From Sugarcane To Ethanol: The Historical Process That Transformed Brazil Into A Biofuel Superpower

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Abstract. Brazil is a biofuel superpower and a pioneer in the large-scale production and use of sugarcane ethanol. The country has plans to replace 10 percent of the world's fossil fuels by 2025 with biofuels (Novo et al., 2010). Brazil is also part of a multilateral agreement signed at the Paris Climate Conference (COP-21) in 2015 and has committed to reducing its greenhouse gas (GHG) emissions by 43% until 2030 compared to 2005 levels (Brazilian Government, 2015). The proposal for GHG reductions is mostly based on the increase of biofuels in the Brazilian energy mix. With historical institutionalism as its theoretical framework, this paper looks at how Brazil grew from a sugar exporter into a global ethanol powerhouse. This research's main question looks at the key historical processes and national actors behind ethanol development in Brazil. Analyzing how sugarcane-based fuels evolved is central to understand how past energy transformations have occurred and will offer insights into future energy transformations concerning Brazil's increasing reliance on ethanol.

Introduction

Brazil is a biofuel superpower and a pioneer in the production and use of ethanol on a large scale. Brazil has developed know-how and technological expertise in biofuels that few countries in the world have (Goldemberg, 2009). The country is a major producer, consumer and exporter of sugarcane ethanol (or 'alcohol') and has plans to replace 10 percent of the world's fossil fuels by 2025 with biofuels (Novo et al., 2010). The contemporary development of ethanol in Brazil is connected to a historical context in which sugarcane was the most important export commodity during the colonization period. This paper asks: what are the key historical institutional processes behind ethanol development in Brazil? This paper argues that national institutions have structured the biofuel sector in Brazil through systematic interventions in the sugarcane sector since the nineteenth century. These interventions include policies to provide credit, subsidies for the construction of mills and new refineries, mandatory mixing targets in gasoline, investments in research, and creation of national demand for ethanol. Analyzing this historical process is critical to understand how sugarcane-based fuels evolved and continue to be developed in Brazil.

Biofuel is not a new phenomenon in Brazil. The country is the second-largest bioethanol producer after the United States, and they collectively account for almost 90% of global production (Marin, 2016: 75). What is new is the increasing worldwide interest in renewable energy to replace fossil fuels and reduce greenhouse gas emissions (Demirbas, 2009; Kopetz, 2013). The recent global interest in biofuels has a direct impact on sugarcane production and consumption in Brazil. Despite the recent trend, the biofuel production in Brazil needs to be understood with a historical perspective (Novo et al., 2010). This study uses historical institutionalism as its theoretical framework to analyze how governmental interventions shaped processes and political outcomes that determined the historical trajectory of the biofuel industry in Brazil.

Theoretical Framework

Some authors define institutions simply as rules that frame or condition action (Hall and Taylor, 1996; North, 1990; Ostrom, 1990). This paper understands institutions as a "regularized

pattern of interaction" that is accepted by the actors involved who interact under formal or informal rules sanctioned and backed by that pattern (O'Donnell, 1996). For Thelen and Steinmo, it is necessary to look at the institutional landscape to answers questions regarding policy outcomes across time and space (1992: 5). In the case of Brazil, with almost 500 years of sugarcane history, looking into the past becomes imperative to analyze its transformation into ethanol. Furthermore, institutions exist in a context; they influence and are influenced by it (Steinmo, 1989). According to a report from the Inter-American Development Bank (IADB), "institutions help explain why reforms endure in some countries, why some countries can easily change policies that are not working well or why some can adjust better when circumstances demand it" (2005: V). The enforcing institutions of a society affect its economic performance and become the forum for interest-led politics and policymaking (Schamis, 1999: 267).

Moreover, institutions define who can participate in a specific political arena, and shape the actors by modifying their political strategies, and can influence what these actors' preferences are (Steinmo, 2001). The central point is that institutions set the context in which actors make policy choices (Hall and Taylor, 1996). Nonetheless, focusing the study on formal institutions does not imply denying the influence of other structural variables that can directly influence social policies and political outcomes. History, beliefs, and attitudes of citizens, culture, and leadership also have influence (ibid.: V).

In this paper, historical institutionalism is used as the theoretical framework. According to this view, human beings are 'norm abiding rule-followers' that will behave depending on the individual, on the institutional context, and the rule (Steinmo, 2008: 163). For historical institutionalists, institutions bestow power or authority upon some actors, and in the same way, they reduce the power of others. It focuses on empirical questions with a historical orientation and is mainly concerned with how institutions structure and shape political behavior and outcomes over time (ibid: 150). This framework helps to analyze choices and outcomes: why were they made, which actors influenced them and what were the consequences. Institutions are not neutral battlegrounds; they are essential because they are the center of political activity and structure this activity over time. As Steinmo argues, the institutional context is so crucial that interests and values do not have any substantive meaning if abstracted from it (1989: 502).

Historical institutionalism is a useful tool to develop a better understanding of how processes affected political outcomes in the ethanol industry in Brazil throughout time. According to Pierson and Skocpol, historical institutionalists ask "big, substantive questions" using macro contexts to analyze the combined effects of institutions in a period, rather than looking one institution or process each time (2002: 695-696). For Peter Hall, historical institutionalists "seek to locate institutions in a causal chain that accommodates a role for other factors, notably socioeconomic development and the diffusion of ideas" (1996: 942). Other authors have used historical institutionalism to look at the biofuels industry in the world (see Daugbjerg and Swinbank, 2015; Yang, 2015). It is not a simple look into the past of sugarcane and the transition to biofuel, but rather how this process developed over time through the influence of different national institutions. The main advantages are the possibility to look at processes continuity over time and space and see how policy outcomes develop in different institutional landscapes. Social and economic developments do not happen overnight; instead, they take time and a series of events in a determined context to exist. Thus, it is important to look at the combined effects of distinct institutions to analyze how institutions have structured the biofuel industry in Brazil.

Importance of Biofuel

Biofuel is any renewable fuel that is obtained through a biological process, such as

agriculture or animal waste, rather than a geological process, and the refined products are combusted for energy (Guo et al., 2015). Some projections indicate that up to one-fifth of the world's agricultural land could be used in biofuels production by 2050 (White and Dasgupta, 2010: 593). Currently, less than two percent of the world's arable land is dedicated to biofuels, and this is expected to increase to four percent by 2030 and 20 percent by 2050 (ibid.: 594). Other projections show that bioenergy will provide almost one-third of the world's demand for energy by 2050 (Guo et al., 2015). In addition, Brazil is part of a multilateral agreement signed at the Paris Climate Conference in 2015 and has committed to reducing its greenhouse gas (GHG) emissions by 43% by 2030 compared to 2005 levels (Brazilian Government, 2015). The proposal for GHG reductions includes an increase of biofuels in the Brazilian energy mix to 18% by 2030. The strength of the ethanol industry in Brazil is a result of a long and complex trajectory in which government support for biofuel production was decisive for it to succeed.

During the 2000s, several studies were published with a focus on the positive impacts of biofuel production (Kojima and Johnson 2005; La Rovere et al., 2014; Smeets et al., 2005). These studies focused on production costs, technological requirements, and land availability and indicated biofuels as a possible sustainable solution to reduce CO2 emissions. At the same time, biofuels were labeled as a "silver bullet" with the potential to supplant petroleum and support rural development (Neville, 2015). When defending Brazilian investment in biofuels in Mozambique, former Brazilian President Luiz Inácio Lula da Silva called bioethanol a "clean source of energy" (Power et al., 2016: 14). Nevertheless, this narrative has been challenged by scholars (Neville, 2015: 25). The fast expansion of biofuels has a social, environmental, economic, and political impact on agrarian relations and despite an institutional discourse framing biofuel as positive for all involved (Borras et al., 2010: 582). The increasing demand for biofuels, Brazil's push for more production, and the concerns surrounding its use as an alternative to fossil fuels make its analysis even more important

The Rise of Biofuels in Brazil

In 1979, José Goldemberg published a pioneering article about the possibilities of supplying the energy needs of the world and particularly of the developing countries based on hydropower and biofuel (1979: 733). It was a follow-up to an article he co-authored in the previous year on the energy requirements to produce biofuel from three different crops in Brazil (Da Silva et al., 1978). The research showed that for Brazil, it was both possible and profitable to invest in ethanol as a renewable fuel from sugarcane (ibid.). At the time, the world was passing through a dramatic oil crisis, and the notion that a plant could help solve the crisis was well-received (Nastari, 1983). In the same context, as we will see later in this paper, the Brazilian government was implementing a program to increase the production and consumption of ethanol (ibid.). A few years later, Barzelay and Pearson used the concept of social profitability to criticize the efficiency of alcohol production in Brazil (1982: 144). According to them, at that time, alcohol was a high-cost substitute for petroleum, and this figure would only change if the price of oil had a significant increase (ibid.). Furthermore, the price had a significant increase in the 2000s.

The biofuel resurgence during the 2000s was an answer to high oil prices and an attempt to reduce dependence on Middle Eastern oil embedded with a discourse of energy security and sustainability (Ragauskas et al., 2006). As concerns over climate change, oil prices, and energy security became a topic of intense interest, biofuels were seen as a possible clean solution to energy concerns and to develop underused lands (Neville, 2015: 25-26). It also gained momentum with mandatory international targets for the use of renewable energy and reduction of carbon dioxide emission (Borras et al., 2010). This increase means that more land is needed to produce more fuel

crops to meet this new demand. The biofuel industry in the world is directly linked to the "ethanol superpower Brazil" (ibid.: 578). Moreover, to understand how institutions influence the biofuel industry in Brazil across time, it is paramount to analyze the historical institutional context in which Brazil developed its ethanol industry and became a leading country in biofuels.

From Sugarcane to Ethanol

In 1532, long before the existence of mass biofuel production, sugarcane was brought to Brazil when the country was a colony of Portugal. At that time, it had almost the same value as gold and was the most important product of the Brazilian economy (Naritomi et al., 2012). Sugarcane is so crucial to Brazilian history that some authors argue that it not only provided the economic incentive to make Portugal heavily invest in the colony, but it also influenced the ethnic composition of the country seen today, as slaves were brutally taken from Africa to work in the sugarcane plantations and mills (Nastari, 1983). The value of sugar exports during the colonial period was twice the value of all gold and diamonds mined in Brazil during the same period (ibid: 2). In the nineteenth century, due to a decrease in the price of sugar and aggressive competition from other countries, coffee became the number one product on the Brazilian export balance (ibid.).

The development and massive investments Portuguese institutions made in the sugar industry in Brazil is an early indication that the biofuel industry in Brazil could not be what it is today without the colonial support of sugar. In 1875, the Brazilian government – no longer a colony from Portugal – established a decree to provide loans with low rates for the construction of modern central sugar factories (Meira, 2009). In a few years, Brazil built several central sugar factories using imported machinery. These new factories started to produce large quantities of residual molasses that were, in turn, used in the production of ethanol. Even though coffee became the main product in Brazil's export list in the nineteenth century onwards, Brazilian production of sugar continued to grow at the beginning of the twentieth century as the old mills were modernized (Nastari, 1983). According to Nastari, "the wide availability of ethanol [in the world] made its use as [a] transportation fuel as old as the automobile" (1983: 4). Later developments of sugarcane been used as a biofuel would not have been possible if Brazil did not have an agricultural complex focused on sugar. The colonial investments and a series of institutional interventions in sugar led to a future necessity to find other uses for surplus production, which led to the early adoption of ethanol and biodiesel.

The growth in the production of sugar was not matched by internal demand. At the same time, the world market price of sugar had a decline despite an increase in worldwide sugar consumption (Herold, 2009). According to Herold, the decrease in the price of sugar affected the Brazilian producers, but the loss of traditional export markets (e.g., the North American market to Cuba and Europe to European beet producers) was another critical factor that led to a crisis in the sector at the beginning of the twentieth century (ibid.). This crisis led to institutional interventions by the Brazilian state – a republican government formed after the end of the empire. In 1931, the Brazilian government published a decree (a mandate known as Decree 19.717), which established that all imported gasoline used in Brazil would have to be mixed with 5% of ethanol. Two years later, Brazilian president Getúlio Vargas created the Institute of Sugar and Alcohol (IAA, Instituto do Açúcar e do Álcool in Portuguese), and gave this newly created agency a monopoly over international sugar trading from Brazil (Szmrecsányi and Moreira, 1991).

The creation of an institutional actor to overview the sugar market and the ethanol production in Brazil had the objective to set prices, regulate, and act as a buyer of last resort after the great depression. The main goal was to achieve a balance between internal production and consumption of sugar and ethanol. According to IAA's first president, Leonardo Truda, "the

defense of sugar [...] is seen to be indissolubly linked to the large-scale production of alcohol as fuel (as) the stable and definitive solution to the sugar problem in Brazil" (Nastari, 1983: 78). His speech is a clear indication of an institutional agenda to shape and influence the biofuel industry in Brazil. During the time of the existence of the IAA, the production of sugar in Brazil increased from 1 million metric tons in 1933, reaching almost 8.5 million metric tons in 1981 (ibid.: 79-81).

In 1938, another decree from the Brazilian government established that 5% of ethanol would have to be mixed with the gasoline produced in the country. During the Second World War, the IAA provided financial incentives and issued administrative acts to develop the sugarcane production and increased the percentage of ethanol mixed with the gasoline to 42%, leading to "an impressive expansion of sugarcane production" in the Southeast of Brazil (Novo et al., 2010: 771-772). After the war, the mandatory percentage of ethanol went down, reaching 2.9% in the next decades. It is important to note that some authors connect the centralized control of markets given to the IAA as a broader reflection of the political values of Getúlio Vargas government, as Brazil was living under a dictatorship after only a few decades of democratic government (Ackrill and Kay, 2014: 30).

The government was not the only institutional actor involved in the development and structuring of the sugar industry in Brazil. In 1959, farmers, mills, and refiners of São Paulo, Brazil's largest state, created the Cooperative of Sugar, Alcohol, and Sugarcane Producers, to unite, support, and finance the sector (Hira and Guilherme de Oliveira, 2009). The international context also influenced the industry. When the US closed its markets to Cuban sugar in the wake of the Cuban Revolution in 1960, the IAA began to promote the expansion of sugar production to take advantage of the new market opportunities for exports. Sugar exports increased by 250% from 1965 to 1974 (ibid.). The institutional decision to promote sugar amid low oil prices did not help ethanol at that time. It was only after the price of oil imports skyrocketed that sugarcane ethanol once again was seen as a solution to a much broader problem.

Creation of ProÁlcool

After a few decades of decline, sugarcane ethanol regained momentum in the 1970s during the oil crisis. At that time, the cost of oil imports in Brazil increased from $606 million in 1973 to $2.6 billion in 1974 (Ackrill and Kay, 2014). Brazil was living a dictatorship, and the military government was having trouble investing in its 1974-1978 National Development Plan as the oil import expenditure was almost half the total exports in 1973 (ibid.: 32). In the meanwhile, the price of sugar also fell in the international market, creating an opportunity for biofuels. Producers of sugar asked for financial assistance, and the military government decided for a broader approach.

The Brazilian government intervened by creating the National Program of Alcohol (ProÁlcool, in Portuguese) to promote the use of sugarcane as a biofuel (Borras et al., 2010). ProÁlcool was created by the military government in 1975 to develop the production and consumption of ethanol further and reduce Brazil's dependence on imported oil, which amounted to almost 85% of all oil used in the country in that period (Ackrill and Kay, 2014). Sugarcane ethanol was not the only biofuel the Brazilian government had in mind. The government also established the National Biodiesel Program (ProÓleo, in Portuguese). Both national programs were a response to the Organization of the Petroleum Exporting Countries oil embargo of 1973 (De Oliveira and Coelho, 2017: 170). The government also created the National Alcohol Commission (CAN) that started controlling prices and setting parity between ethanol and raw sugar; it was a way to orient producers to shift from sugar to ethanol. The result was immediate. Ethanol production increased from 580 million liters in 1975 to 3.676 billion liters in 1979, surpassing the target established for that year by 15 percent (Goldemberg and Nogueira, 2014).

These new institutional policies promoted the use of ethanol for vehicles specially adapted for it. The program objective was to make sure that ethanol was going to be adopted by the automotive industry, as it involved price controls, compulsory supply at gas stations, and a range of subsidies. The government made agreements with manufacturers to develop a market for vehicles made or modified in Brazil to run only on alcohol. Institutional policies were subsidizing the production of sugarcane and, at the same time, creating a market for the ethanol that was produced in Brazil. According to Sorda et al., the commercialization of biofuels proved successful, and 96% of automobiles sold in Brazil in 1985 were ethanol-powered (2010). The creation of ProÁlcool, ProÓleo, IAA, and CNA connects to our argument that national institutions shaped the biofuel sector by creating policies that shaped the outcome of the sector.

According to data from the Ministry of Agriculture, Livestock, and Supply (abbreviated MAPA, in English), Figure 1 shows that in the years that followed the creation of the IAA, Brazil saw a rapid increase in the production of sugarcane, sugar, and ethanol. The institutional impact of the ProÁlcool was such that "by 1986 some 12 billion liters of ethanol was being produced and ethanol-run cars represented some 90 percent of new car sales" (Wilkison and Herrera, 2010: 750). However, the decline in oil prices in the late 1980s combined with the removal of government subsidies after the end of the dictatorship and the rising cost of the policies slowed the ethanol in Brazil (Moreira et al., 2005: 28–30). Goldemberg and Nogueira make a connection between the absence of specific policies and government support to ethanol production as a consequence of the sporadic supply shortages that Brazil endured in 1989 when it had to import ethanol from South Africa (2014).

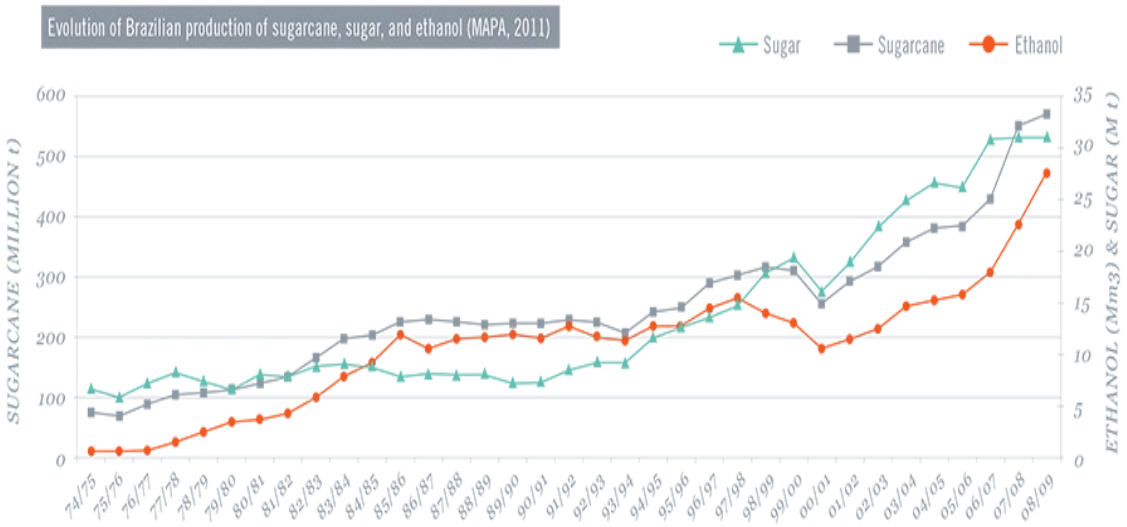

Figure 1 – Evolution of Brazilian production of sugarcane, sugar, and ethanol 1974-2009 (source: Goldemberg and Nogueira, 2014)

Brazil was experiencing a moment of transition from the military dictatorship towards democracy in the mid-1980s. The country had trouble paying its external debt, and the oil continued to dominate imports. In 1983, oil represented 57 percent of all imports (Ackrill and Kay, 2014: 35). Having accounted for 85 percent of new car sales in 1985, sales of ethanol-powered vehicles declined to only 11.4 percent in 1990, showing that the Brazilian experiment with ethanol was coming to an end (Goldemberg and Nogueira, 2014). Ethanol was then relegated and in 1990, in an institutional context of drastic state reduction after the end of the military dictatorship, the IAA was extinguished, and sugar production stopped receiving subsidies (Moreira et al., 2005). Almost 60 years of IAA helped to shape the sugar and ethanol industry. The development of the

sector was not without criticism. Some sugar producers believe that IAA was the reason for Brazilian sugar to be sold at a lower price in the internal market, reducing their profit (Netto, 2007). It was the end of one of the most prolonged state interventions in the Brazilian economy.

Reemergence of Biofuels

Almost thirty years after ProÁlcool was created, Brazil reemerged as a global leader in the biofuel sector in the early 2000s (Dauvergne and Neville, 2010: 635-636). After a sharp decline in the 1990s, ethanol production started to grow again in 2002-2003 (Figure 1). As it happened in the past, the institutional influence was responsible for the reemergence of bioethanol. In 2003, the Brazilian government increased the mandatory percentage of ethanol to be added to gasoline to 25% (Sorda et al., 2010). At the same time, the government pushed for the introduction of Flex-Fuel Vehicles (FFVs), capable of running on any mix of (blended) petrol and ethanol. Brazil had a distribution infrastructure capable of supplying the demand for gasoline and ethanol at petrol stations, and drivers were now free to decide which fuel they would fill their cars with, most of the time, based on the price (Ackrill and Kay, 2014: 38). Consumers were fast in adopting FFVs, and in 2008 almost 92% of all cars sold in Brazil were bi-fuel (can use gasoline, ethanol, or both).

Despite its reemergence, the industry is still heavily dependent on institutional interventions from the Brazilian government to thrive. In the late 2000s, the expansion of Brazilian ethanol agroindustry stalled after a government decision to artificially lower the price of gasoline, making ethanol much less competitive in comparison (Goldemberg and Nogueira, 2014). Nonetheless, sugarcane and ethanol are one of the largest industries in Brazil. After soybean and corn, sugarcane is the third most important crop in Brazil in terms of land use (Marin, 2016: 75). Over a million jobs in Brazil depend on ethanol and sugar production, and biofuel manufacture produces around 1,350 gigawatt-hours per year of electricity (Moreira et al., 2005). The outcomes seen after policy changes and state interventions demonstrate that government institutions play an important role in structuring the biofuel industry in Brazil since colonial times. Institutional interventions in the sugarcane sector and later in the ethanol industry shaped the outcomes that resulted in Brazil been a biofuel superpower.

Conclusion

Brazil is a leading producer and consumer of biofuels in the world. The country's relationship with sugarcane is almost 500 years old, and it has defined the first centuries of Portugal colonization. This paper has demonstrated that the historical background as a worldwide leader in sugar production for almost two centuries was the foundation that led Brazil to become a leading power in biofuels. Brazilian government institutions in the middle of the nineteenth century and at the beginning of the twentieth century created policies to push forward the consumption of sugar and later ethanol. In the case of ethanol, the Brazilian government incurred financial losses to support an industry that was not capable of dealing with excess in production and the international price decrease. The capability and excess in production also led some players in the industry to use the residue of sugar production towards biofuel. A few decades later, under the dictatorship, Brazil developed the first National Program to promote biofuels, which highly regulated the consumption and production of sugarcane ethanol. The military government also created a similar program to promote biodiesel, although not as successful.

This work has asked how institutions have structured and shaped the current biofuels industry in Brazil since colonial times. The historical development analysis presented in this paper shows that formal institutions played a fundamental role in structuring the biofuel industry in

Brazil. The early institutional investment in sugar led to a future necessity to find other uses for surplus production, which led to early adoption and investment in ethanol and biodiesel. This paper has argued that this was only possible due to systematic institutional interventions in the sugarcane sector since the nineteenth century.

In each step of the Brazilian ethanol history, state institutional interventions can be identified as a key factor that contributed to the transformation of massive sugarcane plantations into a fully-fledged ethanol industry. It is a direct result of centuries of institutional policies that promoted sugarcane, structured a biofuel industry, and ultimately shaped the sector. There is a clear correlation between institutional policies and the sugarcane/biofuel industry in Brazil. The historical analysis presented in this paper shows that policies created to support sugarcane had a direct consequence in the development of biofuels in Brazil decades later. As Brazil keeps expanding its biofuel production, the role institutions play lie at the center of the debate.

References

Ackrill, Robert, and Adrian Kay. 2014. *The Growth of Biofuels in the 21st Century: Policy Drivers and Market Challenges*. Basingstoke: Palgrave Macmillan.

Barzelay, Michael, and Scott R. Pearson. 1982. "The Efficiency of Producing Alcohol for Energy in Brazil." *Economic Development and Cultural Change* 31(1): 131–44.

Bernstein, Henry. 2010. *Class dynamics of agrarian change*. Halifax: Fernwood; MA: Kumarian.

Borras Jr, S.M., McMichael, P., and Scoones, I. 2010. "The politics of biofuels, land and agrarian change: editors' introduction". *The Journal of Peasant Studies*, 37(4): 575–592.

Brazilian Government. 2015. Intended Nationally Determined Contribution for Brazil. Available at: http://www4.unfccc.int/submissions/INDC/Published%20Documents/Brazil/1/BRAZIL%20iNDC%20english%20FINAL.pdf. Accessed in October, 2018.

Da Silva, José Gomes, G. E. Serra, J. R. Moreira, J. C. Conçalves and J. Goldemberg. 1978. "Energy Balance for Ethyl Alcohol Production from Crops" *Science New Series*, 201(4359): 903-906.

Daugbjerg, Carsten, and Alan Swinbank. 2015. "Globalization and New Policy Concerns: The WTO and the EU's Sustainability Criteria for Biofuels" *Journal of European Public Policy* 22(3): 429–46.

Dauvergne, P. and K.J. Neville. 2010. "Forests, food, and fuel in the tropics: the uneven social and ecological consequences of the emerging political economy of biofuels". *The Journal of Peasant Studies*, 37(4), 631–60.

De Oliveira, Fernando C., and Suani T. Coelho. 2017. "History, Evolution, and Environmental Impact of Biodiesel in Brazil: A Review." *Renewable and Sustainable Energy Reviews* 75: 168–79.

Epstein, Gerald. 2005. Introduction: financialization and the world economy. In Financialization and the world economy, ed. G. Epstein, 3–16. Cheltenham, UK: Edward Elgar Publishing.

Goldemberg, José. 1979. "Global Options for Short-Range Alternative Energy Strategies." *Energy* 4(5): 733–744.

Goldemberg, José. 2009. "Sugarcane ethanol will take over the world". *Ethanol Summit Offical Magazine*. São Paulo: Camarinha Editora.

Goldemberg, José and Luiz H. Nogueira. 2014. “Sweetening the Biofuel Sector: The History of Sugarcane Ethanol in Brazil” *Bioenergy Connection*. http://bioenergyconnection.org/article/sweetening-biofuel-sector-history-sugarcane-ethanol-brazil (Accessed on December 9, 2017).

Guo, M., W. Song, and J. Buhain. 2015. “Bioenergy and Biofuels: History, Status, and Perspective” *Renewable and Sustainable Energy Reviews* 42: 712–25.

Hall, Peter and Rosemary Taylor. 1996. “Political Science and the Three New Institutionalims”. *Political Studies* 44(4): 936-57.

Hira, Anil, and Luiz Guilherme de Oliveira. 2009. “No Substitute for Oil? How Brazil Developed Its Ethanol Industry.” *Energy Policy* 37(6): 2450–56.

Herold, Marc. 2009. “The Import of European Sugar Machinery to Offset the Sugar Crisis in Bahia, 1875-1914.” *Revista Ciências Administrativas* 15(1).

Isakson, S. R. (2014). Food and finance: the financial transformation of agro-food supply chains. *The Journal of Peasant Studies*, *41*(5), 749–775.

Kojima, Masami; Johnson, Todd. 2005. “Potential for biofuels for transport in developing countries”. *Energy Sector Management Assistance Programme (ESMAP) technical paper series*; ESM 312/05. Washington, DC: World Bank.

Marin, Fábio R. 2016. “Understanding Sugarcane Production, Biofuels, and Market Volatility in Brazil—A Research Perspective.” *Outlook on Agriculture* 45(2): 75–77.

Meira, Roberta Barros. 2009. “Um Sopro de Mudanças: A Companhia Engenho Central de Aracaty e a Produção Açucareira Mineira No Final Do Império.” *Varia Historia* 25(42): 597–609.

Moreira, J.R., L.A.H. Nogueira and V. Parente. 2005. “Biofuels for transport, development, and climate change: lessons from Brazil”. In: K.A. Baumert, et al. *Growing in the greenhouse: protecting the climate by putting development first*. World Resources Institute.

Naritomi, Joana, Soares, Rodrigo and Assunção Juliano. 2012. “Institutional Development and Colonial heritage within Brazil” in *The Journal of Economic History*, 72(2): 393-422.

Nastari, Plinio Mario. 1983. "The role of sugar cane in Brazil's history and economy". *Retrospective Theses and Dissertations*. Iowa State University.

Netto, Natalle. 2007. *A saga do álcool: fatos e verdades sobre os 100 anos de história do álcool combustível em nosso país*. Novo Século, Osasco, São Paulo.

Neville, Kate J. 2015. “The Contentious Political Economy of Biofuels.” *Global Environmental Politics* 15, (1), 21–40.

North, Douglass. 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge: Cambridge University Press.

Novo, A., K. Jansen, M. Slingerland and K. Giller. 2010. “Biofuel, dairy production and beef in Brazil: competing claims on land use in Sa˜o Paulo state”. *The Journal of Peasant Studies*, 37(4), 769–92.

Ostrom, Elinor. 1990. *Governing the Commons: The evolution of institutions for collective action*. Cambridge: Cambridge University Press.

Pierson, Paul and Theda Skocpol. 2002. "Historical Institutionalism in Contemporary Political Science". In *Political Science State of the Discipline,* ed. Ira Katznelson and Helen Milner. New York: W.W. Norton.

Power, M., Newell, P., Baker, L., Bulkeley, H., Kirshner, J., and Smith, A., 2016. "The political economy of energy transitions in Mozambique and South Africa: The role of the Rising Powers". *Energy Research & Social Science*, 17, 10–19.

Rask, Kevin. 1995. "The Social Costs of Ethanol Production in Brazil: 1978-1987". *Economic Development and Cultural Change* 43(3): 627–49.

Schamis, Hector. 1999. "Distributional Coalitions and the Politics of Economic Reform in Latin America". *World Politics*, 51(2), 236-268.

Smeets, Edward, André Faaij and Iris Lewandowski. 2004. *A quickscan of global bio-energy potentials to 2050. An analysis of the regional availability of biomass resources for export in relation to the underlying factors*. Utrecht: Copernicus Institute.

Sorda, Giovanni, Martin Banse, and Claudia Kemfert. 2010. "An Overview of Biofuel Policies across the World." *Energy Policy* 38(11): 6977–88.

Steinmo, Sven. 1989. "Political Institutions and Tax Policy in the United States, Sweden, and Britain" *World Politics* 41(4): 500-535.

Steinmo, Sven. 2001. "The New Institutionalism", in *The Encyclopedia of Democratic Thought*, ed. Barry Clark and Joe Foweraker, London: Rutledge.

Szmrecsányi, T., and E. P. Moreira. 1991. "O Desenvolvimento Da Agroindústria Canavieira Do Brasil Desde a Segunda Guerra Mundial." *Estudos avançados* 5(11): 57–79.

Thelen, K. and S. Steinmo. 1992. "Historical Institutionalism in comparative politics". In *Structuring Politics*, ed. Sven Steinmo, Kathleen Thelen and Frank Longstreth. Cambridge: Cambridge University Press.

White, B. and A. Dasgupta. 2010. "Agrofuels capitalism: a view from political economy". *The Journal of Peasant Studies*, 37(4), 593–607.

Wilkinson, J. and S. Herrera. 2010. "Biofuels in Brazil: debates and impacts". *The Journal of Peasant Studies*, 37(4), 749–68.

Yang, Xuna. 2015. *An Analysis of China's Biofuels Policy and Chinese Discourse on Land Acquisition for Biofuels in Africa*. Michigan Technological University.