AI in Context

The Labor of Integrating New Technologies

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Contents

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> *“‘If it weren’t for the people, the god-damn people’* said Finnerty, *‘always getting tangled up in the machinery. If it weren’t for them, the world would be an engineer’s paradise.’”*
>
> **Kurt Vonnegut**—Player Piano (1952)

Executive Summary

In this report, we provide new evidence and frameworks for thinking about the near-term impacts of automated and AI technologies on society. Our report demonstrates the necessity to integrate rather than deploy AI technologies and to account for how AI technologies reconfigure work practices rather than replace workers. We examine two American work environments in which AI technologies often are imagined to have great disruptive potential: agriculture and retail. Specifically, we analyze technologies being used in farm management and grocery retail, contrasting the utopian (and dystopian) visions that tend to accompany AI with the mundane realities of current automated technologies.

Our report demonstrates the ways in which automated and AI technologies tend to mask the human labor that allows them to be fully integrated into a social context while profoundly changing the conditions and quality of labor that is at stake. In our discussion, we focus on the ways in which this dynamic shifts ingrained community norms, interpersonal relationships, daily routines, and skill sets. We find that although new skills are often required, they are usually unacknowledged and uncompensated. We also find that adopting new AI technologies produces economic risks that are not evenly distributed among stakeholders, wherein more vulnerable or precarious communities are exposed to greater risks and harms than those who control the design or use of AI technologies.

In the agricultural context of family-owned farm management technologies, we argue for the necessity to frame the introduction of new AI technologies as being integrated rather than deployed, emphasizing that a technology must be used by specific people within existing norms and practices. This distinction is crucial if we want to understand not only how AI technologies like precision agriculture are changing farming practices but also how these changes are being adopted or rejected and who is likely to benefit. In this context, our research points to the ways in which data-intensive technologies, like crop management tools and "smart" tractors, require new work routines and changes to physical infrastructure, like securing rural broadband internet and reorganizing the layout of barns or fields to facilitate optimal sensor readings. In addition to these physical requirements, cultural shifts in the business logics of family-owned farms are also required. For instance, a physical field must now be conceptualized as a complex dataset to be managed through other digital information and digital tools. Dominant narratives around the future of agriculture focus on the benefits of providing farmers with data-driven insights that can help them make more informed decisions. However, these narratives too quickly gloss over the labor and social conditions that are required to integrate AI technologies and which must be in place to fully realize the promised benefits of AI.

In the retail context of grocery store technologies, we orient our research toward how AI technologies reconfigure rather than replace frontline jobs. We focus on the context and use of self-checkout machines, which are representative of the piecemeal way in which retailers pick up and roll out new technologies. We find that retail experiments, like self-checkout or customer-operated scanners, tend to rely on humans to smooth out technology's rough edges. In other words, the "success" of technologies like self-checkout machines is in large part produced by the human effort necessary to maintain

> the technologies, from guiding confused customers through the checkout process to fixing the machines when they break-down to quite literally searching for customers aisle by aisle when GPS systems fail. The impact of these retail technologies has generally not been one of replacing human labor. Rather, they enable employers to place greater pressures on frontline workers to absorb the frontline risks and consequences of cost cutting experiments. Much of the work that employees must do on the ground to facilitate new systems is often invisible and undervalued, even as popular perceptions of automation frame these roles as increasingly obsolete.

The frames and contexts presented in this report point toward how we might improve future development, assessment, and regulation of AI technologies. Focusing on the integration of AI and the labor that is reconfigured brings into view structures of power that are at stake. This can help us anticipate who will be empowered and who will be left without a voice. Our findings suggest that public understanding and debates would be strengthened if reporting on AI focuses not just on a technology's potential capacity or ideal use case, but also on the labor of integration and the humans who are either left in the lurch or relied upon to smooth out a technology's rough edges. Similarly, if designers keep these human operators and users at the center of development, AI technologies can enhance and complement existing skills and expertise, rather than foreclose the discretionary power of frontline workers. Finally, our research suggests that policy makers and advocates should keep watch of the unevenly distributed costs of experimenting and implementing new technologies. Advocates may consider how the labor of AI integration is often under-acknowledged, and the consequences for how workers are compensated and supported. Given that the labor of AI integration is often invisible or under-acknowledged, it is all the more important to ensure that those who work with and alongside AI systems are adequately protected, supported, and compensated. While "transitional" or "intermediate" phases are by definition temporary, they still are actualities that affect workers in the present and need to be addressed.

AI technologies hold great promise in advancing society and addressing existing problems. However, the potential benefits must not obscure the potential perils of these technologies. These perils have nothing to do with "killer robots" or the coming of "robot overlords." Instead, they will be found in the everyday structuring potentials of AI that will benefit some members of society but leave many others behind.

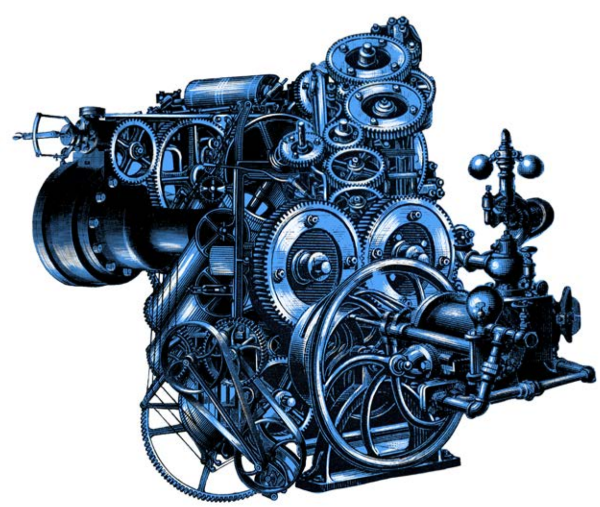
Introduction

> Our concern in this paper is with everyday experience and the perspectives of people whose livelihoods are intertwined with automated technologies.

It's a familiar story these days: the era of Artificial Intelligence (AI) has arrived, and AI will soon render human labor and decision-making obsolete. In this report, we tell a different story. We contrast the utopian (and dystopian) visions that tend to accompany AI with the mundane realities of current automated technologies. There are many ways to talk about the consequences of automation and AI; one might talk about regulatory or legal changes, industry reconfigurations, macro- or microeconomic trends, or effects on the environment. Our concern in this paper is with everyday experience and the perspectives of people whose livelihoods are intertwined with automated technologies. Our research has been undertaken from an empirical perspective, investigating on-the-ground realities of automated technologies that are often spoken about abstractly, without accounting for human experiences.

The technologies we examine range from cutting-edge machine learning models to relatively simple statistical models and automated kiosks. Each tends to be perceived as progressing us toward a better, more autonomous technological future in which these tools will work more efficiently and effectively than humans. Our report troubles this "near-certain" assumption and argues for the ways in which these technologies mask the human labor that allows them to be fully integrated into a social context while profoundly changing the conditions and quality of labor that is at stake.

In this report, we focus on two American work environments within the broad industries of agri-food: family-owned farm management and corporate grocery retail. These contexts represent different workplace dynamics and types of work, allowing us to analyze AI adoption in contrasting contexts. We develop two frames to demonstrate the necessity to integrate rather than deploy AI technologies and to account for how AI technologies reconfigure work practices rather than replace workers. These frames also serve to bring into focus the ways in which automated technologies have had significant but under-examined consequences for everyday life and formations of power.



Both of these frames are useful in unpacking particular implications of AI technologies. In this report, we contextualize our analysis within the frame that we find draws out the most salient aspects at stake. In our discussion of farm management technologies, we choose the term *integrate* rather than the more common *deploy* to describe the processes through which technologies are introduced into the family-owned American farm context. *Integrate* indicates that a technology must be used by specific people within existing norms and practices. The word itself demands more context: "of," "into," or "with what" is that technology being integrated? On the other hand, *deploy*, often used in the context of military action, connotes a kind of context-less dropping in. To *deploy* a technology puts the rhetorical focus on the technology itself rather than the human.

In the case of family-owned farms, this distinction is crucial if we want to understand not only how AI technologies are changing farming practices but also how these changes are being adopted or rejected and who is likely to benefit. The reconfiguration of established agricultural practices to facilitate data-intensive technologies, like crop management tools and "smart" tractors, requires new work routines and changes to physical infrastructure, as well as cultural shifts in the business logics of family-owned farms. The labor of farm management has shifted away from the field and into the office, creating the need for new kinds of digital fluency and rethinking farmland in terms of vast digital datasets. These new ways of thinking can be in tension with existing practices and beliefs. Moreover, while tech companies promise greater profits and efficiency, small-scale farmers are often unable to compete alongside larger, finance-backed conglomerates that can more easily bear the costs of experimentation.

> While grocery technologies have promised seamless integration or decreased need for human labor, this has often not been the case.

In our discussion of grocery retail technologies, we orient our analysis toward how AI technologies reconfigure rather than replace frontline jobs. Many discussions around the future of work focus on whether or not certain jobs will be eliminated by AI and automated technologies. However, there are fewer discussions about how those technologies will disrupt the conditions of jobs that continue to exist. By assuming a future absence, all the ways in which work practices remain present are obscured. Reframing automated and AI technologies as producing reconfigurations, and obfuscations of new labor practices allows us to focus on the quality of the jobs that remain, as well as on those who bear the brunt of technological shortcomings. While grocery technologies have promised seamless integration or decreased need for human labor, this has often not been the case. The introduction of self-service technologies for grocery retail workers has shifted customer service roles to hovering human chaperones mediating between customer and machine. Grocery workers are often called on to shift their skillset in response to automation, performing new, yet unacknowledged, work in the background to enable technologies to function seamlessly.

Our analysis is based on qualitative research methods, including content analysis of general audience media, industry-specific publications, and academic literature reviews. We also conducted 15 interviews and approximately 10 hours of observations in the winter and spring of 2018. This included attending and interviewing visitors at the National Farm Machinery Show in Louisville, Kentucky, and interviewing and observing unionized workers and managerial staff at grocery retailers in Los Angeles, California. In contrast to the universalizing tendencies of AI technologies, the arguments that we make call attention to the specific contexts that determine the contours, limits, and potential consequences of AI integration.

HUMAN INFRASTRUCTURES OF AI

This research project began at the checkout station of a suburban supermarket. One of the co-authors was using a self-checkout machine and had placed a bunch of bananas on the scanner. Immediately, the code for bananas was applied, and the machine's screen displayed the weight and price and then moved on, waiting for the next item. The co-author thought to herself, "That's a pretty impressive machine vision algorithm on this nondescript machine!" Impressed by the high-functioning technology, she continued to scan her items. There was, as there always seems to be, some sort of error that required a cashier to come over to the self-checkout machine and provide an override code to complete the order. The co-author mentioned to her, "This thing is pretty smart! I didn't know it could sense what fruits and vegetables I had!" The attendant laughed and replied, "Oh, it can't! I saw what you had and put in the code myself from my machine." She gestured toward her workstation in front of the rows of self-checkout machines.[1]

> The human worker is an example of what we will call "human infrastructure," the integral human component of a socio-technical system without which that system cannot properly function.

1 Astra Taylor describes a similar incident, wherein an impressed customer wondered aloud how a restaurant app knew his order was ready and the cashier explained, "That was actually me." Astra Taylor, "The Automation Charade," Logic no. 5 (2018), https://logicmag.io/05-the-automation-charade/.

This mistaken attribution of intelligence, in which a digitally savvy customer assumed the effective functionality of a computer system at the expense of the human worker who enabled its intelligent performance, is typical of much of today's AI, or "smart," technologies.[2] The human worker is an example of what we will call "human infrastructure," the integral human component of a socio-technical system without which that system cannot properly function. We define infrastructure broadly as the underlying foundation necessary for a system to function as designed and the notion of human infrastructures[3] within automation and AI as a way to encapsulate how many technologies can perform intelligently only if there are human attendants creating and maintaining the conditions of their intelligence. This might range from replacing batteries or cleaning parts to updating outdated code or even modifying speaking patterns in order to be intelligible to a smart speaker by talking slowly or masking an accent.

These kinds of human infrastructures are often imagined as a stopgap measure and mere intermediate step on the way to better AI and more autonomous machines. However, as increasingly more research argues, the intelligence or autonomy of machines is made

2 Hamid R. Ekbia and Bonnie A. Nardi articulate the dynamic of heteromation as a way to call attention to the unique ways in which new forms of computational media require user engagement to produce value but at the same time do not compensate or value that user engagement as enumerable work. Hamid R. Ekbia and Bonnie A. Nardi, "Heteromation and its (Dis)contents: The Invisible Division of Labor Between Humans and Machines," First Monday, vol. 19, no. 6 (2014), https://firstmonday.org/ojs/index.php/fm/article/view/5331.

3 For the last several decades, infrastructure has proven a useful analytic for theorizing how the social world generates and is generated by material form. Classically articulated by Star (1999), anthropological and Science Technology and Society (STS) studies of infrastructure have provided insight into a wide range of social phenomena (Appel et al., 2015). It could be argued that infrastructure has become an over-relied on analytic trope. Nonetheless, in this report infrastructure provides a useful provocation to conceptualize the human roles within automated and autonomous systems. Moreover, infrastructure is most commonly associated with physical structures such as roads or electric grids —not people. However, the reduction of human to object or interchangeable part is central to successful automation. The term human infrastructure encapsulates the tension between calling out humans as infrastructure and the reduction of human to infrastructural object. Susan Leigh Star, "The Ethnography of Infrastructure," American Behavioral Scientist vol. 43, no. 3 (1999): 377–91; Brian Larkin, "The Politics and Poetics of Infrastructure," Annual Review of Anthropology vol. 42 (2013): 327–43; Hannah Appel, Anand Nikhil, and Akhil Gupta, "The Infrastructure Toolbox," Cultural Anthropology (September 2015), https://culanth.org/fieldsights/725-the-infrastructure-toolbox.

possible through the obfuscation of attendant human labor.[4] This argument is supported by studies on the history of automation in which time and again the promise of eliminating human labor has given way to new forms of uncompensated, invisible, or undervalued labor.[5] The concept of labor is core to our inquiry; however, the invocation of human infrastructure pushes us to consider not only how humans labor alongside AI but also how an AI system's functioning becomes possible only through the human labor that animates it.[6] This then enables a fundamental reframing of how we think about the *intelligence* in *artificial intelligence*.

> We use the term *human infrastructure* to call attention to the people who are often rendered invisible when AI is discussed or planned for.

Our interest in articulating the concept is to draw attention to the current realities in which AI technologies operate. We use the term *human infrastructure* to call attention to the people who are often rendered invisible when AI is discussed or planned for. When we

4 See for instance Lily Irani, "The Cultural Work of Microwork," New Media and Society (2013), https://doi.org/10.1177/1461444813511926; Lily Irani, "Justice for 'Data Janitors,'" Public Books (January 2015), http://www.publicbooks.org/justice-for-data-janitors/; Mary L. Gray and Siddharth Suri, "The Humans Working Behind the AI Curtain," Harvard Business Review, January 9, 2018, https://hbr.org/2017/01/the-humans-working-behind-the-ai-curtain, accessed October 25, 2018; M.C. Elish and Tim Hwang, Praise the Machine! Punish the Human! The Contradictory History of Accountability in Automated Aviation, Data & Society Research Institute, February 14, 2015, https://www.datasociety.net/pubs/ia/Elish-Hwang_AccountabilityAutomatedAviation.pdf.

5 Ruth Schwartz Cowan, More Work for Mother: The Ironies of Household Technology from the Open Hearth to the Microwave (New York: Basic Books, 1985); Karl Marx, Capital, Volume One. trans. Ben Fowkes (New York: Penguin, 1990); David Mindell, Our Robots, Ourselves: Robotics and the Myths of Autonomy (New York: Penguin, 2015); David Noble, Forces of Production: A Social History of Industrial Production. (New York: Knopf, 1984).

6 Lucy Suchman, Human-Machine Reconfigurations: Plans and Situated Actions, 2nd edition (New York: Cambridge University Press, 2007).

keep in mind that AI requires human infrastructures to work, we are better able to look for and see people who will most immediately be affected by AI and trace out the consequences.

THE HYPED MACHINE

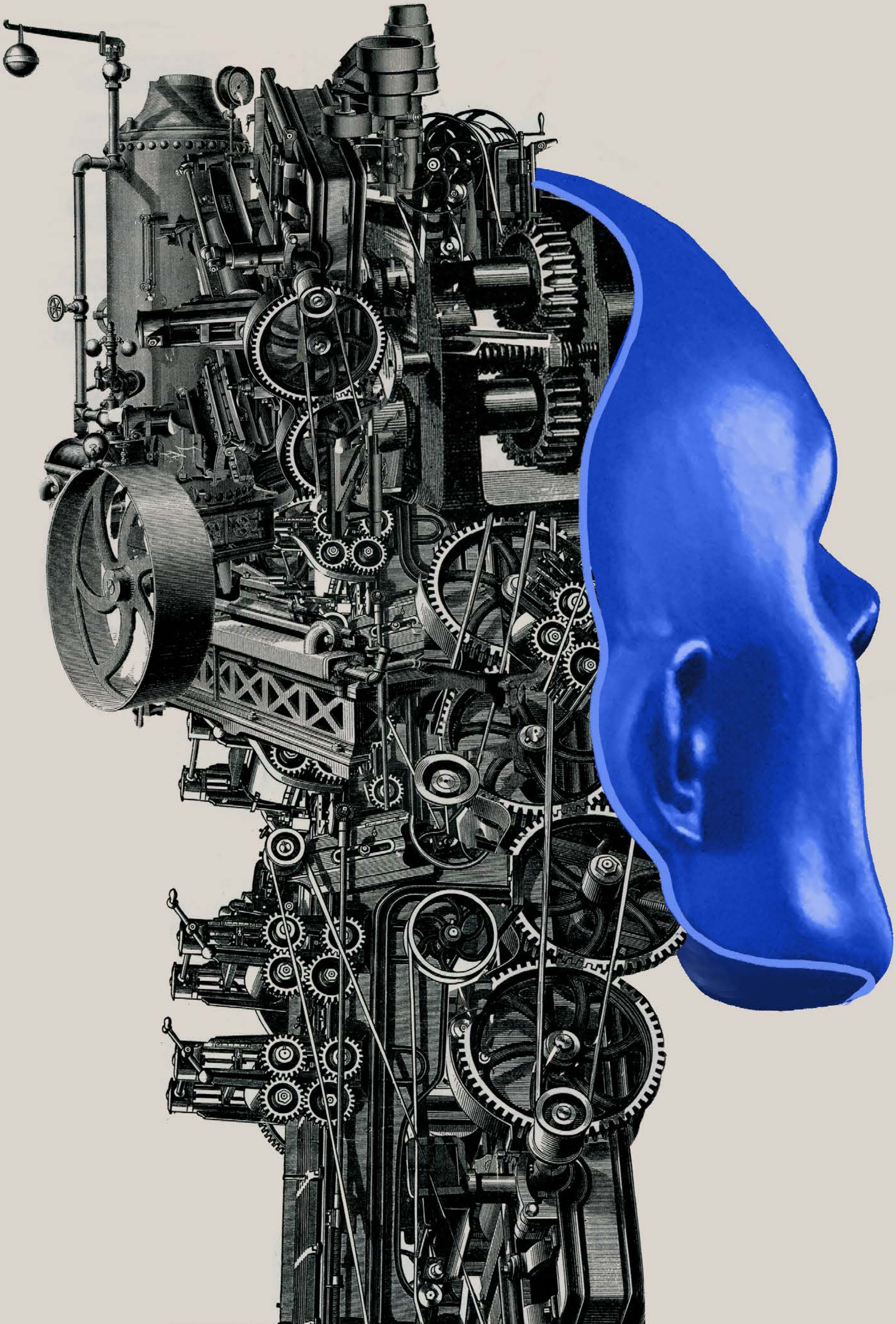
Artificial intelligence is often described as some set of capabilities exhibited by a computer that resembles intelligent behavior. However, intelligence is not defined by a stable or specific set of characteristics but is instead defined differently over time and in relation to existing beliefs, attitudes, or technological capabilities. Computer scientists Stuart Russell and Peter Norvig have written about the varying emphasis on four possible goals for intelligence in the context of intelligent machines: "systems that think like humans, systems that act like humans, systems that think rationally, systems that act rationally."[7]

Moreover, when it comes to understanding the impact of AI, the social perceptions of a technology's capabilities are equally important to technical definitions. Elsewhere we have observed that non-expert understandings of AI are often shaped by marketing rhetoric, which sometimes suggests capabilities that are not yet technically possible.[8] For many developers of AI systems, this potential fuzziness is "not a bug but a feature," so to speak. The public perception of AI is often leveraged to drum up excitement or stand in for a range of automated technologies that haven't yet become fully actualized. The fluctuating understandings of AI will not be universally resolved, and so it is necessary to account for the consequences of AI as defined through both technical definitions and social representations.

7 Stuart Jonathan Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (New York: Pearson, 2009).

8 M.C. Elish and danah boyd, "Situating Methods in the Magic of Big Data and AI," Communications Monographs 85 no 1, (October 2017): 57-80, https://doi.org/10.1080/03637751.2017.1375130.

In the context of this paper, we define AI loosely in order to capture its current technical and social valences. When we refer to AI, we primarily mean to reference a computational system that performs, partially or fully, a type of task that has been or might theoretically be performed by a human or a human team. This might involve deep learning or other machine learning techniques, in which algorithms detect and predict patterns in vast datasets. This might also involve complex automated machines that perform a discreet set of tasks relatively autonomously, involving sensors that are able to receive input from an external environment and take actions according to pre-programmed rules. In the following sections, we explore automated and AI technologies as broadly existing on the same continuum and focus less on technical specifications or capacities and more on highlighting human behaviors and perceptions of technology in use.



Farm Management

"The future of agriculture is in the hands of the machines," proclaimed Wired magazine in 2016.[9] Although agricultural machines are far from new, agriculture is widely believed to be about to undergo a "revolution."[10] Major agribusiness corporations, from fertilizer vendors to equipment manufacturers, have pivoted to big data and smart technologies. Industry reports often paint a picture of farming as "on the verge of turning into a high-tech industry,"[11] oriented toward a future bright with innovation. According to many industry observers, a watershed moment occurred in 2013, when agribusiness giant Monsanto paid nearly $1 billion to acquire a six-year-old start-up called The Climate Corporation, which leverages vast datasets and finely tuned data models for predicting weather. The Climate Corporation's original product was insurance, but the acquisition signaled a broader commitment to digital, data-driven services.[12] In addition to these major corporations, smaller tech companies, many emerging from Silicon Valley, are competing to gain farmers as clients.[13] Investment in "agtech," short for agricultural technologies, has been steadily growing, and in 2017, over $1.5 billion was invested in agtech start-ups globally.[14]

9 Matt Simon, "The Future of Humanity's Food Supply Is in the Hands of AI," Wired, May 25, 2016, https://www.wired.com/2016/05/future-humanitys-food-supply-hands-ai/.

10 Anthony King, "Technology: The Future of Agriculture," Nature, April 26, 2017, https://doi.org/10.1038/544S21a.

11 Thierry Laugerette and Franziska Stöckel, From Agriculture to AgTech: An Industry Transformed Beyond Molecules and Chemicals, Monitor Deloitte, August 2016, https://www2.deloitte.com/content/dam/Deloitte/de/Documents/consumer-industrial-products/Deloitte-Tranformation-from-Agriculture-to-AgTech-2016.pdf.

12 Bruce Upbin, "Monsanto Buys Climate Corp for $930 Million," Forbes, October 2, 2013, accessed September 27, 2018, https://www.forbes.com/sites/bruceupbin/2013/10/02/monsanto-buys-climate-corp-for-930-million/.

13 See, for example, conferences like the multi-city AgTech Summits, run by ForbesLive: https://www.forbes.com/forbes-live/event/agtech-summit-2018/.

14 Arama Kukutai and Spencer Maughan, "How the AgTech Investment Boom Will Create a Wave of Agriculture Unicorns," Forbes, January 16, 2018, https://www.forbes.com/sites/outofasia/2018/01/16/how-the-agtech-investment-boom-will-create-a-wave-of-agriculture-unicorns/.

Precision agriculture has become one of the fastest growing applications of AI in agriculture.[15] It encompasses an approach to farming rather than a specific product and relies on the collection, interpretation, and analysis of diverse forms of digital data. For instance, some of the simplest precision agriculture technologies include GPS-equipped combine harvesters that produce georeferenced data.[16] Tools that can track harvest yield allow for the analysis of field variability, like differences in soil makeup, water, or fungus. Variable rate technologies provide predictions and analysis so that farmers may customize the amount of input, such as fertilizer or pesticide, on any given portion of a field.[17]

For farmers, precision agriculture promises the tools to help them optimize resources and minimize costs effectively, and by doing so increase yield and profits. Existing alongside these promises, the commercial drive to augment farming practices with AI often invokes rising global concerns about food security, climate change, and the capacity for current practices to effectively feed increasing populations.[18] Agtech innovations are invoked not only as efficient but also imperative in the context of saving the earth and its human and animal populations.

While these narratives drive much of the rhetoric around the agtech "revolution," local decisions around farmer adoption are complicated by more imminent concerns and limitations around

15 Kelsey Nowakowski, "Farming: There's an App for That," National Geographic, June 5, 2018, https://www.nationalgeographic.com/environment/future-of-food/food-future-precision-agriculture/.

16 Combine harvesters, more often called simply combines, are automated machines that combine three harvesting functions (reaping, threshing, and winnowing) and have been iteratively developed and used since the mid-19th century.

17 Remi Scmaltz, "What Is Precision Agriculture and How Is Technology Enabling It?" AgFunderNews, April 24, 2017, https://agfundernews.com/what-is-precision-agriculture.html/.

18 See, for example, Lyndsey Gilpin, "How Big Data Is Going to Help Feed Nine Billion People by 2050," TechRepublic, accessed October 11, 2018, https://www.techrepublic.com/article/how-big-data-is-going-to-help-feed-9-billion-people-by-2050/. Scholar Michael Carolan has characterized discourses around big data and precision agriculture as both "anticipatory" and "moralizing," specifically in the context of climate change. Michael Carolan, "Publicizing Food: Big Data, Precision Agriculture, and Co-Experimental Techniques of Addition," Sociologia Ruralis vol. 57, no. 2 (April 1, 2017), 135–54, https://doi.org/10.1111/soru.12120.

integrating new tools into existing practices, as well as weighing the risks that experimenting with new technologies entails. This section argues that there is a disconnect between the dominant vision of AI-driven agriculture – which assumes a model of deployment – and the actual labor, resources, and reconfigurations needed to facilitate integration.

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Our field interviews draw from only one small subset of the larger ecosystem: family-owned commodity-crop farmers in mid-Atlantic and mid-Western United States. These farms are where the majority of US commodity crops – that is, crops sold to the commodities market, such as soybeans and corn – are grown. Because the kinds of technologies currently in use in this context vary widely, we did not focus on a single type of tool but on data-driven technologies used in precision agriculture in this context. These are tools that directly impact farm management, as opposed to other categories, such as robotics, that automate manual farm labor like crop harvesting and which are largely in prototype phasing now.[19]

19 Emma Cosgrove, "Harvesting Robotics Market to Reach $5.5bn from Early Adopters Alone — Report," AgFunderNews, January 10a, 2018, https://agfundernews.com/harvesting-robotics-market-early-adopters-report.html/.

SHIFTING ROLES: THE LABOR OF INTEGRATION

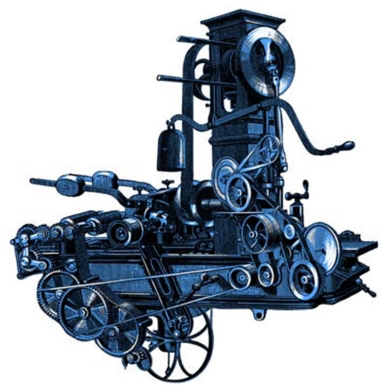
The adoption of precision farming technologies has not been as rapid as many proponents had hoped, although use is slowly rising. According to a 2014 American Farm Bureau Federation survey of US farmers, more than half of respondents reported plans to increase their investment in data-driven technologies within the following two years.[20] Yet despite the touted benefits, existing research shows that adoption of data-driven technologies has been uneven.[21] This section briefly explores some of the labor involved in integrating precision agriculture technologies on the ground. At the level of farm management decisions, this work can include shifts in ingrained community norms, interpersonal relationships, daily routines, and skill sets. Additionally, there is the labor of reconfiguring physical infrastructure to render farmland amenable to the data collection that makes AI possible. This is not always a smooth process, and the extent to which farmers can benefit from precision agriculture tools often depends on the conditions and resources already available.

Agtech companies generally market themselves as a solution to a problem farmers have long faced: how to collect better, more accurate data about farm conditions and how to use it to make effective decisions that improve farm outcomes. For instance, OnFarm, a California-based start-up, claims on its website to have the "largest network of connected devices and data in agriculture" and promises to automate the collection of data to "fit your specific

20 AFBF, "American Farm Bureau Survey Shows Big Data Use Increasing, Big Questions Remain," American Farm Bureau Federation Newsroom, October 14, 2014, http://www.fb.org/newsroom/american-farm-bureau-survey-shows-big-data-use-increasing-big-questions-rem.

21 David Schimmelpfennig and Robert Ebel, "On the Doorsteps of the Information Age: Recent Adoption of Precision Agriculture," US Department of Agriculture Economic Research Service, August 2011, https://www.ers.usda.gov/webdocs/publications/44573/5732_eib80_1_.pdf?v=0. See also the annual CropLife/Purdue Precision Dealer Survey at http://agribusiness.purdue.edu/precision-ag-survey.

needs without worrying about managing complex data."[22] Importantly, tools like sensor-equipped farm machinery promise not only to make higher- quality data available to farmers but also to provide a broader scale of data. Often, these tools aggregate multiple types of data to provide analyses and recommendations.



Many of the marketing promises of these technologies are based on optimistic assumptions or projections of farmers' available resources and physical infrastructures. Nonetheless, on the most basic level, broadband internet may be unavailable to many farmers. As Ruth, a farmer from North Dakota on a family-owned farm said, "You don't really have internet connectivity in the farms and a lot of places there's a lot of hurdles." During a question- and -answer session at a product booth at the 2018 National Farm Machinery Show in Louisville, she asked an analyst answering questions about precision agriculture ecosystems whether "the rural internet can support all this tech." His response, similar to the predictions of other analysts, was that while the answer is currently no, demand for more access will grow supply and capacity. However, these future supply and capacity expectations are far from certain. US Department of Agriculture data from 2017 reports that farmers' connectivity has grown in the last decade, with 71% reporting internet access via computer but showing smaller percentages of access across other methods,

22 http://www.onfarm.com/data-from-anywhere.

such as mobile.[23] Broadband access continues to lag significantly behind in rural area as compared to the rest of the US.[24] In addition to internet connectivity, new physical resources may be required to use precision agriculture techniques. This may involve reorganizing fields to fit new machines or reorganizing the layout of barns or silos to facilitate optimal sensor readings. To become legible – and sometimes quite literally malleable – to digital sensors and techniques, physical reconfigurations are often required.

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The abundance of data itself also presents new challenges. Industry publications in recent years have reported on the problem of the farmer "awash in data" collected by farm machinery, with farmers often lacking the training and resources to integrate new data-driven systems with their farm equipment.[25] In 2016, the *Wall Street Journal* reported a decline in venture capital funding for precision agriculture technology, with many companies closing down or redirecting their businesses to farm robotics and biotechnology.[26] An important factor cited in the article was the difficulty farmers have faced in interpreting the vast amounts of data these systems aggregate, as well as discerning their correlation with boosts in farm productivity.

23 Farm Computer Usage and Ownership, USDA National Agricultural Statistics Service, August 2017, http://usda.mannlib.cornell.edu/usda/current/FarmComp/FarmComp-08-18-2017_correction.pdf.

24 2018 Broadband Deployment Report, Federal Communications Commission, February 5, 2018, https://www.fcc.gov/reports-research/reports/broadband-progress-reports/2018-broadband-deployment-report.

25 Hembree Brandon, "Today's Farms Awash in Data: But What to Do with It?" Delta Farm Press, December 2, 2014, https://www.deltafarmpress.com/agriculture-technology/today-s-farms-awash-data-what-do-it.

26 Eliot Brown, "Why Big Data Hasn't Yet Made a Dent on Farms," Wall Street Journal, sec. Business, May 15, 2017, https://www.wsj.com/articles/why-big-data-hasnt-yet-made-a-dent-on-farms-1494813720.

In the field management context, tools for data collection and analysis do not save labor as much as they increase efficiency per acre. In principle, tools like variable-rate technology reduce input costs and increase crop yields. But in practice, a wide range of variables affect the extent to which farmers see these benefits, often requiring more labor on the part of the farmer to experiment with and interpret changes in farm yields. The factors contributing to a given yield may be difficult to discern, given that farms are not controlled environments and external variables like weather patterns or pests can obscure cause and effect.[27] Even the order and combinations in which farmers adopt new technologies can be a significant factor in the efficacy of precision agriculture tools.[28]

> This contradiction underscores that adoption is driven not only by availability but also by the capacity and desire to use such technologies.

Some industry analyses interpret these complications as temporary hurdles. A 2016 industry report from consulting firm Accenture paints a picture of the present state of precision agriculture in the form of the “confused farmer,” who is “overwhelmed by data.”[29] He is represented by an illustration of a farmer scratching his head as his smartphone buzzes with myriad data inputs. His plight is

27 David Schimmelpfennig, Farm Profits and Adoption of Precision Agriculture, US Department of Agriculture Economic Research Service, October 2016, https://www.ers.usda.gov/webdocs/publications/80326/err-217.pdf?v=0; Joseph Byrum, “The Challenges for Artificial Intelligence in Agriculture,” AGFunderNews, February 20, 2017, https://agfundernews.com/the-challenges-for-artificial-intelligence-in-agriculture.html/.

28 David Schimmelpfennig, Cost Savings from Precision Agriculture Technologies on U.S. Corn Farms, US Department of Agriculture Economic Research Service, May 2, 2016, https://www.ers.usda.gov/amber-waves/2016/may/cost-savings-from-precision-agriculture-technologies-on-us-corn-farms/.

29 Digital Agriculture: Improving Profitability, Accenture, https://www.accenture.com/nz-en/insight-accenture-digital-agriculture-solutions.

presented as an awkward transitional phase on the path to a brighter future of data insight through fully integrated technologies.[30] In reality, however, the issues described above, in addition to other emergent concerns around data privacy, often lead farmers to opt out of using available technologies.[31]

According to an industry analyst we spoke to, official numbers in reported uses of precision agriculture tools are likely misleading; most John Deere equipment, for instance, comes with pre-installed software, but there's no indication of whether it is actually being used. Other reports similarly suggest that some farmers may capture data using these tools but leave it on the field machine and do nothing with it.[32] This contradiction underscores that adoption is driven not only by availability but also by the capacity and desire to use such technologies.

Unsurprisingly, with new technologies comes the need for new skills and new forms of expertise. Agtech technologies often require a reconceptualization of the work and business of farming, which we discuss in further detail below. This is in part because precision agriculture technologies not only automate but also "informate," to borrow a term from Shoshana Zuboff, who wrote about this distinction in the context of information technologies in the workplace in the 1980s.[33] Informating an environment describes the work that is done to render actions and objects as digital information (data) that can be acted upon. In this case, for instance, a field becomes a complex dataset to be managed through other digital information and digital tools. Not all farmers have experience in working with digital data in

30 Digital Appetite in Rural America: Innovative Agricultural Technologies and the Potential for USDA, Accenture, January 2017, https://www.accenture.com/t20170420T220015__w__/us-en/_acnmedia/PDF-50/Accenture-USDA-Agriculture-PoV-v08.pdf.

31 Karen Levy, Solon Barocas, and Alexandra Mateescu, "Reap What You Sow? The Privacy of Agricultural Data," Northeast Privacy Scholars Workshop, October 20, 2018, Fordham University School of Law, New York, New York.

32 Jennifer Alsever, "Is There an AgTech Bubble?" Fortune, July 25, 2016, http://fortune.com/2016/07/25/agriculture-farming-tech-startup-bubble.

33 Shoshana Zuboff, In the Age of the Smart Machine: The Future of Work and Power (New York: Basic Books, 1988).

this way. At the same time, farmers often need to adjust and calibrate tools or sensors to fit local contexts and needs, requiring specialized skills in agtech software and hardware.[34] Finding ways to develop the necessary skills or experience can be a challenge.

However, we found a marked difference between farmers' attitudes toward these changes, often falling along generational lines. Matt, a man in his early 20s who works on his uncle's corn and soy farm in North Dakota, was typical of what is often described as "the new generation" of farmers. This new generation has grown up with iPhones and iPads and is comfortable with using digital technologies in every aspect of life. Matt is happy to embrace something like an iPad or screen in a tractor, but his uncle finds this "mentally fatiguing."

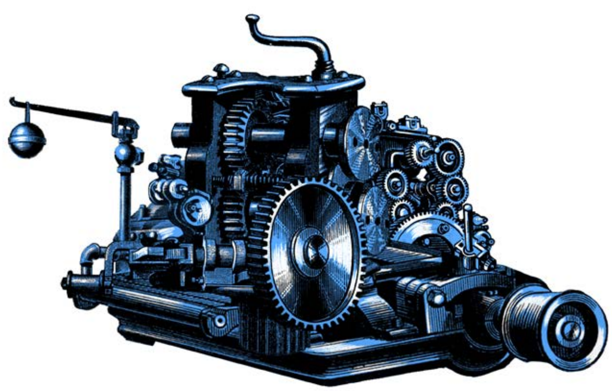
Finally, adoption of precision agriculture tools also impacts the experience of living and working as a farmer. The model of what farming looks like on the ground is slowly changing, raising questions about how those changes may come into tension with existing self-perceived identities. One farmer from Indiana explained, "I wish I could go out in the fields more, but it's more valuable for me to be in the office in front my computer." This sentiment was widespread among the farmers with whom we spoke. Industry publications have similarly noted that the "plethora of sensors, software, and embedded interface systems" may grate against some farmers' preferences for "hands-on" involvement in the field, as well as their already established methods and routines.[35] Unlike many professions, farming

34 Most prominently, this issue has emerged in the "right to repair" movement that advocates for farmers' rights to modify farm equipment software themselves, as well as to do their own repairs rather than depend on manufacturer technicians. Companies like John Deere have used copyright law and license agreements to try to restrict these practices. In response, some farmers have formed DIY "tractor hacking" communities, and a black market for pirated equipment software has emerged. Kyle Wiens and Elizabeth Chamberlain, "John Deere Just Swindled Farmers Out of Their Right to Repair," Wired, September 19, 2018, https://www.wired.com/story/john-deere-farmers-right-to-repair/; John Naughton, "Why American Farmers Are Hacking Their Own Tractors," The Guardian, March 26, 2017, https://www.theguardian.com/commentisfree/2017/mar/26/why-american-farmers-hacking-own-tractors. For an analysis of farm hacking communities, see Michael Carolan, "'Smart' Farming Techniques as Political Ontology: Access, Sovereignty and the Performance of Neoliberal and Not-So-Neoliberal Worlds," Sociologia Ruralis vol. 58, no. 4 (October 1, 2018), 745–64, https://doi.org/10.1111/soru.12202.

35 Sensors Staff, "AgTech Sounds Good for Some, Not All," Sensors Online, August 15, 2016, https://www.sensorsmag.com/components/agtech-sounds-good-for-some-not-all.

is an industry people are typically born into, as part of a wider farming community dominated by family-owned businesses.[36] As such, the industry depends on establishing continuity between generations.[37] For instance, Matt, the young tech-savvy farmer above, expressed disdain for the growing popularity of "urban farming"—often touted by proponents as a key to building food sustainability.[38] He explained, "You can't just start up a farm. You need to have been in it.... It's hard to describe if you're not in it. It's like a lifestyle, not a business."

As this section has shown, it is not enough to bring new technologies into the hands of farmers. Dominant narratives around the future of precision agriculture focus on the potential benefits of providing farmers with data-driven insights that can help them make more informed decisions. However, including all of the activities necessary for integration reveals the labor that must happen around AI technologies in order to realize their promised benefits.



36 Within our research, every farmer we spoke with – from those in their late teens to those in their 50s and 60s – had been a member of Future Farmers of America (FFA). The organization, founded in the 1928, was and continues to be a way to nurture community and pride around farming and to develop interest and knowledge in a range of agricultural careers. Currently, there are over 650,000 members in more than 8,500 chapters throughout 50 states. "FFA History: National FFA Organization," Future Farmers of America, accessed September 24, 2018, https://www.ffa.org/about/what-is-ffa/ffa-history.

37 On cultural mythologies surrounding the American farmer's identity and history, see Richard Hofstadter, "The Myth of the Happy Yeoman," American Heritage, vol. 7, no. 3 (April 1956), https://www.americanheritage.com/content/myth-happy-yeoman.

38 Amy Crawford, "Big Data Suggests Big Potential for Urban Farming." Wired, February 20, 2018, https://www.wired.com/story/big-data-suggests-big-potential-for-urban-farming/.

UNEVENLY DISTRIBUTED COSTS OF EXPERIMENTATION: DON'T BE THE SEA LION

Farmers take on serious risks when adopting any new form of technology. As the previous section discussed, the promised benefits of precision agriculture technologies are not guaranteed but require the marshaling of labor, resources, and time to adequately integrate. This section examines the ways that precision agriculture adoption places much of the risk of adopting new technologies onto farmers.

The business model and organizational structure of farms vary widely. There are important differences between commodity or field crop producers and fruit and vegetable producers, as well as between family-owned farms and corporate-owned farms.[39] The economics of a farm likewise varies widely between small farms and large industrial farms. These differences are consequential for farming labor practices, as well as the potential returns from investments in technologies; as scholars have observed, the adoption of new farming technologies requires resource-rich farms, enforcing a cycle in which inequities among farmers are reproduced and entrenched.[40] Smaller farms will see diminishing returns when investing in costly technologies.[41] Large industry operations, by contrast, are better poised to benefit from economies of scale, in which even a 0.25% increase in yield productivity can be a huge sum, from purchasing farm inputs (such as fertilizer) in bulk to possessing the capital to invest in new technologies.[42]

39 Robert Hoppe, US Farms Large and Small, US Department of Agriculture Economic Research Center, January 13, 2015, https://www.usda.gov/media/blog/2015/01/13/us-farms-large-and-small; Lydia DePillis, "Farms Are Gigantic Now. Even the 'Family Owned' Ones," The Washington Post, August 11, 2013, https://www.washingtonpost.com/news/wonk/wp/2013/08/11/farms-are-gigantic-now-even-the-family-owned-ones/?utm_term=.c9d2718597ef.

40 To start, see Lindsay Ferris and Zara Rahman, Responsible Data in Agriculture, Global Open Data for Agriculture & Nutrition (Godan), September 15, 2016, https://www.godan.info/documents/responsible-data-agriculture.

41 Michael Hickins, "For Small Farmers, Big Data Adds Modern Problems to Ancient Ones," Wall Street Journal, February 26, 2014, https://blogs.wsj.com/cio/2014/02/25/for-small-farmers-big-data-adds-modern-problems-to-ancient-ones/.

42 Roni Neff, Introduction to the US Food System: Public Health, Environment, and Equity, (Hoboken, NJ: John Wiley & Sons, 2014), 271.

Secondly, farms are not self-enclosed systems: agricultural operations are facilitated by an array of stakeholders and business relationships. The traditional vision of the US farmer is mismatched with the current reality. For instance, the prototypical farmer is someone who owns a farm, works the land, and sells his (often the traditional image is of a man) crop or livestock for profit. However, these characteristics are no longer always contained within the same person. Producers, those who manage a farm and sell the goods, may call themselves or be referred to as farmers. Yet to grow a crop, a farmer's resources – including land to farm, seeds to grow, and expertise and technology to manage and harvest, as well as labor – are likely provided and controlled by different actors. For instance, many farmers do not own the land they farm, instead leasing it from a landlord. If they do own some land, they may lease additional land. According to 2012 US census data, 39% of farmland acres were rented out from landowners, 87% of whom were not farm operators.[43]

Financial institutions are an important part of this ecosystem. In farming, as in other industries, analytics and AI technologies are facilitating the growth of financialization, which economists describe as the trend toward increasing the size, role, and influence of the financial industry, including financial institutions, instruments, and markets.[44] One example of this is the role of insurance companies, which are relying on increasingly large amounts of data to calculate the risks taken on by farmers.[45]

43 2012 Census of Agriculture Highlights: Farmland Ownership and Tenure, USDA National Agricultural Statistics Service, September 2015, 1, https://www.nass.usda.gov/Publications/Highlights/2015/TOTAL_Highlights.pdf.

44 On financialization of agriculture, see James W. Williams, "Feeding Finance: A Critical Account of the Shifting Relationships Between Finance, Food and Farming," Economy and Society vol. 43, no. 3 (July 3, 2014), 401–31, https://doi.org/10.1080/03085147.2014.892797; Sarah Ruth Sippel, Nicolette Larder, and Geoffrey Lawrence, "Grounding the Financialization of Farmland: Perspectives on Financial Actors as New Land Owners in Rural Australia," Agriculture and Human Values vol. 34, no. 2 (June 1, 2017), 251–65, https://doi.org/10.1007/s10460-016-9707-2. See also Mike Konczal and Nell Abernathy, "Defining Financialization," Roosevelt Institute, July 27, 2015, http://rooseveltinstitute.org/defining-financialization/.

45 Ari Libarikian et al., "Harnessing the Potential of Data in Insurance," McKinsey, May 2017, https://www.mckinsey.com/industries/financial-services/our-insights/harnessing-the-potential-of-data-in-insurance.

The abundance of agricultural data has also raised concerns about the possibility of market manipulation.[46] Furthermore, in everyday practice, the turn to automation in the market threatens more traditional farming experiences. Following a trade show presentation on markets, one farmer in his 60s explained, "In my day, you had a relationship with the trader in Chicago ... but now it's just some mathematical algorithm that's driving everything. It's lost a personality, and it's very isolated. There's no camaraderie. Not fun to live through it."

Financialization has also contributed to farmers' experiences of financial precarity. A landowner we interviewed who no longer farms confided that she just didn't understand how farmers were managing these days: "I know what I pay at the grocery store for things, I know what they make, I know what their expenses are, and I just know they aren't making enough." Another soybean farmer explained, "Nothing drives a farmer nuts like having prices go crazy out of supply and demand. There's an emotional toll to have to suffer those shocks." Many people we spoke with gave the sense that everyone was taking a piece, and farmers were being left with scraps. One grain producer relayed a story he found emblematic about how a farmer, feeling uncertain about market prices, sold to a buyer "low," then watched as his buyer turned around and "sold it to another place, right after, for a higher price. It's all about those few cents mounding up."

At the 2018 National Farm Machinery Show in Louisville, Kentucky, an analyst advised a packed room of farmers, producers, and landowners, "The funds are the sharks in the ocean, and you shouldn't be the sea lions they feed on." He continued, "Be the fishes feeding around them. Work with the shark. Work with the shark." The funds the analyst was referencing were people who trade

46 Katherine Noyes, "Cropping Up on Every Farm: Big Data Technology," Fortune, May 30, 2014, http://fortune.com/2014/05/30/cropping-up-on-every-farm-big-data-technology/; Neal Rasmussen, "From Precision Agriculture to Markey Manipulation: A New Frontier in the Legal Community," Minnesota Journal of Law, Science and Technology vol. 17, no. 1 (February 2016), https://scholarship.law.umn.edu/cgi/viewcontent.cgi?article=1008&context=mjlst.

commodities and futures in financial markets. Visiting the show and talking with attendees and exhibitioners, there was a pronounced sense that farming was not only being "reduced" to a business but also being held hostage by the "boys on the coasts who like to play in the markets," as one audience member later put it.[47]

Similar tensions are also emerging between the business logics put forward in tech companies' marketing rhetoric and established farm business practices. Some legacy farm- equipment companies, which establish their reputations locally at dealerships and trade shows, rely on marketing rhetoric that speaks to a sense of calling and tradition.[48] Newer, typically Silicon Valley–based, technology companies appeal to different logics that speak more to the economic strains faced by farmers, encouraging them to manage their farms like any other data-driven business. These tools, and others being developed by smaller start-ups, promise "smart" solutions through digital data collection. Accompanying this goal is the normative messaging that pervades precision agriculture tech marketing, which tends to devalue certain forms of expert knowledge, underscoring that "good farmers do not follow their gut, they follow data."[49] At a farming trade show session on technology, a representative from a major agricultural tech company told the audience that farmers need to change the way [they] farm," starting with ensuring accurate data collection, in order to "make profitable decisions." The representative warned the audience that "the longer you wait to work with [data-driven tech], the harder it will be." But as one crop consultant we met explained, many farmers weren't equipped to make this transition:

47 On fund manipulation of crop commodity markets, see James W. Williams and Nikolai M Cook, "Econometrics as Evidence? Examining the 'Causal' Connections Between Financial Speculation and Commodities Prices," Social Studies of Science vol. 46, no. 5 (October 1, 2016), 701–24, https://doi.org/10.1177/0306312716658980.

48 As one equipment dealer's slogan declares on its website, "Strong Heritage, Strong People, Stronger Future!" Helle Farm Equipment, http://www.hellefarmequipment.com/.

49 Michael Carolan, "Publicizing Food: Big Data, Precision Agriculture, and Co-Experimental Techniques of Addition," Sociologia Ruralis vol. 57, no. 2 (April 1, 2017), 135–54, https://doi.org/10.1111/soru.12120.

> [Farmers] haven’t managed these individual fields like an individual production factory, like a normal business would. And so they’re not managing a P&L [profits and losses] per production factory. It’s hard for them without really good records and good tools to improve the efficiency and the effectiveness of their farm. They don’t know the return on investment of this field versus that field.

Many AI technology companies have entered the industry with promises to cut out the middle man and help producers get the most value out of their crops, “to capitalize on the profit that’s being driven from the top down,” in the words of one “intelligent storage” start-up. However, within the context of wider trends in the industry described above, the farmers we spoke to expressed a sense of cynicism toward new intermediaries, especially if they were new to the agriculture industry and had not gained the trust of farmers. One representative from an agrochemical company described this disconnect: “Quite often the Silicon Valley company is trying to apply their capability to agriculture, but they don’t understand enough about agriculture to know the relevance of what they’re doing. Quite often it’s apparent they don’t know corn plants from oak trees.” And while new tech intermediaries promise greater profits, they also entail greater risks and the ability to experiment is limited by practical – and often temporal – constraints. For example, the timescales and seasonal cycles of farming impose a particular rhythm that can feel counter to speed of the tech world. As one market research analyst we spoke with emphasized:

> Farmers only have one kind of chance to test technology a year and the weather changes a lot year by year. ... That really slows down technology adoption. Unless you have something that is really, extremely impactful in terms of efficiencies,

> farmers will not see that because they’re testing very little once a year and there’s too many variables that are playing together.

Although the large-scale, long-term impacts of data-driven and AI technologies on agricultural economics are unknown, this section has laid out some of the ways in which adoption of data-driven technologies comes with certain risks. For some farmers, this new landscape has prompted anxieties around the future, including the potentially exploitative role played by new technology intermediaries.[50] Importantly, narratives about precision agriculture tools from vendors, market analysts, and proponents of big data tend to elide the resultant frictions on the ground.

> Quite often the Silicon Valley company is trying to apply their capability to agriculture, but they don’t understand enough about agriculture to know the relevance of what they’re doing. Quite often it’s apparent they don’t know corn plants from oak trees.”

50 Karen Levy, Solon Barocas, and Alexandra Mateescu, “Reap What You Sow? The Privacy of Agricultural Data,” Northeast Privacy Scholars Workshop, October 20, 2018, Fordham University School of Law, New York, New York.

Grocery Retail

The grand opening of the Amazon Go store in January 2018 elicited considerable media coverage, which proclaimed it the death knell of frontline retail jobs. Amazon Go is a grocery store in Seattle operated by Amazon using a combination of technologies that use computer vision and sensors throughout the store to detect when shoppers pick up specific store items and then charge them to shoppers' accounts as they exit the store. As a result, the store has no cash registers, cashiers, or other frontline workers, although a small staff continues to stock shelves and prepare baked goods behind the scenes.[51]

In response to the apparent obviation of human staff, an article in VentureBeat began with the proclamation that the "illusion of job safety for the 3.5 million cashiers in America was shattered" now that the Amazon Go concept has been proven operational.[52] The *New York Times* likewise identified Amazon Go as a catalyst to a "global race to automate stores,"[53] while Fortune speculated that nearly half of all retail jobs would now be lost to automation.[54] Following the Seattle store's opening, Amazon announced that it would be opening a second store in Seattle, as well as stores in

51 Natt Garun, "Amazon Just Launched a Cashier-Free Convenience Store," The Verge, December 5, 2016, https://www.theverge.com/2016/12/5/13842592/amazon-go-new-cashier-less-convenience-store.

52 German Chastel, "The Amazon Go Effect: How Bots Fit into the Future Workforce," VentureBeat, February 1, 2018, https://venturebeat.com/2018/02/01/the-amazon-go-effect-how-bots-fit-into-the-future-workforce/.

53 Nick Wingfield, Paul Mozur, and Michael Corkery, "Retailers Race Against Amazon to Automate Stores," the New York Times, August 7, 2018, sec. Technology, https://www.nytimes.com/2018/04/01/technology/retailer-stores-automation-amazon.html.

54 David Morris, "Retail Automation: Nearly Half of All Retail Jobs Could Be Lost," May 21, 2017, http://fortune.com/2017/05/21/automation-retail-job-losses/.

Chicago, San Francisco, and New York, although the company has not made clear its long-term plans for Amazon Go's expansion.[55]

Although Amazon Go is currently more experimental project than established retail competitor, its model has been described as the future toward which legacy grocery retailers will aspire in the coming years.[56] Supermarket, grocery, and drugstore retailers are one of the most scrutinized retail ecosystems. For these businesses, the push to deploy artificial intelligence and other technologies is in part motivated by fears that legacy grocery retailers are being undercut by "category killers" – chain retailers that provide a wide array of products at heavily discounted prices – like Amazon and Walmart, whether through e-commerce or cutting-edge technologies deployed within stores or throughout the supply chain.[57] Currently, companies are developing AI applications to help retailers perform customer service functions, personalize marketing, identify new trends, predict demand of goods, and streamline logistics and just-in-time manufacturing.[58]

Operating on extremely thin profit margins, supermarket retail has throughout its history relied on technology to cut labor costs, target consumers, and influence in-store shopper behavior through architecture and the spatial organization of products. As media scholar Joseph Turow states, in the last 20 years, supermarket chains have been inundated with the message from technology companies that they "will succeed only if they figure out how to

55 Chaim Gartenberg, "Amazon Is Opening a Second Cashier-Less Go Store in Seattle This Fall," The Verge, July 3, 2018, https://www.theverge.com/2018/7/3/17532188/amazon-go-seattle-new-store-location-fall-2018; Nat Levy, "Amazon Go Is Coming to New York City, 3rd Market Outside Seattle for Checkout-Less Grocery Concept," GeekWire, September 7, 2018, https://www.geekwire.com/2018/amazon-go-coming-new-york-city-3rd-market-outside-seattle-checkout-less-grocery-concept/.

56 For instance, futurist Martin Ford describes the retail spaces of the future as "scaled-up vending machines" that would consist of an "automated warehouse with an attached showroom where customers could examine product samples and place orders." Martin Ford, Rise of the Robots: Technology and the Threat of a Jobless Future, reprint edition (New York: Basic Books, 2016), 20.

57 Rajiv Lal and Jose B. Alvarez, "Retailing Revolution: Category Killers on the Brink," HBS Working Knowledge, October 10, 2011, http://hbswk.hbs.edu/item/retailing-revolution-category-killers-on-the-brink.

58 Surviving the Retail Apocalypse: The Technologies and Trends That Can Help Brick-And-Mortar Thrive Again, CB Insights Research, April 24, 2018, /research/retail-apocalypse-survival-technology-trends/.

trace, quantify, profile, and discriminate among shoppers as never before."[59] Consumers are increasingly positioned as valuable not only because of spending power but also as sources to mine for valuable data. By contrast, the future envisioned for frontline retail workers is either one of obsolescence through automation or a rechanneling of the workforce into higher-skilled positions. The argument goes that these workers will be repurposed for more fulfilling customer-facing roles, because tiring and repetitive manual tasks will be performed by AI-powered systems and robots in the background. Less consideration is given to how existing low-wage service jobs may be reconfigured in other, potentially detrimental, ways.

> The self-checkout machine is more representative of the piecemeal way in which retailers pick up and experiment with new technologies, relying on humans to smooth out the rough edges.

Technology has shaped and reshaped retail spaces for decades. This section takes a previous technological innovation – the self-checkout machine – as an avenue for understanding how frontline workers enable the everyday functioning of technology. Unlike many technologies poised to disrupt retail, self-checkout does not rely on machine learning. Instead, it relies on the refashioning of older digital technologies, using system design to externalize the labor costs of scanning and bagging groceries onto shoppers.

59 Joseph Turow, The Aisles Have Eyes: How Retailers Track Your Shopping, Strip Your Privacy, and Define Your Power (New Haven: Yale University Press, 2017), 3.

In many ways the self-checkout machine is more representative of the piecemeal way in which retailers pick up and experiment with new technologies, relying on humans to smooth out the rough edges. And unlike Amazon Go's self-enclosed system, ordinary supermarkets are patchwork spaces, layering new systems onto old ones as they contend with the realities and limitations of existing physical infrastructures.

Self-checkout machines initially incited widespread fears from workers, unions, labor advocates, and others that cashier jobs would become obsolete, as they would soon be replaced with machines.[60] But while they first became a commonplace technology in the 1990s, by 2013 there were only roughly 191,000 self-checkout stands in use worldwide.[61] Retailers have periodically expanded and scaled back their use over the years. Some, like Target, have begun to expand the number of self-checkout stands in their stores, while others, like CVS, have reduced their use.[62] Typically, retailers engage in survey work of local markets to gauge the extent to which installing self-checkout machines will assist or hurt sales. Yet despite the ebbs and flows of self-checkout's popularity, its effect has been similar to that of ATMs on bank teller jobs: while individual bank locations began employing fewer tellers, banks also began to open more branches, thus increasing the total number of tellers countrywide.[63] Similarly, the total number of cashier jobs in the US has actually increased, and most self-checkout areas in stores are monitored by an attendant.[64] This is a dynamic we will explore in greater detail below.

60 Christopher K. Andrews, "Do-It-Yourself": Self-Checkouts, Supermarkets, and the Self-Service Trend in American Business, PhD diss., University of Maryland, 2009, http://drum.lib.umd.edu/handle/1903/9593.

61 Self-Checkout: A Global Consumer Perspective, NCR, 2013, 2, https://www.ncr.co.jp/wp-content/uploads/files/solutions/self/fl/fl_wpa/RET_SCO_wp.pdf.

62 Barb Darrow, "Yay! Human Cashiers Prevail over Automation at Some CVS Stores," Fortune, October 20, 2015, http://fortune.com/2015/10/20/cvs-self-check-out-stations/.

63 James Bessen, "Scarce Skills, Not Scarce Jobs," the Atlantic, April 27, 2015, https://www.theatlantic.com/business/archive/2015/04/scarce-skills-not-scarce-jobs/390789/.

64 Bourree Lam, "The Unexpected Resilience of Humans in Retail," the Atlantic, April 21, 2016, https://www.theatlantic.com/business/archive/2016/04/humans-retail/479223/.

SHIFTING ROLES: THE EROSION OF FRONTLINE GROCERY RETAIL JOBS

This section provides an overview of some of the dynamics we found in speaking to frontline grocery workers, including cashiers, self-checkout attendants, store managers, and others, in the Los Angeles area, providing insight into some of the ways that self-checkout has unsettled the roles and expectations of cashiers.

> While self-checkout did not kill the cashier job, it did shift the roles, responsibilities, and perceptions of frontline retail workers' jobs in often detrimental ways.

While self-checkout did not kill the cashier job, it did shift the roles, responsibilities, and perceptions of frontline retail workers' jobs in often detrimental ways. Long before the introduction of the self-checkout machine, the supermarket workforce was experiencing a trend of casualization, as employers began to erode workers' wages and benefits.[65] Store clerk roles are increasingly part time and filled by a younger workforce with a higher turnover rate.[66] The workforce today is at a crossroads of this progression: even in our small sample of interviewees, we encountered employees who had worked in their field for as short a period as a few months to more than 30 years, from high school students up to those near retirement age. This split has shaped how employees view their

65 Françoise Carré and Chris Tilly, Where Bad Jobs Are Better: Retail Jobs Across Countries and Companies (New York: Russell Sage Foundation, 2017), 20–21.

66 Christopher K. Andrews, "'Do-It-Yourself": Self-Checkouts, Supermarkets, and the Self-Service Trend in American Business, PhD diss., University of Maryland, 2009, http://drum.lib.umd.edu/handle/1903/9593.

relationship to their work, as the "old-timer" employees we spoke to generally felt that, while they had built a career within the grocery industry, they would soon be replaced with casual part-timers once they retired.

Although the reasons for these shifts are complex, technology has played a role throughout the broader economic and organizational changes to supermarket retail. In the 1940s, self-service was popularized by retailers as an embodiment of American values of independence and greater consumer choice. Once shoppers could pick items from shelves themselves, the assistance of store clerks became less central.[67] Stores also introduced the UPC and bar code scanners in the 1970s, which, along with other trends toward "lean retailing," meant that frontline workers no longer needed to memorize even basic product information, such as price.[68] By the time self-checkout machines were introduced in the 1990s, shoppers had already come to expect minimal customer service from supermarket employees.

With their roles greatly transformed over the course of several decades, frontline workers' productivity became increasingly measured in terms of speed and efficiency. While bar code scanning was not necessarily faster than a seasoned cashier with a good memory, the introduction of the scanners made it possible for retail stores to track cashiers' scans per hour (SPH) as a metric of productivity.[69] Instead of constant managerial oversight, check stand workers could be continuously "scrutinized through a wholly internalized process that actively shapes worker performance" as they tallied up purchases.[70]

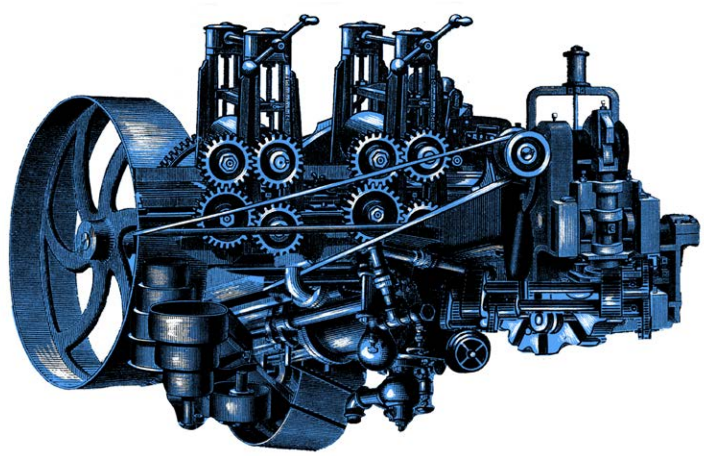
67 Michael Palm, Technologies of Consumer Labor: A History of Self-Service (New York: Routledge, 2016).

68 Françoise Carré and Chris Tilly, Where Bad Jobs Are Better, 128.

69 Emek Basker, "Raising the Barcode Scanner: Technology and Productivity in the Retail Sector," American Economic Journal: Applied Economics vol. 4, no. 3 (2012), 1–27.

70 Rob Kitchin and Martin Dodge, Code/Space: Software and Everyday Life (Cambridge, MA: The MIT Press, 2014), 11.

Speed and efficiency have also been some of the major marketing sells of self-checkout machines, as a solution to customer wait times in checkout lines.[71] Many retail technologies focus on the problem of accelerating and measuring the speed of revenue through the check stand. In 2018, for instance, Walmart patented a system for recording conversations in proximity of cash registers in order to measure the speed of customers' movement through a line.[72]



Self-checkout machines never achieved the efficiency gains they had originally promised, but many cashiers still feel that the machines were the point of comparison against which they were measured and valued by both store management and the shoppers with whom they interacted daily. Lisa, a cashier in her 40s who has worked in grocery for the last 24 years, spoke about how she had gotten used to working both human-operated check stands and monitoring self-checkout areas. However, she felt frustrated that even when she worked the human-operated check stands, customers had a

71 BRP Consulting, Defining a Next Generation POS Platform Strategy, Fujitsu, June 2017, http://marketing.us.fujitsu.com/rs/407-MTR-501/images/Defining%20a%20Next-Generation%20Grocery%20POS%20Platform%20Strategy.pdf.

72 Caroline O'Donovan, "Walmart's Newly Patented Technology for Eavesdropping on Workers Presents Privacy Concerns," BuzzFeed News, July 11, 2018, https://www.buzzfeednews.com/article/carolineodonovan/walmart-just-patented-audio-surveillance-technology-for.

tendency to perceive her not as a person but as an "extension of the machine." This affected not only her ability to socially connect with customers in small ways but also made her feel dehumanized. She said, "The ones that see you as a person are willing to be more patient and wait for you. The other ones that see you not as a person, but more as an extension, they could care less who's next." Instead, she added, receiving immediate assistance is their only concern.

At the same time, cashiers often reported feeling like they face contradictory expectations from management to both provide satisfactory service and to process transactions quickly. This puts strain on the relationships that employees have with long-time grocery shoppers, particularly at local stores with an older customer base. As one cashier explained, "If you have a customer that's been coming to the store for who knows how long, X amount of years, and they know you, you're not just going to check them out as if they're just an object." The "human touch" was often cited as an important part of the work for the cashiers we spoke with and was often a reason why an employee chose to work in the front rather than behind the scenes. But often frontline workers found themselves too pressed for time to converse with customers.

Self-checkout machines have played a role in the casualization of retail employment by making it easier for stores to reduce total worker hours and to more heavily rely on part-time staff, because the machines can be made active or inactive on an as-needed basis.[73] However, explanations for what this flexibility enables in practice differed between the store management and frontline workers we interviewed. As explained by management in conversation and official company statements, self-checkout machines provide faster service to shoppers while easing pressure on check stand workers, freeing them up to do other necessary work. As one store manager

73 Christopher K. Andrews, "'Do-It-Yourself": Self-Checkouts, Supermarkets, and the Self-Service Trend in American Business, PhD diss., University of Maryland, 2009, http://drum.lib.umd.edu/handle/1903/9593.

said, "If you want it, there's a person there. But [self-checkout] does free up what would generally be a cashier position to do something else in the store or to help the store in a different way." She explained that the machines ensure one-to-one service between employees and shoppers in need of help at any given time.

However, frontline employees tended to view self-checkout machines as a company tool for cost cutting by reducing worker hours, placing more pressure on cashiers. Some frontline employees expressed frustration and confusion over what they believed to be management's intentional, routine understaffing of the human-operated check stands. As one cashier explained:

> When [self-checkout] was introduced, they basically reduced the staff at the front, making the customer use these machines rather than wait in line. But what happens now is that since they don't really use the staff up front, they'll purposely allow the lines to get so long, and the customer of course gets frustrated and is forced to use the machine.

While self-checkout technology is often marketed as a response to "natural" consumer demand,[74] cashiers are often instructed to funnel shoppers to the self-checkout lanes as much as possible. Stores typically receive quotas from higher levels of management for the desired percentage of shoppers taking their purchases through self-checkout. Frontline workers complained that this target percentage for self-checkout was being periodically raised. At one store we visited, for instance, the staff was working toward increasing shoppers' use of self-checkout machines up to a rate of 30%. However, this proved to be challenging because of regional

74 For example, a 2014 market study by automated kiosk manufacturer NCR Corporation concluded that "tech-savvy consumers appreciate the convenience and speed of retail self-checkout. Retailers are responding to consumer demand and usage, and the loyalty and impact on the bottom line that the technology can drive in-store." "Global Study Reveals That Shoppers and Retailers Widely Value and Adopt Self-Checkout Technology," NCR, September 30, 2014, https://www.ncr.com/news/newsroom/news-releases/retail/global-study-reveals-shoppers-retailers-value-adopt-self-checkout-technology.

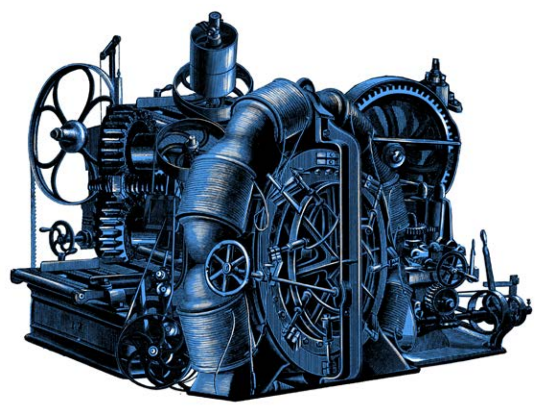
and demographic variation in preference for use of self-checkout machines; while some shoppers embrace the technology, others must be convinced. Employees at one store we observed found it very difficult, for example, to convince elderly shoppers to use self-checkout machines. Even when they did, these shoppers often slowed down the line by needing significant assistance.

These trends – the casualization of the workforce, new efficiency pressures, and feelings of devaluation – have likely contributed to the high worker turnover of supermarket retail. While frontline workers feel the consequences through periodic understaffing, store management struggles with hiring, training, and scheduling. At one supermarket location, a sales manager pointed out that their store's turnover rate for employees had reached a high of 75%. Management held regular meetings to discuss strategies for fostering higher employee retention, and the company had instituted an internal program for addressing this issue. But Arnold, a grocery clerk who has worked in the industry for 25 years, was skeptical of these efforts, pointing out that the fundamental root of the problem was that as employers, supermarkets no longer provided the benefits and wages that attract and retain employees:

> What's really clear is there's not the incentives there used to be for people, that just aren't working, and you see that in the turnover now. ... They're not getting paid much, there is no benefits, so there is a bigger turnover as far as people quitting, and us having to hire new people.

He further observed that processes for training new employees had been sped up, relying increasingly on computer modules and pamphlets rather than more intensive, one-to-one training that had been standard in the past. This is in line with broader trends in the retail industry, where companies have invested in technology-facilitated training in lieu of more labor-intensive training with human supervision. In 2018, for instance, Walmart piloted an associate training program conducted via virtual reality headset.[75]

As this section has shown, the impact of these retail technologies has generally not been one of replacing human labor. Rather, they facilitate cost-cutting measures such as relying more heavily on part-time employees, understaffing, and intensifying work activities. In this context, employers can place greater pressures on frontline workers to absorb the consequences of these business decisions. In other words, the "success" of technologies like self-checkout machines is in large part produced by the human effort necessary to maintain them.



UNEVENLY DISTRIBUTED COSTS OF EXPERIMENTATION: MINDING THE MACHINES

While intuitively it would seem that the introduction of technologies like self-checkout machines would require supervision from less-experienced employees, this has not been the case. Two rows of self-checkout machines line each side of the check stands at

75 Mariella Moon, "Walmart Turns to VR and Oculus Go for Associates' Training," Engadget, September 20, 2018, https://www.engadget.com/2018/09/20/walmart-vr-training-oculus-go/.

a particularly large, bustling Ralphs supermarket in northern Los Angeles. Checkout employee Lisa deftly alternates between talking about her work and keeping her eyes and attention fixed on the long line of shoppers waiting to scan their items. “I hate working the side with six machines,” she says in a tone of frustration, pointing to the automated station on the side opposite her own, where only four machines are installed. Overseeing six machines, she explains, pushes the limits of her ability to keep the flow of customers running smoothly. The amount of assistance shoppers need to complete a transaction seems to vary widely. When shoppers do need assistance, they don’t often ask for it directly but instead freeze mid-transaction at their stations, uncertain what to do next. Lisa must keep her eyes on shoppers’ body language to know when to step in, usually to do something as simple as pointing out the “Credit” button on the touch-screen interface. In addition to keeping the line flowing, she is frequently approached by shoppers who cluster near the side of her station to ask questions. Lisa does her best to assist them even though she cannot leave her station or pull her attention away from the machines for too long.

> The human infrastructures of self-checkout include not only the know-how and input of the self-checkout attendant but also the labor of the consumer.

Lisa’s experience, and those of other employees that we interviewed, underscores the extent to which self-checkout technologies require human infrastructures to function. The human infrastructures of self-checkout include not only the know-how and input of the self-checkout attendant but also the labor of the consumer. This practice has commonly been termed shadow work, which sociologist Craig Lambert defines as "all the unpaid tasks we do on behalf of businesses and organizations" and in which a "technological innovation enables a business, like a restaurant, to remove one or more employees from transactions."[76] For retail companies, a primary benefit of self-service technologies has been offloading labor onto shoppers to reduce labor costs.

> Filling the gap between shoppers and checkout machines requires a different skill set than that of simply operating a check stand, more akin to that of a traffic officer coordinating vehicles at a convoluted intersection.

However, shoppers do not make efficient workers. The automated message "unexpected item in the bagging area," used to indicate when the weight-based detection system fails to identify a product, has become iconic of consumers' frustrations with self-service technologies.[77] Filling the gap between shoppers and checkout machines requires a different skill set than that of simply operating a check stand, more akin to that of a traffic officer coordinating vehicles at a convoluted intersection. As one sales manager said, "Usually, we want our most experienced cashiers on these robots.

76 Craig Lambert, Shadow Work: The Unpaid, Unseen Jobs That Fill Your Day (Berkeley, CA: Counterpoint, 2015), 141.

77 Adriana Hamacher, "The Unpopular Rise of Self-Checkouts (and How to Fix Them)," BBC, May 10, 2017, http://www.bbc.com/future/story/20170509-the-unpopular-rise-of-self-checkouts-and-how-to-fix-them.

Just the fact that if you're not paying attention and if somebody's not scanning an item, you're just giving it away, you know?" Workers monitoring self-checkout need competencies including diagnosing a shopper's source of confusion, being able to spot potential theft,[78] and dealing with the fatigue of maintaining attention, multitasking, and standing for long stretches of time. In some cases, frontline employees had also taught themselves to do basic mechanical and software repairs, since the machines often broke down and managers were reluctant to call in a technician. Luis, a cashier in his 50s, described how he was often called upon to fix mechanical issues, such as unjamming the cash dispensers. Although this was not a part of his official job description, he gained a reputation among staff as being "mechanically inclined" because of his previous work experience repairing Bell and Howell equipment in the 1990s.

> While retailers experiment with new ways of reconfiguring shopping practices through technology, frontline employees struggle to compensate for these new systems' shortcomings.

78 See Emmeline Taylor, "Supermarket Self-Checkouts and Retail Theft: The Curious Case of the SWIPERS," Criminology & Criminal Justice, April 18, 2016, https://doi.org/10.1177/1748895816643353. An unintended consequence of self-checkout technology is that retailers have been plagued with a "shrinkage" problem—the loss of merchandise through theft, intentional or accidental. Self-checkout machines are typically designed with weight-based anti-theft systems, but these measures are often inadequate, as shoppers often unintentionally walk off with products or have found ways to game these systems. Although we hypothesized that self-checkout monitors would be held liable for thefts occurring on their watch, we found that retailers have generally accepted shrinkage as inevitable, although monitors were still perceived as playing an important role in reducing loss through the self-checkout lanes.

While retailers experiment with new ways of reconfiguring shopping practices through technology, frontline employees struggle to compensate for these new systems' shortcomings. Self-checkout areas are typically arranged so that one attendant has a clear line of sight on all of the machines at once. This model grants employees both a sense of control and a clearly delimited territory for which they can be held responsible during a given shift. But in recent years, supermarket retailers have introduced scan-and-go systems that shift self-service systems from check stands into the aisles. For instance, major supermarket retailer Kroger has recently introduced a program called Scan, Bag, Go, with which shoppers can download an app or use a handheld scanner to check out products as they get them from the shelves.[79]

> Usually, we want our most experienced cashiers on these robots.

An employee at a Kroger subsidiary supermarket where Scan, Bag, Go had been installed explained that one of the biggest challenges that scan-and-go systems posed was that they often made it harder to provide adequate customer service. The app or the handheld scanner frequently showed error messages, typically with the accompanying message: "Help is on the way! The associate named below has accepted your help request." And while in theory the GPS signal from the shopper's phone or handheld scanner was to be

79 See "Kroger Announces Divisions for Scan, Bag, Go Expansion," Kroger, January 31, 2018, http://ir.kroger.com/file/Index?KeyFile=391984350. Thus far, retailers have had mixed results in integrating these systems into the everyday routines within stores, as some retailers have backtracked or abandoned their use. In early 2018, for instance, Walmart tested its Scan & Go system in over 100 of its stores across the US, but a few months later it abandoned the program due to low consumer participation; see: Gregory Magana, "Walmart Shutters Its Scan & Go Program," Business Insider, May 17, 2018, https://www.businessinsider.com/walmart-ends-cashierless-checkout-2018-5. Walmart then introduced a new program called Check Out with Me, in which sales associates walk through the aisles, checking out customers on the spot using handheld credit card swipers; see Sarah Perez, "Walmart Launches 'Check Out With Me' For On-The-Spot Checkouts in Hundreds of US Locations" Tech Crunch, April 19, 2018, https://techcrunch.com/2018/04/19/walmart-launches-check-out-with-me-for-on-the-spot-checkouts-in-hundreds-of-u-s-stores/.

used to locate the shopper, often this information was imprecise and there was a delay before a store employee could access the shared device that indicated the shopper's location. In the meantime, shoppers tended to quickly lose patience and wander from their original spot. Additionally, shoppers frequently had trouble angling their phones or handheld devices in order to scan barcodes and often got stuck trying to scan an alcohol item. For employees, the task of providing quality customer service for such systems is chaotic. The transformation of the entire store into one large, distributed checkout process created a sense of uncertainty and lack of control for workers, whose workspace boundaries were now nebulously defined.

> Our research shows that self-service technologies have not reduced but rather reconfigured the skills and responsibilities that fall on cashiers.

Our research shows that self-service technologies have not reduced but rather reconfigured the skills and responsibilities that fall on cashiers. Often, the technologies are intensifying the work of customer service and creating new challenges, such as balancing between performance pressures from store management and the demands of shoppers. From a top-down perspective, much of the work that employees must do on the ground to facilitate experimentation with new systems raises questions about how this work may be invisible and undervalued, even as popular perceptions of automation frame these roles as increasingly obsolete.

Conclusion:
The Who, What, and Where of Disruption

Examining the realities of AI and automated technologies through the lens of integration rather than deployment and reconfiguration rather than replacement allows us to see not only how these technologies are actually working but also for whom and to whose benefit. While the hype and marketing around AI technologies point toward broad benefits and universal gains, on-the-ground consequences are much more complicated. AI technologies must be integrated into existing social contexts, through the work of particular human bodies and practices. These human infrastructures are necessary to realize the promises and goals of automated and AI technology.

In the cases of farm management and grocery retail technologies, we articulated two common categories of consequence occasioned by the introduction of automated and AI technologies: shifts in work roles and expectations, and unevenly distributed costs of experimentation. However, within these two common themes there are significant differences to articulate. Farmers and checkout workers have different degrees of agency and choice when it comes to adopting technology. While we described the pressures of acquiring new resources and skills in the family-owned farm context and the kinds of tensions and risks associated with these acquisitions, farmers are able to act as decision-makers about adopting new technology. While their decisions may be shaped or constrained by social and economic forces, they have degrees of choice. In contrast, grocery retail workers have little to no agency in deciding the types of technologies with which they work and the conditions of that work. Looking forward, planning for and assessing new AI technologies must take into account the kinds of agency and variable power that different types of populations will be able to exercise.

The frames and contexts presented in this report point toward how we might improve future development, assessment, and regulation of AI technologies. Focusing on the integration of AI and the labor that is reconfigured brings into view structures of power that are at stake. This can help us anticipate who will be empowered and who will be left without a voice. Our findings suggest that public understanding and debates would be strengthened if reporting on AI focuses not just on a technology's potential capacity or ideal use case, but also on the labor of integration and the humans who are either left in the lurch or relied upon to smooth out a technology's rough edges. Similarly, if designers keep these human operators and users at the center of development, AI technologies can enhance and complement existing skills and expertise, rather than foreclose the discretionary power of frontline workers. Finally, our research suggests that policy makers and advocates should keep watch of the unevenly distributed costs of experimenting and implementing new technologies. Advocates may consider how the labor of AI integration is often under-acknowledged, and the consequences for how workers are compensated and supported. Given that the labor of AI integration is often invisible or under-acknowledged, it is all the more important to ensure that those who work with and alongside AI systems are adequately protected, supported, and compensated. While "transitional" or "intermediate" phases are by definition temporary, they are still actualities that affect workers in the present and need to be addressed.

While machine learning systems are increasingly underpinning interactions with mobile and internet applications (from search and news curation to virtual assistants like Siri or Alexa), applications in everyday physical locations like corn fields and supermarkets have tended to be more limited, involving simpler automation, relatively limited user bases, or prototype-phase AI technologies. The integration of AI into every aspect of daily life may come one day, but it is not here yet. Now is the time to develop new ways of thinking about and designing AI technologies.

AI holds great promise for advancing society and addressing existing problems. However, the potential benefits must not obscure these technologies' potential perils. These perils have nothing to do with "killer robots" or the coming of "robot overlords." They will be found in the everyday structuring potentials of AI that will benefit some members of society but may leave many others behind.

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