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Authors
de L. T. Oliveira, Gustavo
Schneider, Mindi

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FLEX CROPS AND COMMODITIES SPECIAL FORUM

The politics of flexing soybeans: China, Brazil and global agroindustrial restructuring

Gustavo de L. T. Oliveira and Mindi Schneider

The political geography of the global soybean complex is shifting. While the complex has long been controlled by US-based transnational corporations, new agribusiness actors, business logics and power relations rooted in South America and East Asia are emerging, based in part on commodity flexing. We explore how soybean flexing is shaping and being shaped by global restructuring of the soybean processing industry. Using the divergent histories and uses of soy in China and Brazil, we propose that in order to understand the changing soy landscape, we must examine the relationships between soy's multiple-ness and flexible-ness, the political economy of soy processing, and the relationships between crop 'flexors' – those powerful firms that control the soy complex – with each other and with governments. We demonstrate that the agribusiness actors who are gaining more control over the soy complex are doing so in part through flexing, and that the ability to flex may ultimately determine the trajectory of global agroindustrial restructuring. Finally, we raise questions and make suggestions for further research on flex crops.

Keywords: flex crops; soy; agribusiness; biodiesel; meatification; livestock-feed complex; China; Brazil

Soybeans as a multiple and flexible crop

In terms of production volume, land use and international trade, soy is among the most important crops in the world today. State- and agribusiness-led processes of agro-industrialization have profoundly expanded soy's frontier, such that over the past 60 years or so, global soybean production has increased by almost 1000 percent, while the land area under soy cultivation has more than quadrupled (FAOSTAT n.d.; USDA 2014). The United States became the world's leading producer, processor and exporter of soybeans

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Editorial Note: The Journal of Peasant Studies (JPS) is publishing several exploratory papers on flex crops and commodities (JPS flex crops special forum). The purpose of the forum is to help generate systematic discussion on the idea and phenomenon of flex crops as a step towards identifying a possible future research agenda. There are several papers in this forum, including: (i) the introductory and framing paper by Borras, Franco, Isakson, Levidow and Vervest, (ii) Gillon on corn, (iii) McKay, Sauer, Richardson, and Herre on sugarcane, (iv) Schneider and Oliveira on soya, (v) Alonso-Fradejas, Liu, Salerno and Xu on oil palm, and (vii) Hunsberger and Alonso-Fradejas on policy narratives. JPS would like to acknowledge the important intellectual and logistical contributions by the Agrarian, Food and Environmental Studies group at the International Institute of Social Studies (ISS, www.iss.nl/afes) as well as the Transnational Institute (TNI, www.tni.org), which jointly organized the initial research and authors' workshop that helped shape the papers in this forum.

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in the mid-twentieth century, and US-based companies still control most of its production technology and trade. Since the 1990s, however, there has been a dramatic shift in soy's political geography. South America's Southern Cone, where soy is the 'the monoculture "starlet" of the agro-export model', accounts for 57 percent of world soybean exports (Rulli 2007, 16; see also Oliveira and Hecht forthcoming). At the same time, East Asia is the leading consumer of soybeans from international markets, surpassing Europe since the year 2000, and currently accounting for more than 65 percent of total imports. This new agroindustrial geography reveals much about the multiple and flexible uses of soy, and analyzing the history and political economy of these uses within and between Brazil and China – key nodes in the global soybean complex – enables a more nuanced understanding of the current politics of 'flex crops' and agroindustrialization.

As a crop defined largely by the value and usefulness of its *co-products* – namely, soybean meal and soybean oil – soy might be regarded as a fundamentally flexible crop (see Borras et al. 2014). Of the world's total soy production, only 6 percent is consumed in the form of whole beans, tofu or other whole-soy and fermented foods. The remaining 94 percent is crushed, either mechanically or chemically, to produce soybean meal and oil for further processing: a crushed bean produces about 79 percent meal, 18.5 percent oil, and 2.5 percent waste and hulls (HighQuest Partners and Soyatech 2011; WWF 2014). Worldwide, the meal portion of the crush is predominantly used in livestock feed (98 percent), while the remainder becomes soy flour and soy protein for food processing industries. Soy oil is largely refined as edible oil (95 percent), with the rest funneled to industrial products, including biodiesel (Soyatech 2014).

Technically, these multiple industrial uses are possible because soy protein and oils can serve as a petroleum replacement, attending multiple other functions in chemical concoctions for use in manufacturing. Livestock feed and vegetable oil producers might source raw material somewhat flexibly between soybeans and other grains or oilseeds according to market price and availability, but as soybeans become increasingly cheaper, better designed to attend multiple uses and more widely available than their alternatives, major soybean traders and crushers become strategically positioned to control downstream industries. Politically, soy's multiple-ness and flexible-ness are a consequence of the structure and operation of the global soy complex, which is controlled by a few major agroindustrial processing and commodity trading companies, some of which hold their position as legacies of North Atlantic-based agribusiness governance, with others emerging from new geographies and new relations of power.

Among these key agroindustrial actors in the soybean complex, many anticipate further multiplication of soy's uses, and propose that such flexing will bring social and ecological benefits. Gustavo Grobocopatel, for example, head of the leading Argentinian soybean agribusiness Los Grobo, stated:

> What is to come in ten years is a sort of Green Industrial Revolution, plants begin to be transformed into factories. That is, a plant that until now produced grain begins to produce energy, bio-plastics, molecules and enzymes for industrial use … . We are on the eve of an industrial revolution process of the same magnitude of the one that began in England during the 18th century, [but this] new revolution has some optimistic particularities: these plant-factories do not have chimneys, don't emit carbon dioxide but absorb it. These factories are friendly to the environment, they use renewable energy from the sun instead of coal or nuclear energy.[1]

[1]Translation by Gustavo Oliveira from Martinez (2014), cf. Lovatelli (2014).

Mr. Grobocopatel's statement is telling of how flex crops are being framed in agribusiness and development as a solution to the convergence of climate, energy and food crises. But to claim 'sustainability', these discursive representations rest on an incomplete accounting of energy and carbon cycles, and ignore the impacts of industrial agriculture. They also conceal the politics underlying a global food–feed–fuel complex, including the significance of flex crops in agroindustrialization and contemporary agrarian transformations. In order to understand these politics for the case of soy, we must understand the relationships between its multiple-ness and flexible-ness, the political economy of which co-product is driving the soy processing industry in particular places and globally, and the relationships between crop 'flexors' – those powerful firms that control the soy complex – with each other and with governments.

In the sections that follow, we examine these issues as expressed in and between China and Brazil. We make two main arguments. First, by tracing ongoing restructuring in the global soy industry, we argue that as multiple and flexible uses of soy are expanding, (1) there are important new players entering the global soybean assemblage from different global geographies and using different business logics, yet (2) not all actors can capitalize on these dynamics, as soy farmers and different processing industries find themselves in starkly varied power relations. These developments, we argue, not only recast the global soy landscape, but also express new relations in the corporate food regime. Second, using the divergent histories and uses of soy in China and Brazil, we argue that the multiple-ness and flexible-ness of commodities are contingent on a variety of factors, which are irreducible to price mechanisms alone. Issues related to class formation and reproduction, state-led agroindustrialization and the creation of segmented markets are key in the political economy of flex crops. In addition to a thoroughgoing analysis of the politics of flexing soybeans in China and Brazil, this contribution also raises questions for future research on flex crops more generally.

Global restructuring of the soybean processing industry

Over the past 25 years, three trends are particularly salient for situating the emergence of soy as a flexible and multiple crop. First is the massive expansion of soy cultivation, processing and consumption on a global scale.[2] Second is the expansion of uses and markets for soy and soy products, including food, feed, fuel and other industrial uses.[3] And third is the global restructuring of the soy industry, from an era of North Atlantic domination up until the 1990s, to the present moment when South American and East Asian actors are gaining power and control. We understand the first two trends as a dialectical convergence, in which the drive to increase soy cultivation also drives the research and development of

[2]Annual soybean production has increased from 26.8 million metric tonnes in 1961 to 285 million tones in 2013, an increase of almost 1000 percent (FAOSTAT n.d., USDA 2014). Similarly, soy was cultivated on 23 million hectares in 1961, rising to almost 105 million hectares in 2012.

[3]Among the industrial uses of soy proteins and oils are: adhesives, analytical reagents, antibiotics, asphalt emulsions, anti-corrosive agents, anti-static agents, binders for wood/resin, caulking compounds, cosmetics, core oils, disinfectants, dispersing agents, dust control agents, electrical insulation, epoxies, films for packaging, foams and anti-foaming agents, fungicides, herbicides, inks and crayons, insecticides, linoleum backing, leather substitutes, metal casting, oiled fabrics, paints, plastics and plasticizers, plywood, protective coatings, polyesters, pharmaceuticals, putty, rubber manufacture, soaps/shampoo/detergents, textiles, vinyl plastics, waterproof cement and wallboards (Iowa State University 2007b).

Table 1. Deconcentration of soybean production and crushing industry.

	Share of global soy production		Share of global soy crushing	
	1991 (%)	2014 (%)	1991 (%)	2014 (%)
USA	50	31	37	19
Brazil	18	31	15	16
Argentina	10	19	8	16
EU	0.6	0.4	14	5
China	9	4	4	29
Others	12.4	14.6	22	15

Source: Elaborated by the authors from Goldsmith et al. (2004) and USDA (2014).

multiple industrial uses in order to create new markets for the actors who control the soy complex. In turn, consolidating soy as the preferred raw material for these multiple uses further drives agroindustrial integration, with the soybean crushing industry at its very center. We argue that bridging the third trend, however, requires further consideration for theorizing *who* controls crop flexing – and under what conditions and relations. In other words, we need to understand how soybean flexing is shaping and being shaped by global restructuring of the soybean processing industry. This section opens that task by exploring, first, the geographic deconcentration of soybean production and crushing from the North Atlantic to South America and East Asia, particularly Brazil and China (Table 1); and, second, the emergence of new agribusiness actors, new business logics and new power relations rooted in Brazil and China's emerging agroindustrial partnerships.

North Atlantic concentration: from the 1990s to the early 2000s

In 1990, the US concentrated half the world's soybean production and, together with Europe, which had been the major export destination until then, controlled 51 percent of the global soybean crushing industry. US- and European-based transnational corporations were the dominant actors in international soy processing and trade, with the largest four companies – ADM, Bunge, Cargill and Louis Dreyfus, collectively known as the ABCDs – standing out among them. A few other large-scale trading companies, particularly the Japanese general trading conglomerates (*sogo shosha*) like Mitsui and Marubeni, were the only other significant actors operating in international soybean markets, but they lacked the warehouses and personnel to 'originate' soybeans directly from producers in the United States or South America. Instead, they purchased soybeans from the ABCDs on the Chicago Board of Trade, and then shipped or simply received them at their ports in Japan, South Korea and elsewhere.

The ABCDs, on the other hand, established a virtual global monopoly because they were vertically integrated from the moment farmers took their harvest to their local warehouse, controlling much of the storage capacity and almost the entire transportation logistics within the United States and South America, as well as the port terminals, cargo ships and processing facilities that ultimately crushed the soybeans into meal and vegetable oil (Goldsmith et al. 2004; Morgan 2000). This strategy of 'verticalization' forms the basis of power for these companies, with implications for the politics of flexing soybeans and other agroindustrial commodities: it enables them to increase their control over the soybean production chain and its price setting-mechanisms, increase profit margins, reduce production and transaction costs, minimize risks, engage in future-market hedging and speculation with privileged information and, most importantly for the present discussion, generate complementarities and synergies between the different sectors of the soybean production and processing complex.

These North Atlantic agribusinesses increasingly controlled the entire soybean complex upstream and downstream from farming itself. They did so in concert with North Atlantic-based seed and agrochemical companies such as Monsanto, Syngenta, Bayer and DuPont, which launched strategic partnerships with the ABCDs to advance seeds and agrochemicals to world farmers in exchange for prearranged sales to specific trading companies (HighQuest Partners and Soyatech 2011). Soybean farms in the high plains of North America, the cerrados of Brazil and the pampas of Argentina increasingly looked the same, operated in the same manner, employed the same technologies and ultimately purchased from and sold to the same markets controlled by these few major North Atlantic agribusiness companies. Simultaneously with a broader process of rolling out neoliberal reforms worldwide, soybean agribusiness companies seemed to transcend national borders and establish their own 'United Soybean Republic' across the southern cone of South America (Grain 2013, citing a marketing campaign by Syngenta), which quickly became the world's leading soy-producing region. Concurrently, these companies took advantage of a crisis in China's domestic soybean processing industries to make large-scale acquisitions and launch massive investments in the sector, owning at one point about 80 percent of China's soybean crushing capacity (see 'The Battle of the Beans' below). These firms were major pillars of a 'corporate food regime', which shed the narrow ties between US state interests and regulatory mechanisms that structured the post-war international food and agricultural regime, but further concentrated the power and profits in the hands of these North Atlantic-based transnational agribusiness corporations (McMichael 2012; Turzi 2011). The expansion and deconcentration of the soybean complex that was led by these companies, however, also unfolded with contradictions for their dominance in the international food and agricultural regime, as new corporate actors and logics are emerging in relation to crop flexing. The contemporary political economy of the soy industry is exemplary.

Soy's shifting geography

The boom of soy production and processing in South America during the 1990s took place alongside massive expansion and consolidation of the soybean crushing industry in the hands of the ABCDs. Until 1995, ADM had no operations in Brazil or Argentina, while Bunge, Cargill and Dreyfus owned less than 10 percent of the crush capacity in these countries. With neoliberal reforms that enabled massive inflows of transnational capital into Argentina and Brazil, these companies undertook multiple mergers and acquisitions of small- and medium-scale Argentinian and Brazilian soybean crushing companies, expanded the capacity of their own processing plants and constructed new facilities in port areas where their globally connected operations provided them strategic market advantages. Consequently, the ABCDs collectively gained control of over 50 percent of soybean crushing capacity in Brazil and Argentina by 2002, operating at 100,000 tons per day. Since then, they have continued to expand operations through mergers and acquisitions, but although their combined crush capacity in Argentina and Brazil reached over 180,000 tons per day in 2012, their market share stagnated at around 50 percent of total crush capacity (Goldsmith and Hirsch 2006; Wesz Junior 2013). This stagnation has taken place due the emergence of new large-scale actors from within the South American agribusiness sector itself. In Argentina, the three largest domestic crushers – Molinos Rio de la

Plata (MRP), Vicentín and AGD – own 39 percent of the soybean crushing capacity (Dominguez 2013). In Brazil, new actors with substantial shares of the crushing industry include the Amaggi conglomerate and major cooperatives like Comigo in Brazil, which were established and continued to expand in the central and northwestern areas of the Brazilian cerrados, far from the southeastern region where the ABCDs came to dominate storage and crushing capacity during the 1990s and early 2000s.

Yet restructuring was highly uneven in South America, with Brazil and Argentina ultimately taking up distinct positions in the global soybean complex. Between 1984 and 2010, Argentina's crush capacity increased 325 percent (from around 40,000 to 170,000 tons per day), compared to only 75 percent in Brazil (from around 100,000 to 175,000 tons per day). This was a consequence of distinct fiscal and trade regimes, whereby the Argentinian government encouraged domestic crushing of soybeans by imposing heavy export taxes on unprocessed commodities, while Brazil removed such taxes in order to make its exports of unprocessed soybeans more competitive in international markets. Thus, Brazil's domestic crush fell from 95 percent of total production in 1995 to less than 50 percent today; the majority of meal and oil produced domestically is also consumed by the Brazilian vegetable oil and livestock feed markets, which currently absorb around 25 percent of Brazil's total soy production. The vast remainder is exported as unprocessed soybeans to major consumption and processing regions. Until 2004, Europe absorbed the majority of Brazilian whole-bean exports, which were processed domestically to attend the livestock feed and vegetable oil markets. But once the European farming lobby pressured processors to switch to rapeseed to meet the demand for vegetable oil and biodiesel, it became increasingly more profitable for European companies to outsource soybean-crushing operations to South America (particularly Argentina) and/or import soy meal alone. Meanwhile, China changed the tax and tariff structure for soybeans in the late 1990s to promote whole-bean imports, and began to provide fiscal incentives for foreign investments in the soybean crushing industry on its major ports (see further details in the next section below).

The result of these simultaneous processes was a sharp reversal in Brazilian whole-bean exports from Europe to China. In 2003, 54 percent of Brazilian whole-bean exports still went to Europe and only 30 percent to China, but by 2013, Europe's share fell to 12 percent while China became the destination of an astounding 75 percent (Goldsmith et al. 2004; USDA 2014). In Argentina, on the other hand, where the domestic market absorbs merely 5 percent of total soy production, the fiscal and trade policies mentioned above led Argentina to become the largest exporter of *crushed* soybean products, accounting for 46 percent of global soy meal exports (followed by Brazil at 22 percent and the US at 15 percent), and 49 percent of global soy oil exports (again followed by Brazil at 16 percent and the EU at 8 percent) in 2013 (USDA 2014). With this differentiated restructuring of the soybean crushing industry, Brazil, Argentina and China now produce around 54 percent and crush about 61 percent of all soybeans in the world. The US maintains a reduced but significant share of the crushing industry at 19 percent of global production, but Europe's share fell from 14 to 5 percent (USDA 2104).

The global soybean crushing industry, therefore, has a new landscape: it is no longer centered on the United States and Europe, and even though North Atlantic-based transnational corporations retain a significant share of global crush and trade, they must now compete with Argentinean crushers that supply Europe, and a much larger flow of soybeans from large-scale Brazilian producers and cooperatives to be crushed directly in China by their own companies. China's state-owned agribusiness companies, in particular, have been favored since 2007 to regain control of the soybean crushing industry from the ABCDs (as detailed in the next section below).

New actors, business logics and power relations

The new actors emerging from the recast production and commercial landscape also develop new business logics and power relations in the global soybean complex. The ABCDs established themselves, and continue to sustain their market shares, through worldwide vertical integration of purchasing–processing–trading operations, thereby controlling extremely large volumes of the global soybean trade. This provides them incomparable flexibility when sourcing from and redirecting sales to multiple markets around the world, even rerouting cargo ships mid-ocean to gain marginal profits on large volumes, and speculating on futures markets with the privileged information that results from controlling significant shares of non-transparent markets. Yet new trading companies from Japan, China, Singapore, South Korea, the Gulf States and even South America increasingly begin to challenge their dominance over international agricultural trade (Murphy, Burch, and Clapp 2012; Wilkinson 2009).

Since their new South American and East Asian competitors lack the infrastructure across both ends of the international trade to operate in a similar fashion, they have begun to engage in mergers, acquisitions and joint ventures to transform their commercial relations into new forms of international trading operations. Rather than relying upon capital-intensive vertical integration within a single company, we witness these companies adopting an 'asset-light' strategy to establish strategic partnerships between actors with advantaged information about and access to production and processing markets in China and Brazil. The most notable examples are COFCO (China National Cereals, Oils and Foodstuffs Corporation)'s recent acquisitions of the Dutch-based trading company Nidera and the agribusiness arm of the Hong Kong-based transnational trading company Noble. Both Noble and Nidera have significant operations around the world, particularly in Argentina and Brazil, where they have also been the fastest growing agribusiness trading companies, often through renting warehouses and contracting port terminals and cargo ships rather than investing in fixed assets of their own. When asked about this new relation with COFCO, the Chief Executive Officer (CEO) of Nidera in Brazil explained that 'our goal is not to become a new Cargill', but to develop a 'new business model' based upon special relations and expertise across the main channel of international soybean and other agroindustrial trade.[4]

New power relations arise not only through the emergence of new actors in the soybean crushing industry and new business logics among them, but also through the incorporation of new actors into broader agro-industrial processing operations. Given the multiple and proliferating uses of soybeans and other flex-crops, these new agroindustrial production chains 'have room for non-traditional partnerships: grain processors integrating forward, chemical companies integrating backwards and technology companies with access to key technologies, such as enzymes and microbial cell factories joining them' (World Economic Forum 2010, 20). The global restructuring of the chemical industry is particularly relevant, as it follows a trajectory similar to the one outlined above for the soybean crushing industry.

In the 1990s, US, Japanese and European chemical companies began relocating many of their operations to China, and many Chinese companies – particularly large state-owned enterprises – began to modernize and grow through mergers and acquisitions of smaller domestic companies. China thus became the world's largest producer and exporter of chemical products in general (Hang 2007; KPMG 2013; Perlitz 2005). Considering the

[4]Interview by Gustavo Oliveira, São Paulo, Brazil, May 2014.

sectors of fine chemistry associated with livestock feed and additives, which are most intimately linked with the soybean crushing industry, it is particularly clear that China has become the world's leading producer and exporter with companies like BlueStar (a subsidiary of ChemChina) and Tongwei Group, and it serves as a model for the Brazilian government's efforts to cultivate its own domestic livestock feed and additive sectors (KPMG 2013; Ministry of Development, Industry, and Foreign Trade 2012).

After 2010, there has been a shift in the direction of transnational investments, with Chinese corporations starting to make acquisitions of US and European chemical companies, and outsourcing their operations to countries from which they import much of their raw materials. The recently announced investment by the Anhui province state-owned chemical company BBCA Group in Brazil provides a particularly illustrative case. The BBCA Group is among the Chinese chemical companies that came to dominate global production of vitamins, lysine and citric acid during the 2000s. It currently retains 20 percent of the global market share of citric acid, processed from maize-based glucose. The company is establishing a maize processing facility in Brazil in a joint venture with the JLJ conglomerate, and anticipates the construction of another for soybeans, in order to locally produce the chemical products that it currently exports to Brazil and Latin America (CEBC 2014a; JLJ Group n.d.). Another example is the recent acquisition of the Prentiss Química company in Brazil by the Tide Group from Ningbo, which enables the Chinese agrochemical conglomerate to produce and supply over 65 million liters per year of pesticides and herbicides primarily for soybean production in Brazil. With this successful entrance into the Brazilian soybean complex, the company foresees further investments for research and development of agrochemicals in Brazil (CEBC 2014b).

Akin to the fine chemical industry, the food additive industry has also become an important segment of the soybean complex.[5] There is a wide field of research on food processing, including many publications, that certainly reveals these roles and uses of soy products. Unfortunately, most research on food processing maintains a very narrow focus on technical and nutritional considerations, leaving important lacunae for further research on the political economy and geography of food processors using soy products. This investigation would contribute important insights about new actors and business logics shaping the flexible and multiple uses of soybeans.

There is evidence that not all varieties of soybeans are equally useful (and economically profitable) for processors who aim to produce at least some of these processed foods. For example, in response to the US Food and Drug Administration's (FDA) requirement that trans-fatty acids be indicated on nutrition labels in the US beginning in 2006, the Iowa State University's Soybean Extension and Research Program began developing low-linolenic varieties of soybeans, which can be used in food processing as an alternative to hydrogenation. Major food processors including Kelloggs, KFC and McDonalds have announced their intention to use low-linolenic soybean oil (or a soybean/canola combination) to reduce trans fats in their products.

[5]There are innumerable processed foods that contain soy products in small amounts, such as soy flour, stock, lecithin, glycerol, fatty acids and sterols. These are used in the production (or low-cost 'extension') of breads, cookies, pancakes and other bakery products, noodles, cereals and grits, beer and ales, chocolates, candies and confections, frozen desserts, instant milk drinks, toppings, coffee creamers, liquid shortening and yeast, salad dressing/oils, sandwich spreads, vegetable shortening, sausage casings, dietary products, baby food and, of course, mayonnaise and margarine. Soy products are not only used as processed food ingredients, but also as emulsifying or stabilizing agents, shortening and coatings (Iowa State University 2007b).

> According to the United Soybean Board's 2006 Soybean Quality Report, about 750,000 acres of low-linolenic soybean were contracted in 2006. [In 2007] it was expected [for] this number to triple. While the growth rate of these special use soybeans is tremendous, these varieties currently represent only about 1 percent of US production. (Iowa State University 2007a)

Therefore, despite the general sense that with industrial standardization of soybean production, the commodity has become more flexible, there appear to be important differences between soybean varieties that significantly limit the willingness of soybean crushers to flexibly purchase interchangeable soybeans on the open market. According to interviews with soybean crushing company officials in Brazil, the United States and China, we observe that companies have a strong interest in contracting directly with farmers to source specific soybean varieties that hold particular qualities that make them most technically appropriate (and economically profitable) for their specifically intended production. For example, soybean varieties from the Center-West of Brazil are known to have very high oil and protein content, which is a benefit for crushers who want to produce both livestock feed and edible oil. However, the characteristics of that soil also result in a far darker color of edible oil, which is a marketing concern for many soybean processors in China, who are informed that many customers prefer lighter-colored oil as a sign (accurate or not) of greater quality.

Thus, the interchangeability of soybeans with other grains and oilseeds for the production of livestock feed, edible oil, biodiesel, food additives and other industrial inputs may reduce the dependence of agroindustrial processing companies upon major soybean suppliers. On the one hand, the multiple-ness of soybeans in particular creates the conditions for major soybean trading companies to diversify their operations and control the downstream production chain, and also for new corporate actors to play increasingly larger roles in shaping the soybean complex. Moreover, since investments in soybean crushing and further processing operations are very capital intensive, the scale of operations necessary for firms to benefit from sourcing flexibly between soybeans and alternative inputs, as well as the ability to attend multiple markets for soy-based products, ultimately rests only with the largest and most strategically connected transnational corporations and their main competitors from emerging markets in China and South America. Meanwhile, soybean farmers and small-scale processors in China, Brazil and elsewhere become increasingly dependent upon these key corporate actors.

In the following section, we trace the different legacies and trajectories of the soybean complex in both China and Brazil to demonstrate how the multiple-ness and flexible-ness of this crop have been contingent on a variety of factors related to class formation and reproduction, state-led agroindustrialization and the creation of segmented markets, rather than price mechanisms alone. Understanding these processes may then enable a better account of the new power relations that emerge due to the flexible and multiple uses of this key agroindustrial commodity.

Soy legacies and trajectories: China and Brazil

There is no single path for 'flexing' an agroindustrial commodity like soybeans between food, feed, fuel and other industrial uses. Similarly, there is no single path for soy transformations, as starting points, historical uses and legacies, and trajectories are different under different socio-environmental and political economic conditions. In this section, we turn to changes in the soy sectors over the last four decades in China and Brazil, two key locations in the emerging corporate food regime and the shifting global soy complex. We show that the trajectories of soy developments in each place are related, but in largely opposite directions.

In China, soy has been transformed from a domestic crop with a long history of multiple food and farming uses into the country's most important import crop, traded primarily in service of the industrial livestock sector with soy oil as a constructed co-market. Soy's diversity (of varieties and regions for cultivation) and multiple-ness (of use in diets and agroecosystems) in China has decreased, while efforts to recover the soy industry from the domination of foreign firms may be setting the stage for Chinese firms to become more powerful players among soybean 'flexors'.

In Brazil, on the other hand, soy cultivation developed relatively recently as a non-food cover crop, which was then incorporated into the vegetable oil industry, with livestock feed as the constructed co-market. Only after it became a consolidated industrial input for the vegetable oil and livestock feed markets have soybean processing companies in Brazil begun to promote its use as a human food, a food processing additive and biodiesel. These multiple and growing uses have increased the flexible-ness of operations for oilseed processors and grain traders in Brazil, while simultaneously reducing the flexibility in production decisions among grain and oilseed farmers, alongside the agrobiodiversity of Brazilian rural landscapes and diets.

We turn now to questions of control over soybean flexing, first through a historical analysis of soy developments in China, then in Brazil.

Soybeans in China: from food to feed

Soybeans in China are defined primarily by *multiple-ness* in two senses: the historically multiple and diverse uses of soy in food and farming systems, and the contemporary multiple use of soybean meal and soybean oil as co-products of the crushing industry. While soy foods and industrial soy applications are emerging, they are not (yet) at a scale that compels flexing away from livestock feed production. What's more, soy-based biodiesel is virtually non-existent. For these reasons, we argue that soy's *flexible-ness* in China is currently mostly of the anticipated variety, as defined by Borras et al. (2014). This situation, however, may change in the near future.

Early history: soy as food of the people

Soybeans originated in China, and millennial-scale cultivation of the crop produced around 6000 domestic varieties and rich associated knowledges about soy production, processing and uses (Wang 1987). The northeast (Heilongjiang, Jilin, and Liaoning Provinces) is the historic center of soy cultivation, but soy is considered an agrifood staple and basic ingredient in Chinese cooking generally (Chang 1977).

Soy's versatility, or perhaps its *multiple-ness,* as a protein-rich food for humans explains much of its legacy in pre-reform China. As the 'undoubtedly … most important diet adjunct' over the last six to seven centuries, (Mote 1977, 200), the many uses of soybeans before the 1990s reflected their dietary importance. For most of history, and for most Chinese people, diets were plant-centered, including 'homegrown' soy (domestically or self-produced) as an important protein source.[6] To make it digestible, the soybean was almost always processed.

[6]According to a survey by J.L. Buck, Chinese farmers before 1949 (in other words, most of the Chinese population) received 89.8 percent of their food energy from grains and grain products, 8.5 percent from

Tofu has long been the most typical soy product, with co-products made into other dishes and snacks, and the liquids made into soy milk, and/or saved to be used later for cooking (Anderson and Anderson 1977). Soy flour was also common, especially in the northeast, to make starchy staples of noodles, breads and steamed buns (Wang 1987), and fermentation made soy sauce, yellow and red soybean pastes, black beans and pickled bean curd (Anderson and Anderson 1977). The particularities of these products – their characteristic form and flavor – varied by location, producing even more diversity.

Reform era: soy's multiple-ness as a casualty of restructuring

Today, more soy is consumed in China than in any other place in the world, and in higher volumes than at any other time in history. But while foods like tofu and soy sauce remain common in Chinese cooking and diets, people now consume soy primarily in the form of industrial pork and chicken (fed with imported beans), and, increasingly, as soy oil for cooking. The plant has been transformed from a protein-rich food for human consumption, and a nitrogen-rich crop in domestic agroecosystems, into the country's most important agricultural import, primarily to fuel the industrial livestock industry. Soy's transformation began in the wake of Reform and Opening in 1978, and simplification of its uses continues to the present.

In the reform era (post-1978), a central preoccupation for China's political and economic elites has been 'modernizing' diets, including measures to massively increase meat consumption for the urban middle and upper classes in particular (Schneider 2014). One of the state's earliest moves in this direction was establishing a milling industry to provide compound livestock feed for the budding industrial meat sector. Through a combination of market reforms and government financial support, China's feed industry went from practically nothing before 1975 (when livestock grazed or ranged in smallholder farming systems), to becoming the world's second largest feed producer by 1995, to its current world leading position. Pig feed was the first boom in the 1980s, followed by chicken feed in the 1990s (Ministry of Agriculture 2009). Today, China has a multi-billion dollar (USD) livestock feed industry, of which soybean crushing is a central component. As a result, China also leads the world in industrial pork and poultry production, and is rising in industrial beef and dairy production as well (IATP 2014).

Before soy could become a key ingredient in commercial livestock feed mixes, it had to be redefined as an *industrial* commodity.[7] In the 1990s, the government's decision to cut soy loose from state pricing control, while maintaining stricter regulation of other sectors, was strategic. Although China had long been the world's leading soybean producer, harvests before liberalization were destined for tofu, soy sauce and other multiple uses as described above. As increasing meat consumption became a more pressing goal for legitimizing the state and serving an emerging consumer class, combined with anticipation of

roots, and only 1 percent from animal products (Hsu and Hsu 1977). Similarly, the 'Cancer Atlas' study from the 1970s, upon which Campbell and Campbell's (2006) well-known 'China Study' is based, reported that in rural China (again, the majority of the population at the time), only 9–10 percent of calories came from protein, and only 10 percent of that protein came from animal-based foods. Soy was a key protein source.

[7]In 2002, the central government redefined soybean meal and soybeans as *industrial* rather than *agricultural* products, changing the tax and tariff structure, and promoting more liberalized trade (Solot 2006).

joining the World Trade Organization (WTO), authorities liberalized soy imports while encouraging domestic processing (Schneider 2011).

As a result of this sectoral restructuring in the 1990s, soybean imports have been soaring at an average annual growth rate of about 26 percent. In 2013, China imported 69 million tonnes, or 64 percent of the total global soy trade, predominantly from Brazil and the United States as seasonally complementary suppliers (USDA 2014). Imported beans, which accounted for 85 percent of soy consumption in China in 2013 (Table 4), are crushed domestically to produce livestock feed (soybean meal) with soy oil as a co-product. A profound departure from soy's multiple-ness in China's past, these two agroindustrial uses now drive the country's soy industry, with global implications: China is the world leader not only in soy imports, but in both soy meal and oil production as well.

The 'Battle of the Beans', excess crush capacity and control over flexing

By adopting an import strategy focused on whole, unprocessed soybeans – and hoping to capture the products and profits of crushing, processing and perhaps flexing soybeans at home – the state aimed to support China's participation in the global market without becoming its handmaiden. Yet despite these efforts, about 60 percent of the soy processing sector is foreign owned and operated. While this figure is quite high in comparison with other agricultural sectors in China (Schneider 2013), it is reduced from the 80 percent share multinationals had in the period immediately following the '2004 Soybean Crisis' (2004 *nian dadou weiji*), a watershed moment in China's soy sector (Bo 2014). The crisis began in the spring of 2004, when Chinese buyers pledged to purchase soybeans from the United States at a time when the price was abnormally high. When prices tanked by the time payments came due later that summer, many buyers defaulted on their contracts. Transnational soy traders took the case to the Grain and Feed Trade Association (GAFTA) in London, which found in their favor: the Chinese crushers were required to fulfill original contracts, at substantial losses.

A Chinese Academy of Science study estimated that Chinese crushers overpaid for this soy by a margin of at least USD 1.5 billion (Wen 2008, 30–34). The immediate result was that many Chinese crushers and refineries were forced into bankruptcy, creating an opportunity for transnational agribusinesses to further penetrate the sector. The firms that made the most market headway after the crusher defaults were already leaders in the global soy trade: the ABCDs together bought over 70 percent of the shutdown Chinese crushers, and Singapore-based Wilmar also increased its market share (PRL.org 2009). Transnationals also gained control in the soy oil market when half of all domestic refineries were forced to close. By 2009, foreign firms controlled 80 percent of soybean crushing and 60 percent of soy oil refining in China (PRL.org 2009). This meant that the same firms controlling soybean exports *to* China from production centers in the US and South America were also the major *importers* controlling the flow of soy and soy products through the Chinese food system.

Referred to as the 'Battle of the Beans' in Chinese media, the 2004 crisis profoundly changed the trajectory of soy in China, and further shaped and was shaped by the North Atlantic domination of the global soy complex. Put another way, the crisis ushered in an era of foreign domination in China's soy industry, followed by the contemporary era of domestic protection, recovery and mounting overcapacity in the industry. Government support for domestic firms, and of state-owned firms in particular, is an important strategy (Heilongjiang Agriculture News Network 2013). In crushing, although foreign firms own about 60 percent of the crush, the figure is somewhat deceptive: domestic firms own

Table 2. China's leading domestic soybean importers, by rank, 2013.

	Name	Main activities	Ownership
1	Shandong Chenxi Group	petrochemical production, grain and oil processing (soybean, palm oil, maize)	Private
2	Sinograin (China Grain Reserves Corporation)	storage, trade, processing, and logistics for grains, oilseeds, and oils (soybean, rapeseed, vegetable, sunflower, palm)	State owned
3	JiuSan (93) Group (subsidiary of the BeidaHuang group)	soybean processing (#1 in China), soy oil refining (#3 in China), production of soyfoods	State owned
4	COFCO	foodstuffs (China's largest food processing, manufacturing, and trading firm), cultivation, finance, infrastructure, hotels, real estate	State owned
5	Sanhe Hopefull Grain and Oil Group	primarily soybean processing (meal and oil), with future plans to add soy-based lecithin, vitamin e and other 'high-tech health products'	Private (with party leadership)

Source: The Heilongjiang Agriculture Information Network (2013) is the source of the company ranking. Other information was compiled and translated by the authors from company websites.

72 percent of China's *total crush capacity*, (1) indicating the extent to which support and investments from state and private actors have boosted domestic mill construction and processing, (2) suggesting that the state wants to recover ownership and build processing infrastructure to compete with the ABCDs and (3) indicating the shifting trajectory of the industry in China and the soy complex globally.

In 2012, crushers in China processed 61 million tonnes of soy, which was less than half the country's capacity. This meant that China's crushers were operating at a level of excess capacity large enough to process Argentina's entire soy harvest (McFerron 2013). Most of the excess is in domestic firms, which have increased in number and size in the wake of the 2004 crisis (Nelson 2012). Table 2 lists the leading domestic soybean importers in China from 2013. Specific data on crush capacity in these firms is unavailable.

Overcapacity in China also impacts transnationals. In one sense, the foreign-owned share of the crush in China is declining. In another, Chinese companies are looking for ways to fill their unused capacity, through increased imports (Lloyd 2014) and, notably, through investments in soy production and infrastructure abroad. The International Institute for Sustainable Development demonstrates that Chinese enterprises have sought investments in soybean production and related infrastructure in Brazil, Argentina, Bolivia, Kazakhstan, the Democratic Republic of Congo, Sudan, Zambia and Russia (Smaller, Qiu, and Liu 2012). The extent to which these investments impact the operation and power of the ABCDs and other leading transnational grain traders remains to be seen (Oliveira forthcoming).

Analysts predict that Chinese crushers will soon play a more central role in the global soybean *meal* trade, challenging Latin American crushers in East and Southeast Asian markets in particular[8] (McFerron 2013; USDA 2014). What's more, as Chinese firms – with the support of the state – continue to build crush capacity and try to fill it, they will

[8]According to the most recent USDA (2014) report on oilseeds, China has already started to replace India's soybean meal exports in Asia, particularly to Japan, South Korea and Southeast Asian countries.

Table 3. Ownership of soybean oil retail brands in China, 2012.

Rank	Soybean oil retail brand
1	Jinlong yu (金龙鱼)
2	Fu linmen (Fortune) (福临门)
3	Sheng zhou (盛洲)
4	Pan zhongcan (盘中餐)
5	Haishi (海狮)
6	Jin ri (金日)
7	Ri qing (日清)
8	Hong qingting (Red Dragonfly) (红蜻蜓)
9	Yu lan (豫兰)
10	Huaxiang nong (花香浓)

Source: Chinese Forbes (2012) is the source of the top 10 list. Other information was compiled and translated by the authors from company websites.

not only produce more soybean meal for domestic and export use, they will also produce more soybean oil. Currently, the domestic market for soy oil is nearly saturated. Before soy's rise, people in different parts of China used different kinds of locally produced vegetable oils for cooking (especially rapeseed and peanut oil). Vegetable oil was mostly a supplement to lard, the household production and use of which has declined in the context of swine sector restructuring (Schneider and Sharma 2014). But as soy imports and crushing have increased, so too has the amount of soy oil needing a market. Given that the same firms that dominate crushing also dominate refining (both foreign and domestic), soy is now the leading cooking oil in retail markets. According to one soy expert in China, soy has all but replaced other oils in the country's vast landscape of restaurants and food stands.[9]

Although domestic companies dominate China's soybean oil sector, foreign firms also play a role, many with their own Chinese retail brands (see Table 3). Jinlongyu (金龙鱼) has 30-40 percent of the total market for all edible oils, the highest in China. Its parent company, Arwana, is owned by Kerry Oils and Grains, which is owned by Singapore-based Wilmar. Bunge started the Douweijia (豆维家) brand of soy oil in Nanjing in 2007. ADM and Wilmar have a joint venture in the Jinhai brand (金海) of products, including the Sania (莎妮雅) soy oil brand. Through a joint venture with China National Cereals, Oils and Foodstuffs Corporation (COFCO), ADM and Wilmar also own five companies of crushers and soy oil refiners. Cargill and Dreyfuss don't at present have their own retail soy brands, but instead sell unrefined oil to local refiners or to ADM enterprises.

What economic models call 'demand' for soy oil in China may continue in the short term, as the power of key firms continues to grow, and as it more completely replaces other cooking oils in urban and rural markets. But oil may also become an export for China, similar to the way analysts predict emergent soymeal exports. These are questions that remain open, and relate to ongoing restructuring in global soy crushing.

GMOs, flexing and segmented markets

Another important issue that impacts the context for soy flexing in China is related to debates around genetically modified organisms (GMOs). In the wake of the 2004 soy

[9]Interview by Mindi Schneider, Heilongjiang Province, China, August 2011.

crisis, officials used a number of methods to protect the domestic soy industry and recover some of the ground lost to foreign firms. These moves included: restrictions on foreign ownership in the soy sector, financial and policy support for new and existing Chinese agribusiness firms, minimum soy purchasing prices for domestic soy and construction of a soybean futures market for non-GMO soybean trading (Schneider 2011; Zheng et al. 2012). This kind of market segmentation complicates the ease with which crops can be flexed, or creates segmented, flexible markets.

Currently, China's central government prohibits commercial planting of genetically modified (GM) food crops, but allows imports. Given that Brazil and the United States are the primary sourcing countries, virtually all of China's soy imports are GM, and are priced on the Chicago Board of Trade. Combined with the sheer volume of imports since the 1990s, these two issues have eroded China's domestic soy production, and are key processes in the dispossession of smallholder soy farmers. Since the 2004 crisis, soy acreage has declined nationwide from 144 million mu (9.6 million hectares) in 2005 to 102 million mu (6.8 million hectares) in 2013. In Heilongjiang Province, the so-called 'soy district' or 'soybean's hometown' (*dadou zhixiang*), the area planted to soybeans has declined by more than half, from 6323 wan mu in 2005 to only 3105 wan mu in 2013 (Bo 2014). At the same time, experts estimate that more than 30 percent of smallholder soy farmers in the northeast have left farming for migrant labor in the cities (Ma and An 2010). Pricing here is key: there is no price premium for non-GMO soybeans in China; instead, growing non-GM soy is a liability for smallholders in particular, since their prices are undercut by cheap imported beans. According to Zhao Yusen of the National Committee of the Chinese People's Political Consultative Conference

Table 4. Soy industry highlights: China and Brazil (2013 unless indicated otherwise).

China	
China's soy imports as a share of total global soy trade	66%
Share of soy used in China from imported beans	85%
Share of soybeans in China crushed for meal and oil	85%
Share of soy crushing industry in China that is foreign owned	60%
Soy crushing in China as a share of total global soy crush	28%
Share of crush capacity that is domestically owned	72%
Excess crush capacity in China's soy industry in 2012 (capacity: utilization)	50%
Annual crush capacity added by domestic companies from 2009 to 2010	15 mmt
Annual crush capacity added by multinationals from 2009 to 2010	7 mmt
Number of state-owned enterprises in the list of top 10 crushers	6
Brazil	
Brazil's soybean exports as a share of total global trade	41%
Brazil's soybean exports as a share of total domestic production	51%
Soy crushing in Brazil as a share of total global soy crush	15%
Soy meal exported from Brazil as share of total domestic production	52%
Soy oil exported from Brazil as share of total domestic production	23%
Share of soybean production in Brazil used for biodiesel	10%
Excess crush capacity in Brazil's biodiesel refineries	50%
Annual crush capacity added by all companies from 2003 to 2008	15 mmt
Annual crush capacity added by all companies from 2008 to 2013	8 mmt
Crush capacity of Brazil's state-owned biodiesel company as share of total domestic biodiesel production	28%

Sources: FAOSTAT (n.d.); USDA (2014); Nelson (2012); Heilongjiang Agriculture Information Network (2013); ABIOVE (n.d); APROSOJA (n.d); Petrobras Biocombustiveis (n.d).

(CPPCC), 'Hitting the Chinese soybean market with low-priced GM soybeans is part of a strategy used by transnational grain businesses to monopolize the Chinese soybean industry' (Hou 2013).

To address these issues, the Chinese Soybean Industry Association (CSIA) has proposed alternatives for the soy sector. Along with other experts, the CSIA urges that China should develop new markets for domestic soy so that it doesn't compete directly with cheap GM imports. There are two main proposals. One is to use domestic soy exclusively in the manufacture of foodstuffs such as tofu, soymilk and vegetarian products to be marketed within China. This proposal could also include marketing sustainable soy products to link producers to the growing domestic market for sustainable food products. Presently, there are a handful of Chinese firms using this model. The other proposal is to (re-)develop the export market for non-GM soy to Japan, South Korea and European and North American countries. Both of these proposals aim at separating the markets for domestic and imported soybeans to benefit Chinese producers and processors, who are likely to become the key soy flexors (Table 2).

Soybeans in Brazil: agroindustrial input with multiplying markets

Compared to the millennial-scale legacy of soy in China, the crop's history in Brazil is much more recent, and with a very different trajectory. Soybeans were first planted for experimental purposes in Brazil during the late nineteenth century, and early Japanese migrants planted it for consumption as food during the early twentieth century. Yet Brazilian commercial farmers only began planting soybeans in any extensive manner after the 1940s, as a cover crop and green manure to restore nitrogen to soils degraded by wheat production (Hasse and Bueno 1996; Shurtleff and Aoyagi 2009). In other words, since there was no dietary habit of eating soybeans or soy foods outside immigrant Asian communities, the expansion of soybeans among commercial farmers in Brazil began as an addendum to wheat and other grain production. It was then incorporated into vegetable oil production and subsequently into livestock feed, which now drives the demand for the bulk of domestic soybean crushing operations. With the boom of soybean production in Brazil since the 1990s, the soybean crushing industry began to create new uses and markets for soybean products, especially biodiesel and food additives. Thus, we recognize that real flexing is taking place in Brazil's soybean processing industry, and further multiplication of uses is anticipated by key corporate actors capable of flexing this agroindustrial commodity.

From cover crop to vegetable oil and livestock feed

As production increased during the 1950s and 1960s, soybeans began to be incorporated as a supplementary input for the vegetable oil industry in Brazil, since its growing availability but limited commercial use made it significantly cheaper than alternative oilseeds available in southern and southeastern Brazil. However, the unfamiliarity of Brazilian consumers with soy oil and soy foods inhibited its uptake as the predominant ingredient for edible oil and margarine. According to the executive at Bunge responsible for marketing during the late 1960s and 1970s in Brazil, the company developed new brands of soy-based margarine, advertising one merely as 'hydrogenated' but not admitting it was soy-based, and another as specifically developed for stove and oven cooking, a market in which they figured the consumer's concern over taste/scent would be reduced in relation to price. Sales boomed after 1976, when the company invested heavily in advertising on television, hiring a movie star who was featured in a major blockbuster that year as a lewd cooking instructor.[10] Since then, soybeans became the primary input for margarine production in Brazil, and gradually displaced other oilseed inputs in the production of vegetable oil. By 1986, soybeans were used in the production of 29 percent of all edible oil products consumed in Brazil (Paula and Faverete Filho 1998), a share that has increased to over 86 percent since 2006 (Osaki and Batalha 2011).

It was only after soybeans became established as an input for the vegetable oil industry in Brazil that their use for livestock feed developed as a way to generate profits from soy meal, the by-product of oil extraction that had previously been considered waste in Brazil. This late development of soy meal as an input for livestock feed was also a consequence of the relatively slow development of concentrated animal feeding operations (CAFOs) in Brazil during the twentieth century. Until the 1970s, the vast majority of poultry and pork production in Brazil took place in small-scale, low-technology and geographically dispersed farms. Cattle ranching remains predominantly an extensive practice to the present, although confinement prior to slaughter is increasingly starting to take place as well. Yet the concentration of the poultry and pork industries since the 1980s has become the single largest domestic market for soybean meal (Nicolau, Vargas, and Balzon 2001).

This process began during the 1970s, when the Brazilian state-owned agricultural research company Embrapa launched a program for the genetic 'improvement' of poultry and pork varieties to better survive in CAFOs and gain weight faster through soy-based livestock feed (Moraes and Capanema 2012). With these new varieties and the adoption of additional CAFO technology from the United States, domestic companies like Sadia, Perdigão and Ceval became major players in the Brazilian poultry and pork markets, as well as the soybean complex in southern Brazil. By 1995, these three largest companies controlled 34 percent of the domestic poultry market and over 60 percent of Brazil's poultry exports, as well as 22 percent of the soybean crushing capacity in Brazil (Henry and Rothwell 1995).

After 1995, however, price support mechanisms and export taxes on unprocessed soybeans were removed, which favored the export of unprocessed soybeans (as discussed above) and drastically reduced profit margins for soybean crushing operations. Consequently, poultry and pork companies divested from soybean crushing, which became increasingly controlled by the trading companies that deal with large volumes and thin profit margins. The share of Brazil's soybean crush controlled by trading companies went from 22 to 43 percent between 1995 and 1997 alone (Paula and Faverete Filho 1998; Nicolau, Vargas, and Balzon 2001).

As soy production expanded very rapidly in Brazil during the 1990s, the sector was feeling increasing pressure from overproduction by the early 2000s. Consequently, the soybean production and processing sectors (led by the Brazilian Association of Vegetable Oil Producers, ABIOVE) began to seek out additional markets (and uses) for their products. The primary use found for soybeans in Brazil after livestock feed and edible oil has been biodiesel, and the next most important new market for soy products has been the food processing industry.

From edible oil to biodiesel

Soybean use as feedstock for biodiesel is understandably the focus of much discussion of flexing since it captures a larger portion of total soybean production than other industrial

[10]Interview by Gustavo Oliveira, São Paulo, Brazil, May 2014.

uses, and it plays a very significant role in the articulation of agriculture with energy, environmental, industrial and financial concerns (Borras et al. 2010; Holt-Gimenez and Shattuck 2009). Early experiments with vegetable oils as fuels began in Brazil as early as the late 1910s and 1920s (with a logic of import-substitution triggered by world war disruptions to and price hikes in international oil markets), but it was only with the oil price shocks of the 1970s and the relative success of the government's Proálcool program for ethanol production from sugarcane stock that the federal government established the National Plan to Produce Vegetable Oils for Energy Use (Proóleo) in 1980. But before soybeans and other feedstock could become significantly drawn into biodiesel production, the drop in world oil prices during the 1980s cut short the economic viability of the plan (Langevin 2010).

With the soy boom of the 1990s and pressure from ABIOVE for a new biodiesel program that could increase domestic demand from soybean crushing companies, the Brazilian government finally established the National Program for the Production and Use of Biodiesel (PNPB) in 2004. In the broader context of agrofuels and the energy matrix of Brazil, soy-based biodiesel still occupies a very minor role when compared to sugarcane ethanol, yet biodiesel production is by far the biggest market for soy products in Brazil after livestock feed and edible oil: we estimate that about 10 percent of Brazil's soybeans went into the production of biodiesel in 2013.[11] It also illustrates new actors, new business logics and new power relations associated with the restructuring of the soy complex and the politics of flexing.

The PNPB mandates the mixture of biodiesel in Brazil's diesel supply. A mixture of 2 percent was achieved by 2006, and 5 percent by 2010, when biodiesel production substituted 1.1 billion liters of diesel imports, saving nearly a billion dollars from Brazil's international trade balance and providing 4 percent of the country's energy supply (Langevin 2010). In 2013, 2.9 billion liters were produced, and a mixture of 7 percent will come into effect on November 2014, raising the expectation that 4.2 billion liters will be produced in 2015 (Bianchini 2014). Current plans are for a 10 percent mixture to be achieved by 2020. The National Agency of Petroleum, Natural Gas and Biodiesel (ANP) approved 10 more biodiesel refineries in 2012, and six more projects were under review that year. But growth of production capacity has far outpaced the demand for biodiesel, and the sector currently operates with 50 percent overcapacity (Nielsen and Lima 2013). Thus, ABIOVE continues to pressure the government to increase the biodiesel mixture mandate each year (Lovatelli 2014).

Although private agribusiness interests represented through ABIOVE have driven the government to create and expand the PNPB, the state plays a much greater role in the operations of the biodiesel sector. In order to implement the mixing mandates described above, the government guarantees purchase of 80 percent of the biodiesel market through public auctions held by ANP. It also directly produces biodiesel-refinery technology through EMBRAPA, finances its implementation through the National Economic and Social Development Bank (BNDES) and produces a substantial share of biodiesel through its state-owned company Petrobras.

The establishment of a soy-based biodiesel industry has also produced a segmented market that props some small-scale producers, particularly in southern Brazil, since the biodiesel program provides a 'Social Fuel Seal' with tax exemptions for private companies that

[11]Estimate based upon ANP/ABIOVE data for total soy-based biodiesel production and the soy oil-to-biodiesel conversion ratio calculated by Cavalett and Ortega (2010).

source a certain percentage of their raw materials from small-scale farmers. This was intended especially for small-scale family farmers planting castor beans in the poor Northeast of Brazil (who were to be the archetypical beneficiaries of the 'social inclusion' aspect of the PNPB, according to the Brazilian government), but benefits were also extended to refineries that sourced at least 30 percent of their raw material from small-scale farmers in the South and Southeastern region (where small-scale soybean commercial farmers exist in substantial numbers), and 10 percent from the Center-West region. However, the production of castor oil and other feedstocks by small-scale family farmers – especially in the Northeast of the country – quickly proved to be insufficient and poorly integrated by industrial logistics to attend the rapid demand that the biodiesel mandate created. Consequently, the biodiesel corporations that expanded their refinery capacity and collected the most benefits from the PNPB subsidies were those that sourced soybeans from small-scale soybean farmers in Southern and Central Brazil. This represents a notable failure of the biodiesel program in terms of social inclusion (Bernardes and Aracri 2011; Wilkinson and Herrera 2010).

Still, since 31 percent of current biodiesel production is sourced from small-scale soybean producers (Bianchini 2014), biodiesel production is establishing a geographically distinct and segmented market in which large-scale soybean companies in the Center-West attend the bulk of the biodiesel industry demand, while small-scale soybean farmers in Southern Brazil enable biodiesel refineries to capture the benefits from the 'Social Fuel Seal' (Schneider 2009). Ultimately, the creation of such segmented markets might actually *limit* the flexibility with which soybeans are sought/contracted on open agricultural markets from interchangeable producers. Moreover, this limitation might also affect the soybean producers who increasingly lose control over their production processes to the companies that contract for their crops.

It is also important to mention that the reduced emissions and other environmental benefits claimed by the Brazilian government and biodiesel companies are increasingly revealed to be equivocated. Considering the total emissions from agricultural production, land-use change, soybean processing and refining, and all the associated logistics of the soy-based biodiesel production chain in Brazil, reduced carbon emissions are negligible, while the additional environmental harms of industrial soybean production (e.g. soil erosion, water and soil contamination by agrotoxics, etc.) are very significant, and accounting for the emergy of this production system demonstrates that biodiesel from soybean *cannot* be considered a renewable energy source (Cavalett and Ortega 2010):

> The future of biodiesel is very likely to be linked to the ability of clustering biodiesel production with other agro industrial activities at an appropriate scale and mode of production to take advantage of the potential supply of valuable co-products. [However,] if the biodiesel production systems are not carefully designed according to a *diversified small-scale perspective*, the intensive exploitation of land and fossil fuel for biodiesel production are more likely to generate environmental and social damages than to become a renewable energy source to society. (Cavalett and Ortega 2010, 6, emphasis added).

Leading biodiesel companies in Brazil

The industry is concentrated both geographically in the leading soy-producing states, and also economically. The top four companies account for more than 50 percent of all biodiesel production in Brazil. They also illustrate the process of financialization associated with flexing (cf. Murphy et al. 2012, Borras et al. 2014), the emergence of Brazilian companies that are able to compete with major transnational corporations and the key role of the state not only in establishing the biodiesel program, but also in controlling a substantial amount of the sector through its regulatory agencies and major state-owned company.

Petrobras Biocombustive is a subsidiary of the state-owned oil company Petrobras, and has a production capacity of 821,000 m^3 per year. It was established in 2008 and was focused primarily in the northeast of Brazil, where it operates three biodiesel refineries. However, it nearly doubled its production capacity in a joint venture with the BSBIOS company that operates two refineries in southern Brazil, and it currently plans to expand in northern Brazil to incorporate palm oil and soybean production from the Amazon-Cerrado transition zone (particularly the states of Pará, Maranhão, Piauí and Tocantins). These shifts have taken place in large part because of the failure of expansion and integration of castor oil and other non-soybean feedstock for biodiesel production in northeastern Brazil. The company also further refines biodiesel into fatty acids, tocopherol, glycerol and other chemical products.

Vanguarda Agro, with a production capacity of 640,000 m^3 per year, is an open capital company originally established as Brazil EcoDiesel by the US-based investment fund BT Global and Deutsche Bank, with 50 percent of its stocks controlled by investors from the Cayman Islands and the other 50 percent controlled by Zartman LLC from California, Boardlock LLC and Carleton Towers LLC from Delaware, and Nelson Silveira (who worked with Carleton). It was then restructured with the integration of the Neo-Biodiesel Fund as majority shareholder (operated by the following financial institutions: Bradesco, Fibra, BMG, Bonsucex Holding and Banco Fator) and became Brazil's leading biodiesel producer. In 2011, it merged with the agroindustrial company Maeda and the farmland investor Vanguarda Participações, changing its name to Vanguarda Agro and beginning a process of divestment from biodiesel production to focus on grain production. It is currently Brazil's largest private landholder, managing over 253,000 hectares of farmland primarily in Mato Grosso, but it also leases land in Goiás, Bahia and Piauí.

Granol is the third largest biodiesel company in Brazil, with a production capacity slightly over 600,000 m^3 per year. It is a private company with anonymous and closed stocks, 58% of which appear to still be controlled by the family that founded it in 1965 in Brazil. Its operations are focused in Goiás, Rio Grande do Sul and São Paulo states, and, due to its ownership structure, there is significantly less information about it than about the other major companies. In addition to soy meal, edible oil and biodiesel, it also produces glycerol, lecithin and tocopherol.

Archer Daniels Midland-Brazil (ADM) is the fourth largest biodiesel company in Brazil, with a production capacity of around 300,000 m^3 per year. It is the Brazilian subsidiary of the transnational US-based ADM agribusiness conglomerate, which centers around a major grain and oilseed trading company about which much is already known (HighQuest Partners and Soyatech 2011; Murphy et al. 2012).

Soy foods in Brazil: a market in the making

Soy foods in themselves remain rare in Brazilian diets, with the exception of the Japanese-Brazilian community residing mainly in São Paulo and Paraná. Even though there are a rising number of young, middle-class urbanites who take up vegetarianism and favor soy foods as meat substitutes, there are still very strong and widespread cultural stigmas against eating soy foods in Brazil (Sousa and Vieira 2008). In fact, it is not uncommon to hear someone comment that 'soy is food for cattle' to justify their unwillingness to eat the beans or its products. Tofu is generally called 'soy cheese' in Brazil, which makes it hard for many to imagine cooking it into stir-fry or other common Asian-style meals.

Soymilk, moreover, carries a negative stigma as a low-quality and low-class substitute for cattle milk, because government programs for subsidized public school meals (and meals at other public institutions such as hospitals and prisons) took up soymilk as a nutritious and cheap alternative.

On the other hand, soy products are fast rising in Brazilian diets as inputs for food processing. Most notably, soy protein and oils are being added to processed juices (apparently following a trend in Argentina) in increasingly large scales. Leading this tendency are the main processed box juice corporations operating in Brazil, whether they are domestic or transnational: Unilever has a major share of the Brazilian market with their *AdeS* box juice brand, alongside Nestlé (with *Sollys* juices), and the Brazilian companies Batavo (with *Naturis* juices) and Yoki (a Japanese-Brazilian company, with *Mais Vita* juices), among others. It is notable that the national Association of Soybean Producers (APROSOJA) has been actively campaigning for the adoption of juice-with-soy through legal lobbying and marketing. Physician and nutritionist conferences are also frequently attended by soy-lobby sponsored marketing professionals, providing free samples of juice-with-soy and pamphlets about the nutritional qualities of soybeans. It seems clear that there is still a concerted effort to increase the acceptance and consumption of soy foods among Brazilians, targeting primarily the upper and middle classes, in part to gain a price premium through 'high-level' supermarket chains and brands, but also in part to deconstruct the stigma that 'soy is food for poor people'. Yet the non-food industrial use of soybeans is certain to remain the most important and fastest growing market for soy products after livestock feed, particularly through increasing the mandates for biodiesel in Brazil.

Implications for further research

The flex crop concept arose from the realization that some major agribusiness actors are capitalizing on multiple and flexible uses of key agroindustrial commodities to reduce risks in sourcing inputs, to transform wastes and by-products into marketable commodities, to hedge against price fluctuations across multiple markets and to streamline trading and processing operations (Borras et al. 2014). Although these developments might be taking place at a faster pace and larger scale than before, our initial effort investigating the politics of flexing soy in relation to broader processes of global agroindustrial restructuring underscores the importance of historical contextualization for a more nuanced analysis. After all, the biological basis of agriculture has always created challenges for capitalist accumulation, and agribusinesses have been industrializing their inputs and products for a long time in attempts to overcome those limits (Goodman, Sorj, and Wilkinson 1987). Moreover, the success of major trading and industrial conglomerates like the *sogo shosha* from Japan and the *chaebol* from South Korea during the twentieth century was already predicated on their flexible operation in and synergies across extremely diversified commodity markets, and the ability to effectively flex soy and other crops has followed primarily from the vertical integration that the ABCDs established during the previous century. Some questions remain: What is new or unique about the current development of flex crops? How is it related to and distinct from earlier processes of agro-industrialization and bio-technological innovation? How might we distinguish crop flexing from the horizontal integration of diversified commodity markets under centralized conglomerates like the *sogo shosha* or *chaebol*, and from the vertical integration of trading and processing operations undertaken by North Atlantic agribusiness companies?

Another theoretical insight that triggered research on flex crops is the observation that the financialization of agricultural production and processing with the convergence of multiple crises – energy, environmental and economic – increases agricultural commodity prices and their volatility. This in turn exacerbates the need for agroindustrial companies to hedge against price fluctuations, and simultaneously increases the possibility for windfall profits from timely responses to fast-changing market signals (Borras et al. 2014). Consequently, the boom of flex crops appears to follow primarily from their special position in relation to price mechanisms and variations. But as we have demonstrated with a more nuanced investigation of the development of the soy complex in China and Brazil, the politics of flexing soy is contingent on a variety of factors, which are irreducible to price mechanisms alone. Issues related to class formation and reproduction, state-led agroindustrialization and the creation of segmented markets fundamentally shape crop flexing, and the limits encountered in this process. We can't abstract prices from broader social relations, and, therefore, further research is required to understand how flex crop prices are constructed, and how profit considerations dovetail – or not – with multiple and conflicting political interests that shape agroindustrial production, processing and trade.

As demonstrated in our introduction, the political and environmental implications of flex crops are often framed as a solution to the convergence of climate, energy and food crises. But to claim 'sustainability', these discursive representations rest on an incomplete accounting of energy and carbon cycles, ignore the impacts of industrial agriculture and conceal the politics underlying a global food–feed–fuel complex. Therefore, the political ecology of flex crops and agroindustrial development requires further elaboration and publicity, particularly given the inverse relationship between the development of flex crops and loss of agro-biodiversity. That is, the expansion of a handful of agroindustrial commodities with multiplying and flexible uses has also resulted in a drastic simplification of agroecosystems, genetic erosion of plant varieties increasingly developed for agroindustrial uses, reduced cultivation of non-industrial food crops and broader loss of biodiversity and habitat through expansion of monocultures and agrochemical use. There is already an empirically rich literature on these topics that can be harnessed for discussions of flex crops more specifically.

Important empirical gaps remain for further research, particularly regarding the political economy and geography of the food processing and fine chemistry industries that increasingly incorporate soybean and other flex crops as feedstock. Methodologically, we believe it is imperative to refine studies at the scale of processing facilities and companies, and their research and development operations. This requires collaboration among researchers who are familiar with distinct geographies and commodities (e.g. soybeans, palm oil, maize, sugarcane, etc.) in order to appropriately capture the interchangeability (or lack thereof) among key crops as feedstock, and the flexibility (or lack thereof) in creating multiple products and attending diversified markets. We also call for greater integration of political economy with science and technology studies, particularly around the research and development of flex crops and their uses. In order to do so, it is absolutely necessary to initiate interdisciplinary collaborations that involve food, agricultural, molecular and biochemical engineers. Such collaborations may enable the investigation of questions such as: How flexibly do agroindustrial processors actually source their inputs between multiple soy varieties and other oilseeds? How easily may specific processing facilities and/or companies shift production between their soy-based and other products in response to market signals, consumer preference/campaigns, worker strikes and disruptions? How are petrochemical and crop-based chemical industries and markets transforming through the development of flex crops? What are the material and technical bases and limitations to crop flexing? How are scientists and engineers becoming integrated into agroindustrial companies and production networks, and what new interests, contradictions and possibilities do they bring to agroindustrial development?

Finally, we have demonstrated that there is nothing about the material basis and technical characteristics of soybeans alone that inevitably leads to crop flexing. In fact, the complex political, ecological and economic factors discussed reveal important limitations for flexing to take place in important soy producing and consuming regions (e.g. China) and for many actors to effectively flex soy and other commodities (e.g. farmers and small-scale processors). In addition, the multiplication of uses also appears to trigger the biotechnological development of new cultivars designed for specific purposes, as illustrated by the case of low-linolenic soybean varieties. Similar observations were also made regarding biotechnological development of tree varieties, which might ultimately reduce the flexibility with which these crops are sourced on commodity markets and the multiplicity of uses of particular cultivars (Kroger 2014). Whether and how biotechnological innovations facilitate or curtail flexing for specific agribusiness actors remains to be further investigated empirically. Moreover, as was also demonstrated in the case of flex trees (Kroger 2014), significant ecological, political and economic differences between countries (especially between the Global North and the Global South) appear to play important roles in driving, limiting and transforming the pathways for crop flexing. Thus, important questions remain about the limitations and multiple pathways for flexing, and the role of distinct political economies and ecologies in this process. For example, does the multiplication of soybean uses, agroindustrial soybean varieties and creation of segmented markets impose greater limitations on the flexibility with which processors source their inputs, or on the production practices of soybean farmers? How does the emerging politics of flexing soybeans alter the power and production relations between transnational agribusiness corporations, smaller agroindustrial companies, farmers and workers in the soybean complex and consumers of soy-based products? And, ultimately, how might social movements and others attempting to influence agroindustrial policy strategically address the possibilities and risks involved in crop flexing? Investigating these questions would contribute to the theorization of flex crops and the political engagement with the agroindustrial transformations of our century.

Conclusion

We intended to demonstrate that the significance of soybeans in agroindustrialization and contemporary agrarian transformations requires an understanding of the relationships between soy's multiple-ness and flexible-ness, the politics driving the soy crush in particular times and places, and relationships between key soybean flexors and states. On the last point, the agribusiness actors who are gaining more control over the global soy complex are doing so in part through flexing and/or by positioning themselves to gain even greater control over further and anticipated flexing.

As industrial livestock sectors continue to grow in China, and as the meatification (Weis 2007) of Chinese diets proceeds, feed production remains the primary force behind the crush. This is true even when the price for soybean oil is higher than meal, demonstrating the complex political nature of livestock and meat production, and, consequently, of feed and flexing. Soyfoods and other manufactures are emerging in specialty markets, with firms like JiuSan (in English, '93', a subsidiary of Beidahuang) taking the lead in making soy-based snacks, drinks and pharmaceuticals, as well as lecithins and isoflavones, from soy protein. These markets, however, are not yet significant enough for any substantial flexing. At the same time, biodiesel production, a central component in conceptualizing soy as a flex crop generally, does not involve soy as feedstock in China (Scott and Jiang 2013).[12] For these reasons, there is currently not much flexing between whole beans versus crushed beans, or between multiple uses of crushed beans in China. This situation, however, may change in the near future.

In Brazil, on the other hand, the uses of soybeans were always associated with other agroindustrial production systems: first as a cover crop and green fertilizer for industrialized wheat and maize production, then as an input for crushers that attend the vegetable oil and livestock feed markets. Agribusiness companies positioned at the center of the soybean production and processing complex have increasingly sought to expand and multiply markets for soybean products, including efforts to transform Brazilian diets to include soy foods and soy products as additives. The most significant new use for soybeans in Brazil has been biodiesel, which enables major agribusiness firms to effectively flex soybeans and other agroindustrial commodities between their multiple uses as food/feed and fuel. Given the central role of the Brazilian government in this process, we might venture to say that flexing soybeans has become state policy in Brazil, and further flexing is certainly anticipated.

These distinct legacies and divergent trajectories observed in Brazil and China are in fact converging through the creation of new actors, business logics and power relations in the global soybean complex. As production shifts to Brazil, and crushing to China, the large-scale agribusiness companies emerging from these countries – and the incipient partnerships they are beginning to establish with each other – have the potential to challenge the hegemony of North Atlantic-based agribusiness companies that have controlled the soybean complex for the past century. The ability to effectively flex soybeans and other agroindustrial commodities may ultimately determine the outcome of this global agroindustrial restructuring.

Notwithstanding competition among traditional and emerging agribusinesses in the soybean complex, more meaningful conflicts emerge between large-scale agribusinesses that can effectively flex soybeans (and other agroindustrial commodities) and smaller firms, farmers and the rest of society. Biodiesel production, the most extensive soybean flexing at present, has been clearly shown to fall short of its imagined social and environmental benefits (Bernardes and Aracri 2011; Cavalett and Ortega 2010; Wilkinson and Herrera 2010). The unfolding dynamics of flex crops and commodities is an expression of the appropriation and substitution of biological for industrial processes that can render both raw materials and products more fungible in the interest of capital accumulation (Goodman, Sorj, and Wilkinson 1987). This contradictory process, whereby a multiplication of uses of a single monoculture also reduces the diversity of agro-ecosystems, diets and even cultural practices, ultimately increases our collective vulnerability to catastrophic pest outbreaks, price shocks and market volatility, food crises, and the ensuing social upheavals and rush for land, water and other natural resources (Oliveira 2009). Most ominously, the agribusiness and financial corporations that are best situated to flex soybeans and other agroindustrial commodities are also the firms that profit and benefit the most from such market volatility and increased food prices (HLPE 2011; Murphy, Burch, and Clapp 2012). Soybean flexing is already taking place in Brazil to a significant extent, and further flexing is anticipated in China, Brazil and the rest of the global soybean complex. A more careful understanding of this process undercuts the optimistic arguments

[12]Measures to support biodiesel include the 2006 Renewable Energy Law and the 2007 Long-term Renewable Energy Development Plan (Baidu Baike 2014).

of leading soy flexors, and can help to reveal socio-environmental alternatives that move beyond the current agroindustrial fixation.

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Gustavo de L. T. Oliveira is a PhD candidate in the department of geography at the University of California, Berkeley. He researches social and ecological transformations in the Cerrado region of Brazil, the international soybean complex and global agroindustrial restructuring. His dissertation analyses the political ecology of Chinese investments in Brazilian agribusiness and logistics infrastructure. He is a member of the Land Deal Politics Initiative and the BRICS Initiative for Critical Agrarian Studies. He can be reached at: oliveira@berkeley.edu

Mindi Schneider is an assistant professor of Agrarian, Food and Environmental Studies at the International Institute of Social Studies (ISS) in The Hague, Netherlands. With a China focus, her current research is on industrial meat regimes, agroecology and food security politics. She can be reached at: schneider@iss.nl