

Biofuel transitions and global governance: lessons from Brazil

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Abstract

Arguably the world's most ambitious transport biofuel programme so far, the Brazilian alcohol fuel programme, launched in 1975, has recently gathered speed and attracted renewed interest as a result of rising concerns for climate change and energy security. This paper traces the trajectory of the use of alcohol fuel from a small niche market to an integral part of the 'socio-technical regime' of the Brazilian transport fuel supply. In providing the sugar and alcohol sector an outlet from its crisis, the military regime of the 1970s forced the introduction of the sector into the transport fuel supply regime against the will of powerful regime players – especially the car and oil industry. This period of 'purposive regime transition' came to an end with the shift to civilian rule, drop in oil prices, inset of economic crisis and liberalisation of the mid-1980s. The sugar and alcohol sector retreated to a position of an established niche within the regime, yet the continuous efficiency improvements helped to make ethanol an economically competitive alternative to petrol. The introduction of flex-fuel cars in the market in 2003, and the opening of export markets opened new opportunities to the sugar/alcohol sector and stimulated the entry of new, global players in the regime. Throughout the history of the biofuel programme, the Northeast sugar and alcohol aristocracy has lost power to their counterparts in the Southwest, yet the subsidies to the alcohol programme have perpetuated the unequal power relations in the Northeast. The fate and future sustainability of the Brazilian biofuel transition in the face of further expansion of sugarcane cultivation will increasingly depend on the capacity of the globalising biofuel governance to take into account the power relations at the local level in Brazil on the one hand, and the integration of the country in global centre-periphery relations on the other.

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Introduction: Brazilian bioethanol and regime transitions

Arguably the world's most ambitious transport biofuel programme so far, the Brazilian alcohol fuel programme, launched in 1975, has recently gathered speed and attracted renewed interest as a result of rising concerns for climate change and energy security. The improved efficiency of alcohol production and developments in vehicle technology have helped to make ethanol an economically competitive alternative to petrol, and therefore to rise from a 'niche' position to become an integral part of the dominant socio-technical fuel and transport regimes. This seemingly successful Brazilian example has attracted worldwide interest not only in terms of its transferability to other countries, but also because imports from Brazil could offer many EU countries and the US a way to reduce their oil dependency, and reach their ambitious biofuels consumption targets in the transport sector. Hailed by some as the ultimate solution to transport-related climate problems, and cursed by others for causing social inequality and environmental destruction, biofuels display unprecedented challenges to global governance, by virtue of the numerous trade-offs involved between environmental, social and economic objectives, and the multiplicity of stakeholders both at national and international level.

This paper describes the trajectory of the Brazilian ethanol fuel experiment from an internal Brazilian affair – a response by the military government to the oil crisis that threatened its power base – to a matter of global biofuel governance. The ethanol programme is here viewed in light of the theories of socio-technical transitions. Particular attention will be paid to the role of power relations, at various governance levels, in shaping the evolution and the way in which the evolution of the ethanol experiment itself has transformed these power relations. This way, the paper aims to improve understanding of the current challenges in increasingly global and multilevel governance in the area of biofuels.

Brazilian alcohol fuel programme as a socio-technical transition

The evolution of the Brazilian alcohol fuel programme is here examined as an example of a transition of the 'socio-technical regime' of transport fuel supply. Socio-technical regimes can be defined as "relatively stable configurations of institutions, techniques and artefacts, as well as rules, practices and networks that determine the normal development and use of technologies" (Rip and Kemp 1998; Smith et al. 2005).¹ Such a regime therefore includes a series of complex, nested real world phenomena, embodying natural and artificial physical elements, as well as social, economic, cultural and cognitive attributes (Rip and Kemp 1998; Geels 2002a, 2002b; Smith et al. 2005). Examples of regimes are different types of agricultural production – 'modern' or organic – or an electricity-generating regime. A regime typically hosts several subordinate, nested regimes.

¹ Another definition sees a socio-technical regime as a dominant actor-network and institutions (Kemp & Loorbach 2006, 108) with "dominating practices, norms and shared assumptions, which structures the conduct of private and public actors" (Kemp & Rotmans 2001, 7).

A regime can be defined in terms of its societal function on the one hand, and regime membership on the other. The object of study here is the socio-technical regime whose main function is to supply transport fuel to the Brazilian transport system. This regime can be placed within the national energy regime, but also within the broader global fuel supply regime, dominated by multinational oil companies. On the other hand, it can be seen as a sum of different sub-regimes – including a part of the agricultural regime – the sugar/alcohol sector – which became an integral part of the transport fuel supply regime. Another way would be to look at the transport regime as a whole. This would bring into the analysis not only supply-side solutions to what is considered as a given transport system, but would also allow the analysis of the demand-side: how should the transport regime be organised in order to optimise possibilities for mobility while minimising its harmful environmental and social impacts? Both the Brazilian transport system and transport fuel regime are embedded in the global transport and energy regimes, which are increasingly influenced by climate and energy security concerns.

Defining regime membership is far from straightforward, especially in view of the multiple layers of regimes and governance contexts. In this article, special attention is given to tensions between different levels of regime membership – from the level of sugarcane field workers producing feedstock for fuel alcohol up to policymakers of industrialised countries. In short, defining what constitutes a socio-technical regime can be tricky (e.g. Berkhout et al. 2004; Eames and McDowall 2006). There is no single ‘correct’ way of defining a regime, but any given regime definition highlights different aspects of the phenomenon under scrutiny.

The Brazilian alcohol fuel experiment illustrates interaction processes between three key regimes. Throughout the post-war era, the country’s *energy regime* had become increasingly based on cheap oil imports from the Middle East, but the quadrupling of oil prices in 1973 threatened to bring this development to an end and compromise the military government’s legitimacy, which rested essentially on fast economic growth. The transport regime constituted an essential part of the Brazilian “economic miracle”, with GDP growth at double-digit numbers during the early years of the military rule. The role of the car industry in bringing about this growth was crucial, and the country’s transport system had become increasingly based on road transport. Ethanol fuel had been a small niche within the transport fuel supply sub-regime – mainly to dampen the effects of fluctuations in sugar world market prices, small amounts of sugarcane-based ethanol had been added into petrol during the entire post-war period. The launching of the ‘Proalcool’ ethanol fuel programme in 1975 transformed the sugar/alcohol sector from its hitherto position as a niche within the transport fuel supply regime to become an integral part of the regime. The historically unequal power relations within the sugar/alcohol sector were to prove crucial for the ethanol fuel programme.

Selection pressures, regime responses, and adaptive capabilities

Changes in socio-technical regimes can be perceived as a function of ‘selection pressures’ bearing on the regime, and the coordination of resources available, inside and outside the regime, to adapt to these pressures (Smith et al. 2005).

The *selection pressures* can be directed at specific regimes (the anti-nuclear movement being a typical example) or they can be more general changes, emanating from the socio-cultural ‘landscape’ (Geels 2004), such as the ebb and flow of environmental attitudes in society, demographic shifts, and the rise of consumer culture or neoliberal model of globalisation. The pressures can also be more tangible economic forces from other, competing, regimes, or may emanate from below, from ‘technological niches’. (e.g. Geels 2004; Smith et al. 2005). The numerous pressures acting on any given regime often push in different direction. The governance challenge is then to try and reorient the pressures so that they would act as coherently as possible towards a direction deemed desirable in society (Smith et al. 2005).

The responses of the socio-technical regime – its adaptation to the selection pressures – determine the direction of change and type of transition (e.g. Geels and Schot 2007). The *adaptive capabilities* of the regime members to respond to the selection pressures are determined by the ability of the regime members to fulfil the functions that contribute to the reproduction of technological systems. Such functions include (Smith et al. 2005; Bergek et al. 2006):

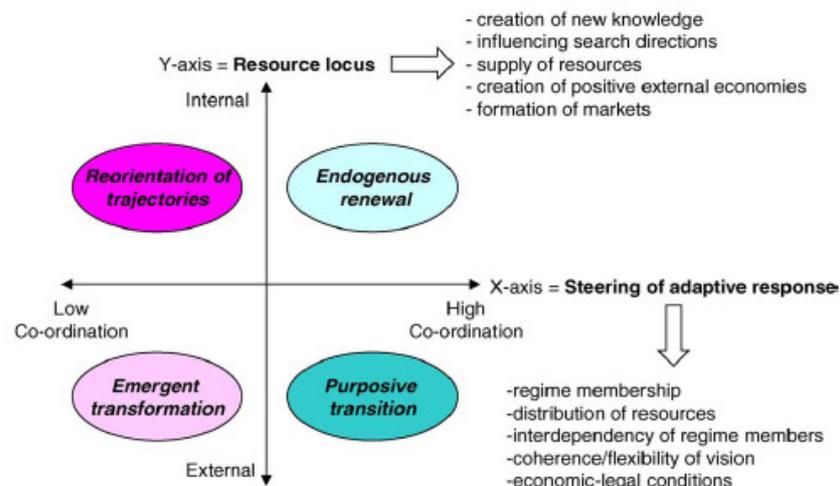
- *creation of new knowledge*, learning, and the diffusion of this knowledge within the system (Bergek et al. 2006);
- *influence over the direction of search processes* and the influence of different actors on the direction of search *within* the regime;
- *entrepreneurial activities and experimentation* to deal with the uncertainties involved in regime transformation;
- *supply of human, financial and other resources*
- *creation of positive external economies*, e.g. positive ‘spill-over effects’, e.g. in terms of knowledge development;
- *formation of markets* for the new technologies and products;
- *legitimisation* through conscious actions by various organisations and individuals (e.g. through advocacy coalitions).

These functions can be used in order to delineate boundaries for regime membership, by analysing note that “the degree to which different actors participate in carrying out functions reproducing the regime” (Smith et al. 2005, 1505).

Four *transition contexts* can be constructed (figure 1) by identifying the regime adaptation processes along two dimensions:

1. The degree to which the adaptive responses to the selection pressures are articulated towards a given direction or goal, i.e. whether the transition is intended or unintended. The former situation is usually characterised by the existence of a shared guiding vision among core regime members, whereas conflicting ideas and competing visions tend to create uncoordinated selection pressures (e.g. Eames and McDowall 2006).
2. The extent to which resources required for transformation come from inside or outside of the regime.

Figure 1. Transition contexts (Smith et al. 2005, 1499).



'*Endogenous renewal*' corresponds to a situation in which regime members undertake conscious, coordinated efforts in response to selection pressures. In '*reorientation of trajectories*', selection pressures prompt action by regime members, yet these actions are uncoordinated and highly unpredictable. '*Emergent transformation*', in turn, entails a situation whereby resources for adjusting to pressures come from outside the regime – for instance from scientific activity or small firms outside the regime – and the responses are uncoordinated and unpredictable. Finally, '*purposive transition*' comes closest to what has become known as 'transition management' (e.g. Kemp and Rotmans 2004): actors outside the regime bring about transformation into a desired and clearly defined direction.²

Agency and power: bioethanol from centre-periphery perspective

To address the problem of defining regime membership, this paper suggests looking at the issue through an analysis of power relations from a centre-periphery perspective. Rather than being a question of 'in' or 'out', regime membership would be seen as a continuum between the central/core and the peripheral/marginal members of the regime.

Smith et al. (2005) suggest to concentrate on regime membership (core vs. 'peripheral' members), distribution of resources (tangible economic resources, ability to control material artefacts, influence over the production and definition of what is deemed as salient knowledge; legitimacy, credibility and authority), and 'guiding visions' (e.g. the degree of coherence between the actors' mental frameworks, implicit theories, expectations, discourses, and representations of problems and solutions) (e.g. Hajer 1995; Weber 2003).

This paper applies the three-level framework of Galtung (1971), which examines power relations within a centre-periphery perspective. Galtung developed his theory to analyse unequal power relations particularly among nations, within an imperialistic system. For Galtung (1971, 83), imperialism is characterised by three elements involving:

² For examples of each type of transition context, see Smith et al. (2005).

- a harmony of interest between the centre in the Centre nation and the centre in the Periphery nation;³
- more disharmony of interest within the Periphery nation than within the Centre nations; and
- a disharmony of interest between the periphery in the Centre nation and the periphery in the Periphery nation.

What is centre and what is periphery is defined essentially by three interrelated approaches. First, the absolute properties of the individuals or entities in terms of 'rank', i.e. the resources of the actors measured by variables such as the level of income, training, and organisation, type of work (manual vs. intellectual), living area (rural vs. urban). The second dimension defines the interaction relation in which most of the benefits of exchange accrue to the centre, while the periphery carries most of its costs. The third approach defines the interaction structure, the centre being more centrally located in the interaction networks than the periphery. The three dimensions of power are often interrelated, strength along one type of power strengthening one's position along the two other dimensions (for example, money, or possibility to exercise physical force, make it easier to acquire a central position in the networks). (Galtung 1971, 103.)

Centre-periphery relationships are not defined merely in terms of economic and political power, but unequal exchange also involves cultural, ideological and communication-related dimensions. In the following, particular attention will be paid to these less tangible aspects of 'power play'. Moreover, even though the simple dichotomy between centre and periphery can be a helpful way of highlighting power relationships, in reality, the division is less clear-cut and involves instead a continuum, with an extensive middle layer in between the extremes (Galtung 1971, 104).

In this paper, centre-periphery approach will be applied to an analysis of the entire transport fuel supply regime on the one hand, and the role of the most traditional sugarcane producing region in Brazil, the Northeast.⁴ Galtung's (1971, 84) observation that imperialism is a combination of international and national phenomena enhances the relevance of the approach to the analysis of the globalisation of biofuel governance. Essentially, the following analysis attempts to describe the historical evolution of the 'power play' within the Brazilian alcohol fuel transition on the one hand, and examine the relevance of such an analysis within the present, globalised situation.

The following section describes the different phases of the evolution of ethanol fuel use in Brazil.

³ Galtung uses capital letters to denote Centre and Periphery nations, and small initials for centre and periphery within those nations. In our analysis, the notions of centre and periphery are applied more broadly, to refer to sub-national entities, yet the idea of each Centre and Periphery having its own centre and periphery is retained.

⁴ The analysis is to a large extent based on the author's Master's thesis on the Brazilian fuel alcohol programme, from 1993.

Pre-oil crisis: oil, cars and the ‘Brazilian economic miracle’

The background for Brazilian biofuel policies was laid by the post-war import substitution industrialisation policies aimed at rapid industrialisation in the spirit of increased independence from the industrialised countries. By the early 1960s, this model was reaching its limits, and the military government in taking power in 1964 combined the emphasis on national sovereignty and independence with a policy aimed at facilitating the entry of multinational capital in the country, the multinational car industry being a typical example as perhaps the strongest ‘engines of growth’. The country’s car fleet increased tenfold between 1960 and 1976 (Borges et al. 1985, 174), and the consumption of oil – most of it imported – grew at an average rate of 16.2% in the period, while the economy grew at 11.2% per year during the same period (Borges et al. 1985, 7-8).

At this time, ethanol produced as a by-product of sugar industry provided an opportunity to stabilise influence of price fluctuations, and can be considered as a niche market. Importantly, full technological capacity for larger scale alcohol production existed, and sugar industry was loosely tied to the transport fuel supply regime. In the 1960s, the government had active policies aimed at supporting sugar industry so as to help it capture a greater share of world sugar market. Capacity of the sugar industry almost doubled during the first half of the 1970s (Borges et al. 1985, 22-23) In the Northeast of Brazil, this led to further concentration of ownership to industrialists and large scale producers, at the expense of independent producers that had formed the backbone of the region’s sugarcane production for centuries. These subsidies also lead to increasing proletarianisation of the farm workers, and reinforced the one-sided agricultural production structure. (de Andrade 1988, 399-498, 526, 547; FIPE 1991, 4-7; Demetrius 1990, 29-35.)

From the perspective of transport fuel supply regime, the period was one of stability and consolidation, with the rapidly growing and car-owning middle-class fuelling the growth.

Regime members and power constellations

The core the transport fuel supply regime was made up of the national oil company, Petrobras, multinational car manufacturers installed in Brazil, national energy ministry, and the core of the military government – the armed forces. The car owning middle class, whose support was crucial for the military government, can be considered as a mid-range between ‘centre’ and ‘periphery’ of the regime, while the alcohol industry can be conveniently placed in the periphery. The large industrialists can be classified as the centre of this Periphery, the workers in sugar and alcohol factories and sugarcane fields being the periphery of the Periphery, and independent sugarcane growers selling their cane to the industrialists occupying the middle ground. Within the sugar/alcohol sector, the traditional cane-growing area of the Northeast had undergone continuous decline since the 1950s, as São Paulo region gained ground – partly because of the more favourable natural conditions, and partly because of their more entrepreneurial approach, as opposed to the traditionalism of the landowning aristocracy of the Northeast. The socio-political conditions in the sugarcane growing coastal area of the Northeast had changed little since sugarcane cultivation began in the region in the 16th century, based on slave labour. The sugar

aristocracy had retained its close links with the political elite, and had been able to retain its privileges.

Oil crisis, sugar crisis and national security: first phase of the Proalcool programme 1975-1979

The shift that brought the sugar/alcohol industry to become an integral part of the transport fuel supply regime was triggered in the first instance by the oil crisis, which threatened the economic basis and legitimacy of the military government, and secondly by the collapse of sugar world market prices in 1975, which threatened the politically powerful sugar and alcohol industry. At the outset of the oil crisis, 43% of Brazilian energy supply came from oil – 80% of which was imported – which therefore threatened not only economic growth, but was perceived as a question of national sovereignty (Borges et al 1985, 7). The drop in sugar prices, in turn, was particularly serious because of the overcapacity stimulated by the subsidies in the late 1960s and early 1970s. The industry almost doubled its capacity in first half of the 70s.

Expanding the use of alcohol as a transport fuel was therefore seen as a solution on the one hand to the pressures bearing upon the core of the transport fuel supply regime, while at the same time solving the problems within the agricultural regime. The ideology of national independence and sovereignty prevailed not only within the government, but had also a lot of support in the Brazilian consciousness in the time; among intellectuals, dependency theories were strong in Latin America, while the media displayed the development of an alcohol programme as a possible response to the oil crisis. The public was also worried about the prospect of the high fuel prices driving the country to a paralysis. Researchers in state research institutes and universities held strong convictions about the need to develop national capacities to avoid technological dependency on industrialised countries. The Centre for Aerospace Technology, in São Paulo, played a crucial role in carrying out first tests on car engines capable of using neat alcohol, which fuelled beliefs among the research community in its ability to develop a car running on pure ethanol. (Puppim de Oliveira 2002, 132.) Together, these pressures and trends in the politico-economic and intellectual landscape created favourable conditions for the emergence of an alcohol fuel programme.

Regime responses to the crises: alcohol to the rescue

The Proalcool programme was launched by a government Decree in late 1975 (Decreto 76.593 from 14 November 1975), with the explicit objectives to:

- save foreign currency by substituting alcohol for petrol/oil in road transport and chemical industry
- reduce regional disparities – expansion of agriculture to non-cultivated or marginal areas
- reduce income inequality between social classes and professions (labour-intensive agricultural sector would mostly benefit from Proalcool)
- increase GDP by harnessing previously unused or underused factors of production

- increase capital goods production by increasing the demand for distillery equipment

The objective to quintuple alcohol production by 1980 to 3 mrd litres per year – this would allow 20% of non-hydrous alcohol to be added to all car fuel in the country. The 20% limit was at the time the maximum possible without need to significantly modify engine technology.⁵ These objectives were to be achieved through following policy measures:

- credit guarantees and low-interest loans to investments in both agricultural and industrial sections of production chain
- import restrictions on ethanol – guaranteed market for domestic alcohol producers
- alcohol pumps to be installed at all gas stations of the nation
- alcohol prices set lower than those of petrol (retail price guarantee to provide security to car-owners/consumers)
- R&D programmes – from crop biotechnology to mechanical engineering to develop alcohol engines
- marketing campaign under the banner: “Let’s unite, make alcohol” (Sandalow 2006)

The Central bank and regional development banks were responsible for the financing of the investments under the programme.

Special subsidies were given to Northeast alcohol producers, because production costs in the region were a third higher than in Sao Paulo (Lima 1988, 178). The programme was largely financed through revenue from fuel taxes and vehicle registration tax.

The output objective was superseded, as alcohol production reached 3.4 mrd. litres in the harvest season 1979-1980. Production increase came primarily from the existing sugar/alcohol distilleries, which had plenty of unused capacity following the investments of the past years, and there was hence little need to build new distilleries autonomous from sugar production. Despite the increase in production, the area cultivated by sugarcane increased by only 31% (Borges et al. 1985, 34).

The programme was not to rely exclusively on large-scale monoculture of sugarcane, as social and regional development arguments were put forward along with the economic ones. About 8% of alcohol was to be produced from manioc to provide income to small farmers, and small ‘mini-distilleries’, with low initial capital costs, would be constructed. In practice, neither option turned out to be economically viable and the subsidies were clearly designed to favour large-scale production. Alcohol production from manioc was far from enjoying the same level of technological development as the one based on sugarcane, which had an advantage by virtue of its centuries-long tradition. (Demetrius 1990, 50-52, 83-87.)

Changes in regime membership and power constellations: integration of the sugar/alcohol niche to the regime

⁵ Later, blends of up to 25% of ethanol have become possible.

The sudden shift in selection pressures brought about fundamental changes in the power relations between regime members (see also Smith et al. 2005, 1506). The oil crisis and concern for excessive dependence on imported oil weakened the 'rank' of the car industry and the national oil company Petrobras, which had not yet made the important oil discoveries that were to change the situation in the 1980s. However, their central position in exchange relations and interaction networks – the car industry as the engine of growth being crucial for the government's legitimacy, and Petrobras by virtue of being the country's largest company and a key political actor (Surrey 1987, 14) – put them in a central bargaining position. The army gained greater legitimacy, as the country's independence was seen to be at stake.

Initially, Petrobras opposed the alcohol fuel programme, because of the investments it would require in terms of setting up the alcohol distribution and stocking capacity, and shifting the cracking ratio between different fractions of oil products in favour of diesel. Also, price controls that kept petrol prices below those of alcohol reduced the company's income and profits. Presumably, Petrobras also feared the loss of its monopoly in fuel distribution. (Borges et al. 1985, 29-30; Fernandes 1988; Demetrius 1990, 107.) The support of the sceptics was 'bought' through the generous support and Petrobras agreed to organise retail sales of alcohol and construct the distribution network (Puppim de Oliveira 2002, 132).

The car-owning middle class was still in a key position, as the legitimacy of government dependent on the support of middle classes; restrictions on individual liberties were tolerated as long as living standards kept rising. The car-owning middle class lost in economic exchange to the extent that the money needed for keeping ethanol prices below those of petrol came from petrol taxes, but on the other hand, subsidies for ethanol was a means to keep the car-centred development model intact, and thereby benefited all car-owners. The lack of a nationwide car-owners' organisation weakened this group's rank, but private car continued to be a symbol of modernity in the rapidly developing country, thereby giving car-owners a strong position in ideological exchange.

The National Alcohol Commission (CNAL) was entrusted with the strategic management and administration of the alcohol fuel programme at the national level. CNAL was composed of the ministries of planning, trade and industry, finance, agriculture, mines and energy, and interior. This management structure suffered, however, from internal power struggles within the commission.

The key shift in regime membership came with the integration of a part of the agricultural regime – the sugar and alcohol industry – within the transport fuel supply regime. The growing alcohol and sugar industry in the state of São Paulo had strong links with state and federal government and thereby changed the power structures within the regime. As part of the transport fuel supply regime, the sugar and alcohol sector of course gained a more prominent position in the power structures of the state. The military government, in turn, had an important supporter in the conservative Northeast sugar aristocracy, which dominated regional politics. While the Northeast sugar and alcohol sector was in a continuous economic decline at the national scale, and even at the regional level, the importance of sugar and alcohol sector for the traditional sugarcane states of the Northeast was gradually declining, it was far from

insignificant.⁶ Moreover, the political influence of the sugar elite showed no signs of decline: the ‘sugar barons’ had secured positions in the centre of political decision-making both at the federal and state level (Johnson 1983; Demetrius 1990, 26).⁷ Horizontal and vertical integration of production is another way for this elite to retain its central position in interaction networks. Finally, the sector had a strong ally in the IAA, the National sugar and alcohol institute, which had a central role in setting both retail and producer prices as well as regional production quotas for sugarcane, sugar and alcohol. Since its establishment in the 1930s, IAA had been perceived as one of the main supporters of the Northeastern sugar producers, and in particular of the independent cane growers. In ideological exchange, however, the Northeast sugar aristocracy were in decline already at the time of launching of Proalcool, considered increasingly out of phase with the ideals of modernity.

The way in which sugar had shaped the cultural landscape and identity especially in the state of Pernambuco illustrates the importance of the ideological and cultural factors: there is a long tradition of neglect of food crops as inherently inferior to the only crop considered viable in the coastal zone of the Northeast – the sugarcane – and the region has suffered from a notorious lack of ecological awareness (Cavalcanti et al. 2002). Furthermore, labour relations were long characterised by near-feudal conditions, which had since the 1950s led to clear confrontation between the landowning and working classes. Subsidies to sugarcane cultivation and alcohol production in the Northeast served to consolidate these archaic production systems, increased monoculture and economic dependency on one single crop, and further consolidated the marginalised position of the landless workers in the ‘periphery’ of the sugar and alcohol sector. Like the sugar sector modernisation and expansion programmes of the 1960s and early 1970s, Proalcool on the one hand allowed inefficient producers to stay in business, but on the other hand accelerated the concentration of landownership into fewer hands, as the large-scale producers reaped the bulk of the benefits accorded under the programme. Likewise, the programme fostered the ‘proletarianisation’ of the farm workers: historically, the landless peasants were often allocated a plot of land within in the sugarcane fields to provide for their subsistence needs, and the landowner often ensured a minimum of social protection of his workers. With modernisation, the labour relations became ‘normalised’, and many of the peasants became migrant, seasonal workers, with the responsibility for social protection shifting from landowners to the public and city authorities. (e.g. de Andrade 1988, 399-498, 526, 547; FIPE 1991, 4-7; Demetrius 1990, 29-35).

The rise of the alcohol fuel niche hardly caused any changes in the dominant oil-based transport fuel regime; the previously marginal sugar/alcohol sector become an integral part of the regime, enabling it to survive without fundamental changes in transport structures, for instance. The relationship between the niche and the dominant regime was therefore rather symbiotic than antagonistic.⁸

⁶ In the state of Pernambuco, sugar and alcohol sector represented still in the early 2000s about 4% of the value of production, while its share at the level of the entire country was about 1.5% (Moura et al. 2004, 79). Within the agricultural sector, sugarcane represented in the Northeast on average 21,2% of gross production value in 1993; in Alagoas, the largest producer of the region, this share was 75,4% and in Pernambuco 36,1% (Lima and Sicsu 2001, 9)

⁷ The large-scale landowners and industrialists in the sector choose among themselves a candidate for state elections or support a common candidate.

⁸ In this sense, the transition resembled what Geels and Schot (2007) call a ‘reconfiguration pathway’.

Transition context: purposive transition / endogenous renewal

Part of the resources for regime response – especially technical knowledge – came from within the transport fuel supply regime itself (Petrobras, car industry, energy ministry), but the integration of the sugar/alcohol sector into the transport fuel regime meant substantial new resource inputs from outside or margins of the regime. Moreover, the programme was highly government-led, and change needed to be imposed from the outside; to persuade the sceptics, heavy subsidies were needed from the central government. Hence, the transition context can be defined as one of ‘purposive transition’, with some elements of endogenous renewal, notably because of Petrobras’ opposition.

Second oil crisis, the alcohol car and lock-in to the ethanol pathway: 1979-1985

Selection pressures

The second oil crisis in 1979 coincided with the alcohol fuel programme having reached its limits in terms of the amount of alcohol mixed with petrol: the technical limit of 22% of ethanol had been reached, and the regime was faced with internal pressures stemming from technological reasons. The response was to further integrate the sugar/alcohol sector in the regime, by extending the programme.

Regime responses – road to alcohol path dependency

The production target was further increased: the alcohol production was to be more than tripled in five years to reach 10.7 mrd. litres in 1985. To achieve such an increase, cars capable of running on neat ethanol had to be introduced. The promising experiments carried out in state research institutes were now put into commercial application and the government convinced the car industry to invest in large-scale production of 100% ethanol cars. The government signed agreements with the major car companies (Fiat, VW, Mercedes-Benz, GM, and Toyota) to install assembly lines for ethanol-only cars and produce 250 000 vehicles in 1980 and 350 000 in 1982 (Sandalow 2006). Credit support to purchasers, favourable tax treatment, and keeping ethanol prices below those of petrol were used to boost ethanol car sales. Taxi drivers were given incentives to convert their cars to 100% ethanol (Sandalow 2006).

As the underutilised capacity of sugar industry had largely been taken into use during the first phase of the programme, increasing alcohol output required more support for the construction of autonomous alcohol distilleries. Yet in the traditional sugar producing states such as Pernambuco most new distilleries were built in connection with the existing sugar mills, whereas in states with a weaker tradition of sugar production autonomous distilleries became widespread. Stimulated by generous subsidies and protected from competition, sugarcane cultivation expanded in the Northeast to marginal and less productive lands, or drove food crops to marginal lands.

The entry of the World Bank to finance the programme was crucial. In 1984, the Bank’s share of financing of the programme reached 75% (Demetrius 1990, 100).

The results of the efforts were impressive: between 1983-1986, more than 90% of sold new cars ran on ethanol, and in the mid-1980s, alcohol represented about a half of Brazil's liquid fuel supply. Some supply disturbances were experienced in the early 1980s, but these problems were solved by the government stepping up its support to the programme again.

Regime membership and power constellations – consolidation of the sugar/alcohol lobby's power

Apart from the entry of the World Bank, major changes took place in the management and administration of the programme, as new authorities were drawn in. For instance, labour and transport ministries and the armed forces were included in the formal management structure, which reduced the inefficiencies encountered in the first phase.

The car industry was initially reluctant and lacked enthusiasm in the face of the possibility of the government setting minimum quotas on the number of alcohol vehicles to be produced. Also, a model different from the standard one would reduce the flexibility of production across assembly lines installed in different countries, which had become one of car industry's key strategies (Borges et al. 1985, 35-37). However, it became a major player in helping regime adaptation by adopting the ethanol car technology developed in public sector research organisations (Puppim de Oliveira 2002, 133).

The sugar and alcohol sector had by this stage become an integral part of the transport fuel supply regime. Opinions concerning the impacts of such integration vary widely. On the one hand, the programme was seen as an important source of rural and industrial employment⁹ especially in the poor Northeast region, while on the other hand, critics point out that the pressures to improve efficiency led to mechanisation, hence, to labour reduction. The seasonal character of jobs in sugarcane cultivation means that large amounts of workers were drawn from rural areas and lived in poor settlements near the sugar fields or in city slums. The great increase in land area cultivated by sugarcane was accused of reducing land formerly occupied by other crops, monopolised the utilisation of newly opened lands, and boosted the concentration of land ownership. The programme was hence seen to have reinforced the existing unequal centre-periphery relationships in the Northeast. (Grenier 1985)

Most notably, the subsidies to the producers in the Northeast were seen as a continuation of the centuries-long production pattern characterised by the exploitation of low-wage unskilled labour and near complete lack of willingness to innovate, devote resources to R&D or take entrepreneurial risks. Rather than by profit and efficiency, the landowning aristocracy of the Northeast was said to be driven by the desire to retain control and power in the hands of the family.

At the national level economic and political exchange, the sugar and alcohol sector was a clear winner, whereas the actors such as the finance ministry, banks, and taxpayers lost as the government increased subsidies to alcohol sub-regime.

⁹ Sugar and alcohol sector provided an estimated 700 000 direct jobs and more than 200 000 indirect jobs in the early 2000s.

Transition context – full-blown purposive transition

The resources for regime response continued to come predominantly from the outside, as the military government strengthened its grip and ‘bought’ the support of reluctant key players, such as Petrobras and the car industry. Importantly, the introduction of 100% alcohol cars, and autonomous alcohol distilleries independent from sugar production meant that the programme had reached the point of no return, leading to a near irreversible path dependence, with sugar/alcohol sector having become an integral part of the transport fuel regime (Puppim de Oliveira 2002, 134). The transition context continued to be one of purposive transition – even more so perhaps than in the first phase of the programme, because the government needed to overcome resistance of powerful players in the regime.

Economic crisis, civilian rule, liberalisation: from crisis to ‘hibernation’ (1986-2002)

Selection pressures

The switch to civilian government in Brazil coincided with two factors that reduced the popularity of the alcohol fuel programme: the decline in oil prices and the aggravation of the debt and economic crisis. Indeed, the military government had largely lost its legitimacy with the exhaustion of the ‘Brazilian economic miracle’. Moreover, Proalcool began to be seen increasingly as a ‘monster’ created by the military regime, out of phase with the prevailing spirit of the times emphasising economic liberalism. The Constitution of 1988 introduced a number of mechanisms aimed at decentralisation of power and stimulating the engagement of civil society in political processes. With falling oil prices, the subsidies to ethanol became an increasing burden to the already hard-squeezed state budget. Technical limits to adjusting the ‘cracking ratio’ further aggravated the problems; as the demand for diesel continued to increase along with economic activity, while petrol demand had declined thanks to greater use of alcohol fuel, the country had to export its oversupplies of petrol.

Regime response – retreat of the state, removal of subsidies and incremental efficiency improvements

Beginning from 1986, subsidies to ethanol sector – especially producer subsidies – were cut drastically. Supply bottlenecks emerged in the late 1980s, as consumption subsidies (ethanol prices were kept below those of petrol) were maintained, eroding consumer confidence and support to the programme.¹⁰ The share of alcohol in the gasohol blend was reduced throughout the country, with the exception of São Paulo, where the previous blending ratio was maintained for air pollution reasons. To fill the supply gap, Brazil had to even temporarily resort to imports of methanol from the US.

¹⁰ Until 1985, prices followed average production costs, surveyed by a government mandate by the Getulio Vargas institute. After 1985 prices were set at levels below the average costs of production, while the federal government tried to curb inflation by controlling the average costs of production and consumer prices, including those of fuel ethanol. (Goldemberg et al. 2004.)

The administrative structure responsible for the programme was abolished and its tasks were handed over to the Secretariat of Regional Development (reporting directly to the Cabinet), which led to a drastic cut in the number of civil servants in charge of the programme. Despite its problems and costs, the alcohol fuel programme was kept alive, but became perceived mainly as a social programme, with employment and urban air quality benefits as the main reasons for the continuation of the use of alcohol. Another factor contributing to the desire to maintain the programme was the substantial capacity had been developed in private and public crop improvement and biotechnology innovation and research, to improve productivity in both agricultural and industrial segments of the alcohol supply chain. Both the state of São Paulo and private research institutes (especially Copersucar, sugar and alcohol producers' association in the state of São Paulo) invested heavily in R&D on sugarcane crop improvement (e.g. Martinez-Filho et al. 2006). Progress in alcohol car technology¹¹ also contributed to the 'momentum' of the alcohol sector. (Puppim de Oliveira 2002, 136.)

The IAA was abolished in 1990, which – together with the removal of subsidies – meant mounting problems especially for the producers in the Northeast, because the institute had been responsible for stabilising price fluctuations by transferring funds between good and bad years (Cavalcanti et al. 2002). Likewise, with the disappearance of the IAA, the Northeast was left without agricultural research institutes with special interest in developing crops and methods specifically adapted to the region's conditions (Lima and Sicsu 2001).¹²

With Proalcool, sugarcane had expanded to marginal, less productive lands, whose cultivation was no longer profitable after the withdrawal of subsidies. The sugar and alcohol industry in the Northeast entered into an era of increasing difficulty. The relative decline of the region was in operation since the 1950s, as noted earlier, but the removal of subsidies greatly accelerated the process. As an illustration, between the harvest years 1982-83 and 1994-95, the proportion of the North/Northeast in Brazil's sugarcane production fell from 30,1% to 18,2% (Lima and Sicsu 2001, 4).

By 1997, when ethanol producer price regulation was abolished, alcohol had gone back to a position of a relatively small niche market, but at the same time a stable and integral part of the transport fuel supply regime. It posed no threat to the existing regime, but instead helped the predominantly oil-based transport system to survive. Improvements in alcohol productivity and the existence of stable supply and distribution infrastructure meant that alcohol did not cause excessive burden to the regime. As a result of the cuts in subsidies, throughout the period the focus was on research and development aimed at reducing cost and improving alcohol's competitiveness.

¹¹ Technical innovations included better start-up mechanism, anticorrosive carburettor and tank, and alcohol filtering, helping to increase the car durability and reduce the maintenance costs (Puppim de Oliveira 2002, 136).

¹² The most notable drawback was the termination of the state sugarcane research programme, Planalsúcar, which had developed new cane varieties and cultivation techniques adapted to the conditions of the Northeast (Lima and Sicsu 2001, 6).

Regime membership and power constellations – hegemony of the economic interests

Abrupt changes in the selection pressures triggered shifts in power relations, as had happened a decade earlier with the beginning of the oil crisis. The economic crisis and the shift to a civilian rule meant that authorities in charge of economic and finance matters gained a more central position, whereas especially the Northeastern sugar and alcohol aristocracy suffered not only in terms of concrete economic power, but also in ‘ideological exchange’, as sentiments became more hostile to ‘state intervention’ and subsidies to a group that had become a symbol of stagnation and undemocratic clientelism. The drastic cuts in bureaucracy were largely a result of similar changes in the cultural and ideological landscape.

For the car industry, the plummeting of the ethanol car sales was not a major problem, since petrol car production capacity had remained intact. More important was the opening of the market to imports in the early 1990s, which exposed the hitherto highly protected market to competition. Car industry’s role as the engine of the economy had declined since the early 1970s, and its position in ideological exchange had suffered as it was revealed that labour productivity was considerably poorer in Brazil than in its competitors, and the quality of the domestically produced cars was called into question (e.g. Anfavea 1992).¹³ Private passenger car continued, nevertheless, to be seen as a status symbol (e.g. Borges 1985, 16).

The state oil company, Petrobras, gained a more central position on all dimensions of power, thanks in particular to oil discoveries off the Brazilian coast, and the company strengthened its accusations against the programme blaming its high costs to the economy (e.g. Nitsch 1990; Surrey 1987).

From the late 1980s and throughout the 1990s, the position of environmental authorities improved, especially in the ideological exchange, as air pollution and from the early 1990s also climate change concerns gained more prominence in public debate. In São Paulo, this power was not only ideological, but the state environmental authorities were probably among the most well-resourced even worldwide, let alone among their developing country counterparts. The strength of the environmental bureaucracy, and the presence of a large middle class concerned about health impacts of urban air pollution, certainly contributed to the decision to maintain the high ethanol share in petrol sold in the city. Nevertheless, environmental arguments still remained marginal and subordinate to economic considerations in the decisions concerning ethanol use.

While the São Paulo producers certainly suffered from unfavourable market conditions, within the Brazilian sugar and alcohol sector the São Paulo industrialists have progressively strengthened their position as the absolute Centre of the trade, whereas the Northeast has seen a continuous decline in terms of economic power and competitiveness. São Paulo producers had for a long time already viewed subsidies and protection to the Northeast as an unjustified economic burden, and welcomed what they perceived as a more ‘level playing field’. São Paulo producers had

¹³ Even the president, Fernando Collor de Mello, called Brazilian cars in one of his speeches “carroças”.

continued to improve efficiency, also through an increasing use of by-products.¹⁴ The success of the São Paulo region was not, however, a result exclusively due to their own entrepreneurial skills, but also a result of the overwhelming dominance of the region in the production of intellectual know-how in the form of research institutes, universities, etc.

In Pernambuco, during the period 1987-1996, the already below-national average performance of the sugar and alcohol sector continued to decline on several indicators, be that the region's share of exports, prices (export and domestic market prices were declining), and sugarcane yields per hectare. Labour costs alone could not be evoked to explain this poor performance, as salaries were very low – in the agricultural sector even below the minimum wage – and declining. Education level of labour force very low (3 years of schooling in rural areas) and was improving only in urban areas. Perhaps the main reason for the stagnation in the Northeast is the virtually complete lack of investment in R&D. One explanation to this unwillingness to invest in innovation is the impossibility of producers to reap the benefits of their investments: nothing prevents other producers from copying an innovation adopted by the 'innovator' and thereby benefit from the innovation without having to pay for it. (Moura et al. 2004). Cultural reasons and explanations related to the mentality of the Northeast sugar aristocracy have been evoked to explain part of the stagnation (e.g. Ziravello 1988).

However, differences between producers in terms of productivity are substantial in the Northeast. Lima and Sicsu (2001) estimated that in the end of the 1990s, about one third of the enterprises in the area were economically viable and financially stable, while many had had to give up their activity and many others were deep in debt. As such, chronic indebtedness was nothing new, but instead an enduring characteristic of the sugar sector industrialists in the Northeast throughout centuries; at the ultimate instant, the state had frequently come to the rescue of the struggling companies. What seemed clear was that the ideological and cultural sentiment had shifted and become far less tolerant towards the continuation of support to the sugar oligarchy.

The power of the Northeast sugar lobby has diminished also in the political exchange relations, yet this decline has been far less dramatic, as the large sugar and alcohol producers retain important influence especially at state level. Probably their influence over decisions on sugar and alcohol sector still continues to be disproportionate to their economic power also at the national level (e.g. Lima 1988, 244-279).¹⁵ Even the economic stagnation has been only relative, in that the contribution of sugarcane to the regional economy and employer remains strong, especially in the states of Alagoas and Pernambuco. The dismantling of subsidies to alcohol producers led to an increasing concentration in the sector, this time inefficient production in marginal lands and debt-ridden companies were forced to close down. In 1997, only 25 companies in Pernambuco controlled practically all of the land in the 43 municipalities of the sugarcane-growing region of the state. The disappearance of the small properties has been blamed for the increasing proletarianisation of workers and migration to the periphery of urban areas, loss of as much as 150,000 rural jobs due to

¹⁴ This can be seen as a typical example of creation of favourable external economies – an essential function for the survival of a technological system (Bergek and Jacobsson 2006).

¹⁵ The sparsely populated Northeast has a number of congressmen exceeding its share of the country's total population.

closures of unprofitable plants, and a generalized 'slumming' of the workers, which has aggravated hunger. (Kenfield 2007.) While the impact of the concentration trend can be debated – the closure of unproductive firms can also be seen to open possibilities for improved efficiency and better allocation of resources – the share of seasonal labour in sugar and alcohol sector has increased. In São Paulo state, an estimated 200 000 migrant workers are employed during the harvest of sugarcane, coffee and cocoa, and another 40 000 in sugar and alcohol industry. The progressive mechanisation of sugarcane harvesting put pressure also to increase the standard expected daily cutting by manual workers as well. Not meeting the target means the workers are laid off the following year, which is why workers often bring their families to do the job in order to meet their targets. (Mendonça 2006.)

On the one hand, sugarcane remains a major source of employment in the Northeast coastal zone, while on the other hand, developing more robust and less risk-exposed economic structures in the region would require diversification of the productive base – in particular in the agricultural sector.¹⁶ The concentration of production in fewer hands, resulting from closure of inefficient firms, may be seen as a negative phenomenon as such, but on the other hand, small independent farmers in the region have a notoriously bad track record in terms of respect for labourers' rights, for instance. What seems clear is that given its central positions in the political exchange relations, the Northeast sugar lobby managed to secure for itself generous subsidies under the Proalcool programme, and the removal of these subsidies in the 1990s led to drastic reduction in the oversupply of unviable enterprises in the region (Moura et al. 2004.)

Transition context – from reorientation of trajectories to endogenous renewal

The response of the regime to external landscape changes was far less coordinated than in the earlier phases, when the military government orchestrated and imposed its solution to the problems. In the changing landscape of liberalisation, democratisation, economic crisis, and withdrawal of subsidies, the alcohol fuel sub-regime tried to cope with the new crisis situation, but the relative lack of coordination led to problems such as the discrepancy between supply and demand resulting from the phasing out of producer subsidies while the consumer subsidies were upheld. The interests of the economic authorities, banks and other players with mainly economic functions – now in a more prominent role than during the heydays of the ethanol programme – went to a direction different from that of the alcohol sector, and there was genuine dissent over the future objectives of the programme. Conflicting views were clear also in that the government was frequently accused of attempting to destroy Proalcool and relinquish control of nationally developed know-how and assets to foreign capital (Bueno 1984, 45-49; Bautista Vidal 1988, 184). Similar nationalistic arguments continue to be popular in Brazil, as recent debates on the control of Amazon rainforest have demonstrated.

On the other hand, the removal of subsidies to sugar/alcohol sector was a relatively coherent answer from the government to the selection pressures, and the government

¹⁶ The state of Pernambuco could be analysed as a typical example of a 'staple economy': reliance on one single export commodity tends to create a particular 'staple mentality', which makes it difficult to even imagine alternative production structures. Such lack of alternative visions creates 'staple traps', once raw material becomes scarce or demand goes down. (Raumolin 1984.)

therefore retained a central role in influencing the evolution of the sector. While the state withdrew itself from administering the alcohol fuel use and production, also this transition phase illustrated the central role of the state: the decision to phase out subsidies was a conscious one in favour of ‘laissez-faire’ policy actively pursued by the government.

In summary, the beginning of this period of transition can be characterised as reorientation of trajectories, with most of the resources coming from the regime itself, as the state withdrew its subsidies, and a struggle between different opinions concerning the future of ethanol in transport fuel supply. Towards the end of the period, the context gradually shifted towards endogenous renewal, as consensus on the role of ethanol increased, and the regime itself increased its adaptation capabilities thanks notably to efficiency improvements.

Revival of ethanol: Increase in oil prices, concerns for climate change, and the introduction of the flex-fuel car (2003-)

Selection pressures

Throughout the 1990s, the potential of ethanol to help combat climate change was increasingly used as an argument in favour of ethanol use. Brazil had, indeed, pursued an active role in the UNFCCC climate change negotiations, not only in putting forward its “Brazilian proposal” (taking the cumulative historical emissions into account when defining emission quotas for countries), but also in making publicity for its own ‘clean’ sources of energy, hydropower and ethanol in particular. However, the climate argument alone was not enough to prompt renewed interest in ethanol – this happened only with the concerns over energy security triggered by the terrorist attacks 11 September 2001, and the steep increase in oil prices since 2003. Subsequently, a number of both developed and developing countries started seeking ways to reduce their transport sector’s greenhouse gas emissions, but also, and above all, to reduce their dependence on Middle East oil imports. Targets on biofuel share in transport fuel sales has been one of the most popular instruments used to this end. The lack of technical know-how and experience, and the high cost of most domestic biofuel production options in most developed countries meant that a rapidly expanding export market was opening up for Brazilian sugarcane ethanol. By this time, ethanol had not only become an integral part of the country’s transport fuel supply, but the continuous productivity improvements and cost reductions had meant that the programme now enjoyed widespread political and citizen support and acceptance (Puppim de Oliveira 2002).

Regime responses – flex-fuel car and expansion of sugar/alcohol sector

The final breakthrough for ethanol came, however, from the market introduction of the flex-fuel car by the Brazilian car manufacturers. The industry had showed interest in flex-fuel cars of the kind being built by US manufacturers seeking credit under the CAFÉ law; several automakers hence started talking with the Brazilian government about the possibility of manufacturing flex-fuel vehicles to the domestic market. In 2001, the government agreed to treat flex-fuel vehicles as ethanol-fueled, i.e. eligible to a slightly preferential tax treatment (14% instead of 16% sales tax). Ford launched its flex-fuel prototype in 2002 and VW followed the suit in 2003. The sales of flex-

fuel cars shot up in a short period of time: in November 2004, they represented 30% of the market, during the year 2005 on average 53%, and reached an average of 77% in 2006 (Sandalow 2006; Furlan 2006).

The continuous development of ethanol production methods throughout the period led to the creation of positive externalities (Bergek and Jacobsson 2006) crucial for the success of new technologies.¹⁷ The use of bagasse, the straw residue created in the process of ethanol production, to produce electricity and sell the surplus to the grid had become a common practice in sugar and alcohol mills. International climate change concerns and foreign capital are being harnessed to support ethanol fuel viability through bagasse cogeneration projects within the CDM mechanism under the Kyoto Protocol.

The launching of the biodiesel programme by the government in 2003 is likely to contribute to the consolidation of ethanol as part of the transport fuel supply regime, by helping to redress the balance between diesel and petrol consumption and thereby reducing the oversupply of petrol due to the technical limits to changing the “cracking ratio”. Moreover, the programme, whose objectives are as much social as environmental, has the potential to improve the reputation of biofuels among the public.

The principal means whereby the government can regulate and influence ethanol market is through manipulating the blending ratio between ethanol and petrol in the transport fuel. Other measures in support of ethanol are the above-mentioned slight sales tax preference to ethanol fuelled and flex-fuel cars, and 30% import tariff on ethanol and 20% on sugar.

Changes in actor constellations – globalisation of the regime?

Brazil today looks to the export markets as a key to its ethanol future. For instance, a partnership between the Ministry of Science and Technology and the University of Campinas in São Paulo is currently conducting a study to plan Brazil's ethanol exports to substitute 10% of the global use of gasoline in 20 years. If this plan is successful, the country's ethanol exports will total 200 billion litres by 2025 – an increase of almost 67%. The geographic area planted with sugarcane would increase from 6 million to 30 million hectares. (Kenfield 2007.)

Opening of the export markets and CDM projects under the Kyoto Protocol are not the only international influences on the regime. For the first, foreign multinational and national companies are already investing in ethanol production in different areas of Brazil, which has given rise to calls for government measures to prevent the country from losing its advantage in know-how in alcohol production (e.g. Saturno 2007). The participation of foreign capital in the production of sugar and ethanol is currently

¹⁷ Looking at the entire period from the beginning of Proalcool, sugarcane yields have risen steadily at a 2.3% growth rate between 1975 and 2004 (Martinez-Filho et al. 2006). However, this figure hides great inter- and intraregional variation, the development especially in the Northeast having been minimal. The total amount of direct investments in the agricultural and industrial sectors for the production of ethanol for automotive use in the period 1975–1989 reached USD 4.92 billion (US\$ of 2001). Savings in foregone imports were estimated at USD 52.1 billion (Jan 2003 US\$) from 1975 to 2002 (Goldemberg et al. 2004).

4.5%, and growing. Foreign investors are attracted in part by the production costs, which are among the lowest in the world. (Kenfield 2007.) The agreements at the level of heads of state – George W. Bush and Luis Inacio Lula da Silva – on US-Brazilian cooperation in the area of ethanol production can be seen as an entry of new players in the regime, at the highest political level. Another change in selection pressures comes from the concerns by international and national NGOs regarding both the environmental and social implications of ethanol in Brazil. While these pressures do not directly change the regime, they may indirectly induce changes if importing countries adopt certification schemes for ‘sustainable biofuel’. Finally, an expansion of ethanol production and exports in Brazil could have potentially drastic impacts on global sugar markets. The European sugar industry has already expressed its worries about the loss of markets as a result of cheap imports from Brazil, and therefore likes to emphasise the negative social and environmental impacts of sugarcane cultivation in Brazil (2006).

As the selection pressures bearing upon the regime become increasingly international, the regime itself is hence also undergoing transformation, with the beginnings of global regulatory system for biofuels, and by the entry of new regime members through foreign capital. The results of these transformations on the power relations are uncertain. However, the history of the alcohol fuel programme suggests that the Brazilian government and domestic key players are likely to retain their central positions. In the light of the increasing globalisation of biofuel debates, the positioning of Brazil in the global centre-periphery relations, and the implications of this at the sub-national level are of key importance.

Environmental authorities have been in the centre of neither the fuel supply regime, nor were they decisive players in bringing about the alcohol fuel programme. However, their power – especially in ideological exchange, in influencing and legitimising policies – has increased constantly throughout the past 30 years. In the 1980s, their support to alcohol fuel stemmed from its beneficial impact on urban air quality, while climate change concerns gained importance from the beginning of the 1990s (e.g. Macedo 1991; Copersucar 1991). The recent perceived urgency of combating climate change, coupled with the rise of energy security on the policy agenda, have brought environmental authorities closer to the centre of the regime. Recent debates concerning the benefits of ethanol and the huge interest in ethanol exports indicate that environmental concerns are still likely to be overridden in case they would clash with energy security and export interests.

Transition context – from endogenous renewal to reorientation of trajectories?

After a period of turbulence and uncertainty that started in the late 1980s, the Brazilian transport fuel supply regime returned in the context of the changing selection pressures of the early 2000s towards purposive transition. There is a relatively broad consensus in the society on the desired direction of change, i.e. the desirability to expand the production and exports of fuel ethanol. Resources for adaptation come mainly from inside the regime – the ethanol sector has gained sufficient know-how and capacity to survive without state subsidies as long as oil prices remain above approximately £35 dollars per barrel. However, as in the past, the role of the state remains crucial, notably in creating possibilities for exports. Both state and private research institutes and activities have become an integral part of the

regime. Despite the relative consensus inside Brazil about the benefits of the use of ethanol fuel, criticism or at least scepticism is arising abroad, due to the potentially harmful impacts of ethanol production in terms of forest destruction, labour conditions, and competition with food crops. The entry of foreign investors and entrepreneurs in the field previously dominated exclusively by Brazilian firms marks the beginning of a new shift in regime membership.

Table 1. Summary of regime changes throughout the phases of the Proalcool programme.

	Selection pressures	Regime response	Transition context	Centre-periphery relations in the sugar/alcohol sector
1975-1979	Oil crisis, sugar crisis	Integration of sugar/alcohol sector in the margins of the regime	Purposive transition/endogenous renewal	Expansion of Southwest producers' hegemony, consolidation of centre-periphery relations in the Northeast
1979-1985	2 nd oil crisis, technical limits of 'gasohol pathway'	100%-ethanol cars, autonomous alcohol distilleries, full integration of sugar/alcohol sector in the regime	Purposive transition	Acceleration of the hegemony of the Southwest; concentration of power in the Northeast to the hands of industrialists and large landowners
1986-2002	Economic (debt) crisis, drop in oil prices, domestic oil discoveries, liberalisation, civilian rule	Reduction & removal of subsidies, technical improvement and R&D, retreat of sugar/alcohol sector to a well-established niche in the regime	From reorientation of trajectories to endogenous renewal	Drop in the rank of sugar/alcohol sector within transport fuel supply regime; disappearance of unproductive producers; weakening of the 'middle class' of sugar/alcohol sector in the

				Northeast
2003-	Terrorism, energy security, climate change, international demand for ethanol	Flex-fuel vehicle, investments in supply increase, entry of global actors in the regime	From endogenous renewal to reorientation of trajectories?	Improved position of the sugar/alcohol sector within the transport fuel supply regime; new opportunities for Northeast producers(?)

Future of the Northeast sugar and alcohol sector

A crucial question from the perspective of the sustainability of ethanol use concerns the social impacts and power relations within the Brazilian biofuel choices, especially in the country's poor Northeast. Potential for diversifying the productive basis in the region exists, but the modernisation of the sugar and alcohol sector is rendered difficult by institutional factors related to the markets, small producers' capacity to adopt the new know-how, and the lack of investment capacity. (Cavalcanti et al. 2002). A crucial question concerns the capacity of the state governments to promote diversification even if this went against the deep-rooted traditions among the ruling sugarcane elite. The past examples of state attempts to redress inequalities or fight poverty in the Northeast have invariably failed, not least because of the central position of the sugar elite in the networks of power. What has traditionally added to the difficulties in improving the landless workers' situation is that the 'middle class' of sugar and alcohol sector, the independent sugarcane growers, despite their oft-antagonistic relationship with the large sugar and alcohol industrialists, have tended to unite with the latter against the field workers' demands. This can be seen as a manifestation of Galtung's centre-periphery perspective within the Brazilian sugar and alcohol sector: the periphery of the Centre (independent sugarcane cultivators) ultimately shares the interests with the centre of Centre (large-scale sugar and alcohol industrialists), rather than uniting forces with their own periphery (field workers).

What would be the consequences of a significant increase in ethanol demand on the Northeast? At least three scenarios can be envisaged. First, a return to the past archaic structures – or at least slowing down of the modernisation process – could be envisaged, if increased demand would make sugarcane production in marginal lands profitable. A second possibility could be that international pressures, through certification schemes, for instance, would unite the workers, landowners and industrialists against what is perceived as unjustified violation of the country's sovereignty. This perspective seems unlikely, however, in view of the fact that the Northeast sugar lobbies in fact call for a 'social certificate' to create for them a new protected niche market (Bacoccina 2007). There is some irony in the fact that social certification is called for by the very same sugar elite that has been accused of being the root cause of the most serious social problems in the region. A third, optimistic, scenario would be that the most inefficient producers now being out of the business, the increasing demand would be satisfied by the efficient, business-like farmers, whose social and environmental performance would be kept under surveillance through the increasing international pressure. One problem with this scenario is, however, that there are probably still a large number of inefficient producers in the

trade, and that any increase in demand would enable these producers to survive and continue to perpetuate the exploitative labour conditions and power relations.

Conclusions and discussion

The 30 years of investment in ethanol fuel in Brazil have been a success, and has brought about a seemingly lasting transformation of the country transport fuel regime, if seen in terms of improvement in sugarcane yields, efficiency of production, competitiveness of ethanol with petrol, improvement of energy security, and creation of a strong agro-industrial cluster. Sugarcane yields have risen steadily at a 2.3% growth rate between 1975 and 2004 (Martinez-Filho et al. 2006), the USD 4.92 billion (in USD of 2001) direct investments in the agricultural and industrial sectors for the production of ethanol for automotive use in the period 1975–1989 helped to make ethanol fuel to survive without subsidies, and produce an estimated USD 52.1 billion (Jan 2003 US\$) savings in foregone oil imports between 1975 to 2002 (Goldemberg et al. 2004). However, the improvements have taken place almost exclusively in the rich Southwest of the country, mainly in the state of São Paulo, the development especially in the Northeast having been minimal – in some aspects even negative.

The evolution of the ethanol programme through its various stages was largely conditioned by selection pressures coming from outside of the regime, first from the oil and sugar crises, and later from the shift from military to civilian rule, accompanied by an economic crisis and liberalisation of the economy. The present stage was likewise triggered by changes in the ‘landscape’, notably the sudden increase in oil prices, together with concerns for energy security and climate change in industrialised countries. What began as a largely ad hoc response to oil and sugar crises – in terms of Smith et al. (2005) a ‘purposive transition’ with elements of ‘endogenous renewal’ – turned with the second oil shock into a full-blown ‘purposive transition’ as the military government forced its will against that of powerful car and oil industries. The evolution since the mid-1980s – civilian rule, liberalisation, economic crisis, and falling oil prices – led to ‘reorientation of trajectories’, as disagreement on the goals of development increased. Having gained sufficient ‘momentum’ thanks to the earlier government support, the alcohol fuel sub-regime survived and gained increasing autonomy as the average costs of production fell progressively. Towards the end of the 1990s, consensus started to accumulate again on the role of ethanol within the transport fuel supply regime and the context again moved towards ‘endogenous renewal’. Since 2003, the selection pressures have again changed significantly, with new selection pressures in the form of international demand for Brazilian ethanol and know-how, but also through the entry of new global actors as regime members. Yet, the transition context can still be characterised as ‘endogenous renewal’, since the resources to adapt to the changing selection pressures (i.e. by increasing ethanol production and exports) are largely within the regime itself, and there is relatively broad consensus over the direction of change within Brazil. However, the entry of global actors may increase dissent over the direction of change, thus moving the regime back towards ‘reorientation of trajectories’. Smith et al. (2005, 1500) note that, in a situation of ‘endogenous renewal’, “[i]f the process and outcomes... have been appraised positively, then the role of governance lies in deploying and monitoring the implementation of measures to enable and sustain a process of endogenous renewal.” This would most likely take the form of incremental improvements in environmental performance and social equity. If, by contrast, change

negatively assessed, more interventionist style is warranted. This is typically the incremental strategy pursued in recent years in Brazil, with efficiency improvements improving the environmental performance of sugar and alcohol production, yet it is uncertain whether the social improvements have followed. If the globalisation of the selection pressures and regime membership has brought the regime towards 'reorientation of trajectories', predicting the outcome of transition is inherently more difficult (Smith et al. 2005, 1501). Large uncertainty prevails over the consequences of significant expansion of ethanol output and the entry of e.g. multinational actors in the Brazilian sugar and alcohol sector on biodiversity, food production and prices, and social equity (especially in the Northeast), and development of national innovation systems. Smith et al. (2005, 1501) suggest that if, notwithstanding these difficulties of appraisal, the expected outcomes are negative, governance measures would best be oriented towards the 'back-end' of regulatory systems (taxes, regulations, etc.), to create a selection environment that induces the regime to apply its resources towards more sustainable direction, for instance through regulatory measures explicitly promoting environmental policy integration, for instance. While the promotion of such measures is a desirable objective as such, it faces considerable difficulties, first because of the extension of selection pressures and regime membership beyond Brazil's borders, and second, because of the problems of unequal power relations that frequently stand in the way of enhanced environmental policy integration.

Before deciding what type of governance measures would be most appropriate in a given transition context, one needs to determine whether the direction of change is deemed desirable, 'sustainable' or not. This paper has highlighted some of the problems related to the unequal distribution of power among regime members and the potential consequences this has to the sustainability of the transition on the one hand, and to the processes of appraising this sustainability. While the ethanol experiment in Brazil can be deemed a success in terms of CO₂ emission reductions, the social implications and local environmental effects are far more complex and require more research. The history especially in the Northeast of Brazil gives little reason for optimism in terms of participation of different groups of society on a more equal footing in deciding over the desired direction of change. Whether the increasingly international pressures will help to redress the situation by highlighting the inequalities, or whether the pressures towards industrialised countries' desire to fulfil their greenhouse gas reduction targets at any cost will override any social and local environmental considerations remains to be seen. In the new situation, moving from 'reorientation of trajectories' or 'endogenous renewal' towards 'purposive transition' would require 'transition management' at a global scale, with participation from the various players within and outside of the regime. Again, the challenge would be enormous in trying to bring together the interests of Brazilian sugar and alcohol lobby, the government with its desire to expand export and retain its position at the cutting edge of ethanol technology, the sugarcane field workers, the governments of industrialised countries seeking to comply with their Kyoto targets, and the social and environmental NGOs concerned about the potentially harmful side-effects of expanding ethanol production. The centre-periphery analysis presented in this analysis suggests the difficulties if one were to choose who would 'represent' the Northeast of Brazil within such participatory processes.

Brazilian Northeast has throughout the history been at the mercy of international markets, with consecutive cycles of economic 'boom and bust' bringing wealth to the

few and suffering to the many. From this perspective the worries of some observers that the expansion of the alcohol markets would bring about just another such cycle are hardly surprising. A crucial question is how the centre of this Periphery – the sugar oligarchy – situates itself in relation to the more central players: the São Paulo sugar and alcohol sector, the federal government, and the importing countries. The call by the sugar and alcohol industrialists in the Northeast for a certificate to ‘socially sustainable’ ethanol produced in the Northeast is an interesting initiative, yet it makes one suspect the repetition of the old pattern whereby the ruling aristocracy in the region once again reaps the benefits of programmes supposedly aimed to improve the situation of the poor.

Finally, in the light of transition theories, one is led to ask what actually was transformed with the entry of ethanol into the transport fuel regime. Was this an example of a genuine transformation of the regime? The answer depends on the definition of the regime. From the perspective of the transport system, ethanol fuel did not lead to a genuine transformation; instead, the alcohol niche and the prevailing oil-based transport regime live in a symbiotic relationship, without fundamental changes in regime structures. For the transport fuel supply regime, changes were more radical, as ethanol today covers about 40% of the country’s transport fuel needs; not to mention the transformations in the sugar and alcohol regime.

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