NORTH CAROLINA JOURNAL OF LAW & TECHNOLOGY
VOLUME 23, ISSUE 1: OCTOBER 2021

AGCHAIN: DEPLOYING A PUBLIC UTILITY BLOCKCHAIN TO UNVEIL THE MISSING LINKS BETWEEN FOOD ORIGIN & DESTINATION

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Modern agriculture has stretched into an unintelligible supply chain with a global reach, leaving consumers unable to make fully informed decisions related to their food. Additionally, such complexities confound adequate regulation. Blockchain technology, a data system using a distributed ledger on a peer-to-peer network, boasts various theoretical applications born of its ability to deliver security via decentralization and other unique information management strategies. In stark contrast to this technological innovation, the regulatory mechanisms the United States deploys to manage its supply chains lay stagnate. The antiquated and reactive posture with which the United States regulates and controls its food safety and supply is of particular significance. This Article explores the untapped potential in blockchains as supply chain management tools, capitalizing on data abundance to improve transparency for regulators and consumers alike. Because the food supply is one of the Nation's most vital industries but is also one of the most outdated, agriculture should be the first industry converted to a blockchain system. Additional benefits to modernizing the United States' food supply chain include improved ethical transparency to consumers and shielding companies as well as government agencies from harmful cyberattacks. Because of the high underlying capital infrastructure costs for implementing such a system, and because blockchain infrastructure exhibits characteristics of a natural monopoly, a regulated utility would be best suited to create this agricultural blockchain: AgChain.

* J.D. Candidate, University of North Carolina School of Law, 2022. The author would like to extend his deep gratitude to Professor Jonas Monast for guiding the development of this Article; additionally, he would like to thank the NC JOLT editors and staff for their support and feedback during the editorial phases.

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I. INTRODUCTION

Agricultural supply chains have become intricate alongside the globalization of commerce.[1] The increasing complexity of this

[1] Robyn Metcalfe, *An Industrialized Global Food Supply Chain Threatens Human Health – Here's How to Improve It*, THE CONVERSATION (Apr. 5, 2019, 6:42 AM), https://theconversation.com/an-industrialized-global-food-supply-chain-threatens-human-health-heres-how-to-improve-it-112803 [https://perma.cc/64YL-2WBT].

system has plagued regulators and consumers alike with the ever-more relevant question: *Is this safe to eat?*[2] Unfortunately, this question has become progressively more challenging to answer. Dated oversight processes, risks posed by technologically advanced warfare, and foodborne pathogens have illuminated the reality that the United States is alarmingly unprepared to address a large-scale compromise to its food supply.[3]

To provide more certainty surrounding the food supply, the United States should deploy an agricultural blockchain ("AgChain") and regulate the blockchain as a public utility. AgChain possesses many benefits that could enable regulators and consumers to answer vital questions about their food. Because vulnerabilities in the food supply are immediately pressing,[4] the agricultural industry should be the first U.S. industry to implement a blockchain solution.[5] A complex data storage network, such as AgChain, would share many traits of a natural monopoly, like the electricity grid; thus, regulating AgChain like a public utility is the best approach to incentivize capital investment by reducing risks to investors.[6] Natural

[2] *Id.*

[3] *See* discussion *infra* Part II.A.

[4] *See, e.g.*, *FDA Investigated Multistate Outbreak of E. coli O157:H7 Infections Linked to Romaine Lettuce from Yuma Growing Region*, U.S. FOOD & DRUG ADMIN., https://www.fda.gov/food/outbreaks-foodborne-illness/fda-investigated-multistate-outbreak-e-coli-o157h7-infections-linked-romaine-lettuce-yuma-growing [https://perma.cc/T7HV-VQ3T] (Nov. 1, 2018) (describing a recent, representative example of a supply chain vulnerability); *see also* TIMOTHY D. LYTTON, OUTBREAK: FOODBORNE ILLNESS AND THE STRUGGLE FOR FOOD SAFETY 3 (2019) (calling for food regulatory reform in light of 48 million annual illnesses from food contamination in the United States alone).

[5] Other global supply chains could benefit from blockchain-based data management. Essentially, any vital industry that involves sensitive inventory, demanding transparency needs, or that is prone to cyberwarfare targeting from international adversaries would greatly benefit from the numerous security and transparency benefits inherent to blockchain. A comprehensive discussion of the various industries likely to benefit from a blockchain system is outside of the scope of this Article. Vital industries in the United States are characterized at *Critical Infrastructure Sectors*, CYBERSECURITY & INFRASTRUCTURE SEC. AGENCY, https://www.cisa.gov/critical-infrastructure-sectors [https://perma.cc/8SP9-7LXV].

[6] *Natural Monopolies*, INVESTOPEDIA (Jan. 26, 2021), https://www.investopedia.com/terms/n/natural_monopoly.asp [https://perma.cc/N2AF-JNHT].

monopolies can occur where high start-up costs are present or powerful economies of scale create practical barriers for competitors to enter the market.[7] Similar to power providers on a regulated electricity grid, AgChain would have a duty to serve anyone who can pay, and agriculturalists and retailers participating in the supply chain would act as ratepayers.[8]

This Article proposes that utility-based regulation is the best approach to implementing a blockchain-based supply chain for agriculture. Part II discusses the current state of the United States' agricultural supply chain, demonstrating why change is necessary. Part III proposes adopting a blockchain system to usher in the digitalization of regulatory oversight and consumer safety. Part IV discusses some of the potential issues facing the implementation of AgChain. Finally, Part V addresses those potential issues by proposing viable solutions, specifically, treating AgChain as a regulated utility to incentivize investment.

II. THE CURRENT STATE OF AGRICULTURE IN THE UNITED STATES

American agriculture is a valuable and complex machine with a history as old as the United States itself.[9] The industry is deeply interconnected, encompassing a global system of producers, distributors, retailers, and consumers.[10] The original farm-to-table model of agriculture has enjoyed a resurgence of popularity due to

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[7] *Id.* ("Natural monopolies can arise in industries that require unique raw materials, technology, or similar factors to operate.").

[8] For a full discussion on utility regulation principles, *see infra* Part V.

[9] *See, e.g.*, Craig P. Raysor, *From The Sword to the Pen: A History and Current Analysis of U.S. Tobacco Marketing Regulations*, 13 DRAKE J. AGRIC. L. 497, 502–03 (2008) (discussing the export of 1.4 million pounds of tobacco annually from the American colonies to London as early as 1640).

[10] Louise Lucas et al., *20,000 Miles to the Plate*, FIN. TIMES (Feb. 24, 2013), https://www.ft.com/content/128a852e-7b64-11e2-8eb3-00144feabdc0 [https://perma.cc/T43M-JZGM] (following the vast and complex market through which one example of food, cod, must travel before being enjoyed by the consumer).

questionable practices within the global food industry;[11] however, farm-to-table still remains the exception, not the norm.[12] Elongated and unintelligible supply chains have caused serious concerns in the international community, highlighted by numerous catastrophes: horsemeat lasagna in the United Kingdom,[13] infant deaths in China from melamine-laced milk,[14] and dangerously high antibiotic levels in chicken from various fast-food chains in the United States.[15] These concerns highlight that, although supply chains have grown steadily over time, stoked by the hastening effects of globalization, aging regulatory bodies have fallen behind.[16]

A. Antiquated and Reactive Agricultural Regulations Demand an AgChain Solution

Although the size and scope of agriculture have evolved significantly over the years, regulation of the industry has largely remained unchanged.[17] During the last half-century, the few newly

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[11] *See, e.g.*, Dianna Heitz, *Local Dining's Fresh Options*, POLITICO (Dec. 5, 2011, 10:47 PM), https://www.politico.com/story/2011/12/local-dinings-fresh-options-069434 [https://perma.cc/G3WV-ZC69] ("[T]he first family has taken a keen interest in healthful, sustainable and farm-fresh food."); DARRYL BENJAMIN & LYNDON VIRKLER, FARM TO TABLE: THE ESSENTIAL GUIDE TO SUSTAINABLE FOOD SYSTEMS FOR STUDENTS, PROFESSIONALS, AND CONSUMERS 33, 61–64 (2016).

[12] *See, e.g.*, Lucas et al., *supra* note 10 ("The idea you can check every supplier and every ingredient they are supplying you with – it doesn't compute. You can't. It is too enormous a task and at odds with what everyone wants, which is cheaper food.").

[13] Pamela Kerschke-Risch, *The Horsemeat Scandal: The Unknown Victims of Economically Motivated Crime*, 5 J. VICTIMOLOGY 63, 66–68 (2017).

[14] *Id.* at 64.

[15] *See* Lucas et al., *supra* note 10.

[16] Philip K. Howard, *Obsolete Law—The Solutions*, THE ATLANTIC (Mar. 30, 2012), https://www.theatlantic.com/national/archive/2012/03/obsolete-law-0151-the-solutions/255141/ [https://perma.cc/WFK8-G6P9] ("The regulatory state has taken a life of its own, insulated from democratic accountability by thick walls of law . . . Want to do something different, like, say, balance the budget? Sorry, old laws and mandates stand in the way.").

[17] *See generally* Sally Clarke, *Farmers as Entrepreneurs: Regulation and Innovation in American Agriculture during the Twentieth Century*, 17 BUS. & ECON. HIST. 207 (1988) (highlighting the history of American agricultural regulation).

adopted programs faced implementation delays that caused decades to pass before the programs became useful.[18] For example, a 2012 U.S. Department of Agriculture ("USDA") Press Release declared an effort by the government to modernize poultry inspection.[19] The USDA Food Safety and Inspection Service ("FSIS") estimated that 25,000 illnesses per year would be prevented by screening for the two most common pathogens.[20] However, as of July 2020, FSIS reports indicated that only 141 poultry plants had adopted the New Poultry Inspection System ("NPIS").[21] This number of monitored facilities is concerningly small considering that over 5,700 farming families produce poultry products in North Carolina alone.[22] Ultimately, less than 0.0007% of poultry farms in the country have converted to NPIS in nearly a decade.[23] The FSIS claims that the agency only regulates 6,100 plants nationwide, likely due to its limited constitutional authority to regulate the plants; however, this number still only represents a 2.31% NPIS adoption rate for those plants falling under federal jurisdiction.[24] The low adoption rate of

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[18] *See New Poultry Inspection System*, FOOD SAFETY AND INSPECTION SERV., U.S. DEP'T OF AGRIC. (2020), https://www.fsis.usda.gov/wps/portal/fsis/topics/regulatory-compliance/haccp/haccp-based-inspection-models-project/himp-study-plans-resources/npis-plants [https://perma.cc/L7A8-9TDQ] (indicating that less than 300 poultry plants have requested to convert to the New Poultry Inspection System); *see also* Press Release, Food Safety & Inspection Serv., U.S. Dep't of Agric., USDA Seeks to Modernize Poultry Inspection in the United States (Jan. 20, 2012), https://www.usda.gov/media/press-releases/2012/01/20/usda-seeks-modernize-poultry-inspection-united-states [https://perma.cc/FJD6-E6UN] (showing that the USDA adopted the NPIS initiative in 2012).

[19] Press Release, Food Safety & Inspection Serv., *supra* note 18.

[20] *Id.*

[21] *See id.* (showing a chart of all the poultry plants falling under USDA regulation that have requested and also converted to the NPIS).

[22] *Poultry Facts*, N.C. POULTRY FED'N, https://www.ncpoultry.org/facts/facts.cfm [https://perma.cc/6AUN-TM3Q] (last visited Sept. 20, 2020).

[23] *USDA Poultry Production Data*, NAT'L AGRIC. STAT. SERV., U.S. DEP'T OF AGRIC. (May 2015), https://www.usda.gov/sites/default/files/documents/nass-poultry-stats-factsheet.pdf [https://perma.cc/CZQ8-X4E9].

[24] Press Release, Food Safety & Inspection Serv., *supra* note 18; *see also* Thomas E. Travis, *Horne v. USDA: The Takings Clause, the Commerce Clause, and the "World's Most Outdated Law"*, 7 KY. J. EQUINE, AGRIC., & NAT. RES. L. 399, 419 (2015) (providing a discussion of Commerce Clause limitations on the regulatory authority of the USDA).

NPIS illustrates the substantial portions of the agricultural industry that remain ineffectively regulated by federal oversight and also shows the problematically slow rate at which new regulations permeate agriculture.

Twenty-one states rely almost exclusively on federal inspection systems to inform the development of meat processing regulation in their states, instead of relying on state inspection systems of their own.[25] Critics of federal regulation contend that continued deregulation of agriculture is the best approach to reforming the industry.[26] However, this "less is more" approach is concerning for two key reasons: (1) technological development has spotlighted striking vulnerabilities in the agricultural industry; and, (2) the danger of hazards in the U.S. food supply is too great for the federal government to ignore because states are ill-equipped and unmotivated to solve the problem themselves.[27]

National security also calls for federal regulation of the Nation's food supply.[28] Attacking an enemy's food sources—to weaken the enemy and promote internal political pressure to surrender[29]—is a

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[25] *See* Elizabeth R. Rumley & James Wilkerson, *Meat Processing Laws in the United States: A State Compilation*, NAT'L AGRIC. L. CTR., https://nationalaglawcenter.org/state-compilations/meatprocessing/ [https://perma.cc/L8H2-TCDC].

[26] *See* Jon Lauck, *After Deregulation: Constructing Agricultural Policy in the Age of "Freedom to Farm"*, 5 DRAKE J. AGRIC. L. 3, 44 (2000).

[27] *See* Kirsten H. Engel, *State Environmental Standard-Setting: Is There a "Race" and Is It "to the Bottom"?*, 48 HASTINGS L.J. 271, 304 (1997) (explaining how federalism and state-controlled environmental regulatory regimes can prompt a race to lower state standards in order to cut costs for prospective business and increase the state's tax base).

[28] *See Food and Agriculture Sector*, CYBERSECURITY & INFRASTRUCTURE SEC. AGENCY, https://www.cisa.gov/food-and-agriculture-sector [https://perma.cc/6TTH-J9YP] (counting the Food and Agriculture Sector among the other Critical Infrastructure Sectors and stating that agriculture accounts for approximately one-fifth of the Nation's economy).

[29] *See, e.g.*, *The Battle of the Atlantic: Why Britain Almost Lost to Hitler's U-boats*, HISTORYEXTRA, BBC HIST. MAG. (May 27, 2020, 7:15 PM), https://historyextra.com/period/second-world-war/did-britain-almost-lose-battle-atlantic-ww2-athenia-sinking/ [https://perma.cc/5RFA-HBL3] (recounting the Battle of the Atlantic during World War II where, because Britain imported some 70% of its food supply, the decimation of its shipping lanes almost forced British submission to Nazi Germany).

military strategy that dates back to Sun Tzu in the fifth century B.C.[30] While many Americans imagine that wars occur far from home, few realize that the United States is engaging in ongoing cyberwarfare with several technologically advanced countries and is subject to countless attacks every day.[31] American companies,[32] including agricultural firms, regularly fall victim to these attacks.[33]

The Cybersecurity & Infrastructure Security Agency ("CISA") within the Department of Homeland Security ("DHS") has acknowledged the vital nature of agriculture in American

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[30] SUN TZU, THE ART OF WAR 21 (1910), http://www.artofwarsuntzu.com /Art%20of%20War%20PDF.pdf [https://perma.cc/JT62-RJZQ].

[31] *See* Tal Axelrod, *Texas Department of Agriculture Website Features Pro-Iran Image After Cyberattack*, THE HILL (Jan. 8, 2020, 4:02 PM), https://thehill.com/policy/cybersecurity/477408-texas-department-of-agriculture-website-featured-pro-iran-image-after [https://perma.cc/E2BL-4C4S] ("Attempted cyber attacks from Iran against Texas agency websites are occurring about 10,000 per minute."); OFF. OF THE PRESIDENT, NATIONAL CYBER STRATEGY OF THE UNITED STATES OF AMERICA 20 (Sept. 2018), https://www.whitehouse.gov/wp-content/uploads/2018/09/National-Cyber-Strategy.pdf [https://perma.cc/3XPH-BY27] ("Pillar III Preserve Peace Through Strength . . . Objective: Identify, counter, disrupt, degrade, and deter behavior in cyberspace that is destabilizing and contrary to national interests, while preserving United States overmatch in and through cyberspace."); Robert A. Norton & Scott Algeier, *Food and Agriculture Are Critical Infrastructures but also Domains of Future War*, FOOD SAFETY MAG. (Feb. 4, 2020), https://www.foodsafety magazine.com/enewsletter/food-and-agriculture-are-critical-infrastructures-but-also-domains-of-future-war/ [https://perma.cc/6YHU-LN5C] ("[T]he U.S. also is reported to have launched cyberattacks against Iranian missile systems.").

[32] *Significant Cyber Incidents*, CTRS. FOR STRATEGIC INT'L STUD., https://www.csis.org/programs/technology-policy-program/significant-cyber-incidents [https://perma.cc/VD2E-DPDZ] (Sept. 2020).

[33] *See* Mark Niesse, *Malware Disables Georgia Agriculture Department Website*, ATLANTA J.-CONST. (Dec. 15, 2017), https://www.ajc.com/news/state--regional-govt--politics/malware-disables-georgia-agriculture-department-website/97bicqeIIfhlWcwRZEuwiP/ [https://perma.cc/8N3H-PB2L]; *see also* Laurie Bedord, *Midwest Agriculture Is a Prime Target for Theft of Intellectual Property and Cyber Attacks*, SUCCESSFUL FARMING (Apr. 5, 2016), https://www.agriculture.com/content/cybersecurity-is-not-just-a-big-city-problem [https://perma.cc/25UD-H4SK] ("In 2016, Mo Hailong, a lawful, permanent resident and employee of a China-based seed company, was convicted for his role in a long-term conspiracy to steal trade secrets from Iowa-based DuPont Pioneer and Monsanto and to provide that technology to China.").

geopolitical security. In recent guidance, CISA included food and agriculture in its listing of "critical infrastructure sectors whose assets, systems, and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security."[34] The United States' antiquated and dilapidated regulatory systems expose millions to possible victimization if hackers deliberately attack the national food supply.[35]

Increasing technology has enhanced the ability to globalize markets, including agriculture.[36] Unfortunately, fields and fisheries far from American homes critically hamper domestic consumers' and regulators' capacity to exercise meaningful scrutiny over food characteristics and quality.[37] Different countries observe divergent norms relating to genetically modified organisms,[38] pest control,[39] and labor practices.[40] Although technology has benefited the food industry, countries' differing norms illustrate that technology's

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[34] *Critical Infrastructure Sectors*, *supra* note 5.

[35] The Center for Strategic and International Studies ("CSIS") maintains a record of confirmed successful hacks since 2003. While many government agencies in the United States experience hundreds of hacking attempts every minute, few know the magnitude of successful hacking attempts unless the hacks make notoriety through news outlets. At the time of publication, the CSIS's report was a 55-page document with hundreds of successful hacks, including only those incidents the CSIS deemed "significant." *See Significant Cyber Events*, CTRS. FOR STRATEGIC & INT'L STUD., https://csis-website-prod.s3.amazonaws.com/s3fs-public/210129_Significant_Cyber_Events.pdf [https://perma.cc/E3MG-X5NS].

[36] Lucas et al., *supra* note 10 (illustrating how globalization has revolutionized food supply chains).

[37] *See, e.g.*, Kerschke-Risch, *supra* note 13, at 66–68 (providing an example where horsemeat not fit for human consumption was discovered in beef products).

[38] Layla Katiraee, *A Look at GMO Policies in Different Nations*, BIOLOGY FORTIFIED (July 6, 2015), https://biofortified.org/2015/07/a-look-at-gmo-policies-in-different-nations/ [https://perma.cc/4GXG-S6YA].

[39] Nathan Donley, *The USA Lags Behind Other Agricultural Nations in Banning Harmful Pesticides*, 18 ENV'T. HEALTH 44, 54 (2019).

[40] *Child Labour in Agriculture*, U.N. INT'L LAB. ORG. (Sept. 2017), http://ilo.org/ipec/areas/Agriculture/lang--en/index.htm [https://perma.cc/H3BK-PTUX] ("In many countries child labour is mainly an agricultural issue. Worldwide 60 percent of all child labourers in the age group 5-17 years work in agriculture, including farming, fishing, aquaculture, forestry, and livestock. This amounts to over 98 million girls and boys.").

advancements have also perpetuated numerous harms. Domestically, the deep implantation of technology into agriculture, often coined "precision agriculture," is a tempting target for hacking.[41] Further, government systems are regularly subject to hacking and ransomware attacks,[42] and these cyberattacks do not include social engineering and its potentially devastating effects.[43]

Compared to the rest of the world, most consumers in the United States rarely question their continued access to food[44] or whether their food is safe to eat.[45] However, foodborne pathogen outbreaks in the United States are relatively common.[46] The 2018 *E. coli* outbreak in romaine lettuce supplies is just one example.[47] The

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[41] John Farley, *Precision Agriculture Is 'Ripe for the Picking' by Hackers*, GALLAGHER, https://www.ajg.com/us/news-and-insights/2020/feb/precision-agriculture-ripe-for-the-picking-by-hackers/ [https://perma.cc/NZ7G-PF4E] (last visited Jan. 30, 2021) (providing a list of potential scenarios where precision agriculture could be subject to hacking, whereby one example states, "[a] farmer plants hundreds of acres of corn across multiple counties and uses remote weather stations with soil moisture sensors connected to smart watering systems to feed a subsurface drip irrigation system. If one or more of the soil moisture sensors is maliciously hacked, and the sensor indicates that watering is continuously needed when it is not, the automated watering system could flood the fields.").

[42] David Sanger et al., *Scope of Russian Hacking Becomes Clear: Multiple U.S. Agencies Were Hit*, N.Y. TIMES, https://www.nytimes.com/2020/12/14/us/politics/russia-hack-nsa-homeland-security-pentagon.html [https://perma.cc/WTD5-U923] (Jan. 5, 2021).

[43] Steven Thomason, *People—The Weak Link in Security*, 13 GLOB. J. COMPUT. SCI. & TECH. NETWORK, WEB & SEC. 7, 7 (2013) ("The weakest link in any security plan or implementation is a human."). Social engineering is the exploitation of human aspects of systems to gain access and compromise integrity. *See id.*

[44] *See Who Are the World's Food Insecure? Identifying the Risk Factors of Food Insecurity Around the World*, U.S. DEPT. OF AGRIC. ECON. RSCH. SERV. (June 3, 2019), https://www.ers.usda.gov/amber-waves/2019/june/who-are-the-world-s-food-insecure-identifying-the-risk-factors-of-food-insecurity-around-the-world/ [https://perma.cc/F6PT-C5ME].

[45] *See id.*

[46] *Burden of Foodborne Illness: Findings*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/foodborneburden/2011-foodborne-estimates.html [https://perma.cc/G9RP-T5QX] (Nov. 5, 2018) ("CDC estimates that each year roughly 1 in 6 Americans (or 48 million people) gets sick, 128,000 are hospitalized, and 3,000 die of foodborne diseases.").

[47] *FDA Investigated Multistate Outbreak of E. coli*, *supra* note 4.

outbreak caused 210 illnesses, 96 hospitalizations, and 5 deaths.[48] Additionally, when foodborne pathogens threaten the population, ill-equipped oversight systems result in overly broad recalls, causing supermarkets and restaurants to throw out uninfected food in an abundance of caution.[49] The 2018 *E. coli* outbreak resulted in a concerning $71 million shortfall in sales,[50] highlighting that this current system of addressing foodborne pathogens is wasteful and irresponsible, thereby compounding the United States' already outrageous food waste problem.[51]

Further aggravating this economically burdensome process is the reactive nature by which the United States' Centers for Disease Control ("CDC") initiates recalls.[52] When a human infection is finally detected, clinical laboratories compile information regarding

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[48] *Id.*

[49] *See* Jamie Ducharme, *You're Not Imagining It: Food Recalls Are Getting More Common. Here's Why*, TIME (Jan. 17, 2019, 5:00 AM), https://time.com/5504355/food-recalls-more-common/ [https://perma.cc/4EKG-KQ5Q] (explaining that "the vast majority of recalls are precautionary and not linked to any illness" (quotations omitted)).

[50] Kate Taylor, *Romaine Lettuce Sales Are Down More Than $71 Million So Far This Year As The Industry Has Been Pummeled With Food-Poisoning Outbreaks — And Things Are About to Get Worse*, BUS. INSIDER (Nov. 21, 2018, 11:28 AM), https://www.businessinsider.com/e-coli-outbreaks-drag-romaine-lettuce-sales-down-2018-11 [https://perma.cc/B2CC-NYQL].

[51] *Food Waste FAQs*, U.S. DEP'T OF AGRIC., https://www.usda.gov/foodwaste/faqs [https://perma.cc/R8WE-VBVU] (last visited Sept. 14, 2020) (citing a 2010 USDA estimate that food loss and waste occur largely at the retail and consumer levels, accounting for 31% of the food supply, 133 billion pounds of food, and approximately $162 billion in lost revenue).

[52] The CDC provides a description of its surveillance process and highlights the challenges connected to foodborne disease reporting through, what it calls, the "burden of illness pyramid" model. The reactive nature for the surveillance and recall process is demonstrated by the triggering event: exposure to the general population. Because the CDC and FDA have limited capability to sample the entire national food supply, the majority of recalls are initiated through this post hoc process. For more discussion on the CDC's "active" laboratory surveillance, *see FoodNet Surveillance*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/foodnet/surveillance.html [https://perma.cc/YZ6J-6FJL] (last visited Mar. 3, 2021).

the infection into a database called FoodNet,[53] designed to recognize year-to-year trends in illness.[54] Yet FoodNet only surveils fifteen-percent of the United States' population[55] and carries two functional flaws that utterly detract from its effectiveness.[56] First, FoodNet assumes that individuals infected by foodborne pathogens will seek medical attention and have the means to do so;[57] furthermore, FoodNet relies on hospital staff to properly collect and input data for analysis.[58]

Second, FoodNet functions reactively, doing little to intercept contaminated food prior to consumption and thus fails to prevent illness from occurring in the first place.[59] If a simultaneous, large-scale outbreak were to occur due to a viral mutation with increased latency, countless victims worldwide could become infected before a government notification is ever sent to the public.[60] In light of the aggressive rate at which SARS-CoV2 ("COVID-19") spread across

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[53] An interested reader can explore the current statistics compiled by the CDC on *FoodNet Fast*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/foodnet/index.html [https://perma.cc/D3QF-KF2U] (last visited Sept. 20, 2020).

[54] Kyler Massner, *New Kid on The Block: How Blockchain Can Improve the United States Food Sector*, 24 DRAKE J. OF AGRIC. L. 341, 361 (2019).

[55] *Foodborne Disease Active Surveillance Network (FoodNet)*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/foodnet/foodnet-fast.html [https://perma.cc/8XZD-LRDU] (last visited Sept. 16, 2020).

[56] *See id.*

[57] *See id.*

[58] *See id.*

[59] *See id.*

[60] *See generally* Samuel H. Speck & Don Ganem, *Viral Latency and Its Regulation: Lessons from the Gammaherpesviruses*, 8 CELL HOST MICROBE 100, 100 (2010), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2914632/ [https://perma.cc/K922-UXU2] (describing "latency" as the ability of a virus to lie dormant before becoming active and causing symptoms); *see also* Paul M. Lieberman, *Epigenetics and Genetics of Viral Latency*, 19 CELL HOST & MICROBE 619, 619 (2016), https://www.sciencedirect.com/science/article/pii/S1931312816301445 [https://perma.cc/42VB-RRSX] ("Latency can range from selective viral gene expression with partial replication to a complete quiescence with no detectable viral gene expression or replication.").

the globe, this possible outcome has never been more salient than the present.[61]

B. A Cautionary Case Study of COVID-19

COVID-19 has proven to be an exceptionally resilient and persistent virus, disrupting almost every facet of society.[62] However, its repercussions on agriculture and the global food supply have received less press recognition despite their concerning implications.[63] For example, news outlets reported that frozen food imported to China from Brazil tested positive for the virus.[64] Although the CDC claims that the likelihood of contracting the virus from food products and packaging is low,[65] the CDC's understanding of the virus has continuously evolved.[66] Regardless,

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[61] *Timeline: WHO's COVID-19 Response,* WORLD HEALTH ORG., https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline [https://perma.cc/6JD9-9GKR] (last visited Mar. 15, 2021).

[62] *See* Signe Smith Jervelund & Terje Andreas Eikemo, *The Double Burden of COVID-19*, 49 SCANDINAVIAN J. OF PUB. HEALTH 1, 2 (2021) ("The corona crisis represents a double burden for most disadvantaged groups in our societies. They are not only hit harder by the virus itself, but they are also suffering most of the social and economic consequences of lockdowns in terms of job loss, social isolation, reduced household income and reduced access to general healthcare due to the healthcare systems being under pressure, leading to deteriorated health conditions for people with chronic conditions.").

[63] *See* Roxanne Liu et al., *Chinese Cities Find Coronavirus in Frozen Food Imports, WHO Downplays Infection Risk*, REUTERS (Aug. 13, 2020, 5:52 PM), https://www.reuters.com/article/us-health-coronavirus-china-food/chinese-cities-find-coronavirus-in-frozen-food-imports-who-downplays-infection-risk-idUSKCN259330 [https://perma.cc/DL82-NQPA].

[64] *Id.*; Bruce Y. Lee, *Can You Get Covid-19 Coronavirus from Food? Frozen Chicken Wings Test Positive*, FORBES (Aug. 14, 2020, 10:12 PM), https://www.forbes.com/sites/brucelee/2020/08/14/can-you-get-covid-19-coronavirus-from-food-frozen-chicken-wings-test-positive/#392a59a4511e [https://perma.cc/4HFU-8CXA].

[65] *Food and Coronavirus Disease 2019 (COVID-19)*, CTRS. FOR DISEASE CONTROL & PREVENTION, https://www.cdc.gov/coronavirus/2019-ncov/daily-life-coping/food-and-COVID-19.html [https://perma.cc/4JZW-BWPF] (Dec. 31, 2020).

[66] *See Modes of Transmission of Virus Causing COVID-19: Implications for IPC Precaution Recommendations*, WORLD HEALTH ORG. (Mar. 29, 2020), who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-

the agricultural industry should reflect on COVID-19 as a cautionary tale, demonstrating the potential effects if a similarly devastating virus could be transmitted through food. In response to reports of the contaminated imports, China-based officials replied, "It is hard to say at which stage the frozen chicken got infected."[67] The inability of officials to pinpoint the cause of contamination suggests these products might have sat on shelves unnoticed for extended periods of time.[68] COVID-19 also crippled food processing, distribution, and packaging by incapacitating workforces.[69]

The potential risks posed by foodborne pathogens are staggering and would devastate the world;[70] thus, creating a workable solution using modern technology is a vital necessity. Given the insufficiency of inspection, regulatory oversight, and public notification for contaminated food, the United States' agricultural industry must pivot to a technologically modern posture, abandoning reactivity in exchange for proactivity and adopting AgChain to make agriculture more resilient and efficient.

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causing-covid-19-implications-for-ipc-precaution-recommendations [https://perma.cc/4UW3-NUGD] (claiming COVID-19 was not likely airborne, but individuals should observe airborne precautions in certain circumstances). *But see* Lidia Morawska & Donald K. Milton, *It Is Time to Address Airborne Transmission of Coronavirus Disease 2019 (COVID-19)*, 71 OXFORD ACADEMIA 2311, 2311 (2020), https://doi.org/10.1093/cid/ciaa939 [https://perma.cc/Q2CW-8EZS] (urging the scientific community to reassess assumptions that COVID-19 is not airborne).

[67] Liu et al., *supra* note 63.

[68] *See id.*

[69] Dianne Gallagher & Pamela Kirkland, *Meat Processing Plants Across the US Are Closing Due to the Pandemic. Will Consumers Feel the Impact?*, CNN BUS., https://www.cnn.com/2020/04/26/business/meat-processing-plants-coronavirus/index.html [https://perma.cc/RJ9J-ADJS] (Apr. 27, 2020, 8:43 AM) ("Beef processing in the US was down 27%, and pork processing was down almost 20%, compared to this time last year, according to USDA data.").

[70] *See generally* Damir Huremovic, *A Brief History of Pandemics (Pandemics Throughout History)*, *in* PSYCHIATRY OF PANDEMICS (2019) (surveying the causes of many historical pandemics and noting several were likely the result of poor hygiene and food handling).

III. BLOCKCHAIN WILL PROMOTE CYBER SECURITY, REGULATORY EASE, AND TRANSPARENCY

Insufficient data security, reliability, and privacy on the internet are well-illustrated by "The Byzantine Generals' Problem."[71] In this problem, two or more geographically separated generals attempt to coordinate an attack against a strong enemy army.[72] These generals must communicate, but the generals grapple with the risk of being betrayed by another general, or their couriers being intercepted by the enemy.[73] How are the generals supposed to plan an attack when compromised communication, causing poor coordination, would mean inevitable demise? These issues also arise when data is transmitted over the internet, where vital or highly confidential information is subject to compromise at any point along its journey to the intended recipient.[74] How should data authenticity, reliability, and accessibility be promoted in an age when technology permeates so deeply into the social fabric?[75] How can that validated data subsequently be used to best benefit society, national security, and agriculture? By capitalizing on blockchain's inherent security and transparency,[76] consumers, farmers, and regulators alike stand to

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[71] *See* NATALYA FEDOTOVA & LUCA VELTRI, BYZANTINE GENERALS PROBLEM IN THE LIGHT OF P2P COMPUTING 1, 2–3 (2006).

[72] district0x Network, *The Byzantine Generals Problem – An Intro to Blockchain*, YOUTUBE (Aug. 8, 2018), https://www.youtube.com/watch?v=A-mNgqJETQg [https://perma.cc/W2FW-F8YS] ("The blockchain uses a distributed ledger, which functions like the distributed attack. Inputs to the ledger (like the attack messages) must be trusted. Much like the troops surrounding the castle, how can a network trust the other members and ensure that the messages are valid? Here is how: All participating members must agree on every message that is transmitted. If a member is corrupt or the message is corrupt - then the message will be resisted, and the network will not be affected.").

[73] *Id.*

[74] *See id.*

[75] Madeleine Hillyer, *How Has Technology Changed - and Changed Us - in the Past 20 Years?*, WORLD ECON. F. (Nov. 18, 2020) https://www.weforum.org/agenda/2020/11/heres-how-technology-has-changed-and-changed-us-over-the-past-20-years/ [https://perma.cc/2UC3-RQDS] ("Since the dotcom bubble burst back in 2000, technology has radically transformed our societies and our daily lives.").

[76] Tiago M. Fernández-Caramés & Paula Fraga-Lamas, *A Review on the Use of Blockchain for the Internet of Things*, 6 IEEE ACCESS 32979, 32979, 32981 (2018).

gain.[77] AgChain would operate solely as a data management service, satisfying the logistical needs of farmers, supermarkets, regulators, and consumers.

A. A Primer on Blockchain Benefits: Security Through Decentralization and Historically-Based Encryption

Blockchain is a computing tool that functions as a "distributed ledger" and shares data stored on the ledger with the users on a network, known as a peer-to-peer ("P2P") network.[78] P2Ps operate by making all users equipotent, as access to information on the system is a commonly shared privilege for users.[79] The "block" in blockchain describes the nature in which data is stored, accessed, and encrypted on the network.[80] Information stored in blocks is regularly re-encrypted on the network by blockchain miner nodes, which are servers tasked with adding transaction records to the block and time stamping them.[81] Hash functions facilitate digital signatures and link the blocks in a chain in the proper order.[82]

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[77] *See infra* Part III.B (discussing the practical applications for a blockchain integrated agricultural supply chain).

[78] *Id.*

[79] *See* Silvana Castano et al., *Ontologies and Matching Techniques for Peer-based Knowledge Sharing* 177, 177 (2003) (explaining that in Helios, a program designed to work on a P2P network, "peers are equipotential in terms of functionalities and capabilities").

[80] *See* Fernández-Caramés & Fraga-Lamas, *supra* note 76, at 32982 (describing the data being ordered and packed into timestamped blocks by miner nodes).

[81] *See id.* at 32981 ("Every node of the network receives two keys: a public key, which is used by the other users for encrypting the messages sent to a node, and a private key, which allows a node to read such messages. Therefore, two different keys are used, one for encrypting and another for decrypting. In practice, the private key is used for signing blockchain transactions (i.e., to approve such transactions), while the public key works like a unique address."); *see also* Jake Frankenfield, *Block Time*, INVESTOPEDIA, https://www.investopedia.com/terms/b/block-time-cryptocurrency.asp [https://perma.cc/SB85-VV22] (Nov. 8, 2019) (noting the theoretical ten-minute block time on Bitcoin's network compared to the theoretical twenty second block time for Ethereum's network).

[82] Tiago M. Fernández-Caramés & Paula Fraga-Lamas, *Towards Post-Quantum Blockchain: A Review on Blockchain Cryptography Resistant to Quantum Computing Attacks*, 8 IEEE ACCESS J. 21091, 21093 (2020).

While blockchains themselves are complex network programs, two features make the technology an appealing option for revolutionizing the agricultural supply chain and its regulatory oversight: (1) historically-based encryption and (2) decentralization.[83]

1. Historically-Based Encryption Promotes Resiliency

Historically-based encryption allows for an ever-changing cipher upon which new blocks in a blockchain are encrypted.[84] This dynamic encryption directly addresses the risk of data being manipulated or falling into the wrong hands, which is more common for centralized data on servers accessed over the internet.[85] By creating a new block and thereby re-encrypting data at regular intervals, a would-be hacker is thwarted from tampering with the data by the mere passage of time.[86] By the time the hacker might have made progress to crack a cipher to access information on the blockchain, the data block is closed, a new one opens, and the cipher hash changes based on the newly closed block by adding the hash value of the preceding block.[87] This "hashing" process refers back to the history of the blockchain to create the cipher, or encryption consensus protocol, for the new block.[88] Applying historical data in

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[83] *See* Fernández-Caramés & Fraga-Lamas, *supra* note 76, at 32979, 32982 ("[T]he blockchain nodes verify that the broadcast block contains valid transactions and that it references the previous block of the chain by using the corresponding hash . . . [I]f both conditions are verified successfully, the nodes add the block to their chain, updating the transactions.").

[84] *See* Massner, *supra* note 54, at 348–49 (describing cryptographic hash functions, which determine the difficulty of the hashing process and thus secure the information on a block as valid); *see also* Frankenfield, *supra* note 81.

[85] *Id.*

[86] *See* Fernández-Caramés & Fraga-Lamas, *supra* note 76, at 32980–82.

[87] *See* Rui Zhang & Rui Xue, *Security and Privacy on Blockchain*, 1 ACM COMPUTING SURVS. 1, 3–4 (2019) ("[A] block also maintains the hash value of the entire block itself, which can be seen as its cryptographic linkage, plus the hash value of its preceding block, which serves as a cryptographic linkage to the previous block in the blockchain."); Frankenfield, *supra* note 81.

[88] *See* Zhang & Xue, *supra* note 87, at 4 ("Those nodes that are miners will collect transactions into a block, verify transactions in the block, and broadcast the block and its verification using a consensus protocol (a.k.a., Proof of Work) to get approval from the network. When other nodes verify that all transactions

order to access present data protects the integrity of all previous blocks in the chain,[89] effectively preserving the data stored on the blockchain in a way that is "immutable" and thus resistant to manipulation by potential hackers.[90]

Cryptocurrency is based on the blockchain system[91] and can be extremely valuable.[92] At the time of this Article, a single Bitcoin was priced at approximately $55,201.54[93] Bitcoin's high value leaves hackers with plenty of financial incentive to hack and modify the blockchain's code to dishonestly allocate coins to themselves; however, hackers have yet to prevail.[94]

Similarly, substantial incentives exist for enemies of the United States or agriculturalists facing lawsuits to attempt to manipulate the data on AgChain.[95] By manipulating the stored data, hackers could theoretically enable contaminated food to pass undetected or remove evidence of poor food stewardship entirely; however, similar to cryptocurrency hackers, AgChain hackers would be unsuccessful in their attempts. By deploying historically based encryption via hashing in the AgChain, agricultural technology companies would avoid the hacks and ransomware attacks that previously plagued the industry.[96]

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contained in the block are valid, the block can be added to the blockchain."). This process can be made even more secure using "Hash pointers" and "Merkle trees," but delving into the potential variations of blockchain encoding is beyond the scope of this Article. For further discussion on these and other concepts within blockchain, see *id.* at 2–5.

[89] *Id.* at 3.

[90] *Id.* at 8.

[91] *Id.* at 1.

[92] *See e.g.*, COINDESK, https://www.coindesk.com/price/bitcoin [https://perma.cc/UPB2-YR4A?type=image] (last visited Oct. 10, 2021) (demonstrating the market value of a single Bitcoin in October 2021).

[93] *Id.*

[94] *Can a Cryptocurrency Like Bitcoin Get Hacked or Shutdown?*, BITPANDA ACAD., https://www.bitpanda.com/academy/en/lessons/can-a-cryptocurrency-like-bitcoin-get-hacked-or-shut-down/ [https://perma.cc/D7B4-LZV5] (last visited Mar. 3, 2021) (explaining why Bitcoin is often deemed "hack-proof").

[95] For discussion of the cyber vulnerability of agriculture, *see supra* Part II.A.

[96] *See* Massner, *supra* note 54, at 362–63.

2. Decentralization Promotes Validity and Transparency

Another mechanism blockchains deploy to promote security is a "distributed ledger," which decentralizes control of the blockchain's information.[97] For example, each computer running the blockchain acts as a node in cryptocurrency, subjecting each new block to a rigorous checks-and-balances analysis against every other node operating the blockchain.[98] In this system of data validation, also called a "proof-of-work" model, majority rules, and the newly adopted history of a blockchain is whatever the majority deems its history to be when the hashing interval ends.[99] For a hack to be successful, not only would a bad actor need to "crack" the cipher, but the hacker would also need to make identical changes to the blockchain's data on a majority of the nodes holding the ledger.[100]

Advances in data storage and the high-speed wireless connectivity of devices have made the era coined "Internet of Things" ("IoT") a modern-day reality.[101] Cloud-based storage is still a widely used intermediary for devices to communicate; however, devices are much more adept at simply talking directly to one another.[102] As Illustration A[103] in the appendix demonstrates, the

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[97] *See Can a Cryptocurrency Like Bitcoin Get Hacked or Shutdown?*, *supra* note 94.

[98] *See id.*

[99] *See id.* (explaining a 51% attack as requiring a majority of the network's mining power to be compromised by the hacker); *see also* XINLE YANG ET AL., EFFECTIVE SCHEME AGAINST 51% ATTACK ON PROOF-OF-WORK BLOCKCHAIN WITH HISTORY WEIGHTED INFORMATION 261 (2019) ("[A] block is generated and broadcasted to the P2P network. Depending on different varieties of protocol, peer nodes always accept the longest chain or the chain with the largest total difficulty repeatedly to continuously expand the blockchain. The proof-of-work model utilizes this mechanism to determine which node has the right to seal a block. This process is also called mining.").

[100] *See Can a Cryptocurrency Like Bitcoin Get Hacked or Shutdown?*, *supra* note 94 ("This means that a majority of 51% could potentially alter a blockchain's distributed ledger in a way that double spending (execution of the same transaction multiple times) would be enabled. This situation, however, is extremely difficult to achieve and highly unlikely to happen.").

[101] Fernández-Caramés & Fraga-Lamas, *supra* note 76, at 32979.

[102] *Id.* (stating that Machine-to-Machine connections will grow from 780 million in 2016 to 3.3 billion by 2021).

[103] *Id.* at 32980.

complexity of the IoT has increased over time.[104] The IoT further reinforces the strength of AgChain because the IoT increases the possible nodes available to promote the decentralization of the blockchain.[105]

Although the presence of technology throughout the world is commonly recognized, the IoT is critical in unlocking AgChain's full potential.[106] Using sensors throughout the agricultural supply chain increases effectiveness by promoting real-time data collection.[107] For example, imagine that a bag of roasted, arabica coffee beans is shipped from Brazil to Seattle. When those beans are loaded into a shipping container for sea-based transport, a radio frequency identifier ("RFID") reader recognizes and catalogs the coffee beans' information using an RFID chip in the bag holding the beans.[108] That RFID chip includes the history of that particular batch of beans up until that point in time, such as which farm grew the product, who handled the product, and the temperature at which the product was stored.[109] Shipping containers, semi-trucks, and cargo bays at grocery stores could all implement this RFID technology, providing sensors to record and report transit data, such as duration,

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[104] *Id.*

[105] *See id.* at 32980–81.

[106] *See* Konstantinos Christidis & Michael Devetsikiotis, *Blockchains and Smart Contracts for the Internet of Things*, 4 IEEE ACCESS 2292, 2298 (2016) (discussing the usefulness of blockchains in the IoT through examples).

[107] *Id.* at 2299 ("Assume that every stakeholder carries a smart tracker with (a) a BLE radio, (b) a GSM or LTE radio so that it can connect to the Internet, (c) an installed blockchain client. A similar tracker is also mounted to the container. When the two stakeholders meet *and* the container is also present, for example at point A, the devices of the stakeholders can send signed transactions to the blockchain automatically without any user input, and the process can move to the next stage as soon as the required tokens have been exchanged.").

[108] This hypothetical scenario is loosely based on an existing RFID agri-food supply management system in China, which aims to incorporate blockchain. *See* Fernández-Caramés & Fraga-Lamas, *supra* note 76, at 32983.

[109] Much like the RFID chips often embedded into credit cards or anti-theft devices in clothing tags, the information stored on these RFID tags need only be a unique identifier to which attributions of other data may be made. *See, e.g.*, Kimberly M. Wilmoth, *RFID Tags Used to Track Produce Freshness from Farm to Store*, FARMPROGRESS (Sept. 8, 2014) https://www.farmprogress.com/vegetables/rfid-tags-used-track-produce-freshness-farm-store [https://perma.cc/B49L-SRQP] (showing RFID chip application in action).

temperature, and delays. Similar to modern-day John Deere tractors, which incorporate satellite technology for precision agriculture,[110] the world's commercial transportation infrastructure could incorporate analogous technology to capitalize on the IoT and increase producer-consumer transparency. With this wealth of data at their fingertips, how could regulators, retailers, restaurants, and most importantly, consumers use the data stored on AgChain? Because of the adaptability of blockchain as a platform for information management, mobilizing the data can host a variety of benefits, as seen in Figure 1 below.

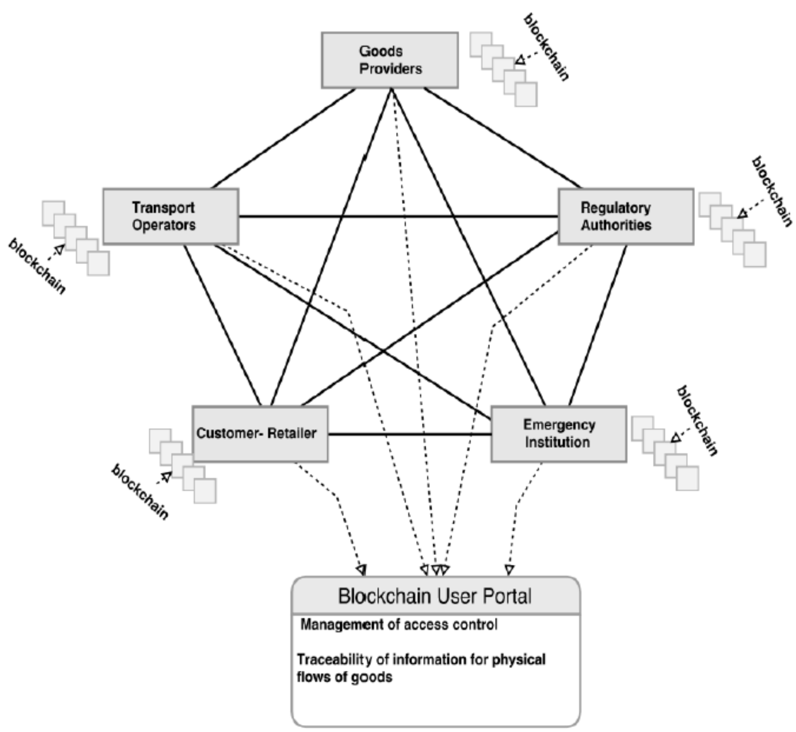

Figure 1: A Decentralized AgChain Can Provide Shared Benefit to A Variety of Users[111]

[110] Laura Hall, *How NASA and John Deere Helped Tractors Drive Themselves*, NASA, https://www.nasa.gov/feature/directorates/spacetech/spinoff/john_deere [https://perma.cc/9B4L-RQY9] (Apr. 20, 2018).

[111] Adnan Imeri & Djamel Khadraoui, *The Security and Traceability of Shared Information in the Process of Transportation of Dangerous Goods*, 9TH IFIP INT'L CONF. ON NEW TECH., MOBILITY & SEC. (NTMS) 1, 4 (2018).

B. Adaptability of Blockchains Using Layering—dApps & eContracts

In addition to the inherent advantages of blockchains and P2P computing, adding "layers" to interface with data on the blockchain will turn the ledger into a powerful tool. Layering interface applications over raw data will make the ledger's data indexable and referenceable, allowing the identities of supply chain participants and exchanged commodities to be pinpointed quickly.[112] These interface layers in AgChain would include decentralized applications ("dApps"), as well as electronic contracts ("eContracts") since these layers provide the most utility for a supply chain system like agriculture.[113]

dApps, or applications with an interface disbursed and decentralized on the blockchain, would incorporate everything from creating user profiles for producers, distributors, retailers, and regulators to collecting data from sensors embedded throughout the supply chain.[114] Sensors throughout the IoT would become a powerful tool for regulators to test water quality, monitor temperature for produce in shipping trucks, and assess humidity in storage units.[115] Artificial intelligence ("AI") programs with machine learning could preemptively identify risk factors likely to cause disease,[116] marking a valuable shift in how FoodNet currently

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[112] Sidra Malik et al., *TrustChain: Trust Management in Blockchain and IoT Supported Supply Chains*, *in* 2019 IEEE INT'L CONF. ON BLOCKCHAIN 184, 187 (2019).

[113] *Id.* at 188; *see* Imeri & Khadraoui, *supra* note 111, at 4 (outlining as an example, three layers on a supply chain blockchain: the data layer, the blockchain layer, and the application layer); *see also* Massner, *supra* note 54, at 349–50 (explaining the interrelationship between eContracts and dApps when using blockchain infrastructure).

[114] *See* Massner, *supra* note 54, at 350 (showing the versatility of incorporating eContracts in dApp layering on a blockchain).

[115] *Id.*

[116] For a more thorough discussion of machine learning and pattern recognition, *see* Ming Xue & Changjun Zhu, *A Study and Application on Machine Learning of Artificial Intelligence*, *in* INT'L JOINT CONF. ON A.I. (2009).

operates.[117] Figure 2 below illustrates the various roles that the layers serve when dApps run over blockchain networks.[118]

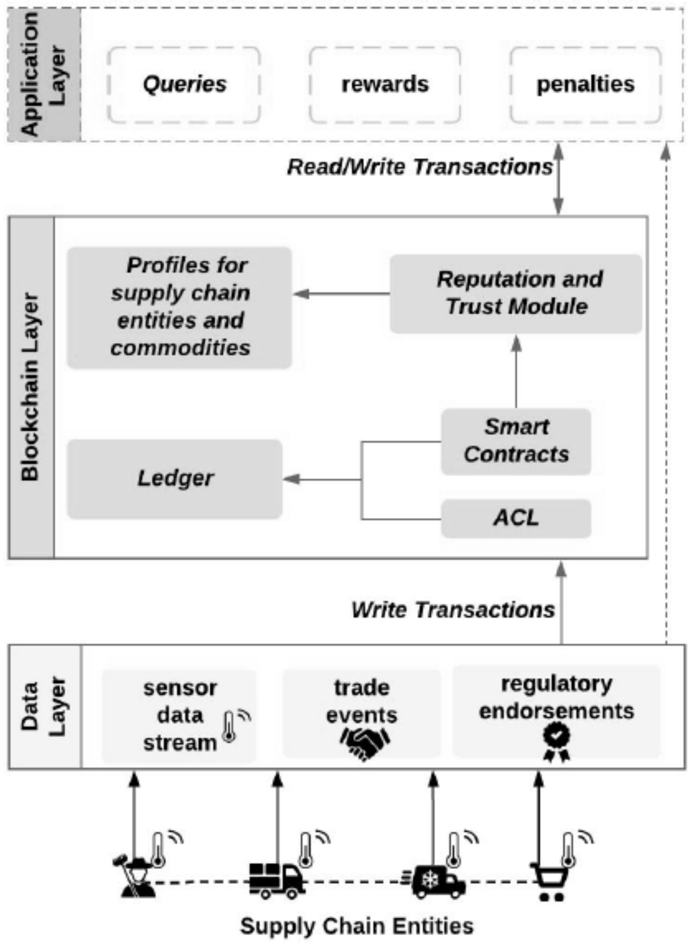

Figure 2: Layers Transform Blockchains from a Compilation of Data into a Usable Tool[119]

By including digital and self-executing eContracts throughout the application layer, the agricultural sector can increase efficiency

[117] *See supra* Part II.A (discussing FoodNet).
[118] Malik et al., *supra* note 112, at 186.
[119] *Id.*

through automation.[120] This automation would reduce unnecessary labor and help offset some of the costs of operating on the blockchain.[121] Additionally, pre-designated data values can prompt independently executable scripts.[122] An example would be a payment disbursement from a retailer to a distributor prompted by the distributor's shipping truck entering a predefined geographic area, such as a retailer's store or warehouse (detected through RFID). Similarly, a consumer could look to these eContracts and their underlying data to verify retailers conforming to ethical standards.[123]

The idea of using applications to create an intuitive, user-friendly interface for the technical novice is a well-established technological norm in many countries.[124] In fact, the entire basis for modern computing—using a cursor to select icons and open executable files—was driven by the desire to make computing power more accessible to non-coders.[125] A similar motivation lies behind the innovation of cell phone applications, blurring the lines between computer and smartphone and resulting in near-full access to the internet using one pocket-sized device.[126] Similarly, cell phone applications can be used to access data on AgChain merely by

[120] *See* Christidis & Devetsikiotis, *supra* note 106, at 2301.

[121] *See* Malik et al., *supra* note 112, at 185 (explaining how an automated framework reduces overhead and increases the scalability of blockchain's utilization of supply chains).

[122] *See* Christidis & Devetsikiotis, *supra* note 106, at 2296.

[123] *See generally* Massner, *supra* note 54, at 353 (outlining regulatory transparency in light of several stakeholders, such as farmers, packers, bakers, retailers, and restaurants). This same regulatory transparency is easily translatable to ethical transparency to the consumer, because much of the underlying information—location, sanitation, and work conditions—overlaps between regulation and ethics. *Id.*

[124] *See* Steven Levy, *Graphical User Interface*, BRITANNICA, https://www.britannica.com/technology/graphical-user-interface [https://perma.cc/4WZC-ECGX] (Mar. 29, 2018) (explaining the origins of graphical user interface or "GUI").

[125] *Id.*

[126] *See* Matt Strain, *1983 to Today: A History of Mobile Apps*, THE GUARDIAN (Feb. 13, 2015), https://www.theguardian.com/media-network/2015/feb/13/history-mobile-apps-future-interactive-timeline [https://perma.cc/MT4E-N5JC].

connecting a cell phone application with a dApp on AgChain itself.[127]

Imagine this hypothetical: Jack participates in his usual Sunday ritual, going to the grocery store. To make more conscious and ethical decisions while purchasing his favorite foods, Jack downloads an app to his smartphone for a nominal fee. This app uses his phone's near-field communication reader to scan the grocery store's information kiosk for a banana. At Jack's fingertips, the programmed identifier in the kiosk instantly reports the banana's history from AgChain—the field that grew the banana, the hands that harvested it, the ethical rating of the employer, and the transportation time and conditions between the field and the grocery store. The transparency now available to Jack via AgChain will empower Jack to make ad hoc, value-based determinations; for example, whether saving a few dollars is worth purchasing produce connected to child labor or unfair working conditions.

Because the power of the dollar in a free market is much like casting a ballot in an election, informed decisions regarding exercised spending power are vital to fostering ethical business practices.[128] Some might doubt consumers' engagement in holding producers accountable; however, the media, nonprofits, and retailers interested in protecting their reputations will certainly serve as a check.[129] Finally, regulators can track products throughout the entire

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[127] This AgChain app would operate the same way a cell phone application provides a convenient interface for bank account or transit information. *See, e.g.*, Alex Lielacher, *How to Access DApps on Your Mobile Phone*, CRYPTO BASICS (Nov. 20, 2020), https://coinmarketcap.com/alexandria/article/how-to-access-dapps-on-your-mobile-phone [https://perma.cc/T3V5-LZS8] ("To use Ethereum DApps, users require an Ethereum wallet that can interact with smart contracts. An example would be Trust Wallet, which enables users to seamlessly interact with decentralized applications on desktop and mobile.").

[128] Whizy Kim, *How to Find Out What Causes a Company Supports Before You Shop*, REFINERY29, https://www.refinery29.com/en-us/where-does-money-go-shopping-tools [https://perma.cc/J95W-JNUH] (July 7, 2020) (highlighting the questions posed by ethical consumerism and why it matters).

[129] *See generally* Bob Young, *The Relationship Between Supermarkets and Suppliers: What Are the Implications for Consumers?*, CONSUMERS INT'L. 4 (July 2020), https://www.law.ox.ac.uk/sites/files/oxlaw/the_relationship_between_

supply chain and initiate safety interventions in a manner similar to Jack. Transparency to this extent was lost long ago amidst the expansion of global supply chains,[130] but deploying blockchain and layering dApps for interface would revitalize confidence and control in agriculture.

IV. PRELIMINARY OBSTACLES FOR IMPLEMENTING A BLOCKCHAIN SOLUTION

Equipping AgChain to sufficiently execute the aforementioned goals faces two key barriers.[131] First, while cryptocurrencies—the most widely used blockchains today—operate by storing relatively small amounts of information on their blocks, AgChain would require substantially more data.[132] Blockchain data must be physically stored somewhere, which is both costly to establish and requires manpower to maintain, even if the data is located on a decentralized set of servers in "the cloud."[133] Second, utilizing the

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supermarkets_and_suppliers.pdf [https://perma.cc/TWH5-A9CQ] ("In the trade of agricultural products, the bargaining power of the supermarkets is reinforced by fragmentation on the supply side. Whereas the retail grocery market is characteristically served by only four or five large supermarket groups, the number of food and food-product producers runs into thousands. The fragmented nature of the supply side tilts bargaining power even further in favour of the supermarkets.").

[130] *See supra* Part II (discussing the current state of agriculture).

[131] Natalya Dyatko, *No, You Don't Store Data on the Blockchain – Here's Why*, JAXENTER (Dec. 16, 2019), https://jaxenter.com/blockchain-data-164727.html [https://perma.cc/B9AF-245N]; *see also* Ron Lyseng, *Big Farm vs. Small Farm: Survival of the Fittest*, W. PRODUCER (Dec. 26, 2019), https://www.producer.com/news/big-farm-vs-small-farm-survival-of-the-fittest/ [https://perma.cc/BF5C-D9KQ] ("A big farmer benefits from economy of scale in making purchases. He also benefits from a substantial cash flow, which allows him to always use the latest technology . . ..").

[132] Dyatko, *supra* note 131.

[133] Tonglai Liu et al., *Secure and Balanced Scheme for Non-local Data Storage in Blockchain Network*, IEEE 21ST INT'L CONF. ON HIGH PERFORMANCE COMPUTING & COMMC'NS 2424, 2424 (2019) (explaining that when portions of a blockchain are stored on the cloud, they are divided into encrypted data chunks). When nodes are organized into a single Consensus Unit, and their disk space is collected, storage space can be substantial. *Id.* This Article discusses a hybrid approach where local and non-local combined storage are used to maximize storage potential, security, and cost.

full power of a blockchain would inherently benefit those with the most access to technology.[134] Thus, many small, rural farmers would potentially be excluded due to their lower participation levels in the IoT, while larger competitors would flourish.[135]

A. Data Storage on a Large Scale is Expensive

Data storage on blockchains has proven exceptional in theory; however, data storage capabilities in the physical world limit seamless implementation.[136] To make AgChain a reality, substantial investment in data storage capabilities is necessary.[137] Presently, the cost of data nodes for one petabyte of storage (one million gigabytes) is approximately $1,000,000.[138] By comparison, the cost of running only a mile of electrical transmission lines ranges from approximately $285,000 to $1,000,000.[139] Both are certainly expensive and are only a small fraction of the total network necessary to create an appreciable public benefit for each of the two industries.[140]

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[134] Lyseng, *supra* note 131 ("A big farmer benefits from economy of scale in making purchases. He also benefits from a substantial cash flow, which allows him to always use the latest technology.").

[135] Peter B. R. Hazell, *Is there a Future for Small Farms?*, 32 AGRIC. ECON. 93, 94 (2005).

[136] Dyatko, *supra* note 131; *see also* Gabriela Motroc, *Running Blockchains in the Cloud: Benefits & Lessons Learned*, JAXENTER (Dec. 17, 2018), https://jaxenter.com/blockchain-cloud-interview-kuhlman-153287.html [https://perma.cc/52UB-VJ72] (highlighting data storage limitations as an obstacle to scaling blockchain).

[137] Eric Savitz, *The Cost of Big Data*, FORBES (Apr. 16, 2012), https://www.forbes.com/sites/ciocentral/2012/04/16/the-big-cost-of-big-data/?sh=1634dbc85a3b [https://perma.cc/32KE-FBX7].

[138] *Id.*

[139] Frank Alonso & Carolyn A. E. Greenwell, *Underground vs. Overhead: Powerline Installation-Cost Comparison and Mitigation*, POWERGRID INT'L (Feb. 1, 2013), https://www.power-grid.com/td/underground-vs-overhead-power-line-installation-cost-comparison/#gref [https://perma.cc/J9XK-U277].

[140] *See id.*; *see also U.S. Electricity Grid & Markets*, EPA, https://www.epa.gov/greenpower/us-electricity-grid-markets#main-content [https://perma.cc/DEB9-EHP7] (July 13, 2021) (reporting that there are 160,000 miles of high-voltage power lines, and millions of miles of lower voltage lines in the United States).

There have been efforts to increase data density that can be stored in physical space by shifting away from conventional, binary-electric methods and towards enzymatic-DNA-based storage.[141] DNA-improved data density would replace traditional computing "ones" and "zeros" with adenine (A), cytosine (C), guanine (G), and thymine (T), which make up DNA, thereby exponentially improving the efficiency of data storage in physical spaces.[142] Additionally, quantum computing aims to perform data storage at the atomic level.[143] However, both of these revolutionary storage methods are too underdeveloped to rely upon for immediate blockchain implementation.[144]

Although these next-generation technologies will likely continue to develop independent of conventional data storage methods, the risks posed by the compromised state of agriculture in the United States demands immediate action.[145] Like the phasing out of fossil fuels for energy generation that has occurred over time, a similar obsoletion of binary, electronic data storage may occur in the future.[146] Still, *possible* innovation is no reason for stagnation in the

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[141] Robert F. Service, *DNA Could Store All of the World's Data in One Room*, SCI. MAG. (Mar. 2, 2017, 2:00 PM), https://www.sciencemag.org/news/2017/03/dna-could-store-all-worlds-data-one-room [https://perma.cc/K9YN-DBXF].

[142] *Id.* ("[R]esearchers report that they've come up with a new way to encode digital data in DNA to create the highest-density large-scale data storage scheme ever invented. Capable of storing 215 petabytes (215 million gigabytes) in a single gram of DNA, the system could, in principle, store every bit of datum ever recorded by humans in a container about the size and weight of a couple of pickup trucks.").

[143] *See generally* Thomas Beth, *Quantum Computing: An Introduction*, IEEE INT'L SYMP. ON CIRS. & SYS. 1 (2000) (discussing the two concepts of "superposition" and "entangled states" as the tools for implementing quantum computing).

[144] For a comprehensive analysis DNA-based data storage, *see* THE FUTURE OF DNA DATA STORAGE, POTOMAC INST. FOR POL'Y STUDS. 24–27 (2018), https://potomacinstitute.org/images/studies/Future_of_DNA_Data_Storage.pdf [https://perma.cc/9PYC-22NK].

[145] *See supra* Part II (discussing on the current state of agriculture).

[146] *See* Rainer Quitzow et al., *Advancing a Global Transition to Clean Energy – The Role of International Cooperation*, 37 ECON. e-J. 1, 2 (2019).

present.[147] One could imagine how stunted human development might have been if humanity decided to forego the necessary costs to implement large-scale electric transmission.[148] Because of these marked similarities, a similar approach to electricity transmission should be employed in digital supply chain infrastructure, specifically, utility-scale data storage to host AgChain.

B. Balancing the Interests of Small Farmers and Large Commercial Producers

Small and mid-sized farms contribute to nearly half of the United States' food productions.[149] Observed at nearly 22% of total food production, small farmers still account for a generous portion of the United States' agriculture.[150] Despite this vital role for the Nation, small farmers are being further jeopardized by large commercial farms.[151] Additionally, small farmers are more likely to distrust new technology because its unfamiliarity and complexity have resulted in companies' past abuse and exploitation of those

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[147] *See id.* ("The global transition to clean energy has accelerated markedly over the past decade. Renewable energy capacities have more than doubled over the past ten years and represented 70 percent of net capacity additions in the power sector in 2017.").

[148] *Access to Energy is at the Heart of Development*, WORLD BANK (Apr. 18, 2018), https://www.worldbank.org/en/news/feature/2018/04/18/access-energy-sustainable-development-goal-7 [https://perma.cc/4G8P-9UYK] ("[Lack of electricity] represents a fundamental barrier to progress for a sizeable proportion of the world's population, and has impacts on a wide range of development indicators, including health, education, food security, gender equality, livelihoods, and poverty reduction.").

[149] USDA, *Farming and Farm Income*, https://www.ers.usda.gov/data-products/ag-and-food-statistics-charting-the-essentials/farming-and-farm-income/ [https://perma.cc/2K2U-D2PZ] (Dec. 2, 2020).

[150] *See id.*

[151] Alana Semuels, *'They're Trying to Wipe Us Off the Map.' Small American Farmers are Nearing Extinction*, TIME MAG. (Nov. 27, 2019, 1:16 PM), https://time.com/5736789/small-american-farmers-debt-crisis-extinction/ [https://perma.cc/CK2R-7EXF] ("The reason for these lowered prices are the twin forces upending much of the American economy: technology and globalization. Technology has made farms more efficient than ever before. But economies of scale meant that most of the benefits accrued to corporate farmers, who built up huge holdings as smaller farmers sold out.").

farmers.[152] Unfortunately, AgChain is likely to be no different unless intuitive and user-friendly interfaces can be implemented. Large commercial farms have greater access to liquidity[153] and are better situated to deploy the distributed network of sensors and computers to best utilize the IoT, deploy the AgChain, and offset costs, thereby improving cash flow and initiating a self-perpetuating cycle. Due to the fact that commercial farms would reduce regulatory inefficiency through AgChain automation that small, low-tech farmers could not take advantage of, small farms would be left behind, saddled with the in-person regulatory burdens of today.[154] Finally, insurance companies might note the value of AgChain-enabled risk mitigation and reward those implementing the system.[155] By reducing the likelihood of claims and lawsuits through AgChain's advantages, insurance underwriters would likely view an AgChain user as a lower risk.[156] While this could improve adoption rates, the small

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[152] *See* Todd Janzen, *Sorry, Right to Repair Advocates: You May Be Right, but John Deere is on the Winning Side of History*, JANZEN AG TECH BLOG (Mar. 31, 2017), https://www.aglaw.us/janzenaglaw/2017/3/29/fixing-the-right-to-repair [https://perma.cc/QK6B-LUA8] (exploring the Right to Repair Movement, prompted by farmers who invested in John Deere tractors, only to be forced to pay expensive transportation and technician costs due to inaccessible, proprietary interface software for their tractors); *see also* AgFunder, *Ag Tech is Useless if We Can't Engage Farmers*, SUCCESSFUL FARMING (Jan. 4, 2019), https://www.agriculture.com/news/technology/ag-tech-is-useless-if-we-cant-engage-farmers [https://perma.cc/RNL5-X48G] ("[A]g tech entrepreneurs have been forcing half-baked products on farmers. Nothing good comes of this; farmers are left frustrated, skeptical of ag tech, and feeling they have been burned. Ag tech entrepreneurs fail to receive valuable feedback that will help them build better products.").

[153] Lyseng, *supra* note 131.

[154] *See supra* Part II.A (discussing the current regulatory processes in agriculture).

[155] Lynn F. Kime et al., *Product Liability Insurance*, PENN ST. EXTENSION (Sept. 8, 2018), https://extension.psu.edu/product-liability-insurance#:~:text=Product%20liability%20insurance%20provides%20protection,from%20consumption%20of%20your%20product. [https://perma.cc/9KUS-ZQT5] ("Product liability insurance provides protection if a food borne illness results from a product you sold. It will pay for injuries and medical treatment resulting from consumption of your product. In addition to addressing the needs of your customers, this coverage will also pay your defense costs in a lawsuit, and any judgments of the court, up to the policy limit.").

[156] *See id.*

farmers unable to adopt AgChain may face higher insurance premiums than their competitors.[157]

On the other hand, small producers are operationally distinct from their big-farm counterparts. For example, small producers often have shorter supply chains and do not experience the inefficiencies or obscurities that necessitate a technological solution for complex, international producers.[158] Small farmers generally retain the short, local supply chains that inherently provide assurances and foster confidence in consumers.[159] Accountability can be administered on a far less onerous, localized basis.[160] Similarly, because agriculture is an economy of scale, and the small farmer's footprint is reduced, insurance premiums are inherently lower to start.[161] Small farmers may even see premiums decrease following the implementation of AgChain, regardless of their participation, as surgical interception of contaminated products would necessitate smaller payouts for smaller recalls.[162]

V. INCENTIVIZING INVESTMENT BY DESIGNATING ONE OR MORE BLOCKCHAIN FIRMS AS A UTILITY

AgChain is not the first socially necessary capital investment in American history that was not immediately embraced by

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[157] *See, e.g.*, John M. Vincent & Cherise Threewitt, *How Do Those Car Insurance Tracking Devices Work?*, U.S. NEWS & WORLD REP. (Feb. 26, 2018), https://www.usnews.com/insurance/auto/how-do-those-car-insurance-tracking-devices-work [https://rb.gy/hkpyxo] (demonstrating how fleet-based service providers are already lowering premiums using GPS technology in cars to demonstrate low-risk behavior to insurance providers).

[158] *See supra* Part II (discussing the current state of complex agricultural supply chains).

[159] Eric Westervelt, *As Food Supply Chain Breaks Down, Farm-To-Door CSAs Take Off*, NPR (May 10, 2020, 10:02 AM), https://www.npr.org/2020/05/10/852512047/as-food-supply-chain-breaks-down-farm-to-door-csas-take-off [https://perma.cc/NCM9-SKYJ].

[160] *Id.*

[161] Patrick J. Kiger, *10 Ways the Transcontinental Railroad Changed America*, HISTORY (Sept. 4, 2019), https://www.history.com/news/transcontinental-railroad-changed-america [https://perma.cc/6A3D-JYKW].

[162] *See generally* Kime et al., *supra* note 155 (highlighting how the cost of injury and lawsuits drive premium costs in product liability cases).

entrepreneurs.[163] Railroads and powerlines, for instance, were not attractive because immense feats of ingenuity and investment were required to accomplish their intended purposes; however, both investments connected the continent in a way many before deemed unimaginable.[164] The government provided assurances, like exclusive service territories, to persuade capitalists to invest in these risky and expensive endeavors.[165] Similarly, AgChain's high costs of entry into the market would require incentivization to make "buying in" more appealing to investors. Subpart A below discusses the processes by which capital investment may be incentivized through designating AgChain as a utility. Subpart B discusses the benefits and obligations inherent to regulated utilities. Finally, Subpart C concludes by explaining the primary criticisms of the regulated utility model.

A. Defining the Incentive to Private Enterprise

Two different, yet complementary, approaches can incentivize capital investments in light of natural monopolies. This Article proposes a regulated utility solution to resolve the barrier to entry posed by expensive capital investment—essentially combining the two approaches.[166] The first strategy involves the government

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[163] Peter J. Gould, *Administrative Law - The Constitutional Limits of the Power to Regulate: Duquesne Light Co. v. Barasch*, 20 N.M. L. REV. 199, 205 (1990) (stating that the electricity industry was a natural monopoly requiring regulation in-part because "the high initial cost of starting a facility for electric generation discourages newcomers from getting into the market").

[164] *See The Transcontinental Railroad*, LIBR. OF CONG., https://www.loc.gov/collections/railroad-maps-1828-to-1900/articles-and-essays/history-of-railroads-and-maps/the-transcontinental-railroad/ [https://perma.cc/SEK7-KSSK]; *see also* Julie Cohn, *When the Grid Was the Grid: The History of North America's Brief Coast-to-Coast Interconnected Machine*, 107 PROC. OF THE IEEE 232, 237 (2019) ("[Establishing the electricity grid] was an engineering accomplishment of the highest order, first envisioned in the early twentieth century, touted by politicians and contemplated by engineers for decades, and finally achieved—nearly undetected by the American public—in 1967.").

[165] *See generally* Gould, *supra* note 163, at 212 (explaining the ratemaking process as a balancing act between consumer and investor interests).

[166] Because the barrier to entry for a complex data storage system like AgChain and similar data systems modernizing supply chains is largely an economic

rewarding an innovator for investment by protecting a return on the investment.[167] The protection includes factoring the innovation cost into the rate base charged for services provided by the utility to provide modest assurances that capital is recuperated.[168] The second strategy to incentivize investment amidst high entry costs requires the government to protect the innovator from competition by excluding market access to competitors in a specific geographic area for a prescribed period of time.[169] Combining both of these strategies—adopting a reasonable rate of return, as well as granting an exclusive service territory—to incentivize AgChain innovators is the best approach to building the infrastructure for mass blockchain data storage.[170] Advancing technologies, such as DNA-based data storage and quantum computing, render present investment in large-scale data storage risky, but these risks are no different from the

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hurdle, another solution, which this paper does not explore, is the possible effectiveness of tax credits and subsidies. *See, e.g.*, David Roberts, *RECs, Which Put the "Green" in Green Electricity, Explained*, VOX (Nov. 9, 2015), https://www.vox.com/2015/11/9/9696820/renewable-energy-certificates [https://perma.cc/F3EH-8F8V] (discussing applications for renewable energy credits in the electricity industry). Using these vehicles to reduce the net cost of implementing a complex and independent data storage system could possibly be as effective as a regulated utility; however, the nature of having all related data tied to a single blockchain means that the coding and encryption must be one single version—a monopoly. *See supra* Part III (explaining that node miners on a blockchain must share the same ledger and be able to communicate with one another). Unlike the tangible natural monopolies seen in electric transmission and railroad tracks, this AgChain version is a new iteration of the natural monopoly: a virtual, natural monopoly.

167 *See generally* James J. Hoecker, *"Used and Useful": Autopsy of a Ratemaking Policy*, 8 ENERGY L.J. 303, 303 (1987) (explaining that "used and useful" capital investments by a utility should be recuperated in the rate of return, but this recuperation may not directly correlate to original cost if some capital is not being used or is not useful to the public).

168 *Id.* at 306.

169 *See* Jonas J. Monast, *Maximizing Utility in Electric Utility Regulation*, 43 FLA ST. U. L. REV. 135, 143 (2015) ("In exchange for an exclusive service territory, the utility is subject to rate regulation by the state [public utility commission].").

170 *See* Hoecker, *supra* note 167, at 306.

energy sector's evolution in the United States.[171] Considering the urgent public need for food security and protection,[172] AgChain must be created and implemented now, so that looming tragedy from devastating hacks, foodborne pathogens, and ongoing food waste is addressed and avoided.

The blended benefits of a regulated, reasonable rate of return for an AgChain investor with the benefits of an exclusive service territory, would incentivize private companies to develop the necessary data-storage infrastructure upon which AgChain would operate.[173] To establish a utility rate, regulators would need to be cognizant of the AgChain's revenue requirements and the consumers' need for "just and reasonable" rates.[174] Just and reasonable rates require a delicate balancing of interests that is highly fact-specific; in other rate-setting instances, courts have mandated an "end-results" test that focuses less on the means of setting the rate and more on the "end," so long as the outcome is just and reasonable.[175] AgChain's ratepayers, such as farmers, supermarkets, and consumers, would be entitled to a similarly just and reasonable rate.

AgChain will attract capital from potential investors because of the stability AgChain will enjoy in the market due to the balancing of investor and ratepayer interests.[176] Additionally, balancing the interests of the ratepayer ensures that those using AgChain are only paying for the benefits the ratepayers enjoy and ensures that the

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[171] *See supra* Part IV.A (discussing innovative data storage technologies besides blockchain); *see also* Gould, *supra* note 163, at 202–03 (discussing the efficacy of advancing nuclear electricity technology post-WWII).

[172] For a discussion regarding over-inclusive food recalls and data hacks, *see supra* Part II.A.

[173] *See* Gustavus H. Robinson, *Duty of a Public Utility to Serve at Reasonable Rates: The Valuation War*, 6 N.C. L. REV. 243 (1928).

[174] Gould, *supra* note 163, at 212 (quoting the Court in *Fed. Power Comm'n v. Hope Nat. Gas Co.*, 320 U.S. 591 (1944) regarding the End Results Test for energy utility rate setting and stating, "[t]he rate-making process under the Act, i.e., the fixing of 'just and reasonable' rates, involves *a balancing of the investor and the consumer interests*.").

[175] *Id.* at 206, 212.

[176] *Id.* at 211 (noting how investors want to rely on a "predictable and steady" return on investment).

utility is fulfilling its primary purpose of meeting a public need.[177] Using a process called "amortization," the original investors in AgChain will be ensured to recover their costs over a determined amount of time.[178] However, for this ability to recuperate costs to be meaningful, AgChain innovators must be assured that competitors will not enter the same market space.

To properly set the scope of the competition prohibition, regulations must identify the geographic and market boundaries for the exclusive service territory.[179] Failure to correctly identify the scope of an exclusive service territory could result in over- or under-inclusive sections of the free-market being restricted for a utility ill-suited to fill the space.[180] As a best practice in utility regulation, exclusive service territories need only extend to the scope of the natural monopoly itself because that scope is the extent to which high capital costs block entry and cause market failure.[181] Stated

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[177] *See id.* (emphasizing that the value in removing speculative capital investment-related risk reduces the cost experienced by the consumer ratepayer).

[178] *Id.* at 201 n.20 (defining amortization).

[179] Monast, *supra* note 169, at 143 (explaining that an exclusive service territory is the benefit a utility gains for subjecting itself to rate regulation by the state utility commission). This exchange of benefits, which includes the power of eminent domain and the right to exclude others from its territory, has historically been dubbed the regulatory compact between a company and the government. *See id.*; *see also* Jim Rossi, *The Common Law Duty to Serve and Protection of Consumers in an Age of Competitive Retail Public Utility Restructuring*, 51 VAND. L. REV. 1233, 1263–64 (1998) (defining a regulatory compact).

[180] This result was seen when the United States fumbled while developing the adequate scope of natural gas regulation jurisdiction, alternating between treating pipelines, well-heads, and distributors as regulated monopolies, despite the fact that only the transportation pipelines were sensibly a natural monopoly. *See* William Flittie & James Armour, *The Natural Gas Experience – A Study in Regulatory Aggression and Congressional Failure to Control the Legislative Process*, 19 SW. L.J. 448, 522 (1965) ("[I]ndirect controls which force non-jurisdictional sales into jurisdictional status, if to be made at all, benefit those in the industry who otherwise would be bypassed and would not participate in the business represented.").

[181] *See* Thomas Brock, *Natural Monopoly*, INVESTOPEDIA, https://www.investopedia.com/terms/n/natural_monopoly.asp [https://perma.cc/N5EV-86TS] (Jan. 26, 2021) (defining a natural monopoly as "when one firm is much more efficient than multiple firms in providing the good or service to the

differently, when circumstances no longer generate natural monopolies, the need for a regulated utility evaporates because traditional market forces are expected to operate effectively.[182] In AgChain, the scope of the natural monopoly would extend to both the physical infrastructure network established, as well as the virtual, natural monopoly that is the AgChain code. The competitive retail sale of storage on blockchains, like AgChain, may even operate similarly to the retail sales of electricity often deemed not to be a natural monopoly; however, such a discussion is outside of the scope of this Article.[183]

By combining rate regulation and an exclusive service territory for investors in AgChain, reluctance to assume the high costs of entering the big data storage market will likely be abated. This combination will allow the implementation of AgChain and the design of dApps for user and regulator interfaces. The software implementations for AgChain is another cost that must be assumed, but both the tangible and intangible infrastructure may be recovered in the rates charged.[184] Finally, at the later stages of implementation, the utility could be expected to add an AI layer that would recognize problematic data or supply chain issues likely to cause outbreaks or other disruptions and relay those warnings to regulators and the

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market. A good example of this is in the business of electricity transmission where once a grid is set up to deliver electric power to all of the homes in a community, putting in a second, redundant grid to compete makes little sense.").

[182] *See id.*

[183] *See, e.g.*, Scott Patterson & Tom McGinty, *Deregulation Aimed to Lower Home-Power Bills. For Many, It Didn't.*, WALL ST. J. (Mar. 8, 2021), https://www.wsj.com/articles/electricity-deregulation-utility-retail-energy-bills-11615213623 [https://perma.cc/A9QR-2HWA]. Many regions in the United States have shifted away from the utility model for electricity and now use regional competitive markets for wholesale transactions. *See* Benjamin A. Stafford & Elizabeth J. Wilson, *Winds of Change in Energy Systems: Policy Implementation, Technology Deployment, and Regional Transmission* Organizations, 21 ENERGY RSCH. & SOC. SCI. 222, 226 (2016). These competitive markets are called Regional Transmission Organizations ("RTOs"); RTOs value the competitive market as a tool to promote innovation, reliability, low rates, and shared energy resources between states. *Id.*

[184] *See, e.g.*, Lielacher, *supra* note 127 (demonstrating the use of dApps on Ethereum's blockchain). These dApps could charge rates to ratepayers as a simple access fee.

affected parties.[185] With these combined technologies, AgChain would be poised to fulfill the modernization of the food supply chain.

B. A Duty to Serve

Another critical tenant of utility regulation is the utility's duty to serve the general public.[186] The duty to serve means the utility is not allowed to refuse service, so long as its ratepayers have the ability to pay the regulator-approved rate charged and the utility has the capacity to serve.[187] For electric utilities, a duty to serve is met by fulfilling all demand for electricity at the rate approved by its regulator; for AgChain, the duty to serve is met by allowing ratepayers to utilize the blockchain's data storage system, dApps, and all other services provided. The duty to serve renders utilities distinct from other private enterprises that may generally refuse to serve customers so long as the basis for refusal is not discriminatory.[188] Because of its duty to serve, the utility is expected to expand and maintain its capabilities to support ratepayer demand—ultimately serving the public need as intended.[189] If the utility fails to satisfy its duty, the utility can be subjected to demanding scrutiny regarding its business operations; if the breach of this duty is sufficient, the utility may face losing the benefits of a

[185] *See supra* Part III.B (discussing software layering on the blockchain).

[186] Rossi, *supra* note 179, at 1243 (explaining the duty to serve as consisting of two distinct obligations in the twentieth century: Service Extension & Service Continuation).

[187] *But see id.* (explaining that in some instances, the utility may even be prevented from disconnecting services when the ratepayer cannot pay). This has been seen as of late when many governors issued moratoriums on utility companies from discontinuing service during the COVID-19 pandemic. *See, e.g.*, N.C. Exec. Order No. 142 (2020) (extending a utility shutoff prohibition previously ordered by Governor Roy Cooper).

[188] Rossi, *supra* note 179, at 1319 ("The duty to serve applicable to public utilities, this Article suggests, has been much more rigorous than obligations that attach to other private property or businesses.").

[189] *Id.* at 1252–57 (explaining the Duty to Extend Service, which is a subset of the Duty to Serve).

regulatory compact, most importantly, its exclusive service territory.[190]

AgChain is not intended to dictate the actions of farmers or manage the supply chain itself; instead, the same farmers and managers would continue to oversee American agriculture, aided by regulators. AgChain would operate solely as a data management service, satisfying the logistical needs of farmers, supermarkets, regulators, and consumers. Just as consumers' rates on the electric grid may vary by consumer type (e.g., industrial, commercial, or residential), the rate AgChain charges for its data management services would vary depending on the type of consumer.[191] For example, Jack would pay a one-time access fee on his phone for downloading an application from the App store, whereas farmers and markets using AgChain to automate contract executions and payments would pay a recurring service rate based on usage. To encourage early adoption of AgChain, the rate would be offset by insurance savings, tax deductions for business-related expenses, and potential government subsidies to encourage early adoption of AgChain.[192] Furthermore, AgChain would be expected to expand its

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[190] *Id.* at 1263–64 ("The regulatory compact, a fictional contract between the utility and the state, views the utility as consensually agreeing to certain obligations, such as the duty to serve, in return for its geographic franchise and expected recovery of its costs of service through regulated rates."). This fictional, or implied contract, sensibly prompts revocation of the benefit under the contract when breached.

[191] Industrial, commercial, and residential consumers often pay different rates when buying electricity. This price discrepancy can be conceptualized by industrial or commercial consumers essentially paying in bulk for their electricity, thereby paying a lower unit price per kilowatt-hour. *See Electricity Explained Factors Affecting Electricity Prices*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/energyexplained/electricity/prices-and-factors-affecting-prices.php [https://perma.cc/3TWF-5AK9] (Apr. 12, 2021).

[192] Instead of individual consumers paying the direct cost of AgChain operation through in-app purchases, a much more likely scenario is that a supermarket would subsume this cost and then pass the cost on to consumers through a minor price increase on goods sold. This rate increase would be quite similar to the fees Amazon charges its Amazon Prime customers for its two-day shipping. *See The Amazon Prime Membership Fee*, AMAZON, https://www.amazon.com/gp/help/customer/display.html?nodeId=G34EUPKVMYFW8N2U [https://perma.cc/WK9X-M26W] (last visited Mar. 2, 2021).

blockchain code, data storage capabilities, and maintain service reliability to meet its duty to serve.[193] If the farmer, the consumer, or the market wants to employ AgChain's data management services, AgChain would have an obligation to serve. By fostering AgChain's infrastructural development, America's vital data management, security, and agricultural regulatory needs could be met.[194] Improving regulatory oversight will reduce food waste, promote proactive policing of foodborne pathogens, and modernize regulation in a vital American industry. Despite criticisms surrounding utility regulation, AgChain is still the best option.

C. *Criticisms—Is a Utility the Right Direction?*

While many American marvels are the byproduct of a regulated utility system (e.g., railroads, telecommunication, and electricity), combining private enterprise innovation with public regulation has its fair share of flaws.[195] These flaws have vexed regulators in the electricity sector, attempting to reorganize markets in ways that minimize regulatory intrusion on the free market.[196] Borrowing some of the lessons learned in energy market restructuring, AgChain regulation may be more narrowly tailored to support data management infrastructure needs (a natural monopoly) while allowing the wholesale and retail sales of data storage space on AgChain as a competitive market. The competitive market on AgChain's storage space could include bidding and opposing businesses promoting innovation.[197] Nonetheless, stifled innovation is an ongoing concern in any regulated market; additionally, the

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[193] *See* Rossi, *supra* note 179, at 1319.

[194] *See, e.g.*, Taylor, *supra* note 50 (illustrating an E. coli outbreak that may have been avoided if AgChain were operational).

[195] *See* David B. Spence, *The Politics of Electricity Restructuring: Theory vs. Practice*, 40 WAKE FOREST L. REV. 417, 418 (2005) (explaining the twofold case for restructuring electric grids to create purely competitive markets).

[196] *See id.*

[197] *See id.* (explaining that the *sale* of electricity is not a natural monopoly). This process is comparable to the fact that the sales of data space on AgChain would not be a natural monopoly. *See id.*; *see also* Sofia Ranchordas, *Innovation-Friendly Regulation: The Sunset of Regulation, the Sunrise of Innovation*, 55 JURIMETRICS 201, 201 (2015) (advocating for more regulatory flexibility in light of lagging regulation slowing down innovation).

issues of regulatory capture and alternative market mechanisms attempt to decrease utility appeal.[198]

Promoting AgChain would not result in data storage innovation stagnation. Many everyday media applications exist that promote improved data storage.[199] For example, improved data storage means that individuals can store 4K versions of their favorite movies on their cell phones to watch on an intercontinental flight instead of the standard definition version.[200] Additionally, computer software is growing more complex and therefore demands better processing power and quick data storage.[201] These common, personal uses for improved data storage would fuel innovation, and an AgChain utility would not interfere with that independent motivation for innovation in other personal technological purposes.

A second common obstacle for utility success, particularly from a consumer's perspective, is the issue of regulatory capture.[202] Regulatory capture occurs when a utility accrues enough influence in government (specifically, the agencies charged with regulating the utility) such that regulation no longer effectively imitates the pressures of a free market.[203] Essentially, agencies start to favor the regulated entity disproportionately to consumers. Regulatory capture can compromise the effectiveness of regulation, resulting in dilapidated infrastructure, decreased reliability, and unfairly inflated

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[198] *See* Rossi, *supra* note 179, at 1274 (explaining regulatory capture incentives for stakeholders).

[199] *See, e.g.*, *Data Storage Devices*, FRONTIER INTERNET, https://www.frontierinternet.com/gateway/data-storage-timeline/ [https://rb.gy/yvsxt7] (last visited May 15, 2021) (demonstrating the various media applications for personal data storage on phones, flash drives, DVDs, etc.).

[200] A single hour of 4K video is 14 gigabytes of data, compared to 0.7 gigabytes per hour for a standard definition video. Stephen Kota, *How Much Data Does 4K Video Use*, EVD DEPOT USA, https://www.evdodepotusa.com/how-much-data-does-4k-video-streaming-use/ [https://perma.cc/U6KZ-5QUC] (last visited Feb. 8 2021). Accordingly, the Lord of the Rings movie, at 3 hours and 48 minutes, would be 53.2 gigabytes of 4K video, but only 2.66 gigabytes of standard definition video. LORD OF THE RINGS (Peter Jackson dir., 2001).

[201] *See supra* Part IV (discussing DNA-based computing and other technological advancements in quantum computing).

[202] *See* Rossi, *supra* note 179, at 1274.

[203] *See id.*

rates.[204] Nevertheless, merely recognizing that private enterprise has a tenacious tendency to seek out improper governmental influence is not unique to regulated monopolies.[205] Improper corporate lobbying power manifests in various governmental facets; however, this unfortunate tendency does not foreclose the actual advantages in a democratic system of government.[206] Similarly, the prevalent advantages of public utility regulation should not be blindly ignored purely due to potential regulatory capture. Instead, vigilance via consumer involvement should police for improper influence, so that the benefits of utility regulation may be enjoyed without defects.

Finally, another outstanding criticism against a utility model for AgChain lies in the potential for monetary subsidies granted to the private company leading innovation.[207] One might propose that government subsidies would reduce the cost of creating AgChain in a way that renders utility regulation pointless, particularly since the high capital costs for entering the commercial data storage market are a critical problem.[208] This point still fails to address two advantages in a utility model: (1) preventing wastefully redundant infrastructure held by market competitors and (2) creating a unified code that collectively creates a more secure AgChain. The value of AgChain as a supply chain tool lies in its ability to amass agricultural data from the IoT on a single system and cohesively and coherently deploy that data for consumers and regulators to use. By merely providing financial means for many new market participants,

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[204] *See* Gerard Caprio Jr., *Regulatory Capture: Why It Occurs, How to Minimize It*, 18 N.C. BANKING INST. 39, 47–48 (2013) (illustrating how regulatory capture contributes to the breakdown of effective finance regulation); *see also id.* at 48 ("As professors, we know that if we let our classes grade themselves, it would be rare for anyone to obtain a grade below A.").

[205] Lee Drutman, *How Corporate Lobbyists Conquered American Democracy*, THE ATLANTIC (Apr. 20, 2015), https://www.theatlantic.com/business/archive/2015/04/how-corporate-lobbyists-conquered-american-democracy/390822/ [https://perma.cc/V583-NPQ7].

[206] *Id.*

[207] *See generally* Roberts, *supra* note 166 (demonstrating that tax credits, an example of pure financial subsidies, are a means to incentivize renewable energy production, which could be mirrored for blockchain innovation).

[208] *See generally* Ranchordas, *supra* note 197 (emphasizing regulatory flexibility as a means to foster innovation).

the ability to create a single viable blockchain is undermined, since the accumulation of data on a single, shared ledger is essential in P2P systems operating a blockchain. Therefore, a utility model is best suited for AgChain.[209]

VI. CONCLUSION

Implementing a blockchain-based solution to the United States' agricultural supply chain would curb transparency and regulatory issues and would prove favorable to consumers and farmers alike. Additionally, employing AgChain to modernize the agricultural supply chain benefits regulators, farmers, and consumers by increasing transparency and security. Although some feasible alternatives to AgChain as a regulated utility present themselves when analyzing AgChain from a purely economic stance, the natural monopoly characteristics inherent in AgChain's physical and virtual infrastructure render a singular utility as the only viable option.

Although improved methods by which data may be stored might develop in the future, the possibility of future innovation or obsoletion is no excuse to wait idly in anticipation of positive change. The hazards of reactive responses to food contamination and cyberattacks continue to grow; COVID-19 and its variants are clear examples of a virus's power to end lives and cripple the global economy. Therefore, immediate action is essential. Akin to the electricity and telecommunication infrastructures of the twentieth century, waiting for potential innovation is an insufficient excuse for delaying present-day inaction. Had the United States waited to develop interstate electricity transmission infrastructure, anticipating the distributed generation capabilities of solar panels, this Article may have instead been written using a typewriter and read by candlelight. Now is the time to capitalize on the real potential of blockchain programs using modern data storage technology; now is the time to stoke private investment in AgChain by rewarding venture capitalists on the avantgarde with assurances attendant to a public utility.

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[209] *See supra* Part III (discussing blockchain operation).

APPENDIX

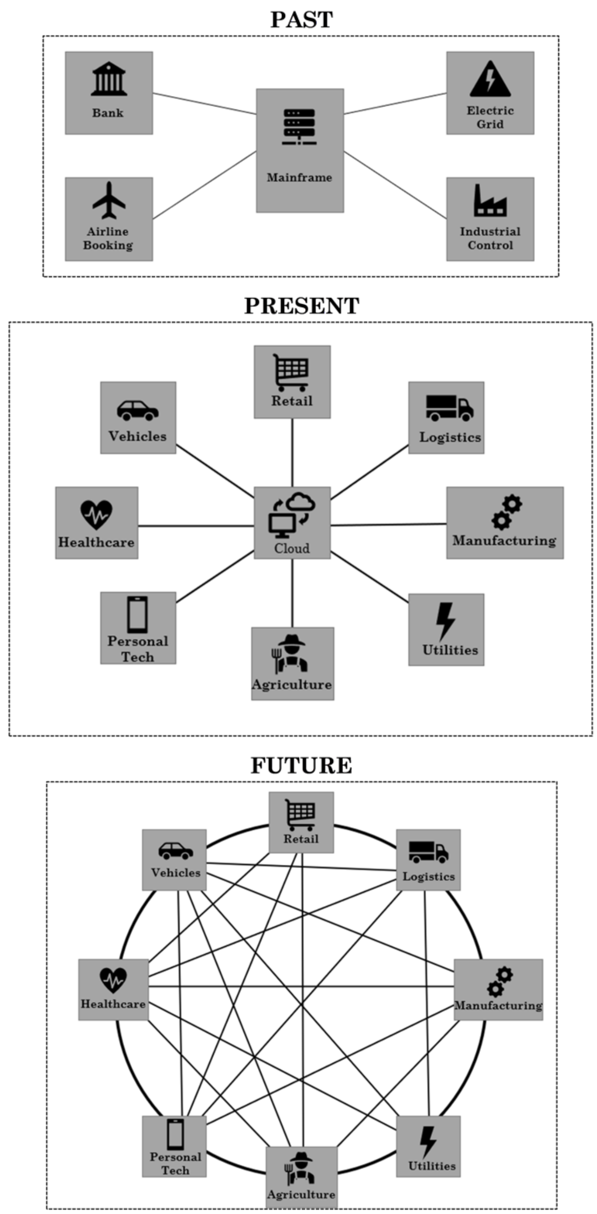

Illustration A: The IoT Creates an Intricate Web of Devices Speaking Directly to One Another[210]

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[210] *See* Fernández-Caramés & Fraga-Lamas, *supra* note 76, at 32980.