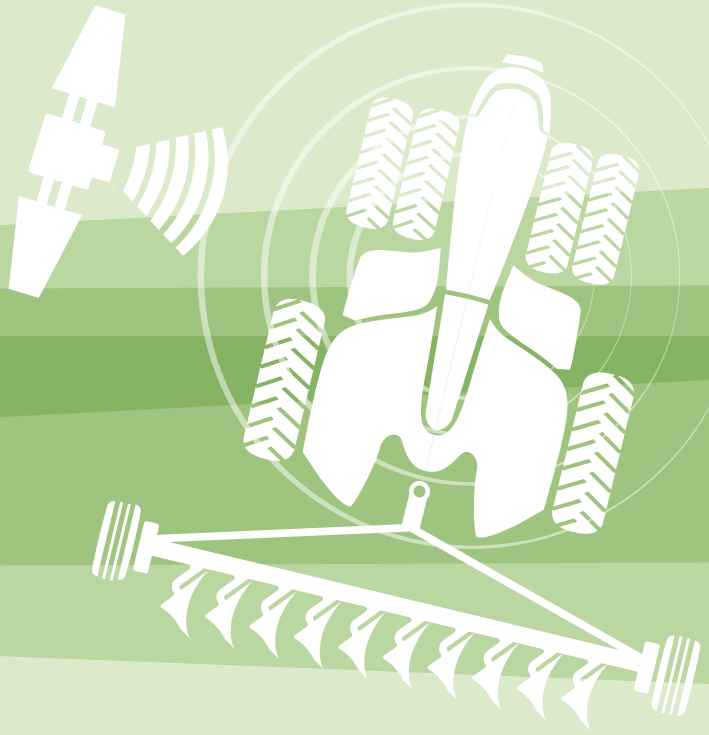
Pat Mooney, ETC Group

Blocking the chain

Industrial food chain concentration, Big Data platforms and food sovereignty solutions



etc GROUP monitoring power tracking technology strengthening diversity
GLOCON Global Change - Local Conflicts
INKOTA netzwerk
ROSA LUXEMBURG STIFTUNG

Editors:

ETC Group
2464 Rue de l'Église, #304
Val David QC J0T 2N0, Canada
Tel.: +1 (0)514 51 65 75 9
Email: etc@etcgroup.org
Website: www.etcgroup.org

Global Change – Local Conflict? (GLOCON)
Boltzmannstraße 1
14195 Berlin, Germany
Tel.:+ 49 (0)838 53 09 0
Email: kristina.dietz@fu-berlin.de
Website: www.land-conflicts.net

INKOTA-netzwerk e. V.
Chrysanthemenstraße 1–3
10407 Berlin, Germany
Tel.: + 49 (0)30 42 08 20 20
Email: inkota@inkota.de
Website: www.inkota.de

Rosa-Luxemburg-Stiftung Gesellschaftsanalyse und politische Bildung e. V.
Franz-Mehring-Platz 1
10243 Berlin, Germany
Tel.: + 49 (0)30 44 31 00
Email: info@rosalux.org
Website: www.rosalux.org

Author:
Pat Mooney, ETC Group

Editorial team:
Benjamin Luig (Rosa-Luxemburg-Stiftung), Franza Drechsel (GLOCON), Jan Urhahn (INKOTA-netzwerk) and Steffen Kühne (Rosa-Luxemburg-Stiftung)

Editorial deadline:
July 2018

Many thanks to:
Marita Wiggerthale (Oxfam Germany) and Simone Gotthardt (INKOTA-netzwerk)

Final editing:
Zoe Goldstein

Layout and illustrations:
Marischka Lutz Grafikdesign

Berlin and Val David, October 2018

ISSN: 2512-8337

This publication received financial support from Stiftung Nord-Süd-Brücken, the Berlin state office for Development Cooperation (LEZ), Engagement Global on behalf of Germany's Federal Ministry for Economic Cooperation and Development (BMZ), Ministry of Education and Research (BMBF) as well as funds from the Church Development Service through Bread for the World Evangelical Development Service. The publishers alone are responsible for the content of this publication, positions in the text do not represent the positions of funding institutions.

be Berlin
Senatsverwaltung für Wirtschaft, Technologie und Forschung

Federal Ministry for Economic Cooperation and Development

stiftung nord-süd brücken

Federal Ministry of Education and Research

Glossary:
All terms underlined in the text are explained in the glossary on pages 6 and 7.

List of companies:
All companies mentioned in the text in italics are described in the company list on pages 42 and 43.

Introduction

Overview

Impacts and implications

Food sovereignty solutions

Concluding remarks

Introduction

Doubling down - Corporate concentration and the Big Data platform

The year 2018 launched with two distinct but powerful demonstrations of how new Big Data platform technologies are changing the world and, along the way, transforming world food security. The first event was, literally, a rocket launch, dependent upon the convergence of four distinct industrial sectors in order to shoot a shiny Tesla roadster toward Mars. The second launch, less celebrated but no less significant, used related technologies to ship soybeans from a grain terminal on the east coast of the USA through the Panama Canal to a feed mills in China.

The rocket launch, orchestrated by serial entrepreneur Elon Musk, united his various Big Data startups in electric cars, spaceships, batteries and something now called fintech (financial technology). As the driverless Tesla zoomed toward Mars, Musk was also applying for US permits to orbit a fleet of low altitude satellites that could spot disease outbreaks, monitor harvests, or count the cars in a *Walmart* parking lot. On the ground, *Louis Dreyfus*, one of the world's oldest commodity traders, was demonstrating that the same Big Data platform could navigate the complexities of international trade without paper – and almost without people – and not only to ship soy, but also to sequence DNA, spray weeds and buy groceries.

More than a computer programmer's 'ones and zeros', this new Big Data platform is also about digital DNA – it has the astonishing capacity to manipulate the four nucleotide bases, A, C, G and T of the double helix. Thus the digital map of an Ethiopian cereal genetically preserved in Braunschweig in Germany can be accessed from a cloud in Iceland by a keyboard in Ludwigshafen (Germany again), where a gene sequence is computer-edited to construct drought tolerant sugar beets for German refiners. Just as easily, the new Big Data platform can allow *Nestlé* in Switzerland to link the sound bites of shrimp feeding off the coast of Alaska to terabytes of data on West African weather patterns and South American soil conditions, in order to hedge its position on a commodity exchange in Chicago.

Market shares of the largest companies in the agricultural and food sector[1]

Worldwide and in Germany (in percent)

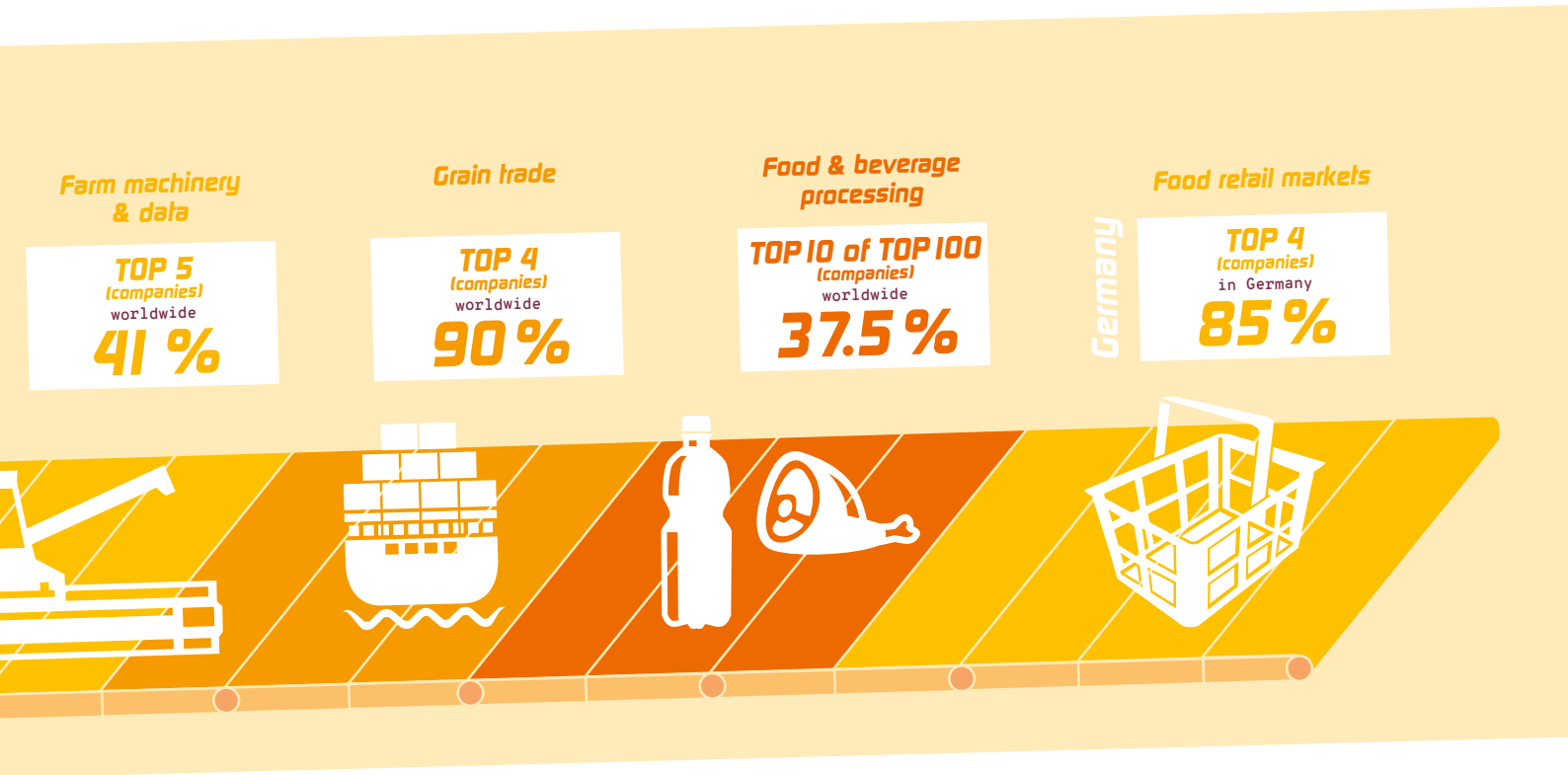
Seeds	Agrochemicals	Fertilizers
TOP 4 (companies) worldwide 67 %	TOP 4 (companies) worldwide 70 %	TOP 5 (companies) worldwide 18 %

The historic division between (a) agrochemical formulators and fertilizer manufacturers, (b) grain traders and plant breeders, and (c) grocery retailers and tractor manufacturers no longer applies. While stockbrokers and antitrust monitors have been watching the mergers of *Bayer* and *Monsanto* (now *Bayer*), *Dow* and *DuPont* (now *Corteva Agriscience*), as well as of *ChemChina* and *Syngenta* (might become part of *Sinochem* very soon), the convergence of powerful new digital technologies – computer data and DNA – means that more profound changes and even greater monopolies are on their way.

Within the machinations of global markets, our food security is entangled in an omnibus data platform where *Apple* and *Google* are competing with *Volkswagen* and *Toyota*; where *Amazon* is segueing into organic groceries, medical supplies and entertainment. And because that's where *Amazon* is heading, private US hospital chains are merging with medical suppliers, and telecom companies such as *Comcast* are competing with content providers like *Disney* for the same takeovers. This new Big Data platform invites – almost requires – cross-sectoral convergence, and those who control the platform can literally regroup the industrial landscape. Not only are new oligopolies or even monopolies created, but barriers are erected that discourage other entrants and suffocate innovation.

Of course, corporate concentration – even global duopolies – are hardly new. *Airbus* and *Boeing* command the commercial skies, *Fincantieri* and *Meyer Werft* reign over shipbuilding to control the seas, and in between *Otis* and *Schindler* run the elevators. But whether it's elevators, planes or ships, few passengers care as long as they reach their destination. The impact of this new Big Data platform on the industrial food chain is more direct. If *Nestlé* merges with *Carrefour* or if the

1 Sector data from 2014–2017; market shares in seed and pesticides sectors are based on pro forma estimates for 2017 reflecting recent mergers and are derived from global market values provided by AGROW-informa, July 2018. Sources: ETC Group 2017, Agrifood Atlas 2017, Bundeskartellamt 2017.



merged *Bayer-Monsanto* company gets together with *Yara* (a Norwegian fertilizer company, currently the world's second largest in terms of turnover), the industrial food chain could be reduced to a duopoly of input and output enterprises, thereby doubling down on a technological platform that may not actually work.

It is as foolish for competition regulators today to judge cross-sectoral food chain mergers in isolation from other events along the Big Data platform as it was 40 years ago for regulators to ignore the takeover of plant breeders by pesticide manufacturers. The tragedy is that over the last 40 years, the companies and technologies have changed a lot, but the regulators have not. Vertical and horizontal integration continues, but regulators have neither the capacity to monitor it nor the legal tools to control it.

This report critiques the onward march of corporate concentration, the Big Data platforms, the specific technologies required and the very nature of global capitalism. As long as a society is unjust and large corporations pressure for profit, the introduction of a platform technology will almost inevitably strengthen the wealthy and weaken the (already) marginalized. 'Objective science' is replaced by political opportunism that privileges – even weaponizes – some technologies over others.

Glossary

Artificial Intelligence (AI) allows a computerized device to perform tasks independently and to learn or adapt over time. Machine learning usually describes an artificial intelligence system that can learn from the experience of other machines.

Big Data refers to a conglomeration of digital information. In agriculture, this data can be historic crop yield and weather information, market information, data on input costs for seeds, pesticides and fertilizers, etc. This is not simply to be collected and stored but to be analyzed with the help of computer algorithms in order to make associations that could, for example, improve efficiency or increase profitability.

Big Data platform is a connected suite of technologies (such as computers, computer software or apps and the Internet) that may positively or negatively impact several sectors of the economy or society, often in unanticipated ways.

Biofoundry refers to a laboratory equipped with high-tech instruments, usually at a private university, that can be contracted or rented to perform tasks such as gene synthesizing or gene editing for other researchers who do not have the time or the technology to do this work themselves.

Blockchains are usually described as digital ledgers that are capable of tracking a contract or an activity with the use of computers via the Internet in such a way as to reassure the parties involved that the contract or procedure has been carried out. Blockchains can be used by bankers and drug cartels alike (among many others) to reduce transaction costs and increase confidence that the arrangement has been completed.

Cloud: In the world of Big Data, the cloud is the location where digital information is stored. Far from being invisible, this information is stored in very real and usually extraordinarily large data server centers around the world, usually close to inexpensive energy sources such as hydroelectric dams, wind farms or cheap coal and, preferably, in cool or cold climates such as Canada or Iceland.

Cryptocurrencies are closely associated with blockchains and are often described as digital cash that can be mined and earned and traded for products or services similar to national currency. However, cryptocurrencies are controlled by algorithms and their blockchains and not by government regulators or banks.

The intention of this report is to demystify this new technology platform and to analyze its potential impacts on the global industrial food chain. We will also expose the players, looking at who is in charge and what is happening now; what can be reasonably anticipated; and what could be done to block the parts that are problematic and advance those initiatives that could support food sovereignty.

After an introduction, we look at the three dimensions of the Big Data platform: its hardware, that is, robots and their sensors, including satellites and computerized farm machinery; its software, or how genomes can be edited and constructed by SynBio (Synthetic Biology); and its fintech, meaning the financial technologies such as blockchains and cryptocurrencies. We subsequently analyze in more detail how the current developments and tendencies of continuous market concentration and lack of public control are impacting peasants and food production, and the further implications this might have. We end the paper by making several suggestions regarding how to place control in public hands and what (inter-)national legal instruments should be implemented to block the chain.

Fintech describes the application of digital information technologies to finance and management. Fintech may utilize algorithms, blockchains and Big Data to increase its effective management of money or resources.

Food security is often assumed to mean the reasonable assurance of an adequate supply of calories. However, the full definition includes that the food supply must be nutritious, affordable and culturally appropriate.

Food sovereignty: In the mid 1990s, the concept of food sovereignty was mainly developed by La Via Campesina, the international movement of peasants and farm workers. It is based on the right of all peoples and countries to define their agricultural and food policies themselves. Each individual should be able to subsist in dignity - according to the respective economic, social, cultural and ecological conditions and without destroying food security and livelihoods of other or coming generations. Food sovereignty is a political concept and not a 'one size fits all' blueprint that can be used in any location of the world.

Gene editing: CRISPR (see acronyms p. 40) is one of many techniques available to edit the DNA of a genome. The technique can cut or add gene sequences to chromosomes to alter the characteristics of the plant, animal or human, either temporarily or permanently. Sometimes described as 'editing the book of life', the technology is claimed to be able to quickly, cheaply and accurately modify the double helix.

Horizontal integration occurs when companies like *Dow* and *DuPont* come together to merge their chemical, crop chemical, and seed interests with other enterprises in the same line of business.

M&As: Mergers and acquisitions are the major mechanisms used in the corporate world to unite enterprises or parts of enterprises. M&As do not include joint ventures or licensing arrangements and involve a transfer of ownership that unites at least two corporate entities.

Morphs are construction components without geometrical boundaries, hence, edges and surfaces can be changed. A morph consists of different elements that can also be used alone. Amongst others, they are currently utilised in cars and airplanes as electronic fittings where buttons only become visible when touched.

Vertical integration arises when a company moves up or down the food production chain to acquire another company in another sector, such as when a grain trading company like *Cargill* buys fish farms or invests in synthetic flavor or fragrance production in commercial vats.

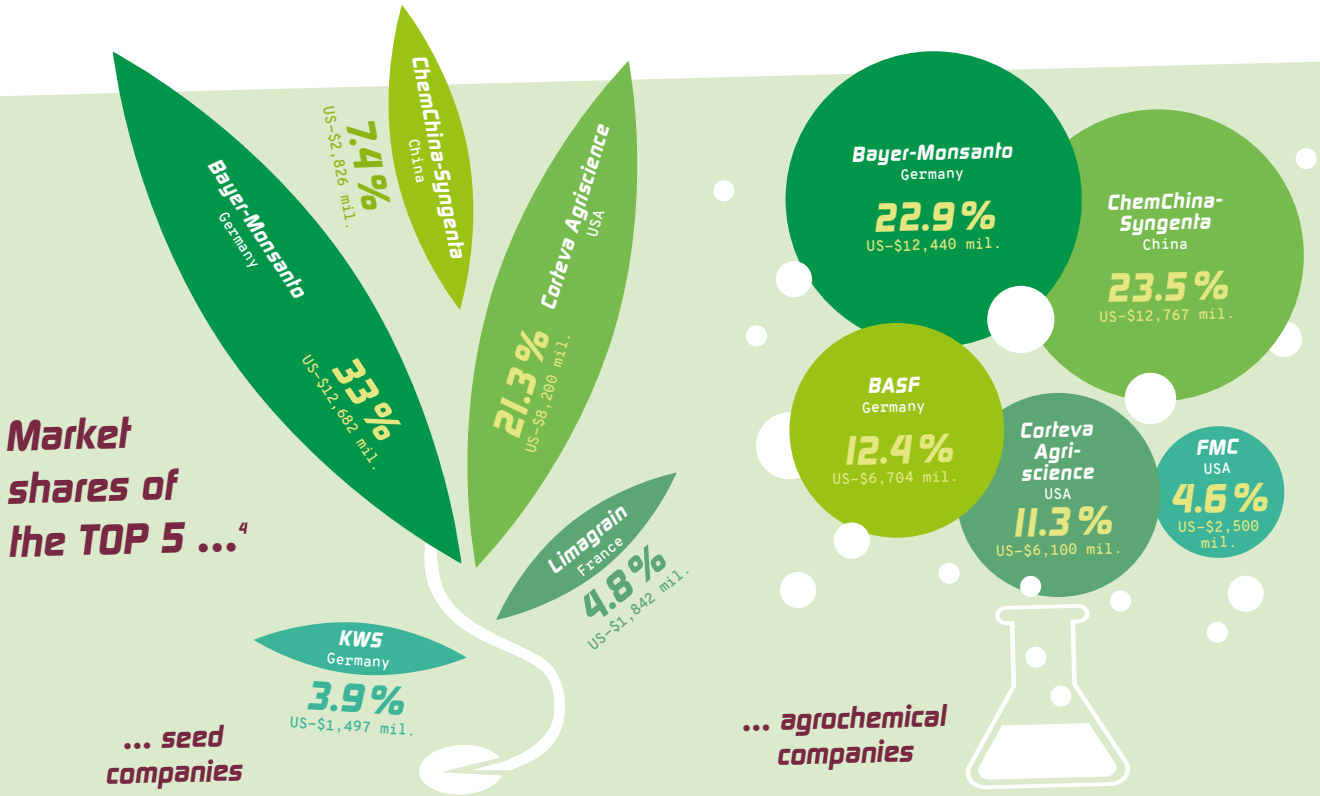
Overview

Chain reactions - The industrial food chain and technological change

"We can now see a legitimate path to a utopian time-not-too-far-away, where 'see and spray' fungicides, microbes, and, of course, weeding in combinations of selective and non-selective herbicides, can be used to tend each plant individually."[2]
Kiersten Stead, MGV (Monsanto Growth Ventures)

The Big Data platform is a phenomenon of the Internet age, which introduces the capacity to store vast quantities of information in the cloud (digital data storage warehouses). Every sector of the industrial economy, including agriculture, is amassing data and striving to make commercial use of it. The world's biggest data managers are well-known: *Amazon*, *Microsoft* and *Google* dominate the global scene; but major Chinese enterprises such as *Alibaba* and *Tencent* are also harvesting enormous quantities of information and aspire to match or exceed their US competitors. Although governments are struggling to control the use of Big Data, the technology is still well ahead of the regulators, as the recent revelations involving *Cambridge Analytica* make clear. In this section, we will look specifically at the industrial agricultural sector, and will discuss how the data platforms are imperiling peasants[3] and wage workers all along the food chain and fundamentally altering the food that reaches our plates.

Generally, Big Data creates new market opportunities, leading to more mergers and grander monopolies. As the industrial food chain reacts to the smorgasbord of new technologies, the main goal of agribusiness is not merely to amass data but to manipulate and monopolize it. Beyond ownership (data accumulation), gaining control includes the ability to manipulate the information via proprietary (including trade secrets



Big Data

The term Big Data refers to the massive accumulation of statistical information by governments and corporations, over decades, that can be processed by sophisticated computer algorithms to pull out interesting trends or patterns. With the advent of the Internet and smart phones, the amount of data being created is literally doubling every year or two. While the potential to manipulate Big Data for different purposes is almost inexhaustible, the reality is still lagging behind. Theoretically, it is possible to connect a farm's historic data on inputs and yield to weather and market information, including real-time information on soil and disease conditions, technology licenses etc., but in practice, this is seldom the case. Nevertheless, data rarely gets old: oil and mining companies are using old data to rejuvenate oilfields and mines that new technologies make viable today. Furthermore, old consumer information may still identify new trends and old drug research may offer new applications. The big question is not just about who is collecting the data, but more importantly who is able to analyze the data to their advantage.

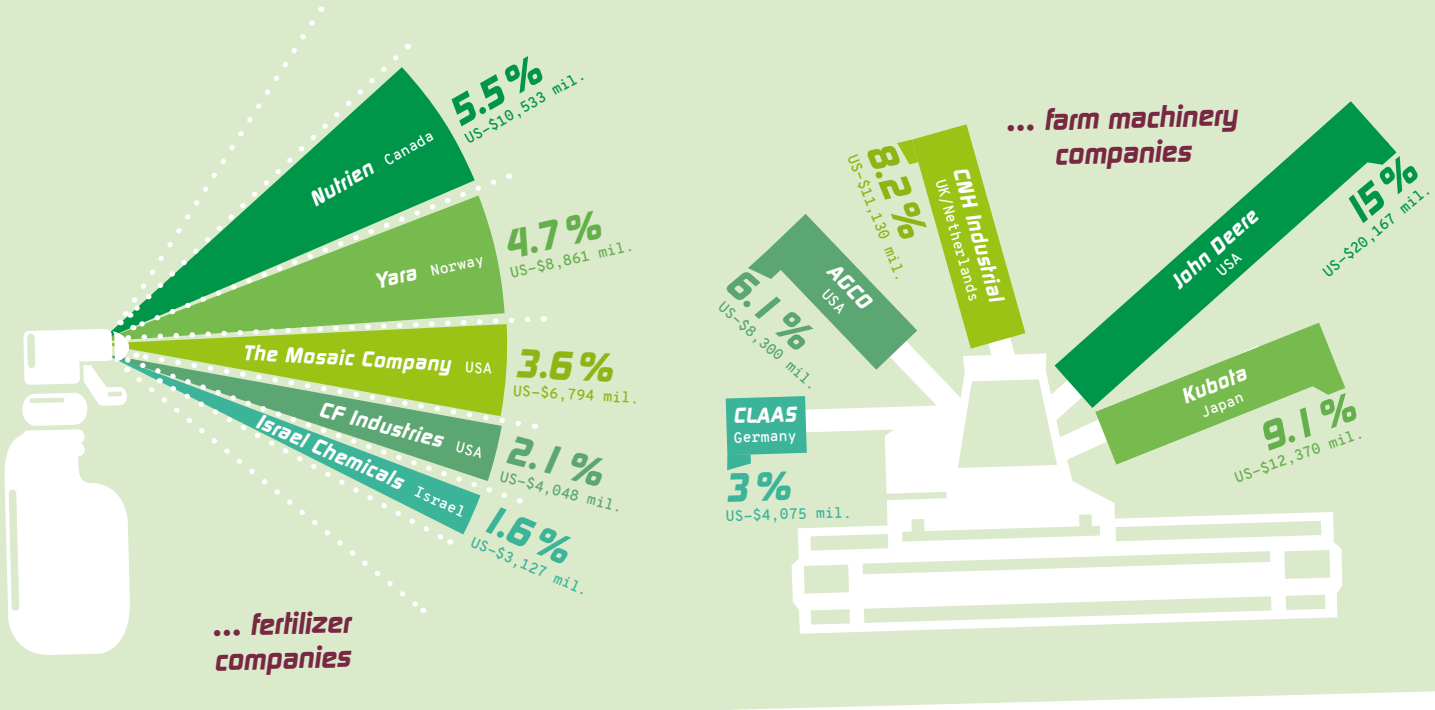
and conventional intellectual property systems) algorithms and distributed networks (blockchains).

Agribusiness's potential to mine Big Data thus encourages corporate concentration. The more a major company is able to amass data and understand the food system, the more it will be able to fend off competitors and increase its profits. Although every link in the industrial food chain collects data, information accumulates at certain hubs along the chain, such as with farm

2 Kiersten Stead, "Blue River Technology's Journey to Acquisition", LinkedIn, September 8, 2017: https://www.linkedin.com/pulse/blue-river-technologys-journey-acquisition-kiersten-stead.

3 A peasant is any person who engages or who seeks to engage – alone, in association with others or as a community – in small-scale agricultural production for subsistence and/or for the market; who primarily though not necessarily exclusively, relies on family or household labor and other non-monetized ways of organizing labor; and whose form of agrarian production is not dominated by capital accumulation.

4 ETC Group from company reporting, with global market values for seeds and pesticides provided by AGROW-informa, July 2018.



machinery companies (production data), food traders (market data), and large processors and retailers (consumer preferences). Indeed, Big Data not only invites but in fact demands greater concentration, since no company at any point along the chain can risk allowing others to gain control of more information. Therefore the tendency for vertical integration along the chain increases.

How likely is another wave of agribusiness mega-mergers? Historically, regulators have worried most about horizontal integration – when one seed company acquires another, for example – and less concerned about vertical integration – i. e. a commodity trader buying a fish farm or food processor. However, during the completion of the report, examples along various points of the food chain show greater (vertical) merger activity than any time in industrial history as each sector adjusts to the new platform. *Sinochem* is expected to acquire *ChemChina-Syngenta* to create the world's largest chemical company with an estimated US-$100 billion in annual sales. The takeover of *ChemChina-Syngenta* would make the new entity a bigger player in agribusiness than *Bayer* even after its merger with *Monsanto*. Meanwhile, industry observers are still expecting the world's largest commodity trader (for minerals et al.) *Glencore*, to make a new bid for *Bunge* (one of the big four food traders) which could make *Glencore* the world's largest food trader. Also, in mid-2018, market analysts were openly wondering about the current biggest food trader, *Cargill*, that is thought to be caught between producers and processors and anxious to acquire other companies along the food chain in self-defence. In each case, the proposed or anticipated M&As (Mergers and Acquisitions) are responding to the demands of the Big Data platform as well as the perceived weaknesses of anti-trust regulators to confront mergers involving vertical integration.

While vertical integration along the entire length of the industrial food chain will continue, it will still take some time for companies at the production start of the chain to digest their most recent acquisitions before they can move on to further takeovers. The farm machinery industry, in particular, has been in a slump and is just now showing signs of recovery and may not be in a position to consider mergers in the near future. Having gone through a period of consolidation already, the fertilizer companies, too, may be slow to move on. In the immediate future, most of the action may thus come from the traders, processors and retailers who are currently acquiring companies on a weekly basis.

Every tool of the data platform impacts every segment of the industrial food chain. While the impacts

The biggest mergers of the last decade[7]

Mergers in the agrifood industry are just as big as in other sectors of the economy

Concentration and current mergers in the agricultural sector

Concentration in the seed and pesticide sector is ongoing. Following the merger of *Bayer* and *Monsanto* in June 2018 (now *Bayer*), the previous mergers of *Dow* and *DuPont* (now *Corteva Agriscience*) and *ChemChina* and *Syngenta* (soon part of *Sinochem*) in 2017, these three corporate giants together with Germany's *BASF*, control an estimated 63 % of the global industrial seed market and more than 70 % of the global pesticide business.[5] Along the whole industrial food chain, from seeds to supermarket shelves, things look similar although very much in flux with many confounding changes. Whereas, in 2014, only four corporations controlled 21 % of the fertilizer market and almost 54 % of the agricultural machinery market, both sectors have been hurt by weak commodity prices and declining demand leaving their market shares uncertain. Likewise, although four firms controlled 70 % of agricultural trade and 54 % of food processing in 2014 and have maintained a steady pace of mergers since, they may actually be losing ground to new high-tech competitors in 2018.[6] As with other industries adjusting to transformative new technologies, the agricultural and food sectors continue to be a highly concentrated but a rapidly-shifting industry.

might most easily be divided between biological manipulations and everything else, every part of the chain uses remote and built-in sensors to gather data, clouds to store data, artificial intelligence (AI) to analyze information, algorithms to manipulate it, and blockchains to distribute it. Applying these tools to nanoparticles, chemical reactions or genetic sequences is highly specialized. In the same way that city planners assess weather information in order to anticipate traffic flows and tweak hospital emergency schedules, those controlling the industrial food chain apply market information, climate projections, and soil and crop disease data in order to tweak fertilizer compositions, seed coatings and crop traits for the next growing season.

Especially in the input sector – namely pesticides and seeds – the dominant companies seek to prescribe

5 IPES-Food, "Too Big to Feed: Exploring the impacts of mega-mergers, consolidation and concentration of power in the agri-food sector", International Panel of Experts on Sustainable Food Systems, Thematic Report 3, 2017: http://www.ipes-food.org/publications.

6 ibid.

7 Timeline, by sector and transaction value in billion US dollars (controlled for inflation, base year 2016), publicly traded companies only, includes announcements. Agrifood Atlas 2017: https://www.rosalux.de/fileadmin/rls_uploads/pdfs/sonst_publikationen/agrifoodatlas2017.pdf.

how, when and where farmers buy and use farm inputs and who can access the resulting data to their market advantage. The industrial food chain is not waiting for policymakers to recognize (much less to regulate) the new technologies, nor even to approve (or not) the current wave of mega-mergers among seed and pesticide companies and others. Fertilizer majors such as *Nutrien* are expanding their portfolios to include seeds and agrochemicals. Farm machinery companies such as *John Deere*, *AGCO* and *CNH* already have alliances with seed, pesticide and fertilizer companies.[8,9] Likewise, pesticide and seed companies such as *Bayer* and *Corteva Agriscience* are acquiring or expanding their investments in biofertilizer, seed coating and crop nutrient technologies. The frontrunner may be the newly supersized *Bayer* which has strong links to all of the major farm machinery companies and is heavily investing in crop nutrients. The fertilizer industry recognizes that if it does not move quickly to take advantage of its biological data strengths, it could lose out to farm machinery companies that have the capacity to usurp field information and combine it with market and weather data.

Hardware

The platform's agricultural machinery

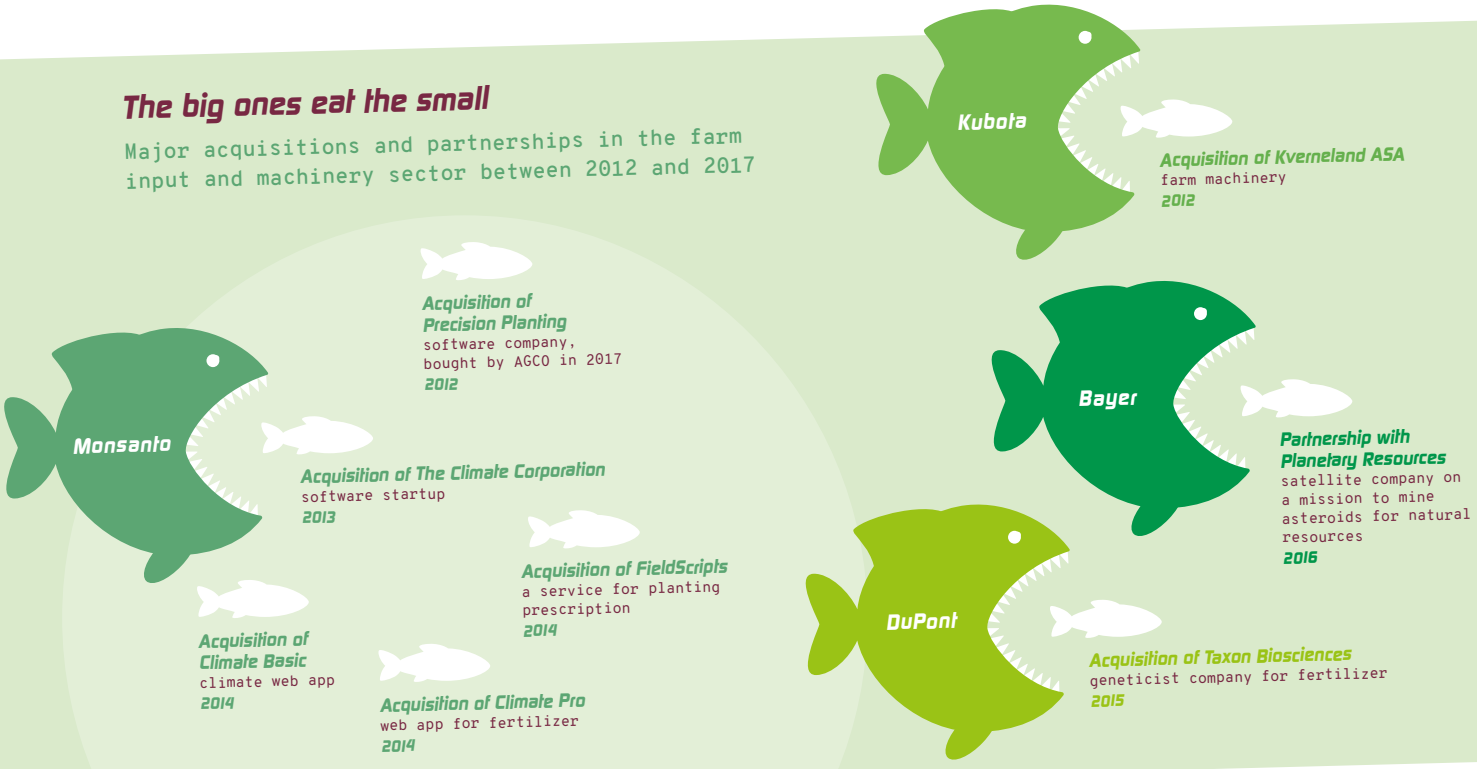
The most prominent 'hardware' in the agricultural Big Data platform involves robots and their sensors. Robots encompass both aerial and aquatic drones, as well as

Robots (a.k.a. 'bots' - artificial intelligence that moves)

Though robots do move, most of them are far from intelligent and only perform rudimentary assembly-line tasks enclosed in a cage where they can do no harm. Drones on the other hand represent an entire new generation of robots, including pilotless planes, and driverless cars, sea crafts and submarines. Even some inexpensive robots can be reprogrammed to perform different tasks. Equipped with machine learning, robots can adapt their actions through experience and – most importantly – through the experience of similar robots. For example, a driverless vehicle can 'learn' from driving through the streets of one city, but it can massively increase its capacities if it learns from other vehicles driving in other cities around the world, as well as other climates, terrains etc.

The big ones eat the small

Major acquisitions and partnerships in the farm input and machinery sector between 2012 and 2017



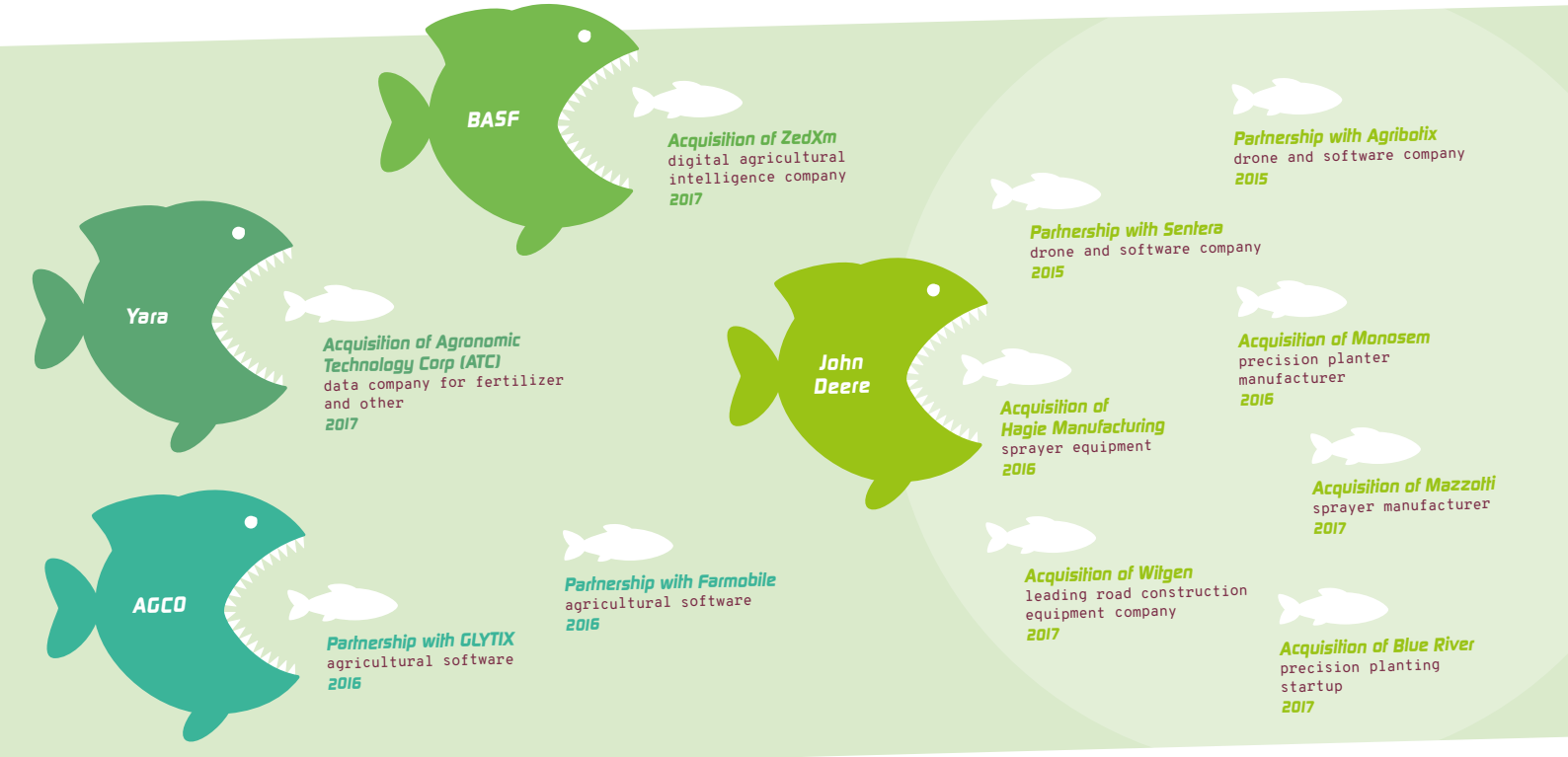
(more pedestrian) driverless tractors. All of these come with AI and a myriad of sensors that can be electrical or biological, acoustical, visual or olfactory, and may range from remote 3-D hyper-spectral imaging (via satellites) to 'in-your-face' smart phone apps. Robots mix cocktails, lift patients, read stories, build cars, decommission bombs and pick tomatoes. The very direct question this raises are how to deal with the fact that jobs are wiped out. This is particularly relevant in manual labor-intensive sectors such as agriculture, food processing and retailing.

The array of technologies surrounding robots is edging its way into every segment of the industrial food chain. Most of the interest is on the ground, with the huge planting and harvesting machines that can subdue the Steppes and the Savannas, the Pampas and the Punjab. The world's leading farm machinery companies, *John Deere*, *CNH*, *AGCO* and *Kubota* (which together account for well over one third of the total market), will begin selling driverless machines imminently. Startups with charming names such as *Rowbot* and *Robocrop* are, however, already puttering in the garden. Nevertheless, despite the presence of these early and still rather small startups, various examples in recent years show that the big machinery companies will quickly take them over. The former either do not have the experience or the money necessary to scale up and they will be left with the option of either going bankrupt, being bought out, or selling their intellectual property assets to the dominant enterprises.

Indeed, the big farm machinery companies have long been active in their pursuit of dominance and control. *John Deere*, for instance, began investing in the new Big Data platform technologies in 2001, as agribusiness joined forces with telecommunications and energy companies to pressure the US government to take its blinkers off commercial satellites to permit meter-by-meter mapping. With its tractors logging GPS data since the turn of the century, *John Deere* began making deals with each of the seed and pesticide majors: starting with *Syngenta* in 2007 (now a subsidiary of *ChemChina*), and by 2015 branching out to *Dow* and

8 Melanie Evans and Laura Stevens, "Amazon's Latest Ambition: To Be a Major Hospital Supplier", The Wall Street Journal, February 13, 2018: https://www.wsj.com/articles/amazons-latest-ambition-to-be-a-major-hospital-supplier-1518517802.

9 ETC Group, "Breaking Bad: Big Ag Mega-Mergers in Play", 2015: http://www.etcgroup.org/content/breaking-bad-big-ag-mega-mergers-play.



Sensors

Often connected with – or reporting to – robots or other artificial intelligence devices, sensors may see, hear, smell, feel or taste, in any combination, either from on-the-ground contact (seed drills, fertilizer nozzles etc.) or from above (via aircraft and satellites linking GPS to audio, video or hyperspectral images). Hyperspectral images can turn ground moisture and heat, for example, into color-coded images assessing potential harvests and crop diseases. Decades-old audio and visual data from satellites can now be repurposed in ways never anticipated to deepen knowledge of historical contexts and predict future scenarios. Governments set the sensory limits of satellites for security reasons, but have gradually allowed greater commercial access and accuracy. In theory, satellites can read license plates, though for now they are usually limited to identifying automobile types.

DuPont, *Bayer* and *Monsanto*, and *BASF*. Each venture connected *John Deere's* data and hardware with the seed and chemical data, as well as the software of these (then) six so-called 'Gene Giants'.

John Deere was in fact pre-empted by the farm machinery industry's number four firm, *AGCO*, which acquired *Massey-Ferguson* in 1994,[10] a farm machinery company that started computerizing field data in 1982. *AGCO* made its first data agreement with *DuPont* in 2014, followed by separate deals with *Bayer*, *Monsanto* and *BASF* in 2015. Indeed, *AGCO* bought one of *Monsanto's* major data subsidiaries in 2017, even as it moved into agricultural drones and joint ventures with a variety of agricultural data startup companies.

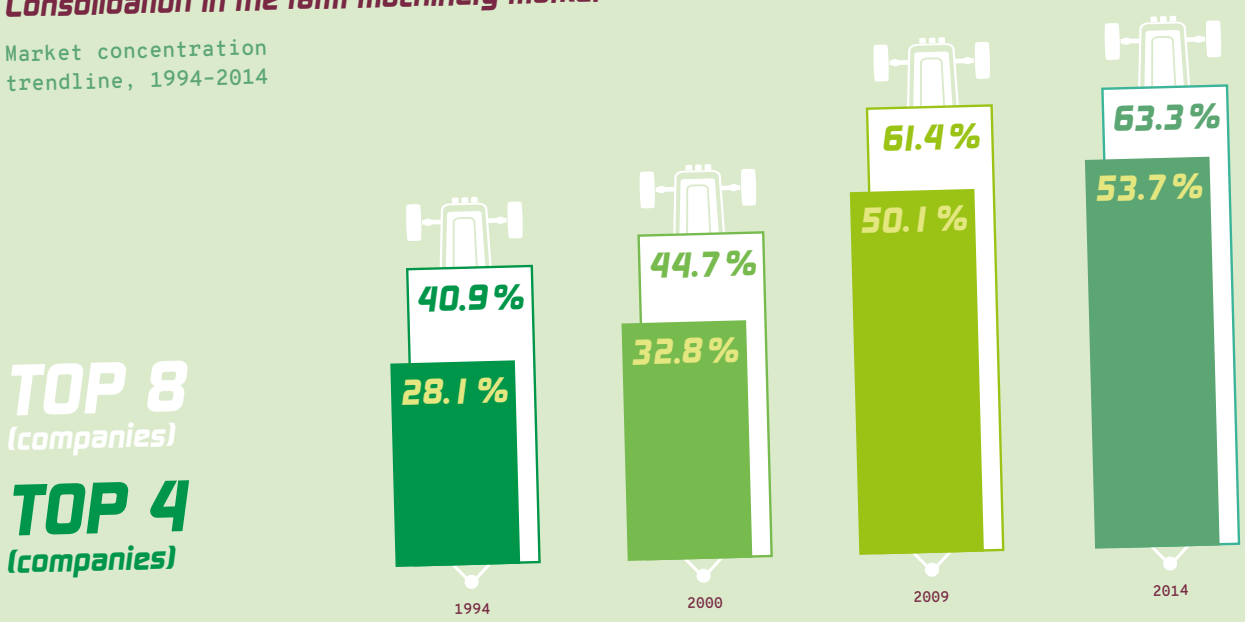
Ranking number three in farm machinery, *CNH* got into the Big Data platform in 2015 in a joint venture with *Monsanto* and, a year later, with *BASF*. But *CNH* has also invested in robotics and announced its first driverless (remote-controlled) tractor in 2016. The sector's number two company, *Kubota* of Japan, is rumored to be at least as aggressive as the other three but more secretive.

Flying high or diving deep: drones

As important as the new Big Data hardware is for field planting and harvesting, the market for aerial and aquatic drones is substantial and their impact on ocean fisheries could be greater than on land. Wall Street's *Goldman Sachs* predicts that the commercial drone market (for all industrial, nonmilitary purposes) in 2020 may be US-$20 billion, up from US-$2.4 billion in 2017.[11]

Consolidation in the farm machinery market[14]

Market concentration trendline, 1994-2014

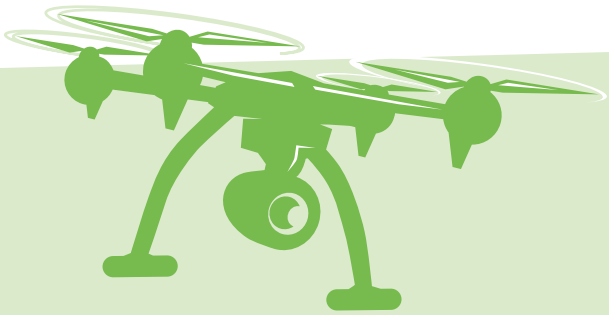


Aerial Drones can sweep low over fields, spotting and spraying weed patches, thus saving fuel and reducing toxins. In Japan, where farmers are aging and rice fields are modest, one-third of the crop is drone monitored and at least two Japanese manufacturers are gunning for driverless tractor sales in 2018. Australian ranchers are experimenting with drones to herd livestock, while oil palm plantations in Malaysia and Indonesia use drones to police deforestation, monitor infestation and track workers.[12] Roboticized dragonflies (which have been neurologically 'commandeered') keep an eye on crops and, if their US manufacturer has its way, will soon be doing the pollinating.

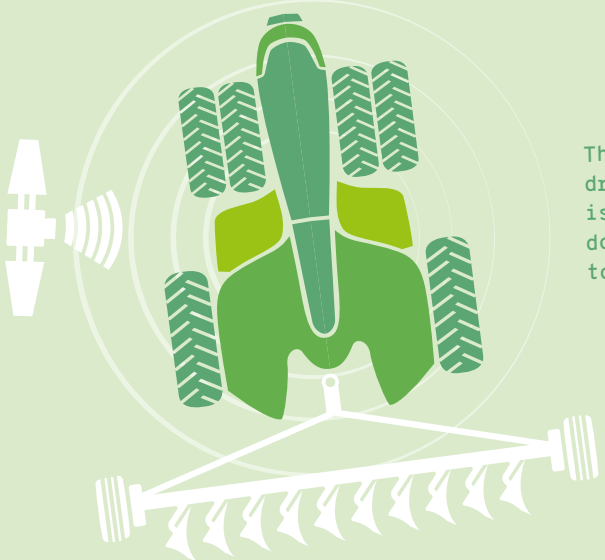
Aquadrones, or submersible drones, can monitor fishnets and even drive target species into the nets anonymously (i. e. untraceable by monitors or fishing regulators), thus allowing for fishing undercover and over-the-horizon in an industry already rife with overfishing and piracy. Developed by the US military to detect underwater mines, the commercial market for driverless vehicles may be US-$4.6 billion by 2020.[13] New surveillance technologies combined with aquadrones could spell the end of the 'open seas', creating an actual 'enclosure' out of one of the world's last great commons.

Aquadrones will reel out, monitor and mend vast mobile cages that can be moved wherever there is the best climate, nutrients and photosynthesis to maximize

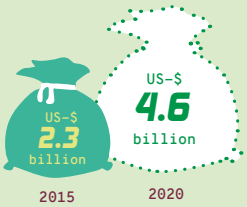
10 AGCO, "Who We Are. History": https://www.agcocorp.com/about/agco-history.html.
11 Sarah Gordon, "Drones Take Flight for Businesses that Can Navigate Red Tape", Financial Times, January 10, 2018: https://www.ft.com/content/2107f088-f53e-11e7-8715-e94187b3017e.
12 Cargill, "Cargill Issues New Palm Oil Sustainability Report", Cargill News, April 6, 2015: https://www.cargill.com/story/cargill-issues-new-palm-oil-sustainability-report.
13 Anonymous, "AI Making Inroads into Maritime Industry via Startups", AI Trends, March 2, 2018: https://aitrends.com/weekly-brief/weekly-brief-ai-making-inroads-maritime-industry-via-startups/.
14 IPES-Food, "Too Big to Feed: Exploring the impacts of mega-mergers, consolidation and concentration of power in the agri-food sector", International Panel of Experts on Sustainable Food Systems, Thematic Report 3, 2017: http://www.ipes-food.org/publications.
Despite colossal mergers in the fertilizer sector in 2017 and 2018, that sector is seemingly less concentrated than before. Likewise, the farm machinery industry continues to be dominated by four companies and each of these is branching out and with joint ventures and buying start-ups even as their market share appears to be eroding.
15 2015/2020: Anonymous, "AI Making Inroads into Maritime Industry via Startups", AI Trends, March 2, 2018: https://aitrends.com/weekly-brief/weekly-brief-ai-making-inroads-maritime-industry-via-startups/. 2017/2020: Goldman Sachs in: Sarah Gordon, "Drones Take Flight for Businesses that Can Navigate Red Tape", Financial Times, January 10, 2018: https://www.ft.com/content/2107f088-f53e-11e7-8715-e94187b3017e.



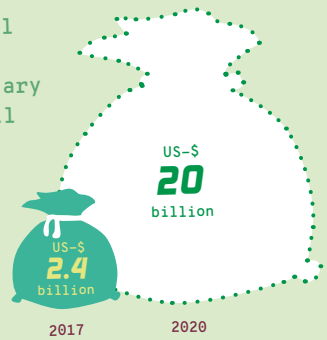
Predictions for market developments for driverless vehicles and flying drones[15]



The market for driverless vehicles is expected to double from 2015 to 2020.



The commercial drone market (for nonmilitary purposes) will increase enormously.



Beer varieties belonging to AB InBev[16]

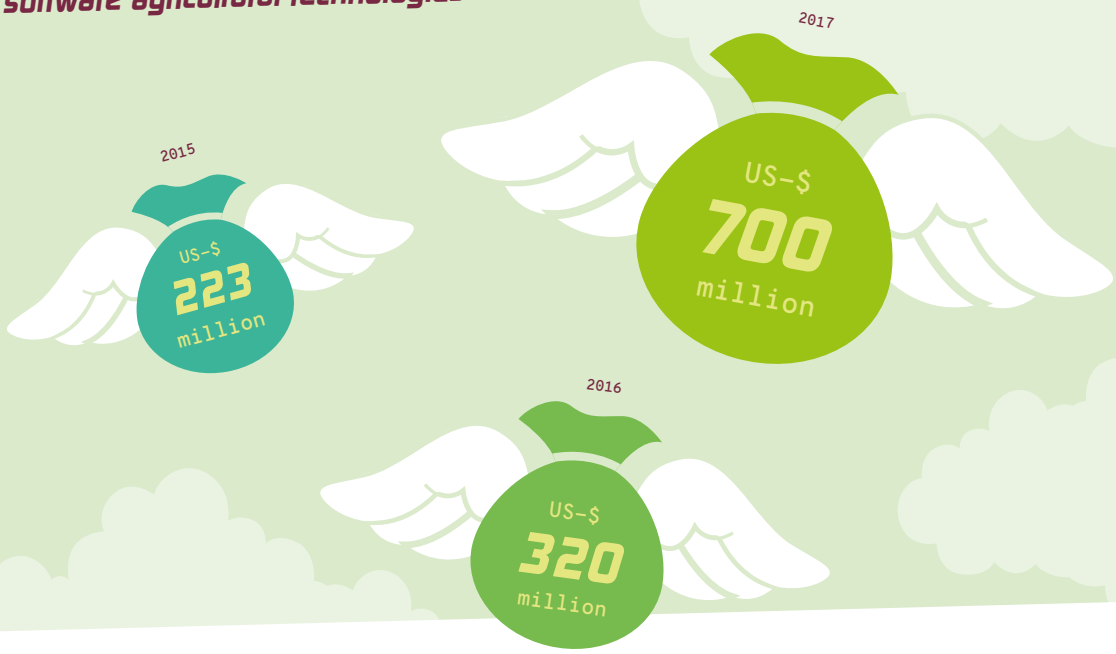
yield. Indeed, as the European Parliament was passing a resolution to end electrified ocean fishnets in January 2018,[18] the world's largest mobile fish cage, with the volume capacity of the Vatican and the weight of the Eiffel Tower, was floating up into the North Atlantic toward Norway.[19] The fishing industry has long been operating at a mammoth scale, with giant trawlers disgorging sufficient nets to circumnavigate the planet twice over. The move towards large-scale algae and fish farming, monitored and supported by a Big Data platform, will take it to another level. Algae farms are already vast, while fish farms are also expanding in size and depth. *SalMar*, a Norwegian company, has recently ordered six portable fish farms. Its US rival, *InnovaSea*, has similar nested farms off the coast of Panama and Hawaii, and there are more to come. These portable cages are ringed with sensors and hold as many as 1.5 million salmon.[20] The owners of these mobile algae and fish cages will negotiate with coastal governments for access to the best territorial waters, thereby creating insecurity for local fishers. This is significant, as at least 800 million people are part of the global artisanal fishing system,[21, 22] and their access to the world's fishing grounds is absolutely vital for their sustained livelihood.

From field to shelf – Robots tending crops and mixing drinks

All of the actors at the input end of the industrial food chain, from seeds to fertilizers to machines, are developing Big Data sensors and working with robotics. Agribusinesses using high-flying satellites, low-flying drones or ground-level tractors to identify crop species, predict yields, analyze chemical usage, and even determine the patents or licenses associated with the plant varieties or chemicals. This data can be gathered either openly or surreptitiously; either with permission or without. In such an arena, victory usually goes to the companies with the deepest pockets. For field crops, this would give the upper hand to the world's largest farm machinery companies that have both the money and the platforms into which everybody else has to place their products.

Facing the accusation that they are exacerbating greenhouse gases, as well as contributing to major soil

Venture capital interest in new hardware and especially software agricultural technologies[17]



and water pollution, the old fashioned bulk fertilizer companies are scrambling to compete with the precision nutrient tools available to the seed and machinery companies. Driverless trucks already play a role in mining fertilizer ingredients such as potash and phosphate. The Norwegian fertilizer company *Yara* is investing in crewless freighters and is looking for other Big Data help. In 2017, *Yara* acquired a 'nitrogen recommendation platform' to optimize field-specific applications by modeling crop, weather and field data.[23] *Yara* also picked up a sensor company that gauges moisture levels and a farm management platform. Furthermore, it has developed a tractor-mounted remote-sensing system to adjust nitrogen applications along with a handheld nitrogen measuring device.[24]

Robots are indeed present at every stage of the chain, and are just as involved in food processing and services as they are in soldering *Kubota* tractors and packing boxes for *Amazon*'s distribution centers. *Amazon's* Whole Foods (an organic retail store chain) uses a US-$14,000 bot that 3-D prints 200 sushi rolls an hour, while the fast food chain *CaliBurger* has a bot called 'Flippy' flipping burgers, as 'Sally' tosses salads for high-end restaurants and another bot makes pizza.

16 AB InBev, "Our Brands", 2018: https://www.ab-inbev.com/our-brands.html.

17 Chloe Cornish, "Ag Tech Fundraising Doubles As Farmers Seek Disruptive Solutions", Financial Times, January 8, 2018: https://www.ft.com/content/02950380-d6f2-11e7-a303-9060cb1e5f44.

18 Fiona Harvey, "European Parliament Votes to End Electric Pulse Fishing", The Guardian, January 17, 2018: https://www.theguardian.com/environment/2018/jan/16/european-parliament-votes-to-end-electric-pulse-fishing.

19 Anonymous, "Blue-sea Thinking: Technology Is Transforming the Relationship between People and the Oceans", The Economist, March 10, 2018: https://www.economist.com/technology-quarterly/2018-03-10/ocean-technology.

20 Anonymous, "Herding Fish: Net Gains. Open-ocean Fish Farming Is Becoming Easier", The Economist, March 10, 2018: https://www.economist.com/news/technology-quarterly/21738060-open-ocean-fish-farming-becoming-easier-net-gains.

21 This estimate includes fishers, fish workers and sellers: TNI Agrarian Justice Programme, Masifundise, Afrika Kontakt and World Forum of Fisher People, "The Global Ocean Grab: a Primer", 2014, p. 6.

22 ETC Group, "Who Will Feed Us?", 2017: http://www.etcgroup.org/whowillfeedus.

23 Yara International, "Yara Acquires Leading Crop Nutrition Recommendation Platform to Strengthen Digital Farming Offering", 2017: https://www.yara.com/corporate-releases/yara-acquires-leading-crop-nutrition-recommendation-platform-to-strengthen-digital-farming-offering/.

24 Emma Cosgrove, "Fertilizer Giant Yara International Acquires Adapt-N Nitrogen Modeling Tech", AgFunderNews, November 6, 2017: https://agfundernews.com/fertilizer-giant-yara-acquires-adapt-n-nitrogen-modeling-tech.html.

The world's largest beer brewing company, *AB InBev*, is aggressively cutting overhead costs by using robots instead of humans at some of their bottling plants. Elsewhere, there are bots pouring bubbly from the hotel mini bar, others mixing drinks in the lounge, and the Massachusetts Institute of Technology (MIT) has developed a heavy duty bot to tend bars on cruise ships.

MIT is doing more, however, than inventing robotic cocktail waiters. Its engineers at the Biomimetic Robotics Lab have crafted an origami bot made from pig intestines that can fold itself into almost nothing and reshape itself into almost anything (theoretically), from shopping carts to tractor parts. A research group in Lausanne has created softball sized bots that can merge into tools or toys, while Singaporean scientists taught a robot couple to use Allen keys to assemble *IKEA* furniture, only to be upstaged by Harvard's 3-legged robot swarm, each one the size of a watch battery, that machine morphs on demand – with no need for an Allen key. This development already has, and will have even more, repercussions for people who currently undertake these tasks and whose labor will henceforth become superfluous. The rise of robotics will therefore not only affect our way of farming, but also of food processing, retailing and consumption – that is, the whole of society.

"I think the biggest impact [of new gene editing technologies] is going to be in agriculture."[25]
Dr. Jennifer Doudna, discoverer of the CRISPR gene editing technique.

Software

The platform's genomic data

The software component of the Big Data platform is anchored in genomics, while being closely connected to agricultural hardware. Just as *John Deere*, *AGCO* and *CNH* made deals with the original six Gene Giants (*Monsanto*, *Syngenta*, *Dow*, *DuPont*, *BASF* and *Bayer*), the Gene Giants also developed their own Big Data genomics tools and struck their own mergers and joint ventures with hardware startup companies.

The latest estimates put the value of agricultural genomics at US-$2.8 billion in 2017, and it is expected to reach US-$5.4 billion by 2022.[26] Compared to hardware machinery, these figures seem almost inconsequential until one remembers that these are costs incurred at the first link in the chain only; the multiplier impact of

Gene editing including CRISPR/Cas9 ('Clustered Regularly Inter-Spaced Palindromic Repeats')

Armed with new techniques that it claims do not produce GMOs (Genetically Modified Organisms), agribusiness admits that the clunky old biotech cannot match the precision of its new tools. It is now cheap and practical to massively modify the DNA of a species without inserting genes from another species. DNA can be computer 'edited' in dozens or hundreds of sites along chromosomes to produce novel traits or to mirror a gene sequence discovered in another species. By silencing a gene sequence, gene editors assume that their new traits will be securely replicated in crosses with other breeds or varieties. This means that in a fast-breeding mosquito, a Terminator (sterility) trait could drive through the species in a few generations, leading to its extinction. When the goal of gene editing is to force a specific trait through the species, it is sometimes described as a gene drive. One of the best known methods is CRISPR. The accuracy and safety of gene editing is hotly debated, and regulators in many countries are uncertain whether to treat the technology as a GMO or to establish a new regulatory regime. Only if the new methods are recognized as genetic engineering are they subject to controls such as a risk assessment, a strict approval procedure and monitoring. In July 2018, the European Court of Justice ruled in a landmark ruling that new genetic engineering procedures such as CRISPR are a form of genetic engineering and must thus be regulated accordingly. The judgment could serve as a role model for the whole world. There is no debate, however, that gene editing is the most powerful and potentially most dangerous biological tool known to date.

Synthetic Biology

Synthetic Biology (SynBio) became controversial 12 years ago as its proponents (as often civil engineers as biologists) asserted that the double helix of DNA was similar to computer circuitry and that the component parts of DNA could be identified and assembled in the same way as electrical networks. In theory, bio-hackers (often amateurs) can take off-the-shelf DNA components/traits and plug them into different organisms with predictable results. Much of the commercial focus is on SynBio to enhance biofuels or isolate the commercially important trait in a living organism, replicate it, and grow it in algae or yeast more quickly and at less cost. The world's most valuable biological commodities can be identified along perhaps a dozen metabolic pathways; if hackers can identify the pathway, they can tweak the DNA to produce a wide variety of products. Flavor and fragrance ingredients are prime targets.

these technologies (and costs) can be enormous. Industrial food chain supporters point out that venture capital interest in new agricultural technologies doubled last year over the previous year, exceeding US-$700 million in 2017 compared to US-$320 million in 2016 and US-$223 million in 2015.[27] This risk capital is spread over both hardware and software, but the greatest interest is where Big Data meets the biosciences.

Four decades ago, tongue-in-cheek, *John Deere's* magazine, The Furrow, advised its customers that genetic engineering would make it possible for farmers to grow wheatbeet, so that farmers could harvest the wheat while the beet grows on. While this is still not on the menu, according to the industry everything else is possible.

In this section, we summarize and clarify the converging technologies and developments that are already being commercialized; those that are moving towards the market; and others that are still theoretical, but are actively being explored.

Digital DNA and gene editing methods

Highly trained biologists and wildly untrained bio-hackers alike can hook up a computer to a second hand DNA synthesizer (the size of a desktop printer, available on eBay for about US-$400) and attach vials of sugars – one for each of the four nucleotide bases, A, C, G and T of DNA. With the hit of a few keys, the electronic map of a genome or a gene sequence can be plucked from a database banked in the cloud, allowing the reconstruction of the real sequence, base pair by base pair, on the DNA synthesizer. A biologist, with a lot of skill, can insert that sequence into a bacterium, butterfly or grain of barley. A bio-hacker with less skill might just email the digital sequence to a biofoundry (biotech industry service provider with advanced equipment) in Singapore, Boston or London with instructions to insert it into the barley variety and FedEx it back. The London biofoundry alone can process 15,000 experiments a day.[28]

Or, more exotically, a scientist can take the downloaded genome and lay it out on a kind of computer spreadsheet and manipulate base pairs or even individual DNA letters. This could include rummaging through the cloud for a rust resistant gene sequence identified in an Ethiopian teff (cereal) variety and then editing the barley variety on the computer to match the teff sequence. No gene transfer – simply gene editing.

As this report was being finalized, the scientific advisory committee of the UN Convention on Biological Diversity (CBD) wrapped up a hotly-contentious debate in Montréal where most governments in the Global South (and several in Europe) passionately argued for a moratorium on the release of any gene-edited life form into the environment. Although the majority of scientists and governments in the UN meeting supported the moratorium, a handful of industrialized countries blocked agreement. Nevertheless, the call for

25 Michael Le Page, "Unicorns and Designer Babies: How CRISPR Creator Sees the Future", New Scientist, March 3, 2018: https://www.newscientist.com/article/mg23731670-900-unicorns-and-designer-babies-how-crispr-creator-sees-the-future/.

26 Knowledge Sourcing Intelligence LLP, "Global Agricultural Microbial Market – Forecasts from 2017 to 2022", Research & Markets, 2017: https://www.researchandmarkets.com/research/w9mfnj/global.

27 Chloe Cornish, "Ag Tech Fundraising Doubles As Farmers Seek Disruptive Solutions", Financial Times, January 8, 2018: https://www.ft.com/content/02950380-d6f2-11e7-a303-9060cb1e5f44.

28 Anonymous, "Robotic Labs for High-speed Genetic Research Are on the Rise", The Economist, March 1, 2018: https://www.economist.com/science-and-technology/2018/03/01/robotic-labs-for-high-speed-genetic-research-are-on-the-rise.

Global livestock genomics markets in 2018

Broiler Genetics (chickens raised for meat): In 1999, seven major companies supplied broiler breeding stock worldwide.[29] By 2008, just three companies controlled the world market for broiler genetics. In 2017, *EW Group*, owner of *Aviagen Group*, acquired *Hubbard* (previously owned by *Groupe Grimaud*). Today, two companies supply over 91 % of the commercial breeding stock for broilers: *EW Group/ Aviagen* (Germany/USA) and *Tyson Foods/Cobb-Vantress* (USA).

Layer Genetics (chickens raised for eggs): Two companies control an estimated 90 % of layer genetics worldwide (*Hendrix Genetics* and *EW Group*). *Groupe Grimaud* accounts for the remaining share. *Hendrix Genetics* claims that its genetics stock accounts for 'roughly 50 % of the chicken eggs' produced in the world.

In sum, globally, three leading companies provide poultry breeding stock for commercial broilers, layers: *EW Group*, *Hendrix Genetics* and *Tyson Foods/ Cobb-Vantress*. Two of them are privately-held.

a moratorium on gene editing will still go to the biennial meeting of government policymakers in the CBD gathering in Egypt at the end of 2018.

Synthetic Biology

Synthetic Biology (SynBio), augmented by Big Data, robotics and AI, tweaks existing biosystems or constructs to make new biological parts that can be inserted into algae or yeast – in effect, turning individual cells into industrial 'factories' that could express the smell of roses, the flavor of citrus, the sweetness of stevia or the jolt of caffeine.

SynBio and other related gene editing technologies are also developing livestock strategies ranging from the outright replacement of animals for meat, dairy, hides and medicinal potions, to reducing livestock's carbon hoofprint in order to increase meat consumption. A US company, *Modern Meadow*, for example, is challenging the US-$100 billion leather industry by transforming yeast into a biologically uniform, easily tailored substitute. Another startup achieved notoriety with its 'Impossible Burger' – a vegan patty doused in a SynBio substitute with a meaty taste. Unfortunately, the start-up jumpstarted its sales without government approval, leading to harsh criticism in the media that cast at least a temporary chill over the entire synthetic food sector.

As attractive as this might seem, the big money is still firmly fixed on increasing livestock productivity, and here gene editing and cloning tools are dominated by never more than three companies. The genetics of commercial laying hens, broilers and turkeys are controlled by three companies, while another three companies dominate pig breeding. One British company, *Genus*, has (excluding China) 30 % of the global pig genetics market, 25 % of beef cattle and 6 % of dairy breeding.[30] Interestingly, *Genus's* main competition comes from the Global South. An Argentine business is mass cloning highly-profitable polo horses, while China and South Korea have joined forces to clone beef cattle. In a countermove, *Genus* bought *InVitro Brasil* for its livestock genetics research.

Gene editing may, plausibly, shift the demand for textile fibers from field to factory. Two companies, *Spiber* in Japan and *Bold Thread* in the USA, are bioengineering little more than yeast mixed with sugar and water to replicate the spider silk haute couture popularized by Stella McCartney.[31] It is still early, but several startups have the same hope of bringing cotton out of the field and into the vat, with enormous economic and livelihood implications for about 300 million peasants and textile workers.[32]

SynBio in flavor and fragrance

Many SynBio companies have moved into high-value yet low-production volume flavor and fragrance products, assuming that their specialist yeasts and algae can replace virtually all of the 250 or so ingredients sought by food and cosmetics processors. *Easy Trading Connect* has, however, a running registry of close to 100 biosynthesis research initiatives and commercial products designed to replace patchouli, saffron, stevia, shark liver oil, vanilla, rose oil, nootkatone (grapefruit oil), cow leather and spider silk – but the list goes on and is getting longer. The biggest food and beverage processors are monitoring developments and investing in these

startups. *Cargill* is aggressively exploring bacteria-based stevia as a supposedly healthy calorie-free alternative to high fructose corn syrup in soft drinks. The Danish beer maker *Carlsberg* has been working with *Microsoft* to identify new bacteria and yeast that could enhance flavor. Along the way, they have developed sensors and analytical tools that apply to plant breeding and crop production. They argue that vat production stabilizes supply, cost and quality, while countering the vicissitudes of nature, greenhouse gas emissions and waste.

Crops such as vanilla, saffron and cinnamon are not only expensive, but they are grown on small plots, in countries that the processing companies regard as commercially unreliable, under changing climatic conditions. *McCormick Seasonings*, for example, the world's biggest buyer, gets most of its ingredients from farms and forests within 10 degrees of the equator.[33] Indeed, 95 % of the market is provided by roughly 20 million peasant families and workers in the Global South on an estimated 250,000 hectares of land.[34, 35]

> "We tell farmers, 'We're giving you a Ferrari but you need to look after it!'"[36]
> Rogelio Trinidad, Nestlé, Tapachula, Chiapas, 2018

The replacement of natural field and forest products with SynBio vats might imply a loss of livelihood for many small-scale farmers and workers, and it is therefore attracting strong opposition from the natural products industry, especially in the USA and Canada. The Silicon Valley startups are claiming that their vat-sourced ingredients are 'natural' and therefore need no special regulation before letting them go toe-to-toe with some of the world's poorest producers. Some insist that vat vanilla, for example, is cheaper than the Madagascan crop and almost as high quality – and much higher quality than the cheap chemical vanilla that has been on the market for decades and that is used in lower quality products. Similarly, another SynBio startup is arguing that its vat stevia tastes better than the stevia grown by farmers in Paraguay and China. Knowing nothing about the growing conditions or economics of the production in Madagascar or Paraguay, these startups often argue that the relocation of the crop production to industrialized countries will allow farmers to grow more food or will protect rainforests. In reality, however, Madagascar's vanilla is grown in the rainforest, and the trees would likely be cut down if the market disappeared. It therefore seems unlikely that the Madagascan vanilla farmers – or the environment – would profit from vat production.

SynBio in mass consumption commodities

SynBio aspires to more than the small flavor and fragrance markets: mass consumption commodities such as coffee, cocoa, tea and bananas are also in its sights. Given the quantities, no one is talking about factory production, but major efforts are underway using gene editing and related techniques.

The coffee industry is massive, valued at US-$200 billion a year and with 21.5 to 25 million peasants producing 85 % of the world's coffee beans.[37, 38] Yet the three major processors are anticipating climate-induced crop losses

29 ETC Group, "Between BlackRock and a Hard Place: What's Happening to the Industrial Food Chain?", forthcoming 2018: http://www.etcgroup.org.

30 James Ashton, "Questor: Animal Geneticist's Risks too Great to Be a Cash Cow", The Telegraph, July 29, 2017: https://www.telegraph.co.uk/business/2017/07/29/questor-animal-geneticists-risks-great-cash-cow/.

31 Robert F. Service, "Spinning Spider Silk Into Startup Gold", Science Magazine, October 18, 2017: http://www.sciencemag.org/news/2017/10/spinning-spider-silk-startup-gold.

32 The cotton sector is estimated to contain 300 million workers. See Fairtrade Foundation, "Cotton Farmers", 2018: https://www.fairtrade.org.uk/Farmers-and-Workers/Cotton.

33 Lauren Weber, "McCormick Spices Up Its Product Line for Home Cooks", Wall Street Journal, January 3, 2012: https://www.wsj.com/articles/SB10001424052970203899504577126892320260290.

34 IFEAT, "News from Around the Globe", IFEATWORLD, 2014: https://ifeat.org/wp-content/uploads/2017/03/2014_may_ifeat_world.pdf.

35 ETC Group's conservative estimate is based on IFEAT and IFRA's statistic that approximately 15 million farmers produce cornmint (source of menthol) in India alone. ETC Group, "Who Will Feed Us?", 2017: http://www.etcgroup.org/whowillfeedus.

36 Jude Webber, "Lab-grown Plants to 'Sow Wealth' for Poorer Coffee Producers", Financial Times, September 24, 2017: https://www.ft.com/content/d4cfa114-51ca-11e7-a1f2-db19572361bb.

37 Gideon Long, "Coffee sustainability: the journey from bean to barista laid bare", Financial Times, September 24, 2017: https://www.ft.com/content/851f940c-51c6-11e7-a1f2-db19572361bb.

38 Charlie Mitchell, "The Coffee Bean Belt: Climate Change Map", Financial Times, September 24, 2017: https://www.ft.com/content/a3b5748e-51c8-11e7-a1f2-db19572361bb.

of 20–30 % by 2100.[39] After neglecting coffee research for half a century, *Nestlé* is taking up the new genomics and is investing heavily in research and experimentation with new coffee varieties, using new techniques that are being supervised by 350 Nespresso (a *Nestlé* affiliate) agronomists. Depending on your perspective, these agronomists are either 'advisors' (a.k.a. aid workers) or 'overseers' (a.k.a. colonialists). Of course, coffee production will remain in the hands of *Nestlé*, making the producers – small coffee growers in countries of the Global South – even more dependent on the company.

Bananas, too, are being threatened not only by climate change, but also by a half-century of genetic uniformity leading to one variety (of the more than 1,500 types), accounting for virtually all export banana sales. Today, the Cavendish variety risks extinction due to the spread of a soil fungus, which is causing companies to spray pesticides that both harm workers and damage the environment. They are exploring the new genomics to gene edit new varieties that can withstand the disease.

The software platform of Big Data – i. e. new gene editing methods – allows for the control and production of crops, livestock and textile fibers. In other words, the food chain's hypes and mistakes over technology's last 'next big thing' (crop chemicals and GMOs) are forcing peasants and countries to gamble on the new 'next big thing' (gene editing and SynBio).

Control over Big Data genomics as a way of dominating more links in the food chain

The diverse Big Data platforms lead to an ever greater concentration of different sectors into ever greater oligopolies or duopolies. The data generated through hardware – that is farm machinery, drones, as well as food processing robots – is linked to the software, through which seeds, and pesticides, fertilizer and livestock are genetically engineered. Furthermore, companies are interested not only in accessing as much data as possible, but also in keeping control of it, thereby impeding other companies, as well as peasants, from accessing it.

While farm hardware companies rejig their tools to control seeds, pesticides and fertilizers, the seed and pesticide majors use Big Data genomics to invade the fertilizer and irrigation sectors. The push by these larger seed and pesticide companies into Big Data sensors and genomics is clearly capturing turf from the traditional fertilizer industry. And although the combined sales of the top seed and pesticide companies are only a fraction of world fertilizer sales, the fertilizer industry has long been a bulk commodity business that has invested little in terms of research and development (R&D), and has therefore been caught off guard by these invasions from other sectors.

One of the best examples of a horizontal and vertical merger within the industrial food chain played out in the fertilizer industry in January 2018, when a new entity, *Nutrien* united *Agrium* and *PotashCorp*, the second and fourth largest fertilizer companies in the world, making it number one. More than a crop nutrient manufacturer, *Nutrien* has extensive international retail operations and describes itself as "the world's largest provider of crop inputs". Another example comes from the former *Monsanto*, which back in 2013 spent US-$930 million to buy *Climate Corporation*, the agricultural sector's most advanced data analytics company. That same year, *Monsanto* struck deals to access plant microbes and screening processes[40] and launched a joint venture with the world's largest enzyme producer, *Novozymes*.[41] It also invested in fertilizer companies and at least three other US and European data startups[42] that analyze water usage and overall farm management.[43]

Beyond fertilizer and water, pesticides also play a role in terms of how vertical integration takes place: *Monsanto's* new owner, *Bayer*, spent US-$425 million in 2013 acquiring a microbial pesticide company, and, two years later, bought an Argentinean company focusing on biological seed treatments. A year later, *Bayer* made a deal with a US company to 'optimize' soil microbes,[44] and, in the same year, bought a firm using satellites to assess soil electrical conductivity and field-level weather information.[45] In 2017, *Bayer* invested in nitrogen-fixing microbials. As is typical of a platform technology, *Bayer* even reached across industrial sectors to partner with *Planetary Resources*, a company best known for its research into asteroid mining, to use the startup's satellites and hyperspectral sensing tech to report on soil temperature and moisture.[46]

Microbial collaboration was also pursued by *Corteva Agriscience*, which first acquired two microbial producers, one British and one US,[47, 48] in 2015 and 2017, then started collaborations with two other companies to develop soybean and maize seed treatments, and also laid down US-$300 million to buy a farm analytics company.

Another way of using the software of the Big Data platform is to identify and distinguish between crop plants and weeds. This is being done by *BASF* on the basis of a self-teaching supercomputer and *Facebook's* imaging technology in a system called Maglis. Meanwhile, *ChemChina-Syngenta* has acquired a high resolution satellite and drone startup that analyzes crops based on patterns of light absorption.

Most of the scientific breakthroughs, however, are linking crop and livestock genomics companies with food processors and retailers. As pointed out, *Nestlé* has not only harnessed Big Data (including robotics and sensors) to streamline manufacturing, but is also taking advantage of digital DNA technologies (and Big Data genomics) to modify raw materials such as cocoa and coffee.

39 Ibid.

40 Anonymous, "Monsanto Buys Agradis Assets and Teams Up with SGI", GEN – Genetic Engineering and Biotechnology News, January 31, 2013: https://www.genengnews.com/gen-news-highlights/monsanto-buys-agradis-assets-and-teams-up-with-sgi/81247932.

41 Monsanto, "Monsanto Growth Ventures Announces First Investment Portfolio", January 6, 2016: https://monsanto.com/news-releases/monsanto-growth-ventures-announces-first-investment-portfolio/.

42 Ibid.

43 Ibid.

44 Bayer Crop Science, "New Research Looks to Improve Crop Yields", September 1, 2015: http://www.elementalenzymes.com/assets/bcs-and-elemental-enzymes-collaboration-release.pdf.

45 Bayer Global, "Bayer bolsters digital farming through acquisition of software provider proPlant", February 15, 2016: https://innovate.bayer.com/news-and-events/news/bayer-bolsters-digital-farming-through-acquisition-of-software-provider-proplant.

46 Louisa Burgoud Taylor, "Bayer Adds to Digital Farming Business with Planetary Resources Partnership as Start-up Raises $21m Series A", Agfunder News, June 2, 2017: https://agfundernews.com/bayer-adds-to-digital-farming-business-with-planetary-resources-partnership-as-startup-raises-21m-series-a5941.html.

47 Dupont, "DuPont Acquires Taxon Biosciences Inc.", April 22, 2015: http://www.dupont.com/corporate-functions/media-center/press-releases/dupont-acquires-taxon-biosciences.html.

48 Dow AgroSciences News Room, "Dow AgroSciences, Synthace Research Collaboration to Accelerate Product Development Using High Tech Tools", October 1, 2015: http://www.dowagro.com/en-us/newsroom/pressreleases/2015/10/dow-agrosciences-synthace-research-collaboration-to-accelerate-product-development-using-high-tech-tools.

Blockchains

Blockchains (i. e. distributive ledgers) are electronic databases of transactions. Contracts or agreements can be uploaded to the chain, where they are stamped and secured by a mathematical equation. The database is shared among numerous 'nodes' or 'miners' on the network. They can range from 'cottage industries' operating out of a private apartment to large-scale factory enterprises operating near a cheap energy source. The nodes or miners use their computer power to process the complex equations that confirm the authenticity of the ledger entry. This makes tampering with the equation arduous – but not necessarily impossible – thus reducing the likelihood that a gatecrasher will steal or alter the deal.

For a fee, miners race to verify and decode transactions. The result is appended as a 'block' to the chain. The ability of blockchains to offer a verifiable public record of transactions between either known or anonymous persons or parties that do not trust one another is their value; in communities where people know one another, blockchains may have no use. Proponents claim that blockchains can do for the nearly free and frictionless transfer of assets what the Internet did for the nearly free and frictionless transfer of information. 'Frictionless' here does not mean 'without energy', however, since the transactions – which demand massive quantities of computation, transmission, and long-term information storage – require enormous quantities of energy. The participants in a blockchain can also choose to either be identified or to remain anonymous, making it a medium of choice for the informal market. In some cases, it also seems that the number of nodes or miners along the chain might be controllable and limited, thus creating the illusion of immutability even when manipulations may actually be possible.

These are still early days for blockchains, but we have to assess this technology in the context of today's vertically integrated food supply chains that are controlled by a handful of transnational companies. It is already very clear that agribusiness, food companies and major financial institutions believe that they can cut their transaction costs by 20–40 %, or possibly more under some conditions, and they will continue to use blockchains to their own – often exclusive – advantage. It is therefore likely that blockchains will become an important part of significant trades or transactions along the industrial food chain.

Fintech

New management technologies

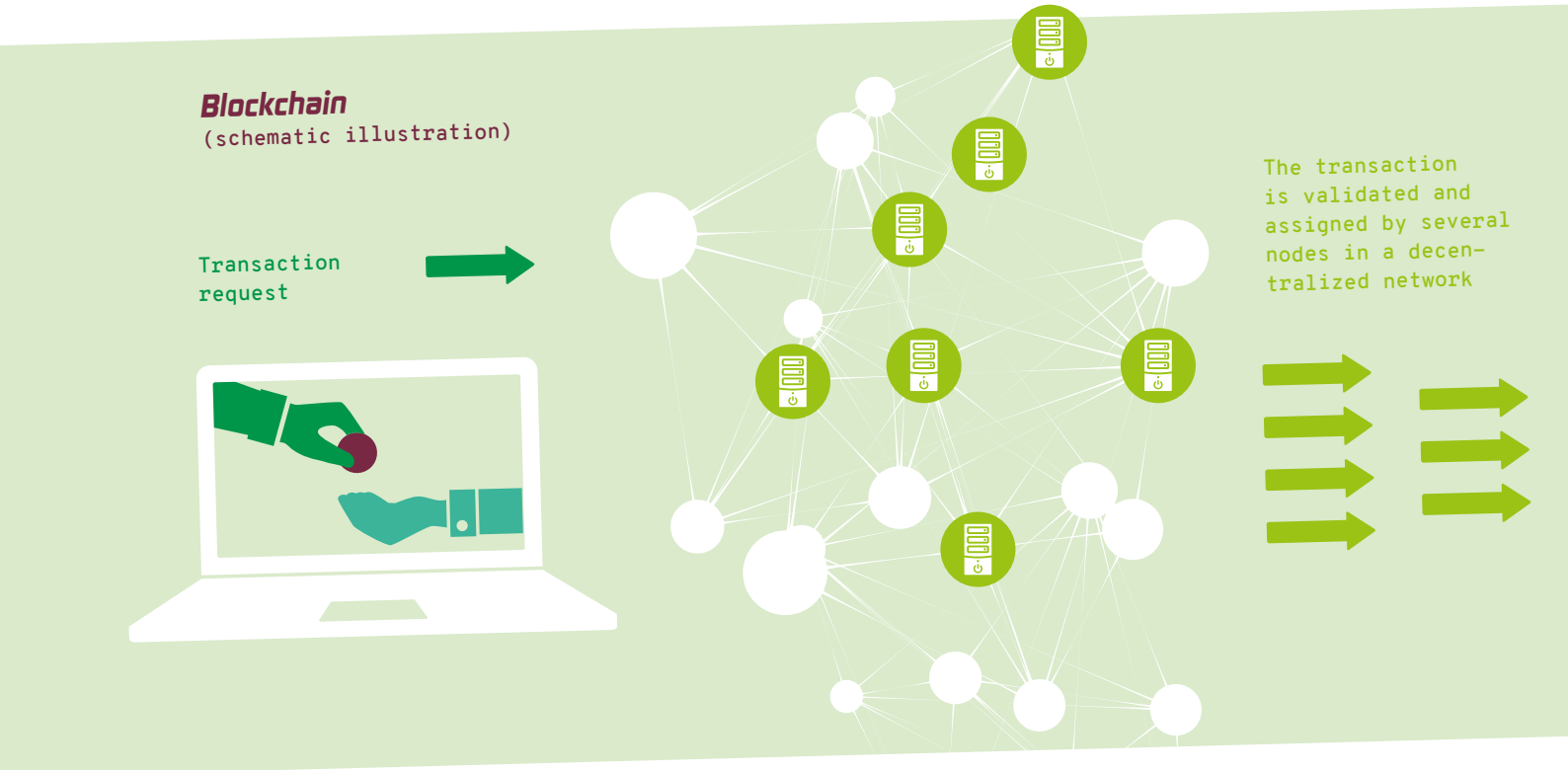
A third dimension on which the industrial food chain is focused is fintech, which includes blockchains and cryptocurrencies – Big Data tools that allow key players to manage not just individual links along the food chain but also their interrelationships. In the context of fintech, agribusiness companies are working with all of the new technologies already discussed, but in a much wider context.

The French retailer *Carrefour*, for example, is sharing data with the largest British food retailer, *Tesco*, and can use blockchains to extract data from its customers in order to advise *Danone* to process more organic yogurt. *Danone* can manipulate the same blockchain to make the merged *Bayer-Monsanto* breed organic soybean varieties, which means that *CNH* will recalibrate its seeders while the commodity trader *Louis Dreyfus* is advised by the blockchain to ready its storage elevators, and the auditing and management consulting enterprise *PriceWaterhouseCoopers (PwC)*, accessing the blockchain, can guesstimate weather conditions. In this way, all of these major actors will jointly activate an automated trade for soybean futures.

This is not theoretical. At the beginning of 2018, a shipment of soybeans was completed on a blockchain platform managed by *Easy Trading Connect*, which digitally handled the certificates for the international movement of soybeans from the US to China, negotiated with *Louis Dreyfus*, *Shandong Bohi Industry*, *ING*, *Société Générale* and *ABN-AMRO*. According to *Louis Dreyfus* and others, using the blockchain cut both time and costs enormously.

Cryptocurrencies

Cryptocurrencies operate through blockchains that verify buyer–seller transactions on the Internet. A cryptocurrency can be used to buy anything from a cup of coffee to a car, within a community or around the world, as long as both parties agree. There are several hundred more cryptocurrencies today than there are national currencies. As with the broader concept of blockchains, it is likely that one or more of the coins will survive and thrive as a credible medium of exchange. The most well-known cryptocurrency is Bitcoin.



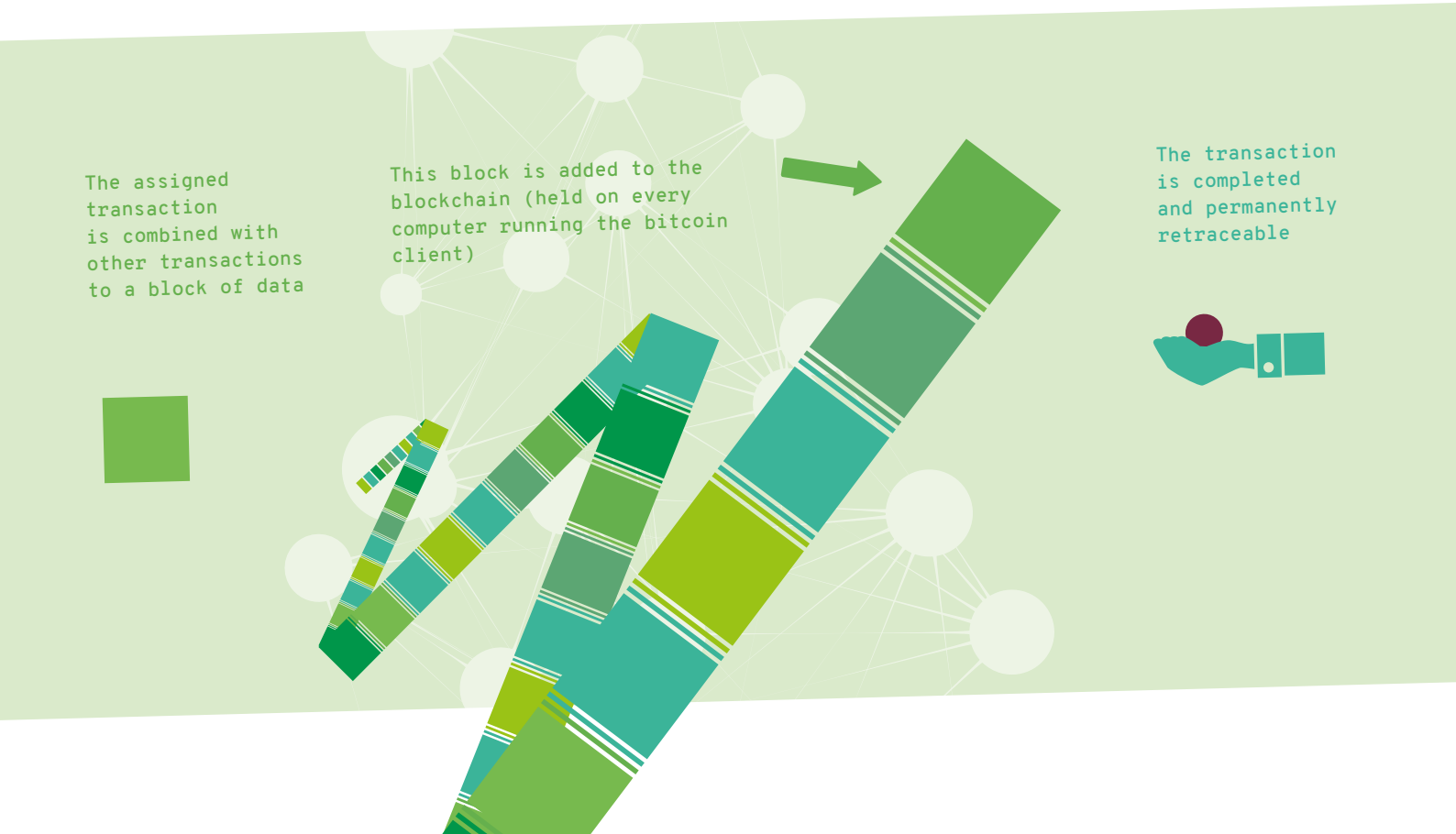
Blockchains and cryptocurrencies have attracted the support of both libertarians – who see fintech as a way of reducing or eliminating government interference as well as breaking up market oligopolies – and some on the left – who see the technologies as a way to subvert capitalism. History suggests that both of these assumptions are naïve. At different times, poets, politicians and populists have all claimed that first the telegraph, then the radio, then television, and more recently the Internet would create at least more equal societies, if not world peace. So far, however, the use of blockchains and cryptocurrencies, rather than decentralizing power, seems to encourage concentration. The world's most famous cryptocurrency, Bitcoin, is a good bad example. Forty percent of all Bitcoins are held by about 1,000 individuals, the top 100 of whom control 17.3 % of all Bitcoins. Just 100 players control 40 % of one of Bitcoin's major rivals, Ethereum, and in the case of three other rivals, the top players control around 90 % of the cryptocurrencies.[49]

Blockchain technologies are not the exclusive preserve of multinational commodity traders; governments, peasants and producer cooperatives could also make use of them. The state government of Andhra Pradesh (India), for example, is committed to shifting to what it describes as agroecological production; as part of its strategy, it is partnering with the Swedish startup *ChromaWay* to design a blockchain system for land registration and records. In theory, the blockchain, controlled by peasants with cell phones, could cut out middlemen profit takers, while also saving time and improving markets.[50] If it works, some hope that a blockchain could track the flow of India's agricultural subsidies (worth US-$4.9 billion in 2017–18),[51] so that more of the subsidies will actually find their way to peasants. A similar initiative is under construction in Peru, where Silicon Valley entrepreneurs have joined forces with local economists to build a blockchain to register land titles, in the hope of extending the technology to a wider range of market

49 Olga Kharif, "The Bitcoin Whales: 1,000 People Who Own 40 Percent of the Market", Bloomberg Businessweek, December 8, 2017: https://www.bloomberg.com/news/articles/2017-12-08/the-bitcoin-whales-1-000-people-who-own-40-percent-of-the-market.

50 Chloe Cornish, "Ag Tech Fundraising Doubles As Farmers Seek Disruptive Solutions", Financial Times, January 8, 2018: https://www.ft.com/content/02950380-d6f2-11e7-a303-9060cb1e5f44.

51 Alekh Sanghera, "How Adoption of Blockchain Technology Will Disrupt Agriculture: Understanding the Implications of Blockchain Technology in Agriculture", Inc42 Media, January 17, 2018: https://inc42.com/resources/blockchain-technology-agriculture/.



transactions. Although local civil society organizations are rightfully suspicious, the Peru's "Potato Park" (a protected agroecological region aimed at safeguarding essential agrobiodiversity and conserving traditional culture, knowledge and livelihoods) is eager to experiment with its own blockchain approach controlled by peasant members.

Advocates insist that blockchains and the other elements of fintech should be able to reduce or eliminate the estimated US-$30-US-$40 billion in counterfeit food trade around the world and possibly take a bite out of the estimated US-$1.2 trillion in food waste by using blockchain transparency to name and shame the wastrels. Illegal logging and illegal fishing might also be exposed through blockchains.

Blockchains, and with them cryptocurrencies, can be further used in scientific management and intellectual property interests relevant to biological diversity – including the genomes, gene sequences and genes vital to crops and livestock.

In January 2018, the World Economic Forum (WEF) proposed a new facility, the Earth Bank of Codes (EBC). If operationalized, this could place all genomic information onto a blockchain to ensure that "nature's biological and biomimetic assets [are] accessible to innovators around the world, while tackling bio-piracy and ensur-

Impacts and implications

Platforms and/or peasants?

"The amount of intelligence on this combine is 5 million lines of code. The first space shuttle that went up had a half-million lines of code."[53]
Eric Hansotia, Senior Vice President of AGCO

Underlying this report is a skepticism of the Big Data platform, its specific technologies, the advance of corporate concentration, and the very nature of global capitalism. But this report also acknowledges that while history is a good teacher, those who experience history are often unreliable messengers.

A platform technology introduced into a society that is not equitable will strengthen the wealthy and weaken the marginalized, and a platform need not be scientifically true nor technologically practical in order to be disruptive and profitable. As long as the technology is pushed by a few profit-driven corporations and does not come under the control of those social groups affected by them (e. g. agrarian producers and food workers), then it cannot benefit the majority.

From these two assumptions, other points arise: mammoth technologies cannot be entrusted to monoliths, and unequal power distorts 'sound science' and 'evidence-based decision making' into political opportunism. Although there are some inherently negative technologies and technological uses, even beneficial technologies can, in the wrong hands, be weaponized against society. This final statement assumes, nevertheless, that a technology, in an equitable society, can be beneficial.

These are controversial statements. After all, global life expectancy is increasing by leaps and bounds while the absolute number of the world population that is hungry or experiencing extreme poverty seems to reduce long term. Techno-enthusiasts claim these

ing equitable sharing of the commercial benefits".[52] The EBC would act as a distributed ledger for verified access to genomic sequences and, in time, would likely connect to cryptocurrency generation. Researchers wanting to access genomic information on the EBC blockchain would have to accept a 'smart contract' – self-executing legal codes with the conditions written into the blockchain.

There is no doubt that blockchains – and with blockchains, cryptocurrencies – will become a significant part of financial and legal transactions within the next decade. If energy costs remain high, fintech will be confined to governments and major corporations. But if energy costs are lowered (which is possible), then the impact of fintech will widen. In either scenario, fintech will inevitably reduce the transaction costs of major corporations, though without improving transparency and to the disadvantage of (already) marginalized peoples. Within the framework of agriculture, while it is possible to consider the use of blockchains and cryptocurrencies between and among peasants, cooperatives and local markets, these theoretical positives will be overwhelmed by their negatives if fintech is dominated by the industrial food chain.

52 Earth Bank of Codes: https://www.earthbankofcodes.org/.

improvements as proof of technological success. Critics would be foolish to just disagree. After all, we should not be surprised that the accumulation of knowledge has advanced human progress. Critics of both capitalism and hyper-technologies can argue, instead, that it is surprising that the pace of human progress has been so uneven, so negligent of marginalized peoples, and so destructive to the environment. Humanity could achieve much more if the world were more equitable and technologies were developed at the service of human interests.

Just to highlight one other case: The pharmaceutical industry takes credit for the vanquishing of childhood diseases and a major increase in lifespan especially in the first half of the 20th century. However, the major changes in children's health in industrialized countries came with simple improvements in sanitation, access to clean water, education, and some improvements in nutrition – mostly classical fields of public services. Still, today, the vast majority of medical breakthroughs come through public research that is surrendered to the private sector for commercial exploitation.

Meanwhile, new technological platforms are routinely used to advance vertical and horizontal integration and eliminate competition. When Andrew Carnegie gained control of a new steelmaking process, he was able to use the technique to build his own railway system and block competitors from accessing either his steel or his railways. John D. Rockefeller used his dominance of fossil carbon the same way and when his control was finally broken up by the US government, he was able to manipulate the market change to increase his wealth. Jeff Bezos at *Amazon* and Mark Zuckerberg at *Facebook* are similarly positioned. The Internet services their companies provide have not benefited the marginalized in the sense of equalizing societies.[54]

53 Tim Hearden, "R&D: Building a better piece of equipment", Capital Press, February 15, 2018: http://www.capitalpress.com/SpecialSections/western_innovator/20180215/rd-building-a-better-piece-of-equipment.

54 Alexander van Deursen und Ellen Helsper, "Third-level digital divide: who benefits most from being online", Communication and Information Technologies Annual: Digital Distinctions and Inequalities, Studies in Media and Communications, edition 10, p. 29–52, December 2015.

Platforms

Links without limits

By definition, a platform is sufficiently broad to catalyze changes in several market sectors. The new Big Data platform is already demonstrating this capacity, as various examples show. Generally, *Amazon* might be one of the most advanced in this regard: together with *Apple* and *Netflix*, it is expanding from an information conduit into a content producer. Consequently, media and telecom companies from *Comcast* and *Disney* to *Qualcomm* and *Star* are merging and bridging. Furthermore, *Amazon's* Big Data control is spurring giant private US hospital/clinic companies to merge with health insurance providers, drug price negotiating companies and medical suppliers, while food retailers and delivery companies are merging and expanding into healthcare and other services.

At the same time, companies that have historically serviced the world's largest multinational corporations are merging, both horizontally and vertically, trying to become 'one-stop-service centres' for multinationals. The companies are motivated by the massively enhanced potential to mine information from Big Data and the new social media opportunities afforded by the Internet. Thus, the world's top three management consulting firms are locked in battle with the world's top four accounting companies, and these two sectors are simultaneously encroaching on the world's top five advertising enterprises. At the same time, the traditional consulting and accounting companies are competing with the much more diversified – yet very powerful – international corporate law firms[55] as well as the world's top five executive search companies. Among these sectors, the most disadvantaged are the traditional advertising agencies, which are under attack from the consulting/accounting firms as well as from the new IT giants – *Google*, *Amazon* and *Facebook* – that are revolutionizing consumer marketing.

For agribusiness, the new opportunities created by the liberalization of satellite access early in the 21st century, combined with the development of Big Data in machinery and genomics, led to a series of joint ventures and mergers, and then to a burst of mega-mergers launched in 2015, as well as further chain reactions in the fertilizer and commodity trade links in 2017.

Without intergovernmental regulation, the Big Data platform has no natural limits. Logically, governments must eventually intervene. For food sovereignty, it is essential that the interventions be immediate and deep.

Big Data

The limits to graphs

In an interview in 2017, the CEO of *IBM* famously declared that fully 20 % of the world's data is computerized.[56] At around the same time, *IBM* announced that farms will yield 20 times more data in 2050 than in 2014.[57] These two calculations do not compute. The industrial food chain does not know what it does not know. Furthermore, companies may have clouds full of data, but that does not necessarily help peasants concerned with family nutrition and local markets, who feed a large portion of humanity.

For example, with almost half of all private sector agricultural research concentrating on one single crop – maize – these plant breeding companies' interest in the 7,000 other food species grown by peasants (under conditions that no robot has yet tread) is negligible. This could lead to governments further marginalizing these 'other crops' in order to create space for more commercial crops.

Furthermore, agribusiness may not know that it sometimes has the wrong data. In 2010, *Monsanto* began crunching 15 years of data using algorithms to adapt its GM maize varieties to each season's predicted diseases. Then, one year, the algorithm neglected to include the Goss's wilt disease in its plant breeding calculations, leading to significant crop losses. More recently, *John Deere's Blue River* subsidiary sent robots trundling through Australia's cotton fields to take more than 100,000 digital photos of the crop in all its stages. But when the company went back to the cotton fields of the American South, the robots' 'see and spray' technology hosed down healthy cotton plants and spared the weeds. Whether the technology misread the images because of

solar and climatic conditions or of something else is not clear, but the consequences were disastrous.

In time, Big Data enthusiasts assure us, robots and algorithms will figure it out. But in the meantime, both large-scale farmers and peasant families, either using the technology or exposed to it in adjacent fields, as well as agricultural biodiversity more broadly, could be wiped out. Powerful companies can use the theoretical potential of new technologies to persuade government regulators to create space for their new inventions in ways that can both directly and indirectly impact peasant producers and consumers. The parallel development of genetically modified crops with intellectual property regulations is an example of this impact.

Intellectual property 4.0

With the usage of Big Data in agriculture, the ever recurring topic of intellectual property comes up once again. During the 2018 WEF, the EBC proposed that blockchains and cryptocurrencies can make genomic information open source. By 'open source', however, the EBC presumes that 'improved' genomic information and materials can be patented and commercialized, as long as the original information and material remain available in the public domain. This has also been the presumption of all patent regimes, but the result for crops – both direct and indirect – has been the use of corporate influence, regulation, and even criminal law to marginalize and exclude non-proprietary information and products.

If agreed to by governments, the EBC could, de facto, commodify all of the world's biological diversity (known and not yet known), which could lead to a global biodiversity enclosure, i. e. intellectual property rights being held over all genes and data and/or their uses, which in turn could undermine the rights of peasants, indigenous peoples, and national governments to benefit from the diversity they have nurtured and cultivated.

To be more precise, new bio patents could come about simply by taking seeds or plant cuttings from a field or forest, assaying the DNA in the field or a local laboratory, and then uploading the digital information about the DNA to a cloud in Canada or elsewhere – without taking any of the genetic material out of the field. Then anyone with access to the cloud could download the digital information onto their laptop and use a gene synthesizer to sequence the specific part of the DNA that is of interest. This newly sequenced DNA would be patentable in many regimes, and in some intellectual property regimes every aspect of this process could have exclusive monopoly protection.

Data abuse

Since the early days of the 'open source' industrial revolution up to the heady days of garage computer builders and basement bio-hackers, everything has been open source until somebody finds a way to make money. Blockchains and cryptocurrencies have already been robbed, and data clouds have already been drained of their information. *Facebook* surrendered the data of 87 million facebook users to C*ambridge Analytica*.

When companies control data, they are likely to abuse it. In the first months of 2018, insider trading was suspected in 40 % of significant Wall Street stock deals (including mergers). Likewise, auditing firms that monitor 98 % of the world's largest companies still made serious accounting errors in 40 % of the audits.[58] In both cases, the bankers, brokers and auditors violated their trust to either pass on or suppress commercially important information.

This abuse is happening when information is passing between or being shared by different companies. Yet

55 Jennifer Brown, "Big four accounting firms well positioned to move in on big law", Canadian Lawyer, February 5, 2018: http://www.canadianlawyermag.com/legalfeeds/author/jennifer-brown/big-four-accounting-firms-well-positioned-to-move-in-on-big-law-15296/.

56 Anonymous, "Technology Has Upended the World's Advertising Giants", The Economist, March 28, 2018: https://www.economist.com/business/2018/03/28/technology-has-upended-the-worlds-advertising-giants; Elizabeth Gurdust, "IBM CEO Ginni Rometty Says 80 % of the World's Data Is Where the 'Real Gold' Is", CNBC, June 20, 2017: https://www.cnbc.com/2017/06/20/ibm-ceo-says-80-percent-of-the-worlds-data-is-where-the-real-gold-is.html.

57 Andrew Meola, "Why IoT, big data & smart farming are the future of agriculture", Business Insider, December 20, 2016: http://uk.businessinsider.com/internet-of-things-smart-agriculture-2016-10.

58 Oscar Williams-Grut, "Audits are meant to protect investors — but almost half have problems", Business Insider, March 12, 2018: http://www.businessinsider.com/ifiar-auditing-survey-2017-global-audit-problems-2018-3.

What companies have given us[59–61]

Companies promised:

In return, companies asked for:

- intellectual property rights over crops and livestock
- cross-cutting mergers between seeds and pesticides
- no competition with the public sector

agriculture's data cloud places a farm's planting, harvesting and trading data in the hands of one single company with strong commercial reasons to use and maintain exclusive control over the information. Thus the only ones left 'in the clouds' will be peasants.

Big Data technologies are already having effects on the production of high-value crops, livestock and fish, and will also impact peasants producing for the marketplace. Furthermore, Big Data control of plant varieties and crop chemicals etc. will have both a regulatory and environmental spillover impact on peasants who have no interest in using these commercial products. Additionally, Big Data – especially blockchains – can be used to manipulate markets and confound small producers. As use of the Big Data platform increases, producers – large or small – who do not accept the new technological platform will become even more marginalized in the marketplace and further subjected to regulatory regimes determined by the corporations.

Agriculture's Big Data strategy is being developed and commercialized in the Global North for the benefit of the Global North and its agribusinesses. Its targets are the largest farms, ranches and fisheries, and its clients are multinational agribusinesses. There is no reason to trust current and proposed Big Data information systems. The scope, storage (or not) and use of farms' and fisheries' information must be controlled (including determined and disseminated) by peasants and their organizations. Along with traditional and community information systems, some new data technologies may, theoretically, have local value and contribute to food sovereignty. One issue is the individual technology; a second issue is the political environment within which the technology is introduced.

Technologies

Assessing the limits

Without underestimating the importance of the Big Data platform, the related technologies each have their own impacts. The hardware machinery – robotics and sensors – are transforming the industrial food chain. The software genomics – gene editing and SynBio – are

changing the nature of food. And while fintech – blockchains and cryptocurrencies – is only beginning, it is already obvious that blockchains will allow those who manipulate them to have greater control over the marketplace and that cryptocurrencies could turn into company-controlled currency forcing producers to both buy and sell at the company store.

Historically, smallholder producers, or peasants, have been of limited interest to big companies because of the transaction costs in managing thousands or millions of small plots. Between aggregating data clouds, disaggregating robots, aerial drones, and satellite surveillance, size no longer matters. To *John Deere* or *Cargill*, *Nestlé*, *Amazon* or *PwC*, it's all about crunching data. The side effect, however, could mean the crushing of peasants.

A look into history shows that companies have promised a lot and given little, thus regulation is necessary to counteract company control. At the production end of the food system, over the past half-century, companies have promised society (1) greater food choices, (2) improved nutrition, and (3) food security, in return for (a) intellectual property rights over crops and livestock, (b) cross-cutting mergers between seeds and pesticides, and (c) the withdrawal of public sector competition. In reality, corporates have given the society (1) a loss of 75 % of the genetic diversity of our major food crops,[59] (2) a one-third 'implosion' in the diversity of foods actually consumed in most member states of the Organization for Economic Co-operation and Development (OECD),[60] (3) a 5–40 % nutritional decline in the remaining foods,[61] and (4) a world in which half of us are malnourished, either from a lack or an excess of food.[62] Along the way, however, (and at the

59 FAO, "Harvesting Nature's Diversity – Biodiversity to nurture people", 1993.

60 CIAT, CGIAR and Global Crop Diversity Trust, "New Study on Increasing Homogeneity within Global Food Supplies Warns of Serious Implications for Farming and Human Nutrition", March 3, 2014.

61 Donal Davis, "Declining Fruit and Vegetable Nutrient Composition: What Is the Evidence?", HortScience, 44, 1, 2009, pp. 15–19.

62 2 billion people are considered malnourished with micronutrient deficiencies; see World Health Organization, "Nutrition: Micronutrient deficiencies", 2017. 1.9 billion people in the world are overweight, which is also a form of malnutrition. See WHO, "Obesity and overweight", 2017.

moment) four companies – *Bayer* (including *Monsanto*), *BASF*, *Corteva Agriscience* and *ChemChina-Syngenta* – have gained oligopolistic control over more than two-thirds of commercial seed and pesticide sales, while decimating the innovative contribution of public sector researchers and threatening the 12,000-year-old right of peasants to breed, save and exchange their seeds. Allowing these same companies unregulated or inadequately regulated domination over powerful and untested gene editing and SynBio techniques – and then allowing these techniques to be linked to Big Data hardware – is highly risky.

From a point just a few years ago where policymakers and academics assumed that peasant food production was marginal to world food security, today study after study is confirming that peasants using only 25 % of the world's arable land are feeding somewhere between 66 % and 75 % of the world's people.[63]

The promise that Big Data technologies improve processing and retailing will not necessarily become true. Too many examples make us doubt the good intentions of big companies. These include the enormous quantities of food that are never consumed as well as the production of unhealthy products. Public trust in the self-regulation of the private sector is not increased when companies use the argument that it was not possible to control all suppliers along the production chain as a way to get around proving good working conditions in each production step. Big Data is now declared as the all-solving opportunity – but the use of data as such does not necessarily lead to producing food of higher quality under fairer working conditions.

The limits of robotics

With the usage of data collecting and AI farm machinery, it is not only the control of the data but also the decisions about production that will shift toward insurance companies. Large-scale farm machinery companies such as the German *Claas* or *Fendt* (the latter belonging to *AGCO*) are talking about swarms of multi-purpose field robots that would come together to manage big fields and then disassemble to take on smaller plots. The robots' sensors allow them to plant (so far) up to three different types of seeds (different species or varieties of the same species) in a single pass, while simultaneously injecting whatever pesticides and nutrients per plant that the algorithm recommends. During the growing season, either on-the-ground machines or their aerial cousins monitor the crops and can spray individual plants or plots. At harvest time, the same machine is back in the field registering yield (every few square centimeters), comparing the yield to its inputs and recording all of this in a proprietary cloud. This data is – from planting to harvest – linked to ever-changing weather and market information. All of this information is vital to the peasant community, but it is also valuable to commodity traders, food processors and retailers, as well as farm insurance companies. In countries where farm insurance is not a public service – or rather a public service not manipulated by the private sector – the production decision can be influenced (or controlled) by the insurer. Companies such as *BASF* and *John Deere* were already showing interest in the insurance industry even before the recent wave of agribusiness mergers and their interest may increase with another wave of consolidations.[64]

Future and quality of work

The wider issues around mergers, in general, and robotics, in particular, are about the future and quality of work. Fears that automation and robots would destroy jobs date back to Henry Ford's assembly-line and Frederick Winslow Taylor's efforts to roboticize workers a century ago. Most recently, some economists have calculated that approximately 47 % of jobs in industrialized countries could disappear with the latest generation of robots. While this concern cuts across every sector of the economy, most analysts consider the food system to be particularly vulnerable. Fieldworkers are already at risk with robots moving in to harvest at least some fruit and vegetable crops. At the other end of the food chain, fast food workers – both in the kitchen and at the counter – are considered ripe for replacement. *Amazon* has already introduced the first – though experimental – supermarket that doesn't require checkout workers. Food workers on processing assembly lines, workers stocking shelves in supermarkets and others filling shipping orders in warehouses are seen to be among the first to lose their jobs, as robots become smarter.

During 2018, however, another round of studies has argued that robots are continuing to take over the jobs that are boring and dangerous and freeing employees to do more creative work. Fast food chains that are using robots to take over their kitchens claim they are putting more staff to work relating directly with customers. Even these techno-optimists, however, concede that ultimately there could be a net loss of jobs and the jobs remaining may not be accessible to the workers that have been pushed out by robots. From farmers and fishers to fast food workers, livelihoods are at risk and trade unions, governments, and societies need to address these risks.

The limits of gene editing and SynBio

Gene editing methods and SynBio enable pharmaceutical and agricultural companies to enhance their intellectual property with less risk. There is no doubting the power and potential of the suite of new genomic technologies brought forward by Big Data. As already described, with the new technologies it is possible to modify genomes relatively cheaply and easily, without moving genes from one species to another – the classical GMO model.

In theory, gene editing and SynBio could help respond to rapid climate change as well as changing demand, while giving us improved nutrition without synthetic fertilizers and chemical toxins. The technologies could also create diversity and reduce the need for agricultural land, making more space for nature. Nonetheless there remain issues of safety and ownership concerning the use of gene editing methods. Gene editing is already becoming the proprietary tool of the world's most powerful pharmaceutical and agricultural companies. Although science is cautious about experimenting on people, it is willing to experiment with nature. It is almost inevitable that we will discover – perhaps too late – that the techniques are not as predictable or retractable as we have been told. The negative implications go far beyond traditional GMOs or even terminator (suicide) seeds.

The precautionary principle should lead us to the conclusion that unknown but powerful technologies should not be introduced without regulation or necessity. Furthermore, and as we have already argued, mammoth technologies should not be surrendered to monopolistic enterprises.

The limits of blockchains and cryptocurrencies

Blockchains and cryptocurrencies are – so far – very marginal in the marketplace, including in agriculture, but will in the long run be of profit to bankers, while disadvantaging the already marginalized. This is important to remember, especially as blockchains are promoted for use by peasants, for instance to resist the power of intermediaries and to better self-organize. When selling to diverse and complex markets and when buying from farm machinery companies, peasant organizations could establish their own blockchains (theoretically) according to their needs, although they would have to be wary of hackers and especially concerned about cryptocurrencies.

There is, however, enormous risk in adopting these technologies at this early stage. In their short careers, blockchains have been shown to be far from invincible and cryptocoins (the tokens of cryptocurrencies) have often either vanished or been stolen. While peasants in Peru or India may be able to organize a march on a local land registration office in order to get their land back, they are unlikely to find the street address of a cryptocurrency manager or a blockchain hacker that stole their money or their land. After all, no one knows the actual location of the mystical inventor of Bitcoin, and Vitalik Buterin, the 24-year-old inventor of its biggest rival, Ethereum (valued at US-$125 billion), has no fixed address.[65]

63 ETC Group, "Who Will Feed Us?", 2017: http://www.etcgroup.org/whowillfeedus.

64 BASF, "John Deere announces new private crop insurance policy", December 19, 2014: https://www.basf.com/us/en/company/news-and-media/news-releases/2014/12/P-13-717.html.

65 Chloe Cornish, "Ethereum's Vitalik Buterin on the Bitcoin Bubble and Running a $125bn Blockchain", Financial Times, April 19, 2018.

Between December 2017 and February 2018, cryptocurrency transactions lost – as in 'disappeared' – US-$530 million in Japan; the value of Bitcoins tumbled by 70 %; and thousands of Bitcoin purchasers were double billed (sometimes up to 50 times)[66] over the course of three weeks in 2018. Since 2014, cryptocurrency clearinghouses have lost US-$1.4 billion, half of which slipped away in the first two months of 2018.[67] Famously, a London stockbroker and a professor at the London School of Economics tried to settle the actual value of a Bitcoin (trading at US-$8,000 that evening) over a bottle of wine. Their sober assessment: about US-$20 – considerably less than the wine bill.[68]

Furthermore, blockchains are not the fast and cheap tools that they were originally assumed. As more blockchains and cryptocurrencies come into play, the time and energy costs required to maintain them are increasing dramatically. A single Bitcoin transaction sucks up the energy necessary to run an average-sized American household for one week.[69] In a year, Bitcoin mining uses as much energy as the whole of Nigeria (a country of 186 million people)[70] or Colombia.[71]

Anybody who wants to 'bet the farm' on a cryptocoin is taking an unconscionable risk. Nevertheless, it is likely that the monstrous energy costs involved in this technology will be reduced. And as with the broader concept of blockchains, it is also likely that one or more cryptocurrencies will survive and thrive as a credible medium of exchange. That day has not yet arrived, but when it does, it will not be the libertarian triumph over the banks that some hope; it will more likely be a banker's tool to reduce transaction costs while maintaining and consolidating the control that the banks currently enjoy.

Concentration

The limits to gross

The most significant impact of the seed and pesticide mega-mergers is that they have created the space for still more – and bigger – mergers. Food chain consolidation is not over. Those who find the kind of concentration discussed here hard to swallow should look to the mergers of the last few decades: 7,000 plant breeding entities have effectively become four; 65 pesticide producers have become nine; seeds have merged with pesticides and corner shops have become *Amazon*. Along the way, we have learned that scale does not strengthen innovation, but it does reduce employment and destroy rural livelihoods.

Links in the industrial food chain have always moved from 'field to fork', passing (simplistically) from producers through traders and processors to retailers; or (with complexity) from soil and water to so-called plant nutrients (fertilizers) and plant defenders (pesticides) and breeders, to seeds supported by farm machinery, to a network of middlemen transporters and traders, through commodity exchanges (markets), to multi-sourcing processors, and onward to grocery stores, restaurants, food services and food delivery to consumers. Complex or simple, each link depends on production, market and weather data. And at each node of the chain, hubs form where particular interests and needs – both physical and practical, and informational and developmental – come together.

The four major input companies (following the mega-mergers) are fighting to control the software hub that coalesces the genomics information expressed by plant seeds and livestock breeds. Water, veterinary medicine, fertilizer and pesticide formulations all depend upon the end product genomics. There is a second hub around farm machinery (the 'tank' that plants the inputs, that is, seeds, pesticides, fertilizers, and harvests the outputs), which can coalesce the data from every production location and forward it wherever it wishes. Because it is further down the food chain, the hardware hub has access to more information and may dominate its software antecedent.

Further along the chain, there is a hub around food and beverage processors who have increasing choices nowadays regarding the origin and nature of their raw materials. They see 'food' as a negotiable (malleable) compilation of extractable bulk and flavor (i. e. carbohydrates, proteins, oils, and taste/texture additives), dependent on price and processing, and derived from a variety of carbon sources. The processing combinations can be adapted to shifting consumer demand, and/or consumer tastes can be adapted to evolving technologies and processor preferences.

Two links along the chain – both of them once hubs – are now vulnerable. The middlemen commodity traders who once had specialist production and market knowledge and political access have lost their unique position and cannot match the Big Data commanded by either the input or the processing hubs. The ABCD companies (*Archer Daniels Midland*, *Bunge*, *Cargill* and *Louis Dreyfus*) have transportation competence, but less valuable information. And in the end, the chain's 'final mile' is confounded by technological choices where *Walmart* must compete with *Amazon* and *Uber* – and even direct delivery by *Nestlé* and *Coca-Cola*. The Big Data platform may turn the current food chain oligopoly into a duopoly, where each hub will be dominated by two companies, uneasily negotiating to determine what food will be harvested from the fields and oceans and what will be brewed and baked by robots.

This is not to suggest that the future is certain. In mid-2018 – on the verge of a full-blown trade war and and with a nervous economy – nothing is certain. For the immediate future, it is reasonable to assume that the seed/pesticide and fertilizer sectors will have to digest their acquisitions before considering other moves. Still at the input end, the farm machinery companies are hoping that 2018 will give them solace to recover from the downturn that has haunted their sales for the last four years. While they are making modest acquisitions and joint ventures, they will be reluctant to consider major M&As until the agricultural trade environment stabilizes.

Even with 2018's trade uncertainties, the big commodity traders may feel they have to move. They have been late coming to the Big Data game and they need to find at least some sanctuary by buying into other parts of the chain. The biggest food and beverage processors and retailers are as jittery as the commodity traders but for different reasons. While they have the deep pockets and the experience to benefit from Big Data, they are losing market share to much smaller startup companies offering consumers more nutritious and more diverse food choices. Alarmed, these companies are moving fast buying up promising new companies and updating their market strategies. Big Data is one of their greatest strengths and best hope for maintaining control over their part of the food chain.

In the midst of this uncertainty, the industrial food chain has become extraordinarily opaque. Where market analysts and investment houses once exchanged information freely or at little cost, this information is now firmly part of their Big Data strategies and no longer available to civil society or governments. Beyond the annual reports of individual companies it is now much harder to understand market shares. The confusion is compounded by China: four or five years ago, China seemed to be mostly a closed food system and most observers had little knowledge of its internal workings. Today, China is a critical factor in everybody's agricultural calculations, but few understand corporate governance structures within China. *ChemChina* may own *Syngenta* but does *Sinochem* control *ChemChina-Syngenta*?

So, even as the big companies consolidate, their market share could wax or wane as everybody adjusts to the Big Data platform and unpredictable economic conditions. Never have multinational agribusinesses seemed so vulnerable. As we discuss in the next section, this may be society's best opportunity to reassert some control over our food future.

66 Paul Vigna, "Bitcoin's Latest Glitch: Double Charges at Fast-growing Coinbase", Wall Street Journal, February 16, 2018: https://www.wsj.com/articles/bitcoins-latest-glitch-double-charges-at-fast-growing-coinbase-1518811376.

67 Paul Vigna, "Crypto Investing Comes with a Big Risk: The Exchanges", Wall Street Journal, March 3, 2018: https://www.wsj.com/articles/crypto-investing-comes-with-a-big-risk-the-exchanges-1520078400.

68 Lionel Laurent, "What Bitcoin Is Really Worth May No Longer Be Such a Mystery", Bloomberg, April 19, 2018: https://www.bloomberg.com/news/features/2018-04-19/what-bitcoin-is-really-worth-may-no-longer-be-such-a-mystery.

69 Christopher Malmo, "One Bitcoin Transaction Now Uses as Much Energy as Your House in a Week", VICE Motherboard, November 1, 2017: https://motherboard.vice.com/en_us/article/ywbbpm/bitcoin-mining-electricity-consumption-ethereum-energy-climate-change.

70 Ibid.

71 Digiconomist, "Bitcoin Energy Consumption Index", 2018: https://digiconomist.net/bitcoin-energy-consumption.

Food sovereignty solutions

Blocking the platform and breaking the chain

"Why do we need a Code of Conduct to obey the law?"[72]
Věra Jourová, EU Commissioner for Justice, Consumers and Gender Equality, commenting on the practice of food processing companies reducing food standards for their branded products in the Czech Republic in 2017

In a 2014 review of the mergers and acquisitions (M&As) scene, the OECD noted that the overall trend among antitrust/competition regulators was favorable to larger and broader M&As; that pressure to control new technologies is a driving force behind M&As; and that (with approval) the merging companies' home countries should lead when adjudicating M&As in order for everyone to avoid delays and conflicting divestiture demands. Although the OECD identified the growing importance of technology, it accepted that the scope and implications of new technologies are always unclear.

In this section, we outline our vision to counter the aforementioned tendencies of duopolisation in the industrial food chain, diminishing public control, increasing property rights on seeds and genomes etc. we argue that several developments are necessary, amongst them a strengthened community-based agriculture, as well as stronger antitrust regulations on the national, regional and international levels. These should enable more transparency, should take into account the implications for human rights and nature, as well as the right to debundle companies that have become too big.

Responses on the ground

The peasant wide web

Food sovereignty, including peasant-led agroecology, should be the basis for the creation of national food policies, with gender equity and community resilience strengthening cooperation instead of competition.

In its 2017 report "Who Will Feed Us?", ETC Group juxtaposes the industrial food chain to the peasant food web, providing evidence to show that while peasants (including farmers, fishers, urban growers, agricultural workers, pastoralists and forest harvesters) produce most of the food that feeds more than two-thirds of the world's peoples, the industrial food chain occupies 75 % of arable land and uses most of the fossil fuels and chemicals ascribed to agriculture.[73]

While the industrial food chain is linear, the complex reciprocities of peasant production and consumption are more realistically understood as a web. Not only are farmers often fishers but – depending on the season and the economy – rural producers are often urban consumers. Production is sometimes for the family, sometimes for the community, and sometimes for far-off markets.

Food sovereignty takes a 'wide-tech' approach to innovation, emphasizing integrated, macro-technological change at the micro (farm or community) scale. Conversely, the industrial food chain privileges 'high-tech' lab-based innovations, where micro adjustments to DNA and data can have macro market impacts around the world. Importantly, the notion of a 'peasant wide web' is not a rejection of high-tech, but it does set the framework within which high-tech can be evaluated, and it places the priority on communities and cooperation.

For this to work, process is critical. The laws and finances guiding competition and technology should be set within citizen-led food policies. Production will emphasize near and local procurement, including markets and community supported agriculture, encouraging agro-biodiversity and culturally appropriate nutrition. Local and national food policy councils can be a useful tool to democratize food production from below. Production, processing and marketing cooperatives should be encouraged at the local level, along with local businesses. An important strength of the local market focus is the potential for innovative exchanges among markets that take full advantage of useful new technologies. This does not preclude (or assume) that new management techniques such as blockchains and cryptocurrencies could, ultimately, be constructive under local control. But those who work in agriculture and the food system, be it as peasants or through wage work, must have a critical voice.

72 Daniel Buffey, "Food brands 'cheat' eastern European shoppers with inferior products", The Guardian, September 15, 2017: https://www.theguardian.com/inequality/2017/sep/15/food-brands-accused-of-selling-inferior-versions-in-eastern-europe.

73 ETC Group, "Who Will Feed Us?", 2017: http://www.etcgroup.org/whowillfeedus.

National and regional responses

People before profit

Sovereign states or regional intergovernmental bodies should establish their own legislation and regulations concerning competition policy (including M&As) and technology assessment. The World Trade Organization (WTO) should not play any role in these regulatory initiatives since it is largely mistrusted by the Global South and considered ineffective by the Global North.

There is an erroneous assumption that Washington and Brussels set the parameters for global competition policy and approve or reject M&As. The recent wave of seed and pesticide mega-mergers depended on at least 30 countries for approval. The governments of Argentina, Brazil, China and India, which together account for one-third (and growing) of global pesticide sales, were vital actors, and shareholders would have rejected a merger that had been blocked by any two (perhaps even one) of these countries.

The recent spate of mergers across sectors has, however, caused governments and academics, from left to right, to wonder if their policies are flawed and accept that controls over concentration must be tightened. There is, for instance, growing recognition that the spin-off effects of seed and pesticide concentration have been a decline in genuine innovation, damage to biodiversity, and a threat to security.

National or regional competition policies should ensure the right of peasants to save and exchange seed, do their own plant and livestock breeding, and have facilitated access to markets and finance. Governments should block all cross-sector mergers (such as farm machinery with seeds/pesticides or crop insurance) and require full disclosure from companies based on the principle that market transparency and the public good supersede so-called proprietary business information. In determining the appropriateness of a merger, third parties (other companies, workers, potentially impacted sectors of society) must have facilitated access to the information, and full consideration should be given to immediate and potential health and environmental impacts along with economic issues and, more broadly, human rights. Particular attention must be paid to ownership and control of digital information, including genomic information, preferencing the right of society over the interests of shareholders. In short, a democratization of data control is needed. Consequences for national third party countries that are not the headquarters of either merging enterprises but are still significantly impacted have to be considered. Generally, if negative consequences are to be expected, the merger must not be approved. Furthermore, legal instruments should be put in place to allow for the unbundling of large corporations because of their size. Finally, the continuous digitization of agriculture must also be better monitored and accounted for, to impede the creation of new mega corporations.

Notwithstanding our support for the proposed international treaties outlined below, national states or regional intergovernmental organizations should have the possibility to implement stricter regulations.

International responses

UN treaties on competition and technology assessment

The United Nations (UN) should negotiate a treaty on competition and a treaty on technology assessment. Not all UN members must ratify these treaties for them to be effective.

Since the founding of the UN, industrialized countries (especially the USA) have expected it to address some of the outstanding concerns from the 1930s Great Depression, including the threat of economic disruption from new technologies and the need to supervise the big corporations developing them. By the beginning of the Thatcher/Reagan era (if not sooner), these concerns were dismissed by OECD states, and in the early 1990s,

the UN mechanisms created to track technologies and corporations were dismantled. The OECD, as well as the G-77 and China, all believed that their interests were better served without interventions by UN bodies.

With the 2008 financial crisis and the increased importance of so-called emerging economies, however, the situation has changed and there are strong reasons for all countries – but especially those in the Global South – to negotiate a UN Treaty on Competition as well as a UN Treaty on Technology Assessment.

At first glance, the notion of either treaty seems unlikely if not absurd. From the perspective of the OECD, the current informal process of vetting M&As – although messy and slow – is preferable to exposing competition policy to the political and economic chaos of the UN. Most (or all) OECD states would refuse to negotiate. From the perspective of the Global South, the price of getting OECD states to the table could be yet another surrender of national sovereignty.

These risks are real, but the reality remains that big countries and corporations are getting what they want now, while the Global South and marginalized peoples are losing out badly. The strong case for treaty negotiation is that the Global South has economic momentum (Africa, Asia and Latin America are, after all, where growth is expected) and the Global North cannot risk standing outside a treaty agreed by these markets.

Likewise, if a Global South-led Treaty on Technology Assessment were to place conditions (or a moratorium) on SynBio, gene editing or driverless tractors, it could render the technology commercially nonviable.

The elements of these treaties would be similar to the above mentioned proposals for national or regional legislation and regulation. However, the treaties would be confined to M&As and technologies with implications for more than single nation states or the scope of regional institutions such as the EU. Treaty provisions could still include conditions under which individual states could implement stricter regulation within their own territory.

The UN has many legally binding treaties that have not been signed by all of the major powers yet which still work well: for example, the US has never joined the CBD and it has made significant progress – many governments would agree – because the US has remained outside. Likewise, the International Treaty on Plant Genetic Resources for Food and Agriculture (Seed Treaty) functioned without US membership, and is now seen to be in serious difficulties since the US joined in 2016. The timetable for negotiating two (conceivably rolled into one) treaties will be long, but the negotiation process will have an immediate salutary impact on M&As and technology assessment.

The UN Conference on Trade and Development (UNCTAD) conducts useful work on restrictive business practices and has a Model Law on Competition Policy. UNCTAD also has a Commission on Science and Technology for Development (UNCSTD), which could provide helpful inputs on technology assessment. In addition, the UN Secretary General's new annual Forum on Science, Technology and Innovation (STI) and its Technology Facilitation Mechanism (TFM) has the interest and potential to take on both technology assessment and, possibly, corporate concentration. The STI Forum brings together all governments and at least 30 UN agencies and creates a special space for the so-called Major Groups associated with the UN (women, farmers, indigenous peoples, workers, business, academia, youth, civil society etc.). Perhaps most importantly, the STI (Science Technology and Innovation Forum of the UN) has attracted the interest of the newly evolving regionally-based technology assessment platforms in Africa, Asia and Latin America, which are collaborations of social movements and scientific unions, among others, that explicitly study the regional implications of new technologies. These new initiatives should be supported regionally and internationally, and they should have formal third party status in governmental review processes.

Concluding remarks

Blocking the chain with pressure from below

Stories of rockets sent to Mars based on knowledge generated through Big Data, of electric cars, spaceships and fintech, of satellites producing data on disease outbreaks, harvests and supposedly empty fields, of paperless trade with sequenced DNA and tailor made pesticides might increase. That hardware – robotics and its sensors – can be combined with software – gene editing methods that can compose DNA as wished – and with fintech – blockchains and cryptocurrencies – opens up incredible possibilities to bring together diverse collections of data. The question of who controls this data and thus its usage is therefore becoming increasingly relevant. Those accessing the data control who profits from its use to whose disadvantage. What we have shown here is that, so far, it is the big companies that have access to the Big Data, and it is therefore they who decide what data is produced. Even if technologies are developed by startups and publicly funded institutions, they are soon incorporated by the same few big companies.

All along the industrial food chain, this development has far reaching repercussions for people across the planet. If robots take over the planting, harvesting and retailing, this will substitute a significant number of occupations that have up till now been done by humans. It will be difficult to replace the jobs lost with new income generating activities – especially in the Global South. On the basis of collected data, AI might decide not only when and where to sow what seed, but also when to spray which pesticide, possibly wiping out whole fields if an error occurs and the wrong decision is taken. The seeds planted might be adapted according to the needs of those in power, without knowledge of what dangers might lie in SynBio and gene editing methods. Those seeds, as well as the tailor made pesticides, fertilizers and machinery might be patented, leaving little to no choice for farmers and workers; while blockchains might regulate access to those patents, rendering them inaccessible to small-scale peasants.

List of acronyms

AI .....Artificial Intelligence
CRISPR .....Clustered Regularly Interspaced Short Palindromic Repeats (a new gene editing method)
CBD .....UN Convention on Biological Diversity
DNA.....Deoxyribonucleic Acid (molecule where genetic material is located)
EBC .....Earth Bank of Codes
EU .....European Union
Fintech .....Financial Technology
GMOs.....Genetically Modified Organisms
GPS.....Global Positioning System
M&As.....Mergers and Acquisitions
MIT .....Massachusetts Institute of Technology

Capitalist production requires this control, and thus stimulates merging processes in order to generate profit. Many vertical mega-mergers have already been established, and there are more to come. This often leaves just two big companies dominating each hub along the food chain (input, machinery as well as food and beverage processors).

We see the danger of these technologies being introduced in an unjust society, where they can strengthen existing power relations instead of empowering those who are already marginalized. We thus call for increased public control as a basis for food sovereignty. National policies should support peasant wide webs, in which farmers, fishers and cattle herders cooperate. Technologies can be part of this, as long as they are in the control of peasants or organizations that they trust. Market concentration should be limited by national and regional as well as international responses.

To reiterate, only when democratic control of the data production and processing – of the technological means as such – is guaranteed, can food sovereignty be lived. This implies that corporate merging processes should be regulated and potentially also prohibited by governments. We therefore also call for UN Treaties on competition and technology assessment as tools to counter corporate control.

At the WEF in January 2018, the rich and famous told us that the world has never changed so fast – and that it will never be this slow again. Both at home and at the UN, civil society must move fast to alter the current course of food production that is reinforcing inequalities and threatening diversity and security. Getting together and pressuring from below, and bringing about new and effective competition and technology policies, is one of the solutions.

OECD.....Organization for Economic Co-operation and Development
R&D.....Research and Development
Seed Treaty.....International Treaty on Plant Genetic Resources for Food and Agriculture
SynBio .....Synthetic Biology
STI .....Science Technology and Innovation Forum of the UN
TFM.....Technology Facilitation Mechanism of the UN
UN.....United Nations
UNCSTD.....UN Commission on Science and Technology for Development
UNCTAD .....UN Conference on Trade and Development
WEF .....World Economic Forum
WTO .....World Trade Organization

List of companies

AB InBev ..... (Anheuser-Busch InBev) – brewing company based in Belgium
ABN-AMRO ..... bank based in the Netherlands
AGCO..... farm machinery company based in the USA
Agrium ..... former retail supplier of agricultural products and services based in Canada (now part of Nutrien)
Alibaba ..... IT company based in China
Airbus..... aircraft manufacturer based in France
Amazon ..... online mail-order company based in the USA
Anthem..... health insurance company based in the USA
Apple ..... technology company based in the USA
Archer Daniels Midland ..... agricultural commodity trader based in the USA
AT&T ..... holding company based in the USA
Aviagen Group..... broiler breeding company based in the USA
BASF..... chemical company based in Germany
BAT..... tobacco company based in Great Britain
Bayer ..... company specialized in seeds and pesticides based in Germany (recently merged with Monsanto)
BG ..... former oil and gas company based in Great Britain
Blue River Technology..... farm machinery company based in the USA (subsidiary of John Deere)
Boeing ..... aircraft manufacturer based in the USA
Bold Thread..... bioengineering company based in the USA
Bunge ..... agricultural commodity trading company based in the USA
CaliBurger..... restaurant chain based in USA
Cambridge Analytica ..... former company specialized in data analysis based in Great Britain
Cargill..... food and feedstuff company based in the USA
Carlsberg ..... brewing company based in Denmark
Carrefour ..... company specialized in retailing based in France
CF Industries..... manufacturer and distributor of agricultural fertilizers based in the USA
Charter ..... telecommunications company based in the USA
ChemChina..... (China National Chemical Corporation) – chemical company based in China (probably soon part of Sinochem)
ChemChina-Syngenta ..... name used here to describe Syngenta as subsidiary of ChemChina
ChromaWay..... IT/blockchain company based in Sweden
Cigna..... health insurance companybased in the USA
Claas..... farm machinery company based in Germany
Climate Corporation ..... company for agricultural data analysis based in the USA
CNH Industrial..... farm machinery company based in Great Britain
Cobb-Vantress ..... poultry breeding company based in the USA (subsidiary of Tyson Foods)
Coca-Cola..... beverage company based in the USA
Comcast..... telecommunications company based in the USA
Corteva Agriscience ..... agricultural division of DowDuPont based in the USA
Danone ..... dairy company based in France
Disney ..... (The Walt Disney Company) – media company based in the USA
Dow..... (Dow Chemical Company) – former chemical company based in the USA (now part of DowDuPont)
DowDuPont..... chemical company based in the USA
DuPont ..... (E.I. du Pont de Nemours anc Company) – former chemical company based in the USA (now part of DowDuPont)
Easy Trading Connect ..... trade finance platform servicing agricultural enterprises based in the Netherlands
EW Group ..... breeding company based in Germany (owner of Aviagen Group)
Facebook ..... social media company based in the USA
Fendt ..... farm machinery company based in Germany (subsidiary of AGCO)
Fincantieri ..... shipbuilding company based in Italy
FMC..... chemical manufacturing company based in the USA
Genus ..... animal breeding company based in Great Britain
Goldman Sachs..... financial enterprise involved in investment and banking as well as advice based in the USA
Glencore ..... commodity trader of minerals, fuels and agriculture based in Switzerland
Google ..... data company based in the USA
Groupe Grimaud..... breeding company based in France

Hendrix Genetics ..... breeding company based in the Netherlands
Hubbard ..... broiler breeding company (part of Aviagen Group)
IBM ..... (International Business Machines Corporation) – IT and consulting company based in the USA
IKEA ..... furniture company based in Sweden
ING Group ..... banking and financial services company based in the Netherlands
InnovaSea ..... agricultural company based in the USA
InVitro Brasil ..... company specialized in biotechnology based in the USA
Israel Chemicals (ICL) ..... fertilizer, metal and other special-purpuse chemical product manufacturer based in Israel
John Deere ..... farm machinery company based in the USA
Kubota ..... farm machinery company based in Japan
KWS ..... plant-breeding company based in Germany
Limagrain ..... seed company based in France
Louis Dreyfus ..... agricultural commodity trading company based in France
Massey-Ferguson ..... farm machinery company based in the USA (part of AGCO)
McCormick Seasonings ..... food ingredients company based in the USA
Meyer Werft ..... shipbuilding company based in Germany
Microsoft ..... company producing software and hardware based in the USA
Modern Meadow ..... biofabricating startup company based in the USA
Monsanto ..... former seed and pesticide company in the USA (now part of Bayer)
Nestlé ..... food company based in Switzerland
Netflix ..... media company based in the USA
Novozymes ..... company engaged in enzyme research and production company based in Denmark
Nutrien ..... merged fertilizer company based in Canada (formerly Agrium und PotashCorp)
Otis Elevator Company ..... lift manufacturer based in the USA
Pfizer ..... pharmaceutical corporation based in the USA
Planetary Ressources ..... asteroid mining company based in the USA
PotashCorp ..... (Potash Corporation of Saskatchewan) – former fertilizer company based in Canada (now part of Nutrien)
PricewaterhouseCoopers (PwC) ... one of the world's largest auditing enterprises based in the United Kingdom
Qualcomm ..... communications company based in the USA
RFS Finance (RFS) ..... financial services company based in Australia
Reynolds ..... tobacco company based in the USA
Robocrop ..... agricultural robotics company based in the USA
Rowbot ..... agricultural robotics company based in the USA
Royal Dutch Shell ..... oil and gas company based in Great Britain
SABMiller ..... former brewing and beverage company based in Great Britain
SalMar ..... fish farm company based in Norway
Schindler Aufzüge ..... lift manufacturer based in Switzerland
Shandong Bohi Industry ..... food processing company based in China
Sinochem ..... chemical company based in China
Société Générale ..... bank based in France
Spiber ..... bioengineering company based in Japan
Star Media Group ..... media provider based in Turkey
Syngenta ..... seed company based in Switzerland (now subsidiary of ChemChina)
Tencent Holdings ..... internet company based in China
Tesco ..... retail company based in Great Britain
The Mosaic Company ..... producer of potash and phosphate fertilizer based in the USA
Time Warner ..... former mass media company based in the USA (now Warner Media)
Time Warner Cable ..... former television company based in the USA (now part of Charter Communications)
Toyota ..... automobile company based in Japan
Tyson Foods ..... breeding company based in the USA
Uber ..... IT/taxi/delivery company based in the USA
Verizon ..... telecommunications company based in the USA
Volkswagen ..... automobile company based in Germany
Walmart ..... retail company based in the USA
Wyeth ..... former pharmaceutical company based in the USA (now part of Pfizer)
Yara ..... fertilizer company based in Norway

www.etcgroup.org
www.land-conflicts.net
www.inkota.de
www.rosalux.org