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A tipping point for agricultural expansion? Technological changes and capital accumulation in Argentina's rural sector

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Abstract

Drawing upon a case study located in central Argentina, we analyse in what ways technology is contributing to the accumulation of capital in a context where prevailing strategies resting on farm-scale extension are no longer effective. We identify two major technological phases that go along with changes in actors' strategies aiming at re-establishing expanded capital accumulation. These phases allow a better understanding of the mediating role of technology between capital accumulation and the appropriation of nature. In a context of increasing depletion of agro-ecological conditions, the call for a new wave of innovations can be seen as an attempt to restore that mediating role. As we suggest, this entails broader changes in multiple levels.

KEYWORDS

agribusiness, business strategies, capital accumulation, technological change, technological package

1 | INTRODUCTION

In a press interview published by La Nación, of Argentina, Gustavo Grobocopatel, CEO of Los Grobo Group and a national paradigmatic referent of agribusiness, pointed out that "in the short term agriculture will be deeply transformed." He referred to an upper stage in the "technological revolution" that turned the Argentinean pampas into a

[1]*Uberisation* refers to a business model based on digital technologies and online platforms where service providers and potential users exchange underutilized capacity of existing assets or human resources, at low transaction costs. In the rural sector, it could be applied to freight shipping, farm workers hiring, farming services, and more generally, to a wide range of short-term activities that can be performed by independent nonpermanent contractors or workers.

world supermarket (Hernández, 2007): "Biotechnology is one of its basis but it will be part of a larger convergence of technologies [...] precision agriculture, robotics, information technologies, the 'uberisation'[1] of logistics, nanotechnologies, a new generation of agrochemicals, a smarter nutrition [and] new photosynthetic platforms are part of what we will be seeing in the coming years" (Grobocopatel, 2016). In this view, the success of farming in the future will no longer be tied up to the control of large tracts of land but to the achievement of new economies of scale through further technological innovation (Friedlander, 2017).

At the core of the "celebration" of this technological development pathway stands a deep restructuring of Argentina's hegemonic agricultural model (Gras & Hernández, 2014), driven by a combination of long- and short-run trends that are reshaping the conditions that have up to date enabled expanded capital accumulation. After two decades of a massive increase in production—fuelled by the adoption of biotechnologies and high commodity prices—Argentina's dominant agricultural model is faced with the slowdown of grains and oilseeds international prices, intensified competition for land, rising production costs, and a number of new productive problems.

In the last decades, as the intensification of agricultural production continues and its environmental consequences are increasingly widespread, concerns over the accelerated erosion of the biophysical foundations of agriculture have led to questioning the sustainability of contemporary capitalist agriculture (Bernstein, 2010; Bernstein & Woodhouse, 2006; Moore, 2010; Weis, 2010) and the extent to which new technological developments may surpass this critical juncture (Moore, 2010).

As in many other places, in Argentina, peasant and family-farmer organizations, NGOs, and scientists have reported the social and environmental costs of the so-called "soy model." It is worth recalling that Argentina is the first world exporter of soy meal and oil and the third of soybeans (Calzada & Rozadilla, 2018). This position results from major land use changes. Between 1991 and 2013, the area sown with soy, corn, and wheat grew from 13.3 million hectares to 33.7 million (+153%). In addition to high international prices, the massive 400% devaluation of the national currency that followed the economic and political crisis of 2001 lowered all production costs that depended on the domestic economy, abruptly raising farmers' profitability. It is estimated that average gross margins per hectare in 2002–2006 were 29.8% higher than those achieved in 1998–2001 (Arceo, 2017).

Since 2000s, increasing social resistance has put into the spotlight issues that had been neglected or overlooked by advocates of the hegemonic agricultural model. Their rising visibility in the public agenda (Delvenne, Vasen, & Vara, 2013; Lapegna, 2014) led to the launching of public policies directed to mitigate—or regulate—some of its consequences (mainly limiting deforestation and crop sprayings near urban populations). Dominant actors acknowledge some of these environmental consequences. On the one hand, they are aware of their impact on productivity[2] and on production costs; on the other, they are actively involved in "green washing" actions to undermine contestations on the alleged benefits of the hegemonic technological paradigm (Cáceres, 2015b).

It seems now apparent for Argentina's main rural actors that they will not be able to sustain capital accumulation through land use intensification. In this context, new farming systems and business strategies are being explored. These are not only the result of concerns over the constraints imposed by environmental consequences but also over social and political contestation. However, as argued here, one central and persistent assumption is the belief that sustaining capital accumulation and restoring previous levels of gain capture are premised, above all, on technological innovation.

Drawing upon a case study located in the North of the Province of Córdoba (which belongs to the Chaco Region of Argentina), this article intends to map out trajectories of technological change among large-scale firms. Our main argument is that technological change is aimed at restructuring farming systems through the intensification of linkages between commodity products and at developing in- and off-farm coupling systems (Gasparri & le Polain de Waroux, 2014). This restructuring can be conceptualized as contingent "resolutions" (Bernstein, 2010; Moore, 2010),

[2]As an advocate of Argentina's agricultural model recently put it, "there is awareness that the kind of agriculture we are working in, helped us to grow technologically, but it made us to neglect soils and the system ended up collapsing, with the proliferation of resistant weeds and pests, and with deficits of nutrients" (Re, 2018).

applied to a particular national context and global world economy and consistent with a specific development narrative (Gras & Hernández, 2016a).

Our analytical framework returns to Weis' argument; for this author, although chronic ecological and environmental contradictions are accelerating and compromising agriculture's biophysical foundations, “this does not mean that the operative logic of the system has yet been destabilized. In fact, on the contrary, [...] new market pressures are actually emboldening the dominant actors in the short run” (2010, p. 317). Following Weis, our hypothesis is that rising demands for biofuels, animal proteins, and livestock feed are fostering new business strategies to (re) “capture economies of scale and of scope (incorporating products that share inputs, markets, and know-how)” (Gasparri & le Polain de Waroux, 2014, p. 290). As we conclude, not all firms are in a position to “redesign” their agricultural business. Our findings highlight the heterogeneity of large-scale firms to properly assess the differential impacts of changing reproduction and capitalization conditions. This is frequently disregarded when analysing agrarian dynamics or issues of technological alternatives from a small-scale labour intensive versus large-scale capital intensive polarized framework (Woodhouse, 2010).

The present conjuncture can be framed as a tipping point in Argentina's rural sector, a moment of instability of a type of technological trajectory, which was decisive in the organization of farming systems and, more broadly, for capital accumulation processes. It is a transitional situation where new technological responses are addressed to “solve” various types of problems that are affecting productivity gains and profitability. These do not only merely entail intensification. They also involve land use changes and, progressively, horizontal and vertical integration strategies developed by farmers; many of which are addressed to international market niches. The outcomes of this transitional situation are not yet clear and must be teased out from different scale level analysis. Here, we highlight the element of “destabilization” rather than that of “stabilization,” seeking to explore issues related to trajectories of technological change and their implications for large-scale firms.

Our analysis is based on a field work carried out between April 2016 and June 2017. We conducted a total of 30 in-depth interviews (18 addressed to farmers, six to agronomists, four to input suppliers, and three to representatives of farming and commercial services). Our sample was intentional and non-representative because our intention was to identify and understand different trajectories of technological change among large-scale firms. With this purpose, our sample was selected through snowball methods; the first informants were contacted from interviewees approached in previous fieldworks. We also participated in field-day events organized by major input providers to present their products to farmers and agronomists. The interviews and field notes were transcribed, organized, and analysed using a “constant comparative” qualitative analytic strategy (Boeije, 2002). Newspapers and other media publications, as well as a variety of online resources, were also used.

2 | AGRICULTURAL CHANGES IN THE NORTH OF CORDOBA

In Argentina, soy is sown in two different regions that have distinct productive potentials. The Pampa Region, with very fertile soils and a favourable climate, has a high agricultural aptitude.[3] On the other hand, the Chaco region is less productive, and neither soils nor climate is optimal for soy cultivation. However, in this region, the growth of agricultural production was particularly intense over the past 20 years, triggering a remarkable expansion of agricultural frontiers (Gasparri & Grau, 2009). The North of the province of Córdoba notably shows this process (Cáceres, Soto, Ferrer, Silvetti, & Bisio, 2010). With an increase of the area sown with soy from 13,500 to 424,000 ha (+3,000%), at an annual rate of 120%, it became one of the most dynamic rural areas of Argentina, despite its ecological limitations when compared with the southeast and centre of the province, which are part of the Pampas.[4]

The above-mentioned figures are indicative of significant land use changes in the North of Córdoba. Until mid-1970s, most of this region was covered by native forests and devoted to extensive goat and cattle rearing and forest

[3]Due to its high productive potential, the Espinal region is included in what is generically called “Pampa region”.

[4]http://datosestimaciones.magyp.gob.ar/reportes.php?reporte=Estimaciones

exploitation. The approval of the use of transgenic seeds in 1996 was decisive for the expansion of the agricultural frontier because it contributed to put into production areas that until then were considered “marginal” or “unproductive” because of soil or weather conditions and the significant presence of peasant economies. In the 2000s, “soy-ization” (Delvenne et al., 2013) gained momentum, consolidating large-scale farming and giving way to a “rush” for land. A fivefold increase in the value of land between 2000 and 2015 (Gras & Cáceres, 2017) followed the intense demand for farmland in the region. Competition was also fostered by non-agrarian capitals, especially financial capitals (investment funds), a process that deepened in 2007 in the midst of global land grabs (Borras, Kay, Gómez, & Wilkinson, 2012; Cotula, 2012). Thus, in a short period of time, a massive revaluation of a key asset for capital accumulation took place.

As Figure 1 shows, farmland values followed the evolution of soy prices: During the 1990s, the former remained relatively stable, leaping significantly since 2002 and more dramatically between 2007 and 2013. Although after 2013, land prices declined, they still are well above those of 2007.

The increase in farmland values also resulted from the extraordinary rents caused by the conversion of native forests to industrial agriculture. It is worth noting that the North of Córdoba experienced one of the highest deforestation rates in Argentina; according to Agost (2015) between 2000 and 2012, around 150,000 ha of woodlands were cleared and converted to agriculture. A second source of land appreciation is connected to the transformation of land for livestock use into farmland fit for agriculture (Gras & Cáceres, 2017).

In the last years, the conditions that boosted the strong growth of agricultural production in Argentina, and more generally the accumulation paths developed by agricultural firms, have changed. Those conditions basically stood on the combination of technological innovations, extension of sown areas, and high international soy prices. Profitability in the North of Córdoba has had a greater dependence on the control of large tracts of land—in addition to the use of technologies—given the lower yields that can be achieved when compared with the fertile soils of the Pampas, where farmland prices are substantially higher.

Undoubtedly, the sharp rise in land prices from the beginning of the century had a major impact on farmers' strategies of capital accumulation. However, whereas competition for farmland forced many small- and medium-scale farmers to opt out—because they were unable to increase their scale through leasing or purchase, or even maintain it in the case of “pure” tenants—large-scale firms were still able to enlarge size all the while international prices continued to be high and the use of technologies rendered acceptable levels of yields.

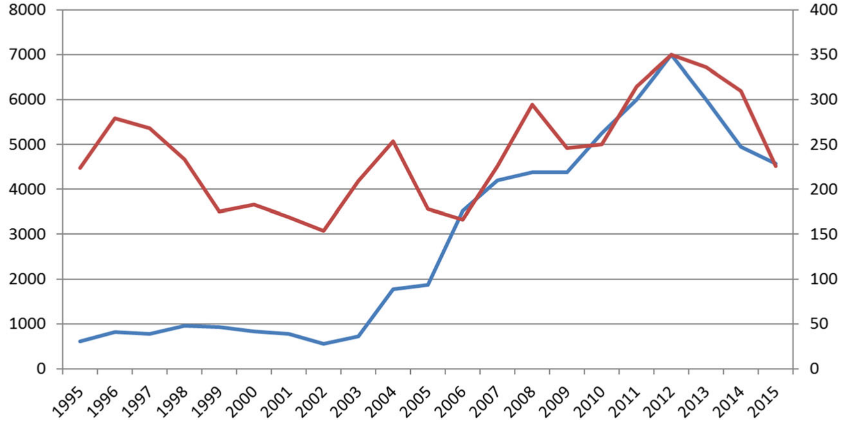

FIGURE 1 Annual variation in the price of land (blue line) with highest productive potential in the North of the Province of Córdoba (U$/hectare); and soy price (red line) discounting tax exports (US$/ton) (1995–2015).
Source: Constructed using data from Revista de Márgenes Agropecuarios

This accumulation path found growing limits as the availability of land decreased. After decades of deforestation and transformation of pasturelands into croplands, there is not much room left for new fluxes of frontier expansion, and recent legal norms protecting native forests are slowing down the opening of new lands to agriculture (Silvetti, Soto, Cáceres, & Cabrol, 2013). In addition, as farmland values rose to record levels, leasing costs began to weigh heavily on the reproduction of large-scale farms.

Simultaneously, since 2009, a period of price volatility closed the 2002–2012 commodities boom and, in 2013–2015, the price of soybeans dropped down 33% (Figure 1). Meanwhile, since 2010, farming costs have steadily increased, mostly those related to inputs and freights rates to ports.[5] These trends were not counterbalanced by the modest evolution of yields (see below) nor by the elimination or reduction of tax exports on export grains in 2015.[6] In addition, resistant weeds have experienced a rocketing expansion, mainly in areas of agricultural frontier expansion. Its control demands the use of higher doses or herbicide mixtures, which could increase costs in more than 100 US$/ha (Re, 2015).

Slow-yield growth, together with rising costs and regressive prices, shed doubts on how the 2002–2009 profitability rates could be retrieved. Indeed, this issue goes to the crux of today's debates on the biophysical contradictions of industrial agriculture and the sustainability of "technological fixes" (Cáceres, 2015b; Weis, 2010). However, it is not our aim here to discuss the sustainability of Argentina's agricultural model; rather, we are interested in how capitalist farmers are responding through technological innovations to the material expressions of these contradictions, particularly those that unleash costs that they can no longer externalize. We believe that this side of the coin has been relatively disregarded.

In order to understand the process leading to what we have previously referred as a tipping point, it is necessary to retrace the technological changes that turned Argentina's agriculture into one of the most dynamics of Latin America. In the following section, we describe the main features of these technological changes and distinguish two phases that take into consideration the problems that, at various levels, accompanied their massive adoption. We also analyse how technological changes have steered the reorganization of farmers' farming and business strategies. This will allow us to ground more clearly our argument on the existence of a tipping point for accumulation.

3 | THE DYNAMICS OF TECHNOLOGICAL CHANGE

The introduction of transgenic seeds in 1996 represented a major milestone that paved the road to a widespread reorganization and intensification of production. Since then, the technological development of Argentina's rural sector has been notable. In this general context, two major phases can be identified.

3.1 | First phase: The time of "easy farming"[7] (1996–2009)

Favoured by a set of legal and institutional regulations (Burachik, 2010), the introduction of the RR soy (resistant to glyphosate) developed by Monsanto was the starting point of a new technological era. Its adoption integrated the use of zero-tillage techniques, fertilizers, and biocides, which jointly are what is known in Argentina as a "closed technological package" (Gras & Hernández, 2014). At a faster pace than in the United States, by 2001, 90% of the soy sown in Argentina was transgenic (Trigo & Cap, 2003).

For farmers, this technological package had clear advantages, because it simplified farming practices and reduced labour requirements (Cáceres, 2015a). Glyphosate was the single most used herbicide, together with one or two

[5]Over a 5-year period (2012–2016), the average freight rate for transporting grains from Northern Córdoba to Rosario's port was U$49/t (about 450 km). Considering average yields, this represents a freight cost of 100–150 U$/ha for soy and 200–250 U$/ha for maize (Gras & Cáceres, 2017).

[6]When President Mauricio Macri took office in December 2015, he removed export taxes to all grains, which were set at 10% in 2002 and later raised to 27.5% and 35% in 2007 by the Kirchner's administrations. In the case of soy, President Macri reduced 5% the export tax and a chronogram was set up in order to progressively eliminate it.

[7]We take this expression from one of our interviewees.

insecticides if necessary, and almost no fertilizers were employed. The demand of labour was also greatly reduced, from three hours to only 40 min/ha (Blanco, 2001). Three other facts can explain the fast embedding of this technological package. On the one hand, biotechnology companies massively financed RR soy and associated agrochemicals; on the other, farmers could replant their own transgenic seeds from one year to the next (Cáceres, 2018). Thus, the technological package brought about a significant drop in production costs given the (relatively) lower incidence of agrochemicals and of transgenic seeds (Delvenne et al., 2013).[8] Last but not the least, it "worked as expected": It fulfilled farmers' expectations and did not face them with significant problems. Weed control was particularly easy and efficient. Basically, farming became a matter of replicating once and again a standard, highly protocolized technological package that could be used likewise in different ecological and productive conditions. In contrast, managerial issues and scaling production became the main concern for farmers. According to one agronomist interviewed "the technology used to sow soybeans [by that time] was so simple that you could write it in the palm of your hand."

Additionally, during the second half of this period, high commodity prices came together with the 2002 devaluation of the Argentine *peso*. The equation of decreasing costs; a simple, efficient and easily accessible technological package; increasing international prices; a rising global demand; and favourable local economic conditions (Cáceres, 2015a) allowed farmers to improve substantially profit making. Around the middle of this phase, this technological paradigm became hegemonic,[9] and business models based on soy monoculture spread rapidly.

Agricultural growth in the North of Córdoba took off during this period. The availability of "unexploited" lands favoured a dynamic of accumulation, which relied mainly on the increase of farm size. Even if the use of the technological package enabled farmers to improve yields (albeit in an uneven and unstable way), the emergence and consolidation of large-scale farming in this period can be explained largely by their ability to capture rents resulting from the integration of "new" lands to the circuit of capital and the appropriation of soil fertility. Indeed, this ability was determined by the amount of capital controlled by farms and their access to technological innovations and financing. But, as le Polain de Waroux et al. (2018) argue, the capture of extraordinary or abnormal rents also depends on the existence of initially cheap land. Hence, those firms with access to capital, technology, and financing, which arrived early to this frontier, were able to control large tracks of land, take advantage of these high rents, and capitalize at a fast pace. Less capitalized farmers, albeit early established too in the frontier, were unable to benefit from the appreciation of land acquired in the area.

Despite the rise of land values (see Figure 1), until 2009, farmers' strategies in the North of Córdoba remained basically the same. Partnerships with a wide range of actors, from agrochemical companies to investment funds and individuals with personal savings, provided farmers with the financial resources needed to increase farm scale. This kind of "financial inclusion" (Clapp & Martin, 2018) was mostly available for large-scale firms with economic networks.

As pointed out before, the conditions that propelled soy expansion changed to the end of the 2000s challenging the "successful outcomes" of the hegemonic agricultural paradigm and bringing to an end a decade-long period of exceptional economic gains. Socio-political contestations became widespread after the political opportunity opened by the virulent conflict held over export taxes between the government and agribusiness organizations in 2008 (Giarracca, Teubal, & Palmisano, 2008; Gras, 2012). With the debate on the environmental consequences of soy expansion installed in the public agenda, new regulations restricting the opening of new lands for cultivation were launched (Aguiar et al., 2018).

[8]It is worth recalling that in the case of GM soy seeds, "the transnational company Monsanto could not patent the [transgenic] event in Argentina, contrarily to what happened in most other countries in the world, including Brazil. This has had huge effects on the cost of the GM soy seeds, which was lower that what it would have been if the IP [intellectual property] regime had been favorable to Monsanto's interests" (Delvenne et al., 2013, p. 156).
[9]The Green Revolution was also based on the use of external inputs. However, in that case farmers had the chance to choose which and how much of these inputs were they willing to adopt. For instance, they could sow a new seed variety, without adopting herbicides (or adopting them partially). This is no longer an option for farmers embracing the biotech revolution: they must adopt the package in full.

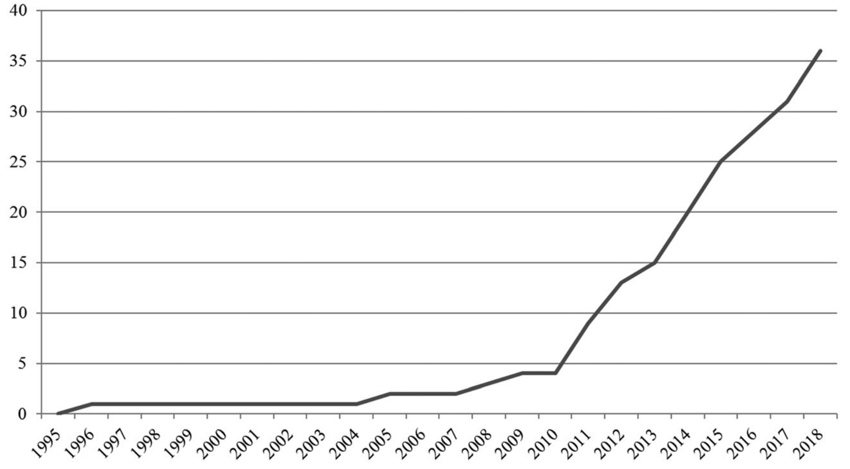

FIGURE 2 Increment of the number of biotypes of weed species resistant to herbicides in Argentina (1995–2018).
Source: REM, retrieved February 20, 2018, from https://www.aapresid.org.ar/rem/alertas/

3.2 | Second phase: A "fine-grain" approach (from 2009 onwards)

In this context, we identify a second phase defined by (a) new productive problems whose resolution demands a more precise and sophisticated farm management (b) changing economic, political, and legal conditions that have impact on profitability and (c) loss of competitiveness of soy production that fosters new business strategies in order to recapture economies of scale lost to a farming system highly dependent on that crop.

Among our interviewees, the opening of a new situation around 2008/2009 is clearly loomed: They increasingly found that the technological package did no longer render those benefits they had so positively assessed, as shown by the appearance of resistant weeds and pests (Cáceres, 2015b), the progressive exhaustion of soils, and their impact on productivity. They also became aware of the need of diversifying farming systems, integrating value chains, and coupling grain with livestock production or biofuels.

As experienced by our interviewees, the initial trigger for this phase was the appearance of herbicide-resistant weeds, which rocketed after 2010 (Figure 2). The occurrence of resistant volunteer corn and soybeans also became an important problem, because in practice, they behave as resistant weeds. Besides showing the diluted efficacy of glyphosate,[10] these problems oblige farmers to use new products or herbicides mixtures. Soil fertility problems related to soy monoculture and increasing insect resistance to insecticides have also emerged as significant productive drawbacks.

Within the dominant technological model, all four problems (i.e., resistant weeds, resistant insects, soil fertility, and yield rise) called for the application of higher doses of agrochemicals as only one solution. As shown in Table 1, the use of pesticides in soy has increased greatly during the last two decades. The number of active ingredients has almost quadrupled, and the amount of kilograms or litres sprayed per hectare has risen 25 times. In addition, the cost of these inputs has experienced a significant raise (+50% and +67% in relation to 1997 and 2007, respectively).

But this solution brings about two further problems: phytotoxicity and carryover effects. Spraying together various agrochemicals is not a simple matter. They often do not mix well, and their interactions can affect their original properties and/or produce the precipitation of active ingredients. Hence, agrochemicals are not sprayed

[10]Transnational companies responded with two technological proposals that follow the ongoing technological pathway: (a) transgenic seeds with stacked genes that combine multiple resistances to different types of herbicides, or that produce different kinds of toxins against certain types of insects; and (b) a more diversified and complex use of agrochemicals (e.g., new products or active ingredients, higher doses, herbicides "cocktails," rotation of different modes of action, and more precise spraying machinery).

TABLE 1 Use of pesticides in soy cultivation in Argentina (1997–2017)

	# of AI	Kg/L of AI/ha	U$/ha
1997	3	0.17	57.04
2007	8	2.34	51.5
2017	11	4.35	85.7

Abbreviations: AI, active ingredients; Kg/L of AI/ha, kilograms or litres of active ingredients used per hectare; US$/ha, price of pesticides per hectare.
Source: Constructed using data from Revista Márgenes Agropecuarios.

uniformly, and this may lead to crop phytotoxicity. In addition, the use of a growing number of herbicides and/or higher doses may cause carryover effects (persistence of herbicide residues in soil from one season to another). These effects are particularly relevant in Argentina where 60% of cropland is under lease contracts (Díaz Hermelo & Reca, 2010). Thus, when renting land, farmers need to know types, doses, and spraying dates of the herbicides used by former leasers to avoid the risk of facing carryover problems.

If from a political economy approach, analyses of agrarian dynamics have been mainly concerned with social relations, agricultural organization, capital control, and technical development to understand processes of concentration and class differentiation (Bernstein, 2010), this second phase makes clear that environmental issues are critical to fully grasp agrarian change.

In that context, technological decisions need to consider what until then had been thought of as "externalities." Farmers now demand effective solutions to very specific problems and associated damages because a considerable share of productive and economic results relies on how they are dealt with. Therefore, technological responses come to be progressively "tailored." As opposed to the simplified and standardized use of technologies, which characterized the first phase, the idea of tailoring can be seen as a threefold approach that centrally evaluates "what," "how," and "when" technologies should be used. Tailoring entails selecting the inputs and farming practices that best fit to certain agro-ecological conditions and analysing the more convenient way and time to use them.

Thus, what could be described as a "broad-grain" technological management (first phase) turned into a "fine-grain" approach. In this approach, the scale for technological planning shifts from the farm, as a unit, to each plot of land (or even subplots). Their particular biophysical characteristics and productive problems set, in this second phase, the basis for designing a site-specific and "customized" technological management. As described by one interviewee: "…before [in the first phase] an agronomist could easily manage 5,000 hectares, but that is no longer possible now."

As two other interviewees observed, technological management has become "more artisanal" and "personalized," while at the same time, technological fixes are increasingly and more recurrently short termed. It demands the access and control of higher amounts of capital, more sophisticated and updated expert knowledge, institutions, and social relations. Contrary to the first phase, when different farm-scale producers adopted the same technological package, these tailor-oriented approaches are clearly addressed to specific farmer profiles.

It could be argued whether the fine-grain approach can still be described as a "technological package,"[11] because it draws away from the use of a relatively small number of industrial inputs in a pre-established sequence or protocol, irrespectively of the diversity of ecological landscapes and productive conditions. Although the fine-grain approach also involves protocols and pre-established sequences, it relies on a more complex and diversified use of industrial inputs, cutting-edge machinery, information technologies, and management skills to rapidly adjust doses, procedures, and priorities.

Precision planting, variable-rate seeding, yield monitoring and mapping, assisted guidance systems, spot-on spraying, and crop-field scanning also illustrate the fine-grain or technological tailoring management. Its adoption

[11]In Latin America, the production of crop commodities such as soybeans and corn is frequently associated with the use of an imported technological package based on industrial inputs, supplied by transnational companies (Barri & Wahren, 2010; Palmisano, 2015; Teubal, 2003).

leads to an increasing reliance on communication technologies. The search for information on various topics (e.g., climate, soil, market data, technical and financial counselling, and training opportunities) is a major driver. If farmers previously looked for information following a conventional one-way style of communication (i.e., from information providers to farmers), now, information flows both ways and includes issues that go far beyond what traditionally was defined as “farming.” A wide variety of companies ranging from multinationals to local companies provide information and advice to farmers, demanding in return information on their plots and farming practices. Currently, a growing number of online applications that can be accessed from farmers' smart phones provide key productive or economic data.[12] The use of information and communication technologies has given birth to the concept of “smart farming.” Although precision agriculture only takes into account in-farm processes, smart farming draws also on data enhanced by context and situation awareness, triggered by real-time events (Wolfert, Ge, Verdouw, & Bogaardt, 2017). Big data, the internet of things, and cloud computing will become major components of this new type of farming.[13]

Even if soy continues to be the most important crop in the North of Córdoba in terms of the area sown, many farmers (including large-scale farms) have decreased the number of hectares cultivated in the past. Crop rotations are also being adopted to improve soil fertility and facilitate resistant weeds control. But these changes go far beyond land use patterns; essentially, they entail a renewed capitalization wave,[14] which pushes to “extend the frontier of technical control” (Moore, 2010, p. 402).

In this context, new technological barriers are emerging, converging towards new dynamics of concentration. These barriers may be also reinforced by land access conditions. During the 2000s, leasing arrangements were established for short periods of time, mainly one year. Although many of our interviewees usually renew their contracts with the same landowners, negotiations are disputed and it is not unusual for farmers to “lose” farmland that they had leased for years (Gras & Cáceres, 2017) and therefore be in need of looking for other plots to lease. Situations where contracts are settled belatedly might also have an impact on resistant weeds control (because of the consequent delay in their treatment) and, in turn, bring about heavier costs and lower yields.

4 | A TECHNOLOGICAL TIPPING POINT

Looked from a diachronic perspective, these technological phases encompass changes in capital accumulation dynamics. The period that goes from 1996 to 2009 can be thought of as an “extensification” moment characterized by a relatively cheap, simple and effective technological package, land availability in areas of agricultural frontier, and high commodity prices. Accordingly, the sown area had an extraordinary growth, and large profits were achieved. A major feature of this period was the externalization of environmental costs derived from the fast appropriation of nature's richness through the opening of new lands. In particular, land leasing has allowed producers to transfer soil depletion and other productive problems to landowners.

[12]Major companies have developed online platforms that can be accessed from farmers' smartphones. For instance, Dow Argentina offers *Mi Lote* (http//: www.milote.com.ar), “a new tool that uses satellite images and farmers' information to provide solutions to farmers aiming at maximizing economic and agronomic yields.” To register, farmers have to provide personal and productive information and identify their plots in an online map. “In return,” the company offers advice on the varieties that best suit farmers' conditions, suggests seed density, calculates likely yields, alerts for weeds or pests, and provides online technical advice. Via email, farmers receive advertisements of agrochemicals and financing options, weather-insurance promotions, and invitations to field training days.

[13]This is also creating new business opportunities: the so called AgTech companies (Waltz, 2017). In Argentina around 100 start-ups using big data and cloud computing were created during the last years (LAVOZ, 2018).

[14]Intensification in the use of capital results in increasing needs of financing. Though partnerships with input and food processing companies continue to be a source of financing and access to new businesses, they have become more restricted. These partnerships also entail differentiated access to expert knowledge. As observed during our field work, small- and even medium-scale farmers, who are not usually summoned to participate in these schemes, cannot afford having personalized technological advice and must resort to the so-called “agronomías locales” (local stores that sell farm inputs) for technological advice “over the counter.” Without a previous diagnosis supported by field visits by agronomists, these farmers may end up implementing technological responses on the basis of “essay and error,” using inappropriate doses and/or agrochemical products, or applying them improperly. All these situations may lead to sharpen those productive problems they seek to overcome.

TABLE 2 Average soy yields (kg/ha) in Argentina and the province of Córdoba (Pampean and Chaco departments) in two different periods: 1997/2006 and 2007/2016

Departments	Soy yield (kg/ha) 1997/2006	2007/2016	Variation (%)
Argentina	2.480	2.693	+8.5
Province of Córdoba—Pampean departments	2.354	2.723	+15.2
Province of Córdoba—Chaco departments	2.477	2.314	−6.5
Province of Córdoba—All departments	2.405	2.572	+7.2

Note. Aggregated data from all the analysed departments are also presented.
Source: Constructed using data from https://www.agroindustria.gob.ar/datosabiertos/ (departments of Córdoba Province), Bolsa de Cereales de Buenos Aires and Bolsa de Cereales de Rosario (Argentina).

The extensification period has been followed, since 2009, by a moment of "intensification" as a response to a bundle of situations already described. Intensification has called forth the internalization of part of the environmental costs (e.g., fertilization to cope with soil nutrients depletion), because previously masked costs are now directly affecting farmers' productive results.

The present conjuncture accounts for more than mere technological innovations. Intensification can be framed in a wider restructuring of agribusiness, which comprises both how farming is thought of and practiced. This restructuring unveils what can be seen as a pressing need and a necessary way forward: a pressing need because new technological responses are being developed to overcome critical problems that are challenging the biophysical foundations of this type of agriculture, and a way forward because these responses are the cornerstone of broader transformations guided by the continuous search for capital accumulation.

As Weis (2010) argues, yield growth is a major and exclusive indicator of the success and efficiency of industrial agriculture. Yield growth also frames development narratives that are recurrently assertive on the need of technological solutions to overcome crisis or limits for agricultural growth (Scoones, Smalley, Hall, & Tsikata, 2019). The link between technological innovation and rising yields is thus crucial for industrial agriculture supporters. In the case of biotechnology, its advocates also spotlight other associated economic and environmental benefits (Brookes & Barfoot, 2017a, 2017b; Goldstein, 2014; Green, 2012; Smyth, 2017). On the contrary, Gurian-Sherman (2009) offers a critical view on this matter. Analysing two decades of use of transgenic soy and corn in the United States, the author concludes that they have not done much to raise yields, despite biotech supporters' claims. He distinguishes between "intrinsic yields" (i.e., potential yield, the highest than can be achieved under ideal conditions) and "operational yields" (i.e., farm yields, when pests or other environmental factors result in yields that are lower than the ideal) and argues that transgenic varieties have been unsuccessful to increase intrinsic yields, although they have rendered marginal gains on operational yields. According to his findings, the most important yield growth observed during the last century is due to traditional breeding.

Although Gurian-Sherman's findings may be controversial,[15] his argument offers an interesting analytical lens to examine the impacts of the dominant technological model on yields growth in Argentina.

In Argentina, soy yields can be high due to favourable ecological conditions—especially in the Pampas—and/or to agricultural intensification[16] (Table 1). However, aggregated figures both at national and provincial level do not show significant raises since 1996. At a national scale, soy yields have slightly improved: The average yield between 2007 and 2016 was only 8.5% higher than that of 1997–2006. Likewise, in the province of Córdoba, the average yield

[15]Some authors are critical of his standpoint (Brester, Atwood, Watts, & Kawalski, 2019; Eddy, 2009), whereas others support it (Moore, 2010; Tokar & Magdoff, 2009). Hicks (2015) makes an excellent analysis of this debate, showing how these contrasting positions present two different sets of claims as evidence, which are supported on two rival epistemological frameworks. Stone (2012) focuses on the narratives supporting GM adoption and discusses some of the risks and fallacies incurred by those who defend yield supremacy of GM seeds over conventional ones.

[16]In 2015, a farmer from the Province of Santa Fe reached a soy yield of 6,700 kg/ha. This was an extraordinary achievement in a plot where cutting-edge technology was used for seed multiplication for Monsanto's associate Don Mario Semillas (Fuentes, 2015).

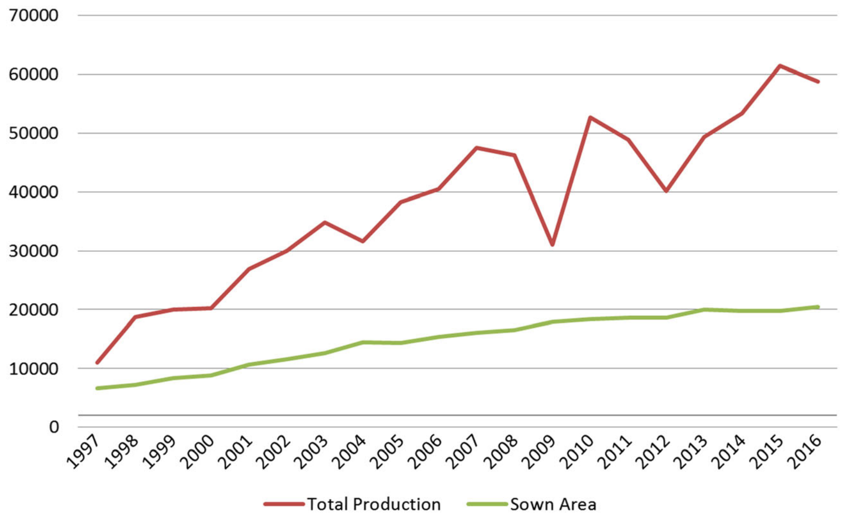

FIGURE 3 Evolution of soy production in Argentina including total production (×1,000 ton) and sown area (×1,000 ha; 1997–2016).
Source: Constructed using data from Bolsa de Cereales de Buenos Aires and Bolsa de Cereales de Rosario

increased 7.2% between 1997–2006 and 2007–2016. However, this figure overshadows significant regional differences. Whereas in the more productive departments of the Pampa Region, the average yield raised 15.2%, in the departments of the Chaco Region, it dropped 6.5% (Table 2).

In the last decade, extreme climatic events, such as draughts and floods, have become more recurrent, severely affecting soy yields.[17] These events are not independent of the expansion of agribusiness and commodity frontiers as shown by the case of the North of Córdoba. Here, deforestation and soy monoculture have had impacts on soil structure and hydrological cycles.[18] Even considering the different productive potential of the Pampas and Chaco Regions, altogether, the figures shown in Table 2 suggest that technological intensification has not led to significant yield growths. Thus, a big share of the soy boom observed both in Argentina and in the North of Córdoba can be mostly attributed to the expansion of cultivated area (Figure 3).

Within this context, biotech companies like Monsanto highlight herbicide tolerance or resistance to insects as the main advantage of transgenic seeds (Moore, 2010). At the same time, the use of industrial fertilizers to supplement fertility in poor soils and/or to reload nutrients in richer soils has increased.[19] Whereas herbicides and fertilizers are nowadays cornerstones of intensification, the production of new high-yielding seeds do not seem to be the main focus of biotech companies, as happened during the Green Revolution when a wide portfolio of varieties was marketed (e.g., hybrid seeds).

The phase opened in 2009 has brought along changes that have (re)structured a technological model guided by a twofold purpose: on the one hand, the use of transgenic seeds together with industrial pesticides to defend crops (at least in the short run) from weeds, insects, and other pests that push down yields, and on the other hand, the addition of fertilizers to compensate soil-fertility problems and "offset" the intensive use of soils under industrial

[17]Most models estimating impacts of global climate change on crops suggest that extreme events will become more frequent (Bouwer, 2019).

[18]After converting native forests into annual-crops farmland, soil organic carbon content diminishes (Conti et al., 2016), which negatively impacts water infiltration and soil water retention. Thus, the amount of water available to crops reduces, what may cause drought effects more frequently. Regarding flood occurrence, a recent report by INTA suggests that annual crops consume nearly a third of the water consumed by natural vegetation. This leads to a progressive water-table raise, making flood occurrence more likely (Bertram & Ss, 2013).

[19]In Argentina the use of fertilizers increased 12 times between 1990 and 2017 (from 300 thousand tons to 3.8 million tons; (https://www.fertilizar.org.ar). Cruzate and Casas (2012) point out that in 2010/2011, only 34.6% of the nutrients contained in commodity grains were returned to soil via fertilizers.

[20]There is yet a third component that fosters intensification: irrigation. It aims at compensating water deficits, but it is still poorly developed in Argentina. Out of almost 40 million hectares of cultivated land, only 2.1 million are being irrigated. No more than 11% of this area is devoted to soy (8%) and corn (3%; FAO, 2015). This technology requires high investments, and it is not suitable for a kind of farming that frequently relies on short-term land leasing.

agriculture (especially as a result of soy cultivation). Therefore, the aim stands mainly on sustaining or marginally improving operational yields through a number of defensive inputs, together with others that seek to overcome the high productive pressure to which soils are exposed.[20] In other words, the so-called Biotech Revolution (Turzi, 2016) is mostly a "defensive revolution." Rather than improving the intrinsic components capable of raising crop yields, the core of biotech developments is now leaning on the production and adoption of off-the-shelf industrial inputs. As pointed out by Brad Mitchell—former Director of Public Affairs for Monsanto—"[transgenic crops] don't inherently increase the yield. They protect the yield" (Cleanteach Group, 2009).

4.1 | The harvest of nature

A fact frequently overlooked when attempting to tease out the contribution of technology to productivity refers to what we call "the harvest of nature." Accumulation does not thus occur through rising capitalization (e.g., mechanization, fertilizer use, transgenic seeds, and organizational forms); it also demands what Moore (2010) conceptualizes as the appropriation of nature as a "free gift." One of the major goals pursued by capital is the search of "pockets" of "underutilised nature" (Moore, 2010, p. 403). It is precisely in those territories where the ratio between capital investment and economic gains is higher.

Driven by the pressure to "liberate new spaces" for commodity production, thousands of hectares of native forests were chopped down in the North of Córdoba. This conversion involved both ecological and social costs. Far from being "empty" or "unproductive spaces," extensive farming (mostly cattle and goat rearing) was practiced by small farmers and peasants. The expansion of intensive industrial agriculture led to their displacement (Cáceres, 2015a) as well as to radical changes in the exploitation of nature. In ecological terms, biogeochemical cycles have been deeply modified (e.g., carbon sequestration, nutrients cycling, or soil–water retention), enabling the rapid appropriation of soil fertility and its conversion into market-oriented grains. Thus, the nutrients accumulated in the soils over centuries were cashed in a short period of time (Silvetti et al., 2013).

The technological innovations adopted in the last decades represent a leap forward in the harvest of soil richness and have a double impact: on the one hand, the waste of those ecological components considered useless or unnecessary (e.g., pre-existing forests, its biodiversity, and all the ecosystem services associated to them), and on the other hand, the targeted grabbing of soil fertility, the single most important component for annual-crop cultivation. Natural-resources dilapidation and the targeted harvest of nature are two necessary sides of the same the coin.

But the appropriation of nature as a "free gift," actually, is not that "free"; rather, it is a twofold and contradictory process. Vast territories are drawn into the matrix of accumulation (Moore, 2010), turning them into "natural capital" that can be exploited and its biophysical surplus appropriated. But at the same time, the appropriation of nature through capitalization undermines the ecological bases upon which capital accumulation rests. In return, capitalization is intensified to restore, sustain, or increase accumulation, joining together productivity and plunder (Moore, 2010). Thus, capitalist agriculture brings about the fast realization of profits from nature as well as the succeeding incorporation of underutilized nature. But the opening of new territories is not always available and sooner or later profits decline as a result of the increasing incidence of facts that undermine productivity. Thus, the strategies followed in the North of Córdoba for compensating the exhaustion of nature's "free gifts" are a sort of "escape forward" because the recurrent use of agrochemicals gives rise to new problems and demands an ever-growing amount of industrial inputs. Although questions on the effectiveness of this technological approach to increase crop yields continue to arise, its underlying logic is still, to a great extent, unequivocal.

5 | NEW BUSINESS STRATEGIES

The technological changes we are witnessing today are far from involving changes in accumulation patterns or rebuilding food systems. Rather, they seek to (temporally) control and overcome biophysical contradictions (Weis,

2010) that undermine productivity gains (Moore, 2010). Within this context, the strategies followed at present by capitalist farmers in the North of Córdoba can be understood as an escape forward that, nevertheless, still stand on the capitalization of nature.

The strategies identified in our fieldwork entail changes in farming systems and, more broadly, in the organization of agricultural business. Altogether, they manifest a passage from soy monoculture to (a) crop production diversification and (b) the development of value-adding activities. In addition, these strategies address social and political concerns over the environmental impacts of industrial agriculture. In fact, many interviewees claimed that the changes they are deploying attempt to make agriculture "more sustainable." However, strictly, they were referring to the shift away from soy monoculture.

Although agricultural firms may—and many do—combine these strategies, we distinguish them for analytical purposes.

5.1 | Crop diversification

As observed in the North of Córdoba, these strategies involve, on the one hand, the development of new niches of rent, with crops that are scarcely produced in the region, oriented to specialty markets (domestic and international). Among the variety of speciality crops (e.g., chickpeas, lentils, mung beans, and popcorn), the firms we interviewed were mainly engaged in chickpea cultivation. In this regard, it is estimated that since 2010, the area implanted with this crop in Córdoba (basically in the North) increased five times, from 13,000 to around 65,000 ha in 2017. Chickpeas are mostly oriented to international markets, and in the last decade, exports have grown at an annual rate of 43% (Neffen, 2018). Compared with commodities, international prices of specialties are higher, but not all firms are able to venture in this type of crops. Though production costs are not more expensive than those of commodities, specialty markets have entry barriers for less capitalized farms. They are relatively small segments, addressed to satisfy specific consumers' demands. Access to these markets depends on producers' abilities to establish business relationships with buyers and accomplish the amounts, qualities, and delivery dates agreed. There are also contractual risks if these terms are not achieved. Because these markets are easily saturated, producers must develop a precise and adjusted productive and commercial management, if they want to avoid price volatilities. Unlike commodities, specialties do not have a specific technological package, and most of them have no tradition in Argentina. Consequently, those firms that have undertaken these productive ventures have had to develop their own technological approach, investing in experimentation and specialized advice.

Diversification strategies also involve retaking activities that farmers had abandoned during the soy boom, mainly livestock rearing. The return to livestock was driven by increasing beef prices (steer prices per kilogram live weight, in US$, increased 73% between 2010 and 2018[21]). With rising freight rates to ports undermining the profitability of exporting grains, many farmers are choosing to convert corn into cattle feed. This strategy is undertaken by a wide range of producers, from small farms that buy calves to fatten and then sell in local markets to large-scale farms that have installed feedlots with the capacity to feed a significant number of animals (from 15,000 to 45,000 per year) and that, in some cases, offer this service to other farmers too. We also found medium- and large-scale farms developing poultry and pork production, using corn as the main animal feed.

The use of corn or soy as animal feed exemplifies commodity flexing strategies. Following Borras, Franco, Isakson, Levidow, and Vervest "flex crops and commodities have multiple uses (food, feed, fuel, fibre,industrial material, etc.) that can be flexibly interchanged (…) the emergence of flex crops partly addresses global-market price volatility"(2015, p. 94). Besides the amelioration of meat prices, corn flexing shows a major productive shift from extensive to intensive production patterns in cattle raising, related to the consolidation of a global meat complex (Weis, 2013). In addition to flexing, these strategies suggest what Gasparri and le Polain de Waroux (2014) have

[21]https://datos.agroindustria.gob.ar/dataset/indicadores-mensuales-sector-bovino/archivo/46c21636-2a4d-44a4-a0c6-052836d51a3f

referred to as sectoral coupling in grain and cattle sectors, a process that suggests that both activities are no longer competing for land as in the midst of soy boom.

Flexing and coupling strategies have different implications for farmers. For small-scale farms, it appears to be mostly conjunctural. As many interviewees put it, this was a response to the fact that "corn had no price" between 2008 and 2015. On the contrary, although this has been the initial driver for large-scale farms too, they later developed a new business line around livestock, with investments of varied magnitude.

5.2 | Value-adding activities

As for the introduction of value-adding activities, we found examples of firms—usually large-scale—that are transforming grains into bio-energies and organic fertilizers. In the case of bio-energies, it is worth noting that in 2016, the province of Córdoba contributed with 39% of bio-ethanol total national production. The incorporation of bio-energy production to pre-existing value chains such as that of grains and meat is relatively recent; in Córdoba, the first public production statistics date back to 2012 (National Ministry of Energy).[22]

One of the firms we visited illustrates this type of strategy. This company dedicates more than 20,000 ha to soy and corn production, other 4,000 to cattle rearing, and has a feedlot with capacity to fatten the 3,000 heads it owns. Corn is destined to animal feed and to the production of ethanol. Aiming at both uses, this firm installed a modular distillery, which can produce five million litres of ethanol per year. Besides producing ethanol from corn, two substitutes for animal feed are made: wet distillers' grains and thin stillage. The investment in the distillery was a result of partnerships with the enterprise that developed this technology. Although the firm has not yet consolidated ethanol as a new business line, these different strategies have widened its scope, integrating to different production webs that share inputs, market linkages, and know-how. In addition, the firm recently started producing olive oil and olives mostly for international markets, from its own plantations (around 900 ha) in the neighbouring province of La Rioja.

Another of the agricultural firms interviewed followed a similar path. Between the mid-1990 and 2007, this second firm devoted the family-owned lands entirely to the production of soy and maize, which it later expanded in leased lands, supported on private investors. Since mid-2000s, the firm reoriented its business strategy; according to its CEO, "we decided to focus on value-adding, to use everything we produce." Following this premise, poultry and fertile egg production were incorporated. A few years later, the firm began to produce cattle (in a feedlot with capacity for 1,500 heads) and pork, utilizing corn for feed, and also installed a slaughterhouse and a refrigeration plant for pork meat. The plant depends mostly on the supply of other farmers; the contribution of own heads is around 25%. In 2018, the firm built a biodigester that transforms animal waste into biogas, which is used to generate electricity and organic fertilizers for the farm.

Other economic activities we found among large-scale firms in the North of Córdoba are the installation of industrial plants for processing and packaging specialties, seed multiplication for multinational companies, agrochemicals fractioning using local brands, and the provision of cutting-edge technology services. Despite their wide variety, the examples described here aim at developing new productive, industrial, or commercial niches that allow capturing supplementary rents and widen the scope of firms.

These examples are indicative of a tipping point: Resistant weeds worked as an early alert indicating that the era of easy farming, easy accumulation, and fast appropriation of nature's gifts had reached a critical point. But besides introducing technological changes to control weeds, it also called for the revision and reorganization of business strategies. Reducing costs, increasing allocative efficiency, responding to market signals, either by developing new market niches or by reshaping "old" activities (e.g., livestock production) are part of an ongoing process. The results of this shift are far from being clear and, much less, stabilized.

[22]http://datos.minem.gob.ar/dataset/estadisticas-de-biodiesel-y-bioetanol

6 | CONCLUDING REMARKS

After two decades of agricultural growth, Argentina's rural sector seems to be at the threshold of further transformations, which invoke technological innovations as the master key to face a series of "blind spots" for capital accumulation. These blind spots are intrinsic to the relationship between capital and nature; in other words, they are indicative of the accelerating erosion of agriculture's biophysical foundations that goes along with productive intensification. Changing economic, political, and social contexts have exacerbated the consequences of environmental costs for capital accumulation. Altogether, these facts have significantly altered the conditions that enabled agricultural growth in the recent past. We have analysed the technological dynamics that, according to agribusiness spokesmen, turned the historic comparative advantages of Argentina's agriculture into competitive advantages. We have distinguished two major phases that account for the various difficulties that came with the massive adoption of transgenic seeds and associated agrochemicals. Both phases allow a better understanding of the mediating role of technology between capital accumulation and the exploitation of nature. If the first phase was characterized by a fast appropriation of ecological surplus in a context of high international commodity prices, externalization of environmental costs, and land availability (agricultural frontier expansion), the second phase is marked by a series of new productive problems, depletion of the agricultural frontier, and, more generally, the end of a period of extraordinary gains. The technological changes we have analysed lead to a new wave of capitalization, which seems to be aimed at restoring the production of ecological surplus through a more intensive exploitation of natural resources. A major feature of intensification is that it brings about the internalization of previously masked externalized costs (i.e., more agrochemicals to cope with resistant weeds and soil nutrients loss).

Resistant weeds worked as an early alert indicating that the era of easy farming, easy accumulation, and fast appropriation of nature's gifts had reached a critical point. However, the passage from one phase to the other is not merely related to responses to tackle this problem but actually involves other domains of technological change. In fact, the phase opened in 2009 brings to light renewed dynamics of capital accumulation. As analysed here, intensification is framed within broader transformations in farming systems and in land control and use. Soy monoculture is progressively giving way to crop diversification and the incorporation of value-adding activities, whereas new productive and sectoral linkages are being fostered. Business strategies are being reshaped to recapture economies of scale and scope. However, the technological and farming changes that characterize the present conjuncture are by no means restructuring accumulation patterns or food systems. On the contrary, what we are witnessing are changing strategies that seek to restore and stabilize firms' capital accumulation.

As our analysis also suggests, these processes are giving place to the emergence of new technological frontiers and minimum capitalization thresholds for the reproduction, expansion, and persistence of farms. Although we have not focused here on small- and medium-scale farms, our work offers empiric evidence of the association of current technological innovations to large-scale farming.

Indeed, major technological innovations triggered the extraordinary growth of agricultural production in Argentina in the last 25 years. As advocates of the dominant agricultural model argue, this "technological revolution" led to increases in basic indicators as yields as well as to the transformation of "unproductive" or "unexploited" land. Unlike other Latin American countries, these facts have, in turn, resulted in the legitimization of technological changes in Argentina (Gras & Hernández, 2016b), obfuscating its interdependence with broader features of capital accumulation such as the expansion of commodity markets, flex cropping, land grabbing, dispossession and enclosures, and social, economic, and productive exclusion. This dominant narrative veils the fast appropriation of "nature's free gift" that fuelled Argentina's agricultural growth. The North of Córdoba, a region of agricultural frontier expansion, is a clear case of what Moore (2010) terms as the dialectic unity of productivity and plunder.

Challenged by productive problems caused by the massive use of the innovations that characterized the first phase (e.g., resistant weeds and soil depletion) and by the failure to improve yields significantly, farmers remain recurrently confident on the adoption of new technological solutions to tackle these challenges, despite the weaknesses that this technological model has shown. We thus understand that the present conjuncture represents a tipping point insofar as (a) in order to restore accumulation, farmers are introducing technological changes, encouraged by new market pressures pushing a still-rising demand for biofuels, animal proteins, and livestock feed; (b) concerns on sustainability are not only arising from social movements or international agencies; sustainability issues are also affecting farmers' costs; (c) the underlying logic of these technological changes seems to be far from contributing to slow down the depletion of agriculture's biophysical foundations; unlike what could be observed until 2009, many of those "environmental costs" can no longer be externalized or masked; and (d) these technological changes can be associated to renovated processes and interactions among actors driving new exclusions.

However, the economic and politic dominance of this agricultural model retains a significant degree of adherence and acceptance. As analysed by Newell (2009) and Gras and Hernández (2014, 2016a), its hegemony stands on the convergence of the material, institutional, and discursive power held by the coalition of forces represented by agribusiness corporations (large agricultural firms, exporters, input suppliers, and food processors). The technological solutions they propose are part of the construction of the ideological leadership through which this coalition has managed to guide the agrarian development model in Argentina (Gras & Hernández, 2016b). A fact that should be addressed in future analysis refers to how this hegemonic model will deal with threats at various levels. Conflicts have aroused in the last years involving an increasing number of social groups, but it must also be mentioned that many of the dominant agricultural model advocates occupy today key posts in President Mauricio Macri's administration. The analysis of technological changes framed as a tipping point puts us in a better (and nuanced) position to understand the restructuring of industrial agriculture and its underlying dynamics.

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