

BIOENERGY, INNOVATION AND THE NEW GEOMETRIES OF POWER: A NEW ERA, OR OLD WINE IN NEW BOTTLES?*

Bioenergia, inovação e as novas geometrias do poder: a nova Era, ou o vinho antigo em novas garrafas?

Brian Garvey¹
Ricardo Junior de Assis Fernandes Gonçalves²

Abstract

This paper presents the reconfiguration of state, corporate and labour relations that follow from the increased international investment by oil companies in Brazil's (bio)ethanol sector. It emphasises how new path-dependent technological and institutional arrangements, conceptualised as a 'techno-institutional fix', interrelate with broader systemic power relations and spatial strategies of accumulation (the spatial fix). These overlap to ensure competitive advantage of agroenergy leaders and increasingly concentrate land, wealth and power in the region of focus, albeit through accumulation strategies that postpone crises rather than resolve inherent instability. Testimonies from landless workers, rural and industrial workers in the fields and factories of biofuel cultivation and distillation counter the institutional discourse linking rural and sustainable development to these new energy extractions. The relatively fixed geographical nature of these workers' collective organisations, however, is a marked contrast to the increasing flexibility and scales of operation of the leading multinational corporations and limits their capacity to resist prevailing relations. Resulting power asymmetries or 'power geometries' underscore the reproduction of inequality, labour exclusion and dispossession in the new frontiers of agroenergy production.

Key words: Biofuel. Innovation. Power. Conflict.

Resumo

Este artigo apresenta a reconfiguração das relações do Estado, das corporações e do trabalho, a partir do aumento de investimento internacional por companhias de petróleo no setor brasileiro de etanol. A pesquisa enfatiza como novas 'trajetórias dependentes' (*path dependent*), arranjos tecnológicos e institucionais, conceitualizados como "arranjo tecno-institucional", se inter-relacionam com as mais amplas relações de poder sistemáticas e estratégias espaciais de acumulação (arranjo espacial). Essa sobreposição se faz para assegurar vantagem competitiva de líderes agro-energéticos e a emergente concentração de terra, riqueza e poder na região de enfoque, ainda que por meio de estratégias de acumulação que postergam crises ao invés de resolver a instabilidade inerente ao capitalismo.

* A primeira versão deste texto foi organizada para apresentação no XXII ENGA – *Encontro Nacional de Geografia Agrária: agentes, processos, conflitos e conteúdos do espaço agrário brasileiro*. Natal, Novembro de 2014. O aprofundamento das discussões e dos dados permitiu consolidar esta versão atualizada e com avanços teóricos metodológicos.

¹ Research Fellow, Business School, University of Strathclyde, Scotland, UK. E-mail: brian.garvey@strath.ac.uk.

² Doutorando em Geografia no Instituto de Estudos Socioambientais, Universidade Federal de Goiás - IESA/UFG. Docente do Curso de Geografia da Universidade Estadual de Goiás – Campus Iporá.

Depoimentos de trabalhadores rurais sem terra e operários nos campos de cultivo e fábricas de biocombustíveis e destilação contradizem com o discurso institucional vinculando o desenvolvimento rural e sustentável para estas novas extrações de energia. A natureza geográfica relativamente fixa de organizações coletivas destes trabalhadores, porém, é marcada pelo contraste no aumento da flexibilidade e escalas de operação das principais empresas multinacionais e sua limitada capacidade de resistir às relações predominantes. Resultando em assimetrias do poder ou “geometrias do poder”, a pesquisa ressalta a reprodução da desigualdade, da exclusão do trabalho e desapropriação nas novas fronteiras da produção agroenergética.

Palavras-Chave: Biocombustível. Inovação. Poder. Conflito.

Introduction

In the wake of the global financial crisis, growing policy concerns regarding issues of resource security (energy, food, water, minerals) are accompanied by further changing relations between states and (global) markets and corporations. This has profound implications for natural resource utilisation and for livelihoods in key regions of production, while unsustainable consumption rates in urban centres continue largely unchecked. State development strategies linked to a neo-extractivism accompany rising geopolitical and economic power amongst large, populous and rapidly changing nation-states and reflect market diversification by leading energy companies. New models of state-capital relations in Brazil, China and in several Latin American countries are also, thereby, gaining greater influence over global political economic trends and norms. This is true also in the pivotal socio-economic arena of technological ‘innovation’, seen as the key *both* to resolving the current challenges (of economic growth, climate change, resource security) *and* to the continuation of national development projects.

Concerned that further economic growth (or socioeconomic development more broadly) does not simply exacerbate the other problems, such as pollution and climate change, there is a new transnational emphasis upon ‘green’ innovation being ‘responsible’ in vaguely specified ways: providing development and decent work in rural areas (EC, 2009; ILO and UNEP, 2012), protecting the environment and upgrading marginalised land. This is evident in institutional discourses promoting the emerging global commodity chain for ethanol as a substitute for fossil fuel, whether these belong to state governments or global organisations promoting business (OECD), trade (WTO) development (World Bank) the environment and jobs (ILO and UNEP 2012; see FRANCO et al., 2010).

In Brazil, however, home to arguably the world's most impressive territorial and technological advances in bioethanol production, instabilities within the liberal market foundations upon which the 'green' economy is being built raise important questions over the social impacts and the future sustainability of liquid biofuels. However, amidst recent and projected factory closures, soil and water conservation concerns and enduring protests over access to land and food, technological progress -in the form of advanced or second generation biofuels -has again been prioritised as a solution to economic, environmental and social critiques.

Objectives

It is against this backdrop that this paper seeks to consider the contemporary reconfiguration of the social and spatial relations between the state, corporations and labour in a region of agroenergy industrial expansion linked to emerging international markets. Specifically it will investigate: a) how does state and corporate promotion of agroenergy, within incumbent paradigms of massive liquid fuel consumption and market financialisation, increasingly concentrate power in the innovation and application of new technologies? (b) how does this technological and institutional convergence relate to, and manifest itself in, territorial and organisational restructuring of leading transnational energy companies and in their relation with labour? (c) what are the implications of power asymmetries or 'power geometries' between leading firms operating across regional and national frontiers and the relatively sedentary or fragmented character of the collective organisations of rural labourers and landless workers?

Rationale, overview and methodology

The paper is the outcome of an interdisciplinary collaboration between scientists from Brazil and UK investigating socially and environmentally committed or 'responsible' technological development and application. We contend that there is an urgent need to envision, innovate and pursue alternatives to contemporary forms of (bio)energy and mineral extraction and consumption that do not hinge on land dispossession, the overexploitation of natural resources and human labour to support unsustainable and unequal modes of living and transport in swelling urban centres. The retention, indeed promotion of automobile culture in new, path dependent, biofuel technological developments that are promoted as 'greener' is

one such example of ‘old wine’ being poured into ‘new bottles’. The incorporation of work and employment issues into formal climate agreements at the Rio+20 UN Conference reflected growing acceptance of broader social implications of climate change and, albeit muted, acknowledgement of labour exploitation in mineral and energy extraction and cultivation.

State, capital and labour relations in Brazil’s agroenergy sector, and consequent agrarian conflicts, have received attention in geographic literature (e.g. THOMAZ Jr, 2002). The present agroindustrial restructuring has not, we would argue, been adequately linked to specific and dynamic technological and institutional arrangements of leading oil majors most responsible for these changes. Furthermore, the link between these strategic and operational arrangements, the broader economic system within which they are embedded and the role of innovation and spatial expansion in overcoming profit accumulation crises and labour conflicts remain under analysed.

We begin the paper with an overview of the methodology for fieldwork undertaken in the bioethanol sector between 2012 and 2014 in western Sao Paulo state. We then outline the two key theoretical underpinnings for this paper, namely the ‘techno-institutional fix’ and the ‘spatial fix’. We highlight the commonality between these distinct concepts and emphasise how in both cases a closer examination of constituent power relations improves upon existing analytical frameworks. Indeed a third concept, that of power geometries, provides a link between these in order to better understand and characterise the shifting social relations and conflicts in the bioethanol sector that are the focus of the next section of the paper. State and corporate policy and strategy are outlined, with particular reference to oil giant Shell and its merger with Brazilian company, Cosan. Its localised regional restructuring is linked to financial markets and globalising networks of energy consumption with which these new spaces are embedded. This is followed by the testimonies of landless workers occupying territory in the region of study, agricultural, industrial workers and their trade unions within the commodity chain. These accounts form the basis of the discussion on asymmetrical power relations in these regions of production that provide significant challenges to rural workers and their collective organisations.

Field work was carried out Pontal de Paranapanema and Mid Paranapanema, in the west of Sao Paulo, in the Central South region of Brazil. Over a period of 18 months, one-to-one interviews and focus group interviews were conducted with managers, industrial

consultants, manual sugar cane cutters and mechanics, machine operators, laboratory and auxiliary staff in four ethanol distilleries. Focus groups with former cane cutters and participant observations were also carried out at one occupation and one settlement of the Brazil Landless Workers Movement. This primary material was complemented with an overview of policy and investment strategies of the Brazilian state, EU, corporate bodies, producer associations and international organisations.

Theoretical framework

The techno-institutional lock in

Normative literature on the required ‘transition’ from high carbon, path-dependent energy systems to a lower carbon economic infrastructure commonly assumes an expert-led, elite process from one technological system to another, within or across benign states. In his concept on the ‘techno-institutional lock-in’ Unruh (2002) highlighted that system dominance of a particular technological system may continue, not necessarily as a result of superior product design, utility or quality, but by its ability to lower economic, social and psychological costs of relative to potential competitors who are ‘locked-out’ (FOXON, 2002). Path dependencies, positive feedback and asymmetries of power meant dominant systems are resistant to change. These characteristics and potential for inertia they share with institutions, the formal or informal constraints ‘that human beings devise to shape human interaction’ (FOXON, 2002). Indeed as a result of economies of scale, learned behaviours, established networks and infrastructures co-evolving interaction between these systems and political institutions culminates in a ‘techno-institutional complex’ (UNRUH, 2002). The fossil fuel basis for industrial economies’ energy and transport systems is one of clearest examples of techno-institutional lock-in. The relentless pursuit of new sources of oil and gas (e.g. tar sands, deep water, shale rock) to support unsustainable infrastructures continues in the face of known consequences (externalities) for the environment, for immediate and future social wellbeing. Concerns with the exhaustion of conventional oil deposits, political volatility in key oil producing regions and modest post-Kyoto mandates for reducing carbon emissions have, however, have coerced governments and oil companies to consider alternatives sources and technologies for energy security. Unruh explained that when environmental externalities such as climate change arise from locked in systems, such as fossil fuel combustion, favoured solutions are those that minimise change to the existing system by treating emissions (indeed

75% of pollution control investment in major industrial countries is from treating emissions) or making incremental, intra-system innovations that seek ‘to maintain as much similarity as possible between the existing system and the new configuration’ (Unruh, 2002: 318). This can be observed in the transition to bioenergy. Among the many possible sources of lower carbon, ‘renewable’ energy, liquid biofuels have been the focus of successful lobbies by automobile, energy, agriculture and biotechnology corporations who have found suitable partners at the levels national and transnational governance (FRANCO et al., 2010). Transport infrastructures and growth patterns are left largely untouched by the substitution of a percentage of conventional hydrocarbon fuels with liquid biofuels to meet lower carbon requirements.

Towards a techno-institutional fix

The particular conception of this techno-institutional complex, while acknowledging that history matters, however, is provided in highly structural manner, with little concept of how transitions are mediated in and by power relations. This sets up a falsely bifurcating conceptual framework in which the ‘existing’ system is ‘locked-in’ and ‘bad’ (high-carbon, irresponsible, exploitative) and resistant to change, while change is wilfully considered ‘good’ (a low-carbon, responsible ‘win-win’) and presented as a discontinuity or rupture to the prevailing complex. A purely institutional analysis of how, for example, innovation and application of technology reflects the aspirations of relatively powerful actors, precludes a deeper understanding of the (often unstable) interaction between these actors and the political economy within which their innovations are embedded and in which they seek to maintain competitive advantage. Rather than present a rupture to the fossil-fuel based technological system, the Brazilian state and oil corporations promote the merits of least disruptive ‘renewable’ biofuels on the world stage, while simultaneously and relentlessly pursuing new sources of fossil fuels, hence diversifying their sources and markets.

Jessop (2014) utilised the term ‘institutional fix’ in order to capture these systemic linkages and to describe the ability of complementary institutions to provide favourable conditions to (temporarily) escape episodic crises, ensure capital accumulation, maintain social order, dilute risk and defer other destabilising forces. In doing so he highlighted the instability and compromise involved in this strategic coupling between state and private sector

interests and pointed to the constitutive power and class relations within emerging technological systems.

Techo-institutional and spatial fixes

In recognising the requirement and ability of capital to divert and postpone crises over time and space in order to restore profit margins, Jessop links the institutional fix to the spatial fix (HARVEY, 2001) or spatiotemporal fix (see JESSOP, 2014 for discussion). Schumpeter (1994) utilised the term ‘creative destruction’ to highlight how capital averts crisis in the short term through innovations that render previous capital value and labour useless over time and restore competitiveness. Harvey (1989: 105-6) emphasised how capital shifts its internal contradictions around in *space*, redistributing risk geographically while compressing the time taken to extract, process and transport its products. Hence globalisation was characterised by ‘time-space compression’. In coining the phrase, the ‘spatial fix’, he described how capital must construct and control new spaces in order to function; however, over time these too are unable to return an adequate rate of profit and so capital relentlessly seeks new spaces for expansion, destroying the previously ‘fixed’ space (including capital assets and labour) for its functioning (HARVEY, 2001a, p. 307; 2001b, p. 24-25). Harvey outlines four key strategies in which capital postpones these episodic crises: 1) new external markets are created across geographic space ; 2) time is ‘bought’ by investing surplus capital in long-term projects such as training, infrastructure, research and communication that overcome spatial barriers and generate profits in the future; 3) by improving existing machinery, technology and creating new production facilities, and 4) expanding the population available to work through the separation of workers from the means of production (ibid, 2001a, p. 304-6).

In prioritising the neoliberal state’s role in providing the conditions favourable for capital accumulation and emphasising new forms of territoriality by market forces, Harvey too has faced charges of reductionism, side-lining constituent elements of the capital productive process, labour in particular (see HARTSTOCK, 2006 for discussion). As Herod argues (2001) just as workers make their own histories, though not necessarily under conditions of their own making so too do they make their own spaces, while similarly constrained. Social mobilisations by rural poor and indigenous have been to the fore of resistance to mineral extraction and biofuel monoculture, underscoring their negative social

and environmental externalities. In doing so they have not only exercised their own forms of territoriality but, alongside feminist critiques, have engendered an epistemological challenge to western-biased, patriarchal discourses of modernity and historic, technical-scientific and economic determinism (PORTO-GONCALVES, 2006). Furthermore, economic clustering in countries such as China and Brazil have led to many examples of industrial strengthening (SILVER, 2003) as workers and their unions recognise the geographical scale of their activities and that they form part of broader production networks that are affected by their local actions. Labour's capacity to disrupt the production process in pursuit of improved wages and conditions is something capital must continue to contend with (WRIGHT 2000) and labour's constitutive role in commodity chains is increasingly recognised (TAYLOR et al., 2013). Marx recognised that while competition for surplus profit was a powerful incentive for entrepreneurship and technological progress, so too was capital's consequent need to reassert control over the labour process, which it seeks to do using a mixture of hard and soft technologies (MANDEL, 1980).

Power, space and power geometries

An analytical framework that is concerned with power inequalities in incumbent and emerging energy infrastructures and systems must account for these above contestations. Capital may *seek* to homogenise processes across distinct regions (MOL,2007) and 'carbon counting' is certainly another way in which diverse resources are removed from their specific and geographic, cultural and political context and commodified (LEVIDOW, 2013). But the ground over which capital must travel is rougher than globalisation's crowing metaphor of fluidity would suggest (SANTOS, 1978). Thus Massey (1994) asks, 'is space really annihilated by time? There are, she argues, 'the groups who are really in a sense *in charge* of time-space compression'... 'who can really use it and turn it to advantage, whose power and influence it very definitely increases' (italics added). There are also, however, 'groups who are also doing a lot of physical moving (migrant labour, poor farmers), but who are not 'in charge' of the process'. Indeed the increasing influence and mobility of the former group depends on the acquiescence, restriction or invisibility of the latter. Hence power is relational and these 'power geometries', the ways in which people are differentially located within 'time-space compression', are complex and varied. The globalization of social relations may bring new encounters and increase the mobility of some, yet it is at the same time 'another

source of (the reproduction of) geographical uneven development’, and reproduces the specific character of particular places. As Porto-Goncalves points out (2006), the logistical and technological advances that overcome spatial barriers and poor soils, reduce transport times and bring new resources into production bring agroenergy companies into conflict once again with the ‘subaltern’; those indigenous and rural communities that have sought to exercise influence over previously remote places. The resistance by these groups has demonstrated that, while time is the dimension of succession and change, space requires the dimension of temporality and of contemporaneous multiplicity (MASSEY, 1994; PORTO GONCALVES, 2006). Space is constantly in the process of being made, unmade or remade, through the establishment *or refusal* of relations (MASSEY, 2009). It is where ‘some processes adapt themselves to pre-existing forms, while others create new forms that are inserted’ (SANTOS, 1978).

We turn now to the new spaces of agroenergy production to consider how techno-institutional and spatial fixes overlap to strengthen the ‘groups in charge’ of energy restructuring in Brazil, unpack how this overlap is reflected in ‘new forms’ of hard and soft innovation and uncover the implications for and responses by workers within and without of the emerging commodity chains for bioethanol.

State, Capital and a new techno-institutional and spatial fix for bioenergy *Kyoto Protocol and the European Union*

With as much as a 70% lower carbon output at point of combustion, conducive to blending with petroleum and now costing around 50 euros to convert an engine to run on either petrol or ethanol, consumption levels, biofuel from tropical sugar cane is a world leading biofuel, (FRANCO et al., 2010; OBERLING et al. 2012). A 20% growth in biofuels, 2004-2009, was dominated by bioethanol, and projections estimate that that it may constitute 7% of global road transport fuel by 2020 and 11% by 2030 (at present 98% of road transport in EU is fuelled by hydrocarbons; IEA, 2011). In the face of uncertainty relating to the longer term economic prospects of bioenergy supply chains, food security, actual savings to carbon, environmental sustainability and certification performance (e.g. SEARCHINGER et al., 2008,), the European Commission support for the biofuel strategy reflected strong political interests (DI LUCIA et al., 2012) and the EU was accused of selective and policy based evidence gathering by its own institutions (LEVIDOW, 2014). Campaigns by small farmers in rural areas; for example Mozambique and Brazil, the very subjects that were to benefit from

energy cultivation (ILO and UNEP, 2012), spearheaded concerns over food security and indirect land use changes that the EC has been forced to consider. Rather than address systemic power, land and income inequalities in this evolving techno-institutional complex for biofuels (to which we will turn), authorities in EU have tread a cautious path between supporting incumbent (first generation) biofuel production and consumption and proposing that it is replaced in the affordable future by more advanced ‘second’ generation biofuels that can be sourced from any lignocellulosic matter and adjudged to be less harmful (see PIETRO and LEVIDOW, 2014). The EU Renewable Energy Directive (RED) of 2009 set a binding target of 10% renewable energy in transport by 2020 and subsequently introduced a 5% cap on biofuels made from food crops when determining progress toward the 2020 target.

It is evident, however, that 27 EU members state committed to the Kyoto reductions have neither the land, climate nor technology to meet existing targets. In its turn to Brazil for biofuel import, the European Commission’s EC initial focus on the need to decarbonise automobility (CEC 2010: 2) has morphed to emphasising the social and economic value added by a new trade in bioenergy:

When favouring the development of the market for renewable energy sources, it is necessary to take into account the *positive impact on regional and local development opportunities, export prospects, social cohesion and employment opportunities*, in particular as concerns SMEs and independent energy producers’ (EC 2009).

Rural development, reduced rural-urban migration, growing schemes for small land holders have been among the forecast benefits (see FRANCO et al., 2010; LEVIDOW, 2014) that have similarly been linked to the ‘Decent work’ agenda of the ILO, in which improved wages, work quality and conditions might result from economic upgrading. *Brazil’s new energy nationalism and internationalisation of Brazilian biofuel* have similarly been linked to the ‘Decent work’ agenda of the ILO, in which improved wages, work quality and conditions might result from economic upgrading.

Brazil’s new energy nationalism and internationalisation of Brazilian biofuel

In the wake of the Kyoto protocol the state promotion of ethanol as a component of energy security and economic growth was given renewed environmental credibility. In the year of his 2003 election President Lula da Silva embraced both the large internal market and a key technological innovation by which Brazilian-designed fuel sensor software allowed for

the more affordable monitoring and handling of ethanol-gasoline blends in automobile engines. The state promotion of the production and consumption of ‘flexi-fuel’ vehicles (FFVs) that could run on petrol or ethanol was a success and now 88% of sales of light-duty vehicles (LDVs) in Brazil. The market built upon the strong command of the commodity chain during the discontinued PROALCOOL programme and re-energised the ethanol industry. Ethanol has been supported continuously by government intervention (by increasing the percentage of ethanol in the fuel mix) each time the price relationship with petrol has been unfavourable to ethanol. By 2020, FFVs are predicted to account for more than 70% of a stock of almost 40 million LDVs.

Following a visit by George W Bush in 2007 to discuss biofuels, Lula’s determination to lead in the sector and find markets further afield was evident, “everyone is eyeing the alcohol...we want to win the foreign market”. His enthusiasm for the internationalisation of bioenergy was consistent with his government’s distinct economic swerve back towards primary commodity production and export. Following 1995 membership of the World Trade Organisation, a 1998 amendment to the constitution forbade discrimination against foreign capital investment in Brazilian industry. Foreign direct investment (FDI) in the primary sector leapt from US\$ 2.4 billion in 2000 to US\$ 13.1 billion in 2007, with mining, soya, sugar and cattle raising activities particularly prominent (PRETTO, 2009). The FDI in alcohol and biofuels increased from 4 million dollars in 2002 to 1.64 billion dollars in 2008. In the 2007-2008 sugar harvest only 7% of the mills had the participation of external capital. In the wake of the financial crisis of 2008 this percentage more than tripled to 22% by 2010-2011 (BEATRIZ, 2011).

Transnational companies arrived to cash in on a staggering \$28.2 billion credit line (2000-2010; by comparison the state planned PROALCOOL programme cost \$7 billion), and found Brazil with its natural endowments, strong command of the production chain and favourable market projections for bioenergy a keen place for investment, particularly given financial instability in North American and European banking institutions. Noble (China), Abengoa (Spain), Cargill, ADM, Bunge (USA), Louis Dreyfus, Tereos (France), Shell (Holland-UK), BP (UK) and Mitsubishi and Sojitz (Japan) were among the investors while Brazilian oil and construction giants, Petrobras and Odebrecht also entered the biofuel sector. Credit was commanded by firms located in Sao Paulo and surrounding states whose new organizational strategies and competencies dominated the regional frontiers of sugar cane.

The land devoted to sugar cane doubled, increased the production of sugar from 258 to 625 million tonnes and ethanol from 11 billion to 28 billion litres between 2000 and 2011. In the face of enhanced competition over one hundred mergers with, or acquisitions of, smaller Brazilian firms took place between 2000 and 2011.

As with many successful corporations involved global commodity trade, diversification of production is key to gaining and retaining competitiveness. The main objective of modern 'biorefineries' is to produce multiple products using a combination of technologies. The ability to switch between sugar and ethanol production according to market price and demand, to produce energy by burning bagasse (the residue of the sugar cane plant) and produce a variety of sugars, hydrous and anhydrous ethanol are typical of the modern plants which boast a range of ISO quality certificates for national and international markets. Increasing land and capital costs are providing new barriers to entry into the sector and, it would appear, that only those corporations with access to international finance to nourish the required territorial expansion while continuing to invest in technological advances are able to remain competitive. This has been even more apparent following the 2008 financial crisis (MENDONÇA *et al.* 2013). With the subsequent squeeze on government-backed credit multinational companies have grown at the expense of those with more limited scales of operation. Thus, fifty-one companies have ceased operations since 2007, with 30 of these folding in just two years (2011 and 2012). By 2012 these closures had extinguished an estimated 13 000 direct and 32 000 indirect jobs (FOLHA DE S. PAULO, 2012).

Secondary, advanced biofuel technologies

Despite government provision of a further R\$1 billion to stimulate research and development of secondary or advanced biofuels, the large internal market which until recently has absorbed almost all nationally produced ethanol (there was in fact a deficit in 2009) and prohibitive start-up costs may explain why many Brazilian firms have resisted investment in these new technologies. As Oberling *et al* (2012) consider, small and technologically progressive firms are developing alternatives and could contribute in world of heterogeneous centres of liquid biofuel supply and consumption. However, in their attempt to reach the market with their products, their acquisition by oil majors suggests that their ability to co-exist with or take alternatives paths to those of the energy majors is unlikely. Shell's absorption of biotechnology firms Codexis and Iogen Energy is a case in point. Shell, like

other oil majors such as BP, Exxon and Petrobras has been concerned with peak oil and, while maintaining access to conventional oil reserves remains a priority, it has diversified its sourcing of energy. By 2012, 12% of its reserves came from non-conventional oil (e.g. tar sands, deep water deposits) and it has been investigating low carbon alternatives in line with export market demand. It pulled out of algae testing in Hawaii in 2011, citing poor return on investment, and decided to concentrate on a cellulosic ethanol project in Manitoba, Canada. It invested in the biotechnology company Iogen Energy and its 50% share was 'aimed at significantly reducing the capital and operating costs per gallon of cellulosic ethanol. After Iogen Energy consulted on its economic strategy with Goldman Sachs Group Inc. the plant was closed in Manitoba, eliminating 150 jobs and Iogen sold off its industrial enzyme business, BioProducts, to pay off debts.

The entire project was moved to Brazil where Shell also contributed its shares in Codexis and Iogen Energy to the partners' venture with Brazilian leading sugar and ethanol producer, Cosan, With the \$12 billion joint venture this new company, Raízen, produces 2.2 billion litres of ethanol 4 million tons of sugar annually from 24 mills/distilleries and has an installed capacity of 900 MW of electric energy derived from sugar cane bagasse, giving it a 23% market share. The company has over 4,500 service stations for retail fuel distribution in Brazil, 700 convenience stores, 53 fuel distribution depots, and aviation fuel businesses in 54 airports in Brazil. Its first step toward the commercialization of cellulosic biofuels technology in Brazil will cover development and engineering costs associated with the front end design of a biomass-to-ethanol facility to be co-located with Raízen's Costa Pinto facility in Piracicaba, São Paulo.

Biofuel financialisation and the spatial fix

Creative destruction is embedded within the circulation of capital itself. Innovation exacerbates instability, insecurity, and in the end, becomes the prime force pushing capitalism into periodic paroxysms of crisis. [...] The struggle to maintain profitability sends capitalists racing off to explore all kinds of other possibilities. (HARVEY, 1989, p. 105-106).

Cosan, a public listed company, had in 2008 signaled its faith in biofuels by using government credit to purchase the Exxon/Esso fuel distribution network. Its swift purchase of the NovAmérica distilleries of Benálcool, Tarumã, Paraguaçu Paulista and Maracaí (and its *Union* brand of sugar) in the region of study the following year increased its number of plants to 24 and raised its annual processing capacity from 44 to 60 million tonnes of raw sugarcane,

producing 4.2 million tonnes of sugar, 2 billion litres of ethanol and 900 MW of electricity (Cosan 2010). Like many large sugar/ethanol companies, NovAmérica had speculated on the financial markets to feed its own expansion, which included a planned US\$500 million plantation and distillery development in the frontier state of Mato Grosso do Sul. With the tightening of government credit after the ‘credit crunch’ of 2008, it fell afoul of the financial crash and debts of R\$723.13 million surfaced.

Cosan’s takeover of the NovAmérica distilleries represented a significant reorganization and specialization of production in the region and beyond. Cosan chose to take over only the industrial complexes, preferring to leave the agricultural section in the hands of NovAmérica. The latter had introduced harvesting machines to the region in the 1990s, availing of the government Modfrota programme that helped to increase the number of machines in Brazilian agriculture from 28.2 million in 1999 to 44 million in 2001. Its economies of scale and a state law for imminent total mechanisation of planting and harvesting have given it competitive advantage in the supply of raw sugar cane and it now supplies 8.5 million tonnes of sugarcane from over 100,000 hectares to Cosan plants in Tarumá, Maracaí, Paraguaçu and Caarapó. Significantly, Cosan has forbidden NovAmérica from constructing a competing distillery within 100km of any of Cosan’s units. In doing so Cosan shored up its competitive advantage in the industrial production of sugar and ethanol and pushes the responsibility for the supply of a high quality and quantity of sugar onto the contracted providers. It also avoids direct responsibility for the labour involved in planting, harvesting and transporting raw sugarcane, seeking to avoid further charges of slave like labour that it faced in 2009. By 2012 of the 43 member companies of the Brazilian Sugarcane Industry Association (União da Indústria de Cana-de-Açúcar – UNICA) that produce 60% of the country’s ethanol in 2012, Cosan and Copersucar commanded 44 per cent of the country’s production. Nonetheless the mechanisation and automation of agricultural and industrial processes and increasing land rents not only phased out smaller competitors such as the neighbouring plant of Pau d’Alho, but also escalated debts for this conglomerate. In its merger with Shell, debts of some US\$2.5 billion were transferred along with its assets of almost US\$5 billion and debts of into this new company, Raizen.

In 2012, Raizen’s Maracai plant was the first in the world to obtain the Bettersugar certification for biofuel export as the joint venture began to deliver on its promise to ‘turn ethanol into an international commodity. However, the trajectory of the above companies

depict the inherent instability that characterises the industry. By 2002 Sao Paulo was managing a cultivation cost of sugar cane of US\$150/tonne compared to US\$300/tonne in the Northeast and US\$450/t for US maize based bioethanol. Technological advances and development of new strains of sugar cane meant that cultivation of raw sugar cane per hectare increased from 50 tonnes to 80 tonnes. But these productivity gains have done little to curb a seemingly insatiable appetite for land. The continued need to borrow in order to invest, maintain plantation and distilleries and rejuvenate plantations every five years means that consultants predict that a further foreign investment of R\$44 billion is required for its predicted expansion of 3.1 million hectares in sugarcane at a time when large quantities of liquid cash is returning to North America and Europe. While the revenue from the sector in the Central South region was US\$60 billion this year, debts in the sector are around US\$56 billion for the 2013/2014 season. A further 60 plants are estimated to close within five years in Sao Paulo state. Eighteen thousand jobs were lost last year alone. When Pau D'alho closed, around 1,000 of the dispensed workers came from Ibirarema, a town of only 7,200 people. As the mayor declared a state of emergency workers faced the prospect of unemployment they could ill afford. Stories of unpaid wages are emerging across the state as workers in small towns these energy firms target for labour look into a very uncertain future.

Power geometries and rural labour

‘The poor will never buy land again’

(Luis, Brazil Landless Workers Movement, Assis, 2013).

The landless

Biofuel production has been accompanied by a popular institutional discourse that perennial crops for biofuels would regenerate marginal land, and an often cited aspiration that small farmers would be the guardians of this cultivation (ILO and UNEP, 2012). It is apparent, however, that the best land has been appropriated by expanding companies while technological advances in soil treatment and new public-private partnerships are extending production into more fragile a savannah terrain. It is also increasingly evident that small landholding, familial farming cannot compete with the industrial scale cultivation, milling and distillation. Brazilian land prices rose on average by 12% between 2006 and 2007, with the sharpest increases recorded where sugarcane expansion was most intense, as much as 17% in south east of the country and subsequently as much as 33% in frontier regions of Goiás, where British Petroleum and Louis Dreyfus located. Furthermore, Shell had only just

completed its joint venture with Cosan when government credit was frozen as a response to its illegal sourcing sugar cane from ancestral, indigenous lands in Mato Grosso do Sul (Reporter Brasil). While the Workers Party government have pointed to a modest reduction in social inequality, the indices of land concentration, the highest in the world, have not budged as corporate multinational strategies replace the huge landholdings of the former latifundios. The three latest censuses of 1985, 1995 and 2006 show that the Gini Coefficient, used to measure the distribution of land use, has been practically unchanged, expressed by 0.857, in 1995/96, and 0.856, in 2006 (an index of 1.0 would mean all the land was owned by one person).

João (aged 57) spoke after a meeting of the Brazil Landless Workers' Movement (MST) beside the rail track leading out of Assis. He puffed on a cigarette rolled from a maize leaf and recalled the days when opportunities for agricultural work were more abundant and varied, and when the *terra roche*, the rich, red soil of this river basin had provided incomes from maize and cattle, coffee and cotton. Life had not been easy, but the seven seasons he and his wife had spent cutting sugar cane in Maracai and Trauma were just part of various jobs that had sustained them and many relatives. "My life has been like that", he stated, "going from cattle to coffee, sugar, here, there, around Assis, a few seasons in Paraná, before the sugarcane took over". His wife Elena had been the first to be dismissed from the fields as women were relegated to planting and then collecting the cane that had fallen from trucks, then the older workers like Joao started to be replaced by younger workers.

Checking that an elderly member of the camp who had taken a stroke a few nights previous is taking the correct medication, Elena, one of the camp's co-ordinators spoke softly and firmly,

In the periphery [of the city] it isn't safe, the unemployment, the drugs are a problem, it's dangerous; people with hunger, going hungry, it's a real problem. That's why we fight for the land. We have a right to it, we know how to work it, grow our own food. We fight for this. But no one wants to help (Interview, June 2012).

They demanded seven hectares of land each; the minimum for family survival. But so far the government institution for agrarian reform, INCRA, had offered nothing. They had been given ten days to leave their occupation by the courts and police, after objections from ALL, the transport logistics company (Cosan have a 10% share in the firm) who own the adjacent rail tracks. The children were lifted from the tracks when an oncoming cargo train of soya charged by. Fourteen months later the camp dwellers, faced with little prospect of

gaining increasingly expensive land in this area of Sao Paulo, disbanded. Eight families had travelled to join a larger camp in Marabá in Pontal de Paranapanema to which they had been invited by the movement, but by Christmas 2013 there had been no progress with the authorities. A co-ordinator who had been among them returned to Assis. His grandfather had worked with cattle, as had he for a short time in Parana. He had sought to get some land so he could bring his children back and live with him there. He arrived to talk to us by bicycle as he had no longer the money to fuel his car. His partner was seeking cleaning work in the town and he was hoping to pick up any kind of job he could. Many of the 80-100 families that had been involved in the occupation returned to the peripheries of the small rural towns. They included former sugar cane cutters from Paraguacu, Assis and Florinea that had been among the ranks of unemployed forming this land occupation, now trying to access the family assistance packages that many of those expelled from the closed distilleries were also relying on across the region.

The assassination of Cicero Guedes, a cane cutter and leading member of the landless workers movement in Rio de Janeiro, 2013 brought to 1 650 the number of rural and indigenous workers killed in land-related conflicts since 1985 and was a stark reminder that land is still keenly contested in Brazil. Yet a convergence of state and agribusiness interests have all but frozen agrarian reform. Only President Fernando de Mello in his short presidency (1990-1992) redistributed less land than President Dilma Rouseff (86 properties by 2013). In 2013 the President announced a further R\$115 billion for corporate agriculture as part of the agricultural plan. Less than 16% of this was set aside for family farming. Furthermore, the westward expansion of the industrialised, agricultural model of biofuel extraction cannot be disassociated from indigenous dispossession and oppression. While the government states that it had demarcated more indigenous land than any other Latin American country, 95% of this has been in remote regions of the Amazon. In stark contrast, a 2012 eviction order was given to the Guarani-Kaiowa people occupying ancestral lands in the state of Mato Grosso do Sul, among the fastest expanding frontiers for bioenergy cultivation. The following year 34 indigenous people were killed, the most of these in Mato Grosso do Sul, where precarious roadside occupations continue in the pursuit of land reclamation which has involved 30 separate action by this group in 2013 alone (CPT, 2014). The concentration of land and employment opportunities in poor, rural areas, along with the increasing inability to reproduce

familial agriculture weighs heavily on the shoulders of remaining poorly paid rural workers in the sugar and ethanol commodity chain to whom we now turn.

Rural workers and their collective organisations

On the same morning that an old, yellow, rural bus carried workers to the Raizen distillery at Taruma, two engineers were flying out to Canada to perfect advanced biotechnologies. Whereas as 2300 cane cutters from the periphery of Assis town stepped out of similar buses in 2000, last season (2012-2013) saw only 230. A union organiser within the distilleries of Raizen Taruma and Raizen Maracai, recalled joining workers who went on strike across the divisions of labour in 1989 and 1990, 'We didn't know anything about unions, but we had had enough'. When she began her work in the sugar and ethanol industry, the town of Maracai had around 13000 inhabitants. By 2011 its distillery that Raizen assumed in 2010 was receiving 1.7 million tons of cane sugar, producing 130 million tons of sugar and 63 million litres of ethanol and became the world's first mill to receive the 'Better Sugar Initiative' certification for export. This UK based certificate, subsequently endorsed by the European Union provides a guarantee of quality standards on environmental and, to a lesser extent, social grounds. In recent presentation to the International Energy Agency, Raizen pointed to the environmental and social record of the plant and emphasised the development opportunities the company brings to rural areas (IEA, 2011). Sugar production began to dominate agriculture in the area ever since NovAmerica took over the distillery in 1957. Soya cultivation had also arrived. Today the population has fallen by around 5,000 to 13,000 inhabitants. According to those involved in the industry over the last three decades, two factors oversaw this exodus; firstly, monoculture replaced the more diverse and small farming agriculture on which the town had been built; secondly, machines began to replace the manual workers in the fields of soya and sugar and automation within the factories negated further job creation. In the 2006-2007 harvest, only 18.6 % of the sugarcane in Brazil was mechanized. In 2008-2010 the figure rose to 45.3%. By 2015 harvest mechanisation in Sao Paulo state may be complete, ending jobs in their tens of thousands. Raizen, despite its global expansion, directly employed around 5,000 less workers across its 24 plants in 2013 than it did in 2012.

As Mandel (1980) states, capital uses a blend of hard (e.g. machines) and soft (e.g. lean organisation) technical innovations to overcome labour resistance, while relying on soft (e.g. welfare policy) or hard (e.g. violent repression) state intervention to avoid tensions

spilling over into overt social conflict (see also Jessop, 2014). A range of strategies have, and continue to be employed across the sector to keep labour and social tension in check. Mechanisation has been ‘disappearing’ the problem of historic slave like labour on sugar plantations in selected sites of production subject to greater public scrutiny. It has also dovetailed with continued breaches of labour law and illegal dismissals of strike leaders by smaller and multinational corporations to intensify manual production (GARVEY and BARRETO, 2014) and ensure that increase in corporate power has, in the eyes of sugar cane cutters, come at the expense of their collective power. As Marcio at the Cocal plant recalled, “We struck before, various times. Sometimes you would get something, other times nothing. But now they have built Cocal II [in neighbouring Pontal of Paranapanema], so you know [he shakes his head], they’re powerful”.

A fellow worker employed in a nearby plantation stated that in relation to taking strike action, “With mechanisation now, it’s harder, they say they just don’t need you”. The dismissal of strike leaders in several plants following several large, but uncoordinated strikes of 2008 was a cursory reminder that internationalisation of biofuel does not necessarily mean job security for low paid workers in the emerging commodity chains. Instructively, Chan et al (2013) demonstrate how recent state promotion of employment and industrial growth in China can both progress ‘pro-labour legal reforms’ while limiting, often severely, worker self-organisation.. In Brazil, trade unions alongside notable actions from the Ministry of Labour have recognised that the increased international visibility of export orientated companies provided a significant leverage to reduce, for example, the outsourcing of manual cane cutting. Corporate claims of social responsibility, however, seek to concentrate attention (and certification) on work security and quality in the ‘central’ or ‘primary activities’ of leading firms, in which Brazilian law forbids (as distinct from prevents) outsourcing, even as they continuously challenge, or breach the law. Leading biofuel companies are clients of one of the three business management companies that have innovated the digitised quality control systems that dominate the industry, TOTVs (38 % market share), SAP of Germany (28 % market share) and US company Oracle (16 % market share). These have helped professionalise management and ‘lean’ organisation practices in which performance based pay and bonuses seek to encourage workers to view their own interests as those of management. To this end they have had some success and have convinced many industrial trade unions and indeed the International Labour Organisation of the merits of their

endeavours towards sustainable development and decent work for new, albeit fewer, skilled jobs within the modernising plants.

Meanwhile outsourcing of harvesting, loading and transport continues, with contracts often struck outside of public and trade union regulation, creating some of Brazil's most hazardous working conditions (GARVEY and BARRETO, 2014).

In sum, while modest social reforms such as minimum wage increases and negotiated collective agreements are improving conditions in specific sites of production, massive rural labour exclusion and factory closures are undoing the hard fought, self-determined gains won by rural workers in 1980s, while basic wages remain stubbornly well below those required for a living wage. As the General Secretary for the Sao Paulo Federation of Workers in Food Industry of workers in food pointed out,

These multinational cause us great problems. Automation continues to replace workers within the plants, perhaps by around 10% per year. For while that was offset by industrial expansion. But with factory closures, over 40 recently, think about it. Perhaps 200 staff in each. When it comes to negotiating, as we expect to do this May (2014), it puts us in a very difficult position (Interview, March 2014).

Whereas before the São Paulo Federation of Workers in the Chemical and Pharmaceutical Industries (which represents workers in the ethanol refining distilleries and laboratories), previously negotiated with industry association, UNICA, now it must also negotiate with the multinationals as one corporation operating across, for example, Sao Paulo, Mato Grosso, Mato Gross do Sul and Goiás is now too powerful to represented by the official governance body (Interview, March 2014).

Hence the geographical flexibility of employers and workers is asymmetrical, a factor which characterizes the emergent labour relations regime in the region. The current logic of accelerated territorial expansion, streamlined organizational capacity and market concentration across state, regional, national and international boundaries that typifies the successful sugar and ethanol corporations contrasts starkly with the relatively fixed nature of the rural trade unions, whose geographical and occupational limits to organizing are enshrined in current Brazilian labour law that dates to the 1940s. The President of *Federação dos Trabalhadores na Agricultura do Estado de São Paulo* (FERAESP), Elio Neves, put it succinctly:

In Brazil we have trade unions, but we do not have a trade union movement. Those are two different things. A movement means the collective good, recognizing the struggle of other workers. Here in São Paulo, that area where you have been, you have workers from Paraguaçu, Maracaí, Tarumá, Florínea, Assis, small towns in Pontal. You've maybe ten rural trade unions in that area representing those workers but you have one company Raizen with 24 distilleries, or two maybe –with Cocal – exploiting all of them!

Discussions on labour reform ground to halt within the Lula administration in 2007. Within the enduring corporate trade union structure inherited from Mussolini's Italy (see Gomes and Prado 2011) a trade union must limit its activities to a defined geographical boundary and the specific occupation of worker that it represents. The result is that the unions are spatially limited and that cane cutters, drivers, and machine operators in factories refining sugar primarily for food and those refining it for ethanol distilleries may all belong to different unions who appear to be more content with co-existence than co-operation. Many of the rural unions prefer cooperation to conflict and prefer their autonomy to alliance with either of the two federations in the state of São Paulo: the traditionally more conservative *Federação dos Trabalhadores na Agricultura do Estado de São Paulo* linked to the *Confederação Nacional dos Trabalhadores na Agricultura* (CONTAG – National Confederation of Agricultural Workers); and FERAESP, borne out of the militant actions of the cane cutters in the 1980s and linked to CUT.

Conclusion

The elements of state, corporate and labour strategies outlined above help to illustrate that technological innovation occurs neither in a vacuum or pristine environment but is part of a hegemonic process whose inception and application carries the mark of the socially and economically powerful. Innovation requires credit in abundance and hence corporations align technological innovation with nation state transnational policy while their financialisation is increasingly linked to risk-adverse shareholders. By extending an analysis of techno-institutional complexes to consider the internal power relations and those systemic social relations within which these are embedded, we have sought to demonstrate that these are unstable contested couplings. Furthermore, as primary commodity production illustrates dramatically, the gaining and maintaining of competitive technological and market advantage relies on an ability to reconfigure space for often ephemeral wealth creation (SANTOS, 1978).

Consequent concerns over the replacement of food crops with energy crops and indirect land use change have incentivised innovation in secondary or advanced biofuels as a less harmful alternative. These can, theoretically, be derived from any starchy, woody species, including the cellulosic waste from existing sugar/ethanol production and have been promoted and accepted as a solution at levels of transnational governance. A more systemic analysis of the emerging biofuel commodity chain, as we have attempted to do at least in part here, would suggest that these assumptions of a ‘better alternative’ underestimate how and why corporations must expand territorial control, commodify additional natural resources and diversify energy sources and markets to secure profit margins. Recent history shows that innovative technologies that open new frontiers for accumulation (drilling in deep sea, improving poor soils, breaking cellular walls) continue in tandem with existing, path dependent, techno-institutional systems. As is demonstrated by the testimonies and frustrations of rural workers here, these corporate strategies continue to rely on state support to guarantee investment and reassure foreign markets, open new spaces, suppress the discontented (by maintaining archaic labour law, stalling land redistribution; evicting indigenous populations). Hence accumulation that depends on the overlap of techno-institutional and spatial fixes requires in turn continued dispossession of competing actors over space and time. The geographical flexibility and mobility of agroenergy leaders relies on the political, economic and spatial limits bestowed on rural populations.

A failed occupation of the MST is more typical of recent occupations in the region than the relative successes of the 1990s. Indigenous populations figure each time more prominently in conflicts over land, water and energy (CPT, 2013). While some rural unions have been challenging the biofuel companies with some success and the leadership of FERAESP has been energetic on broader questions of agrarian reform, outsourcing and migrant worker rights, they are compromised by their own geographic isolation and the acquiescence or compliance of other rural and industrial based trade unions. Across this emerging commodity chain the paper provides a snap shot in time: family assistance packages are sought after by the newly unemployed and dispossessed as institutional leaders meet on international platforms promoting bioenergy trade; logistics companies transporting sugar and soya use the courts to remove the landless, their tents, old cars and their bicycles from beside the rail tracks; eleven former sugar cane cutters play cards near a disused rural bus that they once frequented, while engineers fly privately to Canadian laboratories; indigenous families

are camped alongside a road peddled by trucks racing to the eastern port at Santos. These images, gleaned from the accounts of rural workers in an expanding region of biofuel production, provide a stark depiction of the power asymmetries and geometries strewn across these spaces of biofuel production, of the inequality being reproduced within a key pillar of the green economy, of the pouring of old wine into new glasses.

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