesel Program received US$ 47 million, a much larger amount than that bound for projects related to ethanol. In fact, attention on renewable energies was mostly concentrated on this program, launched in 2005. On the one hand, once transportation in Brazil is mainly by trucks running on diesel, there is an interest to increase production of biodiesel from renewable sources. On the other hand, this shows that government has not been sufficiently committed to sugarcane ethanol as it could, indicating that public policies for renewable energy in the long term have not given priority to ethanol.

Although FINEP has an essential role in providing financial support to research and innovation projects in ethanol, the creation of CTBE and its partnerships aiming studies of biomass and cellulosic ethanol should be highlighted. This is not a problem in Brazil, given that the huge supply of biomass obtained from sugarcane can be used to produce ethanol (Goldemberg, 2011; EPE, 2013). Therefore, efforts to discover new sources of biomass have become unnecessary, instead harnessing techniques economically viable to produce second-generation ethanol from sugarcane. Hence, research on sugarcane varieties has become highly relevant causing the country’s competitiveness in this segment to increase.

MDIC is mentioned in this analysis only due to a few actions taken by its linked institutions, BNDES and APEX (Table 4). All actions of MDIC to the ethanol system have been insignificant, without accomplishing impact on competitiveness of the ethanol sector. Regarding financial resources, a partnership between BNDES and FINEP, the latter linked to MCTI, has provided some support for research on second-generation ethanol. Those actions will be able to achieve effective results in the future insofar as consumption grows and uncertainty about ethanol in domestic market reduces.
Hence, initiatives conducted by APEX have a strategic orientation keeping in mind its medium and long-term goals to strengthen the competitiveness of Brazilian ethanol in the foreign markets. However, this kind of government action does not have impact on the competitiveness of ethanol domestically.

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<th>Table 3</th>
<th>Department of Science, Technology and Innovation – MCTI</th>
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<tbody>
<tr>
<td><strong>Actions/Policies</strong></td>
<td><strong>Short description</strong></td>
</tr>
<tr>
<td>PACTI</td>
<td>Creation of Ethanol Program within PACTI (federal program to foster research and development in many sectors) as a strategic area</td>
</tr>
<tr>
<td>Sectorial Funds to provide grants to public institutions in project with companies</td>
<td>There are 15 Sectorial Funds, but not a specific one for bioenergy or biofuels</td>
</tr>
<tr>
<td></td>
<td>From 2006 to 2013 Ethanol Program, within PACTI, received around US$ 13.4 million from some of the existing Sectorial Funds, while Biodiesel Program had US$ 47 million</td>
</tr>
<tr>
<td></td>
<td>Therefore, biodiesel and ethanol started competing for resources from PACTI. The biggest share was invested in projects related to biodiesel. Moreover, there were priorities to projects related to biodiesel and not to ethanol</td>
</tr>
<tr>
<td></td>
<td>The lion’s share of resources was accrued to only five projects within Ethanol Program, two of which related to cellulosic ethanol</td>
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**Linked institutions**

**FINEP**

- It is a branch of MCTI to set strategic planning and provide financial support, like grants and financing to labs, companies and public institution, including universities
- This institution has defined renewable energies as priority to its operational policies in 2011–2014
- Eleven projects related to second-generation ethanol were approved (US$ 14 million or 31.1% of what was destined to projects involving sugarcane, including the use of biomass to produce electric energy) between 2007 and 2010

**CTBE**

- It is a federal lab and it is focused on second-generation ethanol. Besides, this lab seeks partnerships to conduct research on bioenergy/biomass
- It has an important role in the technological development of cellulosic ethanol in Brazil
- It has set partnerships with public and private sectors involving promising projects related to biomass and cellulosic ethanol. They have regular financial support provided by MCTI

**INPE**

- It is another MCTI’s branch to provide support related to weather forecasting. And they have an instrument (CANASat) to monitor sugarcane crops
- Satellite monitors are essential to watch cropping areas and to prevent climate problems

Source: Own elaboration based on official documents and websites
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Table 4  Department of Development Industry and Foreign Trade – MDIC

<table>
<thead>
<tr>
<th>Actions/Policies</th>
<th>Short description</th>
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<tbody>
<tr>
<td>Ethanol was part of 'Plano Brasil Maior' (PBM)</td>
<td>Although deprived from a strategic meaning in this department, ethanol is part of an important federal program to foster industrial development (PBM). However, ethanol has to compete with other segments for the same resources</td>
</tr>
<tr>
<td>Renewable Energy Council for the industrial matters/projects</td>
<td>The council in charge of issues related to renewable energy in the context of the PBM demanded a study about innovative technologies in which cellulosic ethanol was included, even though no result that could increase technological competitiveness in that sector was produced</td>
</tr>
</tbody>
</table>

**Linked institutions**

**BNDES**
A federal bank whose mission is to provide cheaper financing to foster national economic and social development. Recently they started to work on programs on innovation in ethanol sector. That was a good initiative because private companies were stimulated to invest in R&D on ethanol production (including second generation)  

Innovation was included in the operational routine, benefiting the ethanol sector, particularly researches on cellulosic ethanol  

Creation of Biofuels Department at BNDES  

Five credit lines related to ethanol were created, one of them to support second-generation ethanol (PAISS)  

PAISS has the role of coordinating the transfer of resources to research and development in the ethanol sector  

The amount of funds predicted ended up being shorter of the previous demand

**APEX**
This is a Federal Agency to promote Exports and Foreign Investments in Brazil. Ethanol became part of its concerns in recent years. The biggest action was as the sponsor to Formula Indy, where cars could be filled up with ethanol  

Formula Indy: Diffusion of sugarcane ethanol abroad and use of physical space in competitions for business making  

Partnership with UNICA (lobby of Brazilian producers): marketing promotion of Brazilian ethanol, showing its difference from the American one based on corn and also to eliminate trade barriers and expand its share in the global market

*Source:* Own elaboration based on official documents and websites

As part of federal government, MEC conveys resources to scientific research, both theoretical and applied, taking place in federal universities, which can produce useful knowledge to improve the performance of SPPI and competitiveness of ethanol. RIDESA, a research network of federal universities, has become an important part of the SSIP of ethanol (Table 5). This network has significantly improved farming performance by the development of new varieties and production systems in approximately 60% of the whole sugarcane area, without counting on any regular federal support or financial assistance from the Department of Education and Culture (MEC). After RIDESA was incorporated as part of the university organisation, additional resources for research began to depend on partnerships created by the initiatives of local researchers in charge.
of specific programs, though within the limits established by legislation ruling federal universities. So, based on a perspective of strategic development, the position of RIDESA within the federal government structure could be articulated with other institutions acting on ethanol-related issues like EMBRAPA and CTBE. But this does not happen because, in general, there is competition between federal institutions instead of their cooperation.

Table 5

<table>
<thead>
<tr>
<th><strong>Department of Education and Culture – MEC</strong></th>
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<tbody>
<tr>
<td><strong>Linked institutions</strong></td>
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<tr>
<td><strong>RIDESA</strong></td>
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<tr>
<td>Consortium of federal universities and researchers working on a germoplasm bank, including energy based on sugarcane</td>
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<tr>
<td>Sources of financial support</td>
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<tr>
<td>Royalties from varieties produced by RIDESA</td>
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<tr>
<td>Grants from partnerships and projects submitted to various institutions</td>
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<td>Federal universities get funding from MEC, but they do not provide specific resources to projects managed by RIDESA. Thus, RIDESA’s research is just one project among many others</td>
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*Source*: Own elaboration based on official documents and websites

5 Discussion

Brazilian federal government support to ethanol sector in recent years has been largely based on fiscal allowances and credit concession through BNDES and FINEP, mainly after CIDE (a tax over gasoline price) was written off in 2012. Moreover, based on documents and information used for this analysis, we consider that actions conducted by federal departments and their kin institutions reveal that ethanol has not been included in the long-term development agenda as a strategic area for the country when technological, environmental and economic aspects are regarded. Although policies concerning ethanol sector in Brazil could be valued, most of them focus on short-term problems. However, competitiveness in the ethanol sector, as well as in all renewable energy activities, requires a long-term view. Besides the creation of CTBE (federal lab) and all resources transferences by BNDES and FINEP to foster second-generation ethanol, there has been no meaningful instrument or action looking to the long term by federal government other than the addition of ethanol anhydrous to gasoline.

The four institutions directly involved with R&D activities (EMBRAPA, CTBE, RIDESA and PETROBRAS) have not set a partnership, what could be able to create a synergetic environment favourable to speed up researches on ethanol. In January 2010, CTBE made a formal agreement with EMBRAPA with no meaningful repercussion, except from a project to use D-xylose of hemicellulose extracted from sugarcane pulp that begun in 2012. Another initiative with some result started in 2009 through a partnership between CTBE and University of Caxias do Sul, in which EMBRAPA joined
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in afterwards. In 2010, a partnership was set between RIDESA and EMBRAPA in Alagoas (a state in the Brazilian Northeast and a long-standing ethanol producer). Additionally, RIDESA set partnerships with private companies and research institutions in São Paulo (the richest state in Brazil and one of the biggest ethanol producers). Besides setting partnerships with other private companies to carry out research on cellulosic ethanol, PETROBRAS has not been in permanent cooperation with other federal government institutions.

Therefore, the relationship between these organisations in carrying out R&D related to ethanol in Brazil has been intermittent and ineffective. Despite scattered actions to face technological challenges related to second-generation ethanol, there is no connection or synergy among them and the institutions responsible for that. Moreover, lack of a cohesive policy for R&D from the Brazilian federal government means that there is no coordination able to bring all isolated actions into one national long-term strategy for the segment of ethanol. This is aggravated by the fact that technologies related to development and production of enzymes to break/process biomass, enabling sugar fermentation, are mainly in the hands of foreign companies. This means that Brazil, with a long history and an indisputable international competitiveness in producing renewable fuels, can be in a very frail position if conditions to develop technology internally for its own technological dynamic are not provided.

The euphoria in the ethanol market in Brazil, due to an increase of flex-fuel fleet (vehicles fuelled with gasoline or ethanol) after 2003 did not prevent government actions from being sluggish and uncoordinated in the light of a new scenario with good perspectives in the field of renewable fuels, particularly ethanol. As illustrated by the partnership between FINEP and BNDES (federal financial branches to foster R&D activities), they have supported innovation projects to develop second-generation ethanol, but the allowances to private companies and public labs have not been enough to cope with the current requirements for ethanol competitiveness, mostly concerning technological transformation. On the basis of the evidences collected, we can say ethanol has not been recognised as strategic for the long-term development by the Brazilian federal government so far.

Overall, despite Brazil’s pioneering position, after becoming one of the world’s main producers of biofuel, it is necessary to critically discuss the commitment of the federal government to the ethanol sector. After all, the challenges emerging in the field of energy and renewable biofuels are directly related to ethanol, something that Brazilian government seems to overlook.

6 Conclusions and policy implications

Regardless of the potentials of ethanol as a strategic sector for economic development in Brazil throughout the years given its technological dynamics and its ability to replace fossil fuels by a renewable fuel, and despite the actions and instruments shown above, there is no visible long-term strategy by the federal government to promote ethanol in an organised and coordinated fashion. Hence, the lack of articulation between federal departments with other institutions is critical and is bound to weaken the activity in the light of the more competitive international environment.

As a matter of fact, there are some actions and policies enacted in the Brazilian federal surroundings, but long term and structural challenges cannot be faced with short-
term measures. The main mechanisms used by federal government in Brazilian ethanol market, namely the percentage of ethanol anhydrous added to gasoline and fiscal allowances, can be helpful to expand the domestic market of ethanol. However, the limit of addition of ethanol into gasoline has been reached.\(^{11}\) There seems to be no more space for short-term measures, whereas there is no sign of local and national development strategies taking into account the importance of ethanol. In the early 2015, CIDE (a tax over gasoline prices) was reintroduced, but it is not clear the deadline for it to work as a support to the ethanol market in Brazil. While government has chosen short-term actions, the sector will be facing the same problems, if no strategic decision to strengthen the sector and to foster technological change is taken. As a result, Brazil is bound to remain dependent on fossil fuels and to miss a big opportunity to develop a sector based on new technologies able to increase productivity in biofuel production processing the available biomass from sugarcane crops. Therefore, second-generation ethanol should be more explored and accepted by policy makers, as the country is losing ground in this field. Therefore, as argued in this paper, the role of State in the SSIP of ethanol is very important, as illustrated not only by the history of Brazilian sugarcane industry, but also by the need to support an activity able to outstrip fossil fuels. Technological challenges in the development of lignocellulosic ethanol have demanded a broad support in a way to make it competitive. The approach of SSIP adopted in this paper is a useful theoretical tool to point out how important State can be to induce transformations in that activity.

Policy makers have spoken, widely reverberated by the media, about the importance of biofuels within a new *modus operandi* in the fuel market. Nevertheless, in practical terms, what has been achieved so far in the ethanol sector, though important, has been constrained by the lack of interest to set up an integrated and cohesive policy to promote a pattern of development in which renewable biofuels play an essential role. As discussed here, Brazilian federal government has conducted some actions to give some support to ethanol producers, but those actions do not seem to be based on long-term prospects in order to promote ethanol as a more sustainable biofuel produced from the lignocellulosic biomass by means of modern and productive techniques. By scrutinising actions and positions assumed by federal institutions, we have made clear that ethanol is still not a priority in the realm of Brazilian development policy. So, when asked which guidelines set by federal government have been more responsive to push the sector to a higher level of competitiveness and technological advances in the ethanol market, the answer is rather frustrating, given the lack of a stable guidance and solid policy framework. All actions have focused on short-term demands and disruptive circumstances, in detriment of a project to reduce dependence on fossil fuels and develop technologies in the ethanol sector.

References
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EPE (2013) Análise de Conjuntura dos Biocombustíveis, Nota Técnica 01-2013, Brasilia, DF.


**Notes**

1Despite some differences between federal policy and governmental policy, in this paper both concepts are treated as similar.

2All acronyms are based on the names of federal departments in Portuguese: MAPA – Ministério da Agricultura, Pecuária e Abastecimento; MME – Ministério de Minas e Energia; MCTI – Ministério de Ciência, Tecnologia e Inovação; MDIC – Ministério do Desenvolvimento, Indústria e Comércio Exterior and MEC – Ministério da Educação.

3The end of CIDE (a tax over gasoline price) and the contention of fuel price between 2013 and 2014 illustrate these actions. Moreover, this was made worse by the inexistence of a world market of ethanol like that one which other mineral and agricultural commodities are part of.

4After pressures conducted by the ethanol producers and representative entities, this tax was reintroduced in the beginning of 2015.

5Available at: http://www.cnpm.br/blog/2010/01/21/pa rceria-da-embrapa-promove-desenvolvimento-energetico/

6Related to the project “Aproveitamento da D-xilose da hemicelulose do bagaço de cana-de-açúcar para obtenção de compostos químicos renováveis de alto valor agregado (C5-AGREGA)”. For additional information, see: https://www.embrapa.br/bu sca-de-noticias/-/noticia/1486518/projeto--estudara-aplicaoes-quimicas-e-bioquimicas-da-xilose

7The project is related to the investigation of microorganisms to be used in the production of enzymes able to process sugarcane biomass. According to its leader Jose Geraldo Pradella, the present cost to produce cocktail of enzymes reached by the project in August/2014) is US$ 0.10 per litre of ethanol, and the goal is US$ 0.05, less than what has been regarded as necessary to make its use viable economically. Available at: http://ctbe.cnpm.br/coquetel-enzimatico-ctbe-etanol-2g/


9Available at: http://www.cpatc.embrapa.br/index.php?idpagina=artigos&artigo=9789

10RIDESA has been involved in projects with Centro de Tecnologia Canavieira (CTC) sponsored by companies of the sugar alcohol segment and with Instituto Agronômico de Campinas (IAC), and other companies. Further information can be found at: http://www.agrolink.com.br/noticias/NoticiaDetalhe.aspx?CodNoticia=191946. A case of partnership between RIDESA and Mexican companies can be seen at: http://www.jornalcana.com.br/grupo-mexicano-firma-parceria-com-ridesa-para-intercambio-de-variedades

11In September 2014 federal government raised the percentage of addition to 27.5%, which is still under assessment by National Council of Energy Policy.