

The Rise of Technology in Agriculture—60 min



Keynote Presentation

**Bringing New Technology, Knowledge, and
Opportunity to Agriculture**

KC Ag Business Council

Ag Innovation Forum February 8, 2023

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CHS Chair in Risk Management and Trading

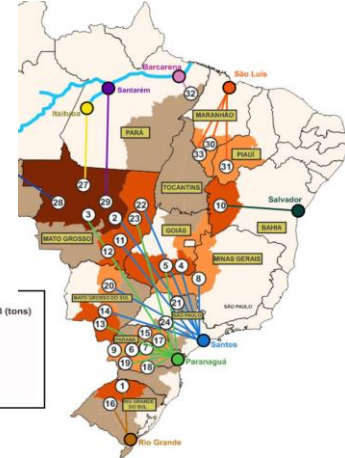
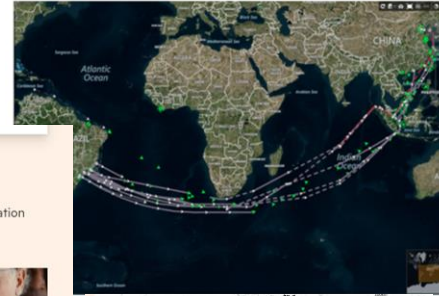
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Topics

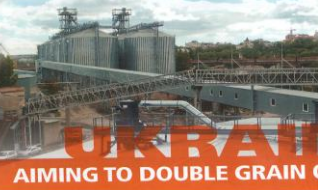
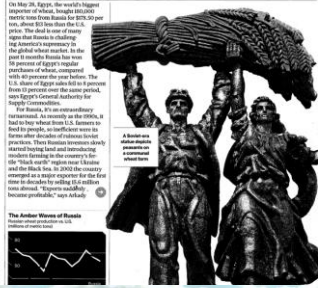
- Motivations
- Evolution
- Technologies
- Digital
- Strategy issues

Soybean to china aprli 9 2015



Global Economics Russia Fights for World Dominance—in Wheat

► It may supplant the U.S. as the world's top exporter in less than 10 years
► "We are completely opportunistic. We ship anywhere there is demand"



Russia squeezing US out as agricultural sup



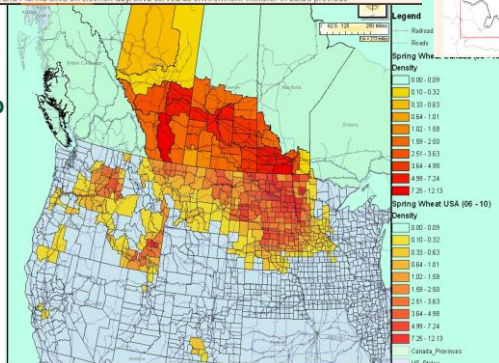
Increased Competition! Technology is Key and Essential

Lula faces struggle to reverse Brazil's environmental destruction

Former minister says climate change will be a top priority after increase in deforestation under Bolsonaro



Lula Inacio Lula da Silva, right, and Marina Silva on election day. Silva served as environment minister in Lula's previous



Major Changes Impacting Ag and Ag Trade

- AgTechnologies
- Russia, China, Ukr
- Soybeans, oilseeds and Refined diesel and Sustainable Aviation Fuel (RD and SAF)
- **Climate change! And Water Shortages**
- **Changing commodity flows**
 - **Decline in US wheat**
 - **AMLO and GM Corn**
 - **Bzl corn to China**
 - **Risk in exporting Black Sea grains**
 - **Field to Fork in EU**
 - **RD in US, Canada and elsewhere**
 - **Increased soybean meal exports**
- **Escalating and volatile grain shipping costs (rail, barge, ocean) in US and ROW**

Heading into Feb 24 2022

- **2021 drought in northern plains US**
- **Emergence of Renewable Diesel and Sustainable Aviation Fuels (SB and Canola)**
- **Pressure on sustainability and climate initiatives**
- **Oil prices increasing (from negative values) to \$66/b to \$140**
- **China restrictions on fertilizer and other ag chemicals**
- **Post-covid economic expansion**
- **Labor shortages constraining rail, trucks, and other logistical functions**
- **HRW drought in 2022**
- **Supply chain problems**
- **Feb 24 2022: Russian Invasion of Ukraine “Special Military Operation”**

**Confluence of Numerous Bullish Factors
Impacting Commodity Markets**

Motivations: AgTech

- US Competitive advantage (traditionally) based on
 - Supply
 - Logistics
 - Technology
 - *Productivity increases*
 - *Ability to differentiate*
 - Investment in ag technology

Substantial changes in development of ag tech

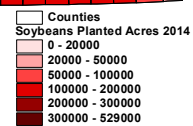
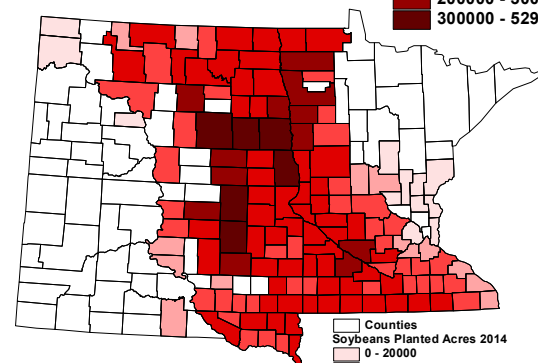
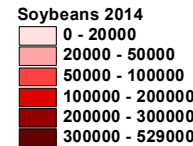
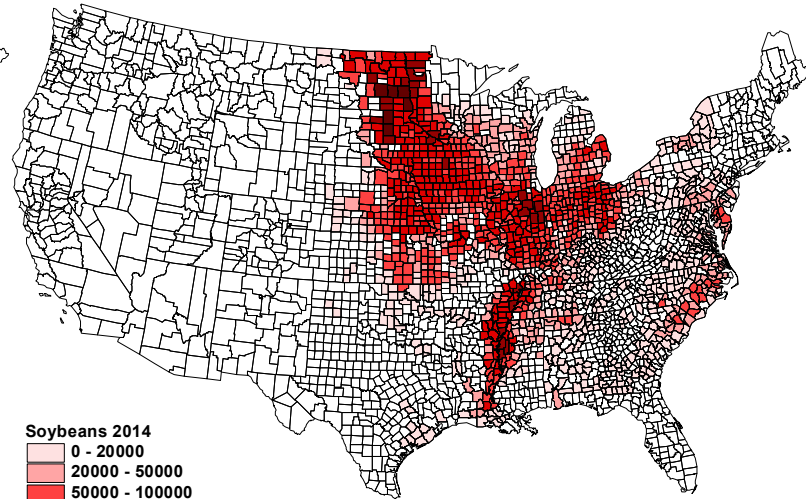
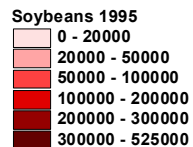
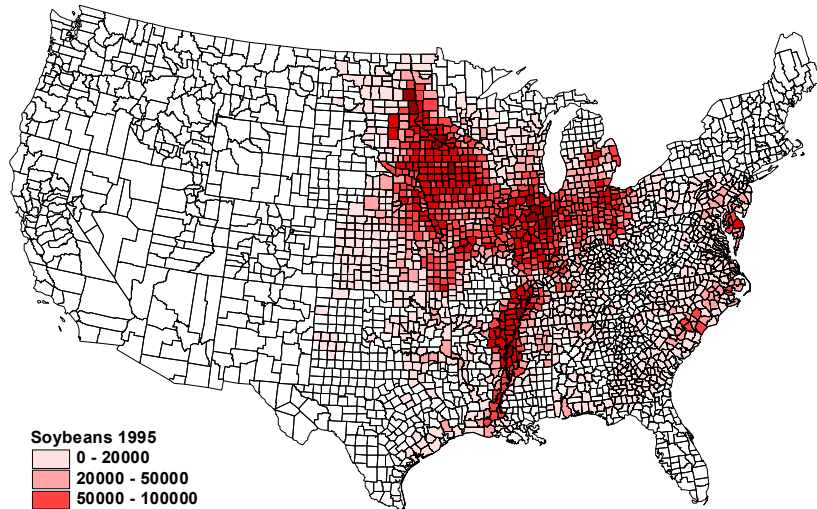
Vibrant industry looking for research

Robust local community of agtech entrepreneurs

Numerous interesting economic research questions

•Soybean Planted Area 1995

•Soybean Planted Area 2021

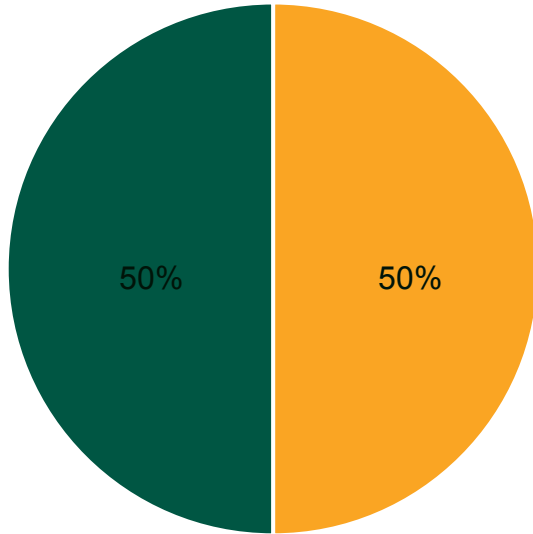


Ag Investing: *Evolution From 2008*

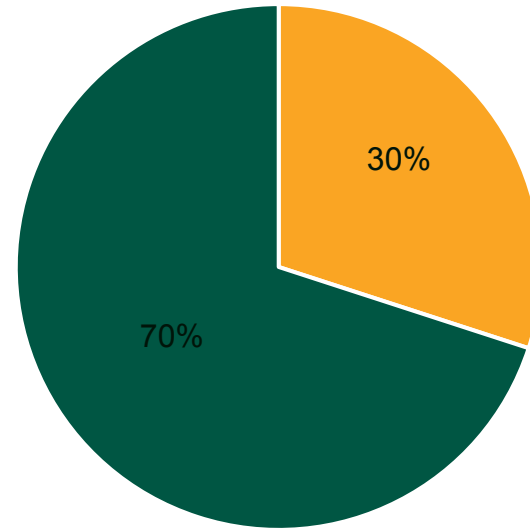
- **2008:**
 - Commodity calamity
 - 9 Billion People
- **Increased opportunity in ag**
- **Investment and funds focused on: Ag Land**
 - Perfect asset [inversely related to equities, positively related to inflation]
- **Ag Research:**
 - Dominated by public sector
 - Decline in public, increase in private R&D
- **Over time: shift to ag technology**
 - Large public firms (e.g., Monsanto, et al)
 - Ag tech entrepreneurs
- **Ag Venture funds**
 - Venture Capital
 - Corporate Ventures

Change in U.S. R&D Funding

Public vs. Private R&D Spend
(1970-2008)



Public vs. Private R&D Spend
(2012)



Company Valuations

- Companies with greater focus on technology, are more valuable!

- Flour mills/pasta: 9.4

- Drives investment decisions in ag tech!

- Monsanto's EV/EBITDA is the last EV/EBITDA compared to Bayer paying 18.6x ev/ebitda

Company	EV/EBITDA
Monsanto	14.29x
Syngenta	14.13x
General Mills	13.30x
Pinnacle Foods	16.70x
ADM	10.34x
Bunge	7.81x
Adecoagro	5.26x
Green Plains	16.44x
Bayer Crop Science	11.18x

Emergence of AgTech as Investment and VC

Monsanto Acquires (2013) The Climate Corporation, Combination to Provide Farmers with Broad Suite of Tools Offering Greater On-Farm Insights

- *Investment creates industry-leading capabilities to meet the needs of farmers in the agriculture information age*
- *Combination to put more information in farmers' hands to increase productivity, utilize resources more efficiently;*
- *There's \$20 billion of "untapped yield opportunity," which can help farmers unlock through the application of "data science."*



ST. LOUIS—(BUSINESS WIRE)—Monsanto Company (NYSE: MON) today announced it has signed a definitive agreement to acquire The Climate Corporation for a cash purchase price of approximately \$930 million. The acquisition will combine The Climate Corporation's expertise in agriculture analytics and risk management with Monsanto's R&D capabilities, and will provide farmers access to more information about the many factors that affect the success of their crops. The companies' combined capabilities will support greater productivity while utilizing the planet's finite resources more precisely.

The acquisition is expected to expand on The Climate Corporation's leadership in the area of data science, which represents the agriculture sector's next major breakthrough, and will immediately expand both the near- and long-term growth opportunities for Monsanto's business and Integrated Farming Systems platform.

"The Climate Corporation is focused on unlocking new value for the farm through data science," said Hugh Grant, chairman and chief executive officer for Monsanto. "Everyone benefits when farmers are able to produce more with fewer resources. The Climate Corporation team brings leading expertise that will continue to greatly benefit farmers and their bottom-line, and we want to expand upon this tremendous work and broaden their reach to more crops and more world areas. We look forward to working closely with our distribution partners and others in the agricultural industry to bring this suite of information resources to the farm."

The Climate Corporation was founded in 2006 by a highly successful team of software engineers and data scientists formerly with Google and other leading Silicon Valley technology companies. Since that time, the company has built the agriculture industry's most advanced technology platform combining hyper-local weather monitoring, agronomic data modeling, and high-resolution weather simulations to deliver a complete suite of full-season monitoring, analytics and risk-management products.

"Farmers around the world are challenged to make key decisions for their farms in the face of increasingly volatile weather, as well as a proliferation of information sources," said David Friedberg, chief executive officer for The Climate Corporation. "Our team understands that the ability to turn data into actionable insight and farm management recommendations is vitally important for agriculture around the world and can greatly benefit farmers, regardless of farm size or their preferred farming methods. Monsanto shares this important vision for our business and we look forward to creating even greater experiences for our farmer customers."

The Climate Corporation has a core set of support tools to benefit farmers. These include products that help them boost yields on existing farmland and better manage risks that occur throughout a crop season. The Climate Corporation will continue to offer its current risk-management products including an online service that provides crop planning, monitoring, and recommendations, and insurance offerings through its network of independent agents.

The acquisition is subject to customary closing conditions and is expected to close in the first quarter of Monsanto's 2014 fiscal year. Following the acquisition, The Climate Corporation will operate its business to retain its distinct brand identity and customer experience. The company will continue to maintain headquarters in Silicon Valley and all of its employees will be offered continued employment.

Combined Company to Be a Leader in Data Science, Acquisition Expected to Drive Near- and Long-Term Growth Potential

The acquisition of The Climate Corporation represents a natural extension of Monsanto's vision to increase crop productivity, conserve more of our planet's natural resources and improve the lives of people around the world. It will also greatly expand The Climate Corporation's capabilities in data science, agriculture's next major growth frontier, an area that represents a potential opportunity of \$20 billion beyond Monsanto's core focus today. The companies estimate the majority of farmers have an untapped yield opportunity of up to 30 bushels to 50 bushels in their corn fields, and they believe that advancements in data science can help further unlock that additional value for the farm.

The combined capabilities will immediately expand both the near- and long-term growth opportunities of Monsanto's Integrated Farming Systems platform and research and development pipeline in the coming years.

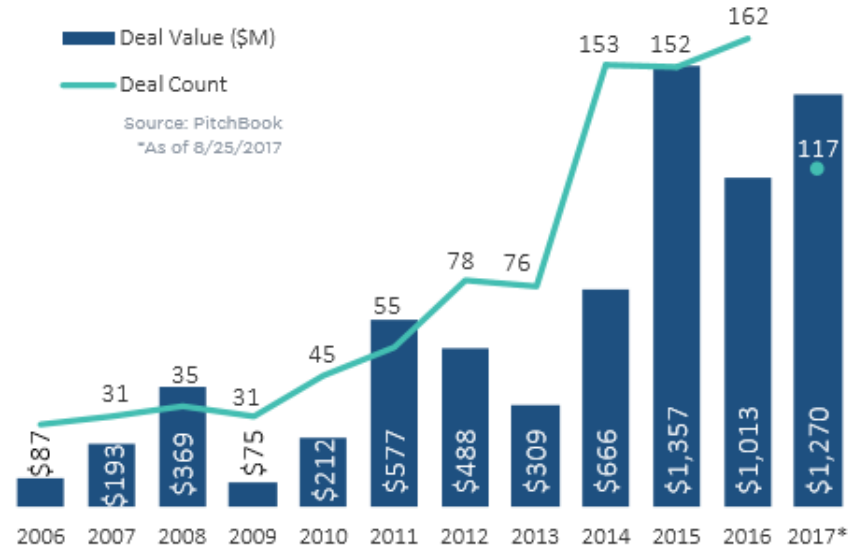
Longer-term, the combination is expected to broaden the product choices available to farmers beyond Monsanto's current row crop and vegetable portfolio, both inside and outside of the United States. This includes the delivery of insight and decision-support tools that could increase agriculture productivity on a billion planted acres around the globe.

AgTech Investment

- **Monsanto acquires Climate Corp. in 2013**
 - **Number of deals double thereafter**
 - Acquisition price \$1 Billion
 - Late 2013
 - Set off a revolution in AgTech startups and deal activity



Private investment (PE & VC) in agtech



Acquisition of Granular *to accelerate into digital*

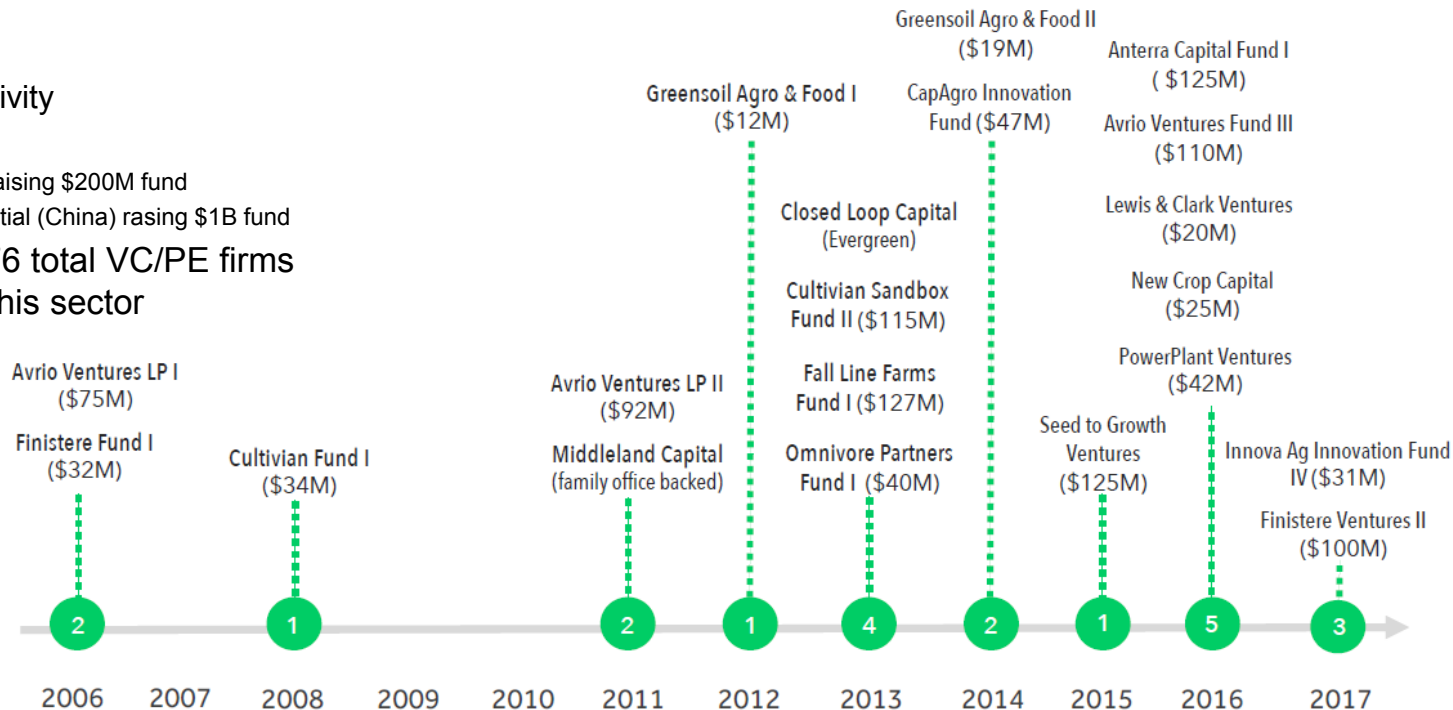
- Big ticket startup in 2014
 - High profile investors
 - Andreessen Horowitz
 - Google Ventures
- August 2017
 - Acquisition price of \$300M
 - Reportedly Revenue at \$3-4M
 - Rev multiple at **100!**



AgTech Investment: Funds

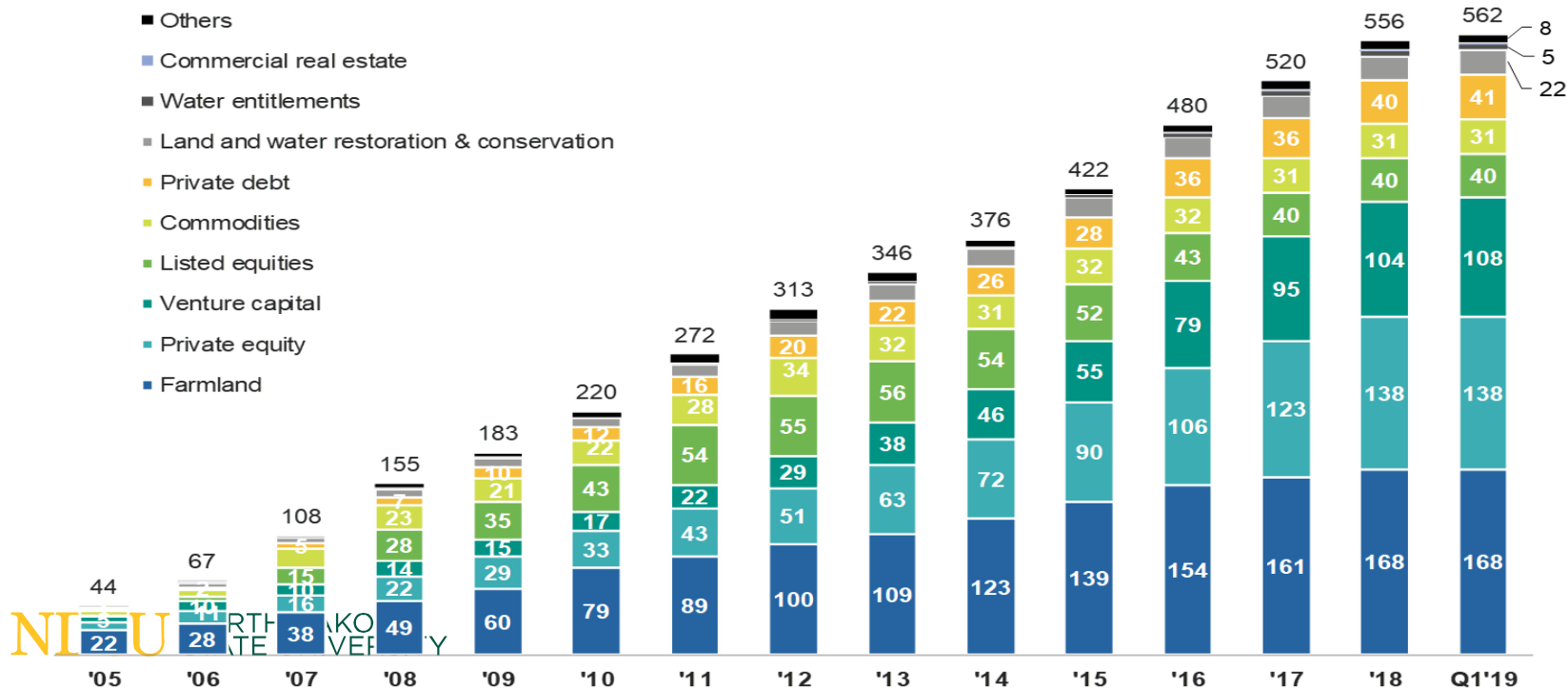
- Timeline

- Increased activity
- Not shown
 - Pontifax raising \$200M fund
 - Tsing Capital (China) raising \$1B fund
- Now about 76 total VC/PE firms focused on this sector



Evolution of Funds Investing In Ag and AgTech

Land, PE, VC, Equities, Commodities, etc....

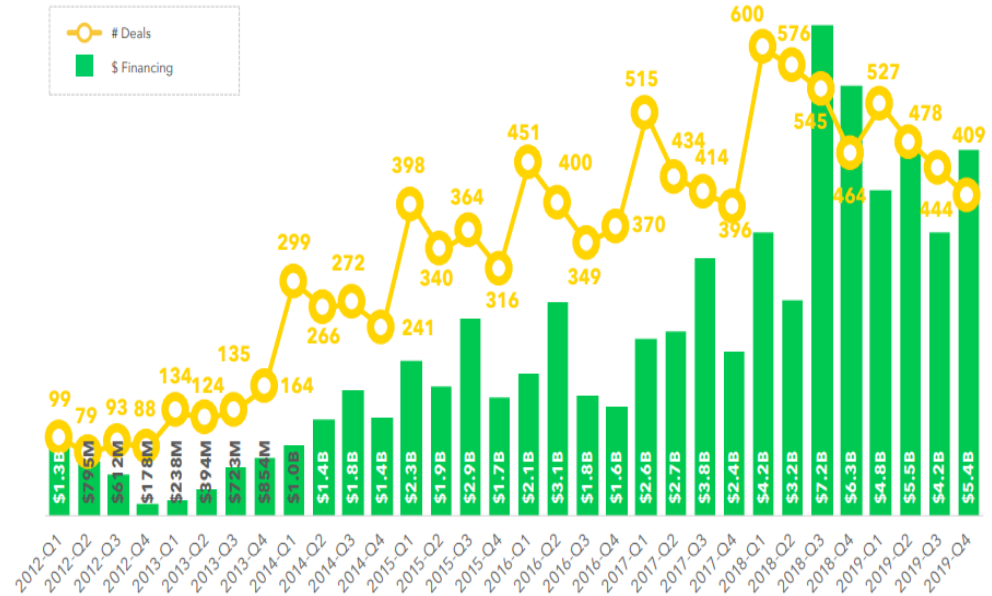


AgTech Funding:

Driven by Industry Tailwinds

- 9-billion population growth by 2050 and their demand for food (FAO, 2012; Economist, 2011).
- Environment-social-governance (ESG).
- Notable exits
 - Blue River (\$305M to John Deere)
 - Climate Corp (\$1.1B to Monsanto).
- Sector ripe for disruption given legacy players, non-digitization, and supply chain concerns.
- \$19.8 billion in global AgTech investment in 2019 across 1,858 deals and 2,344 unique investors AgFunder (2020).

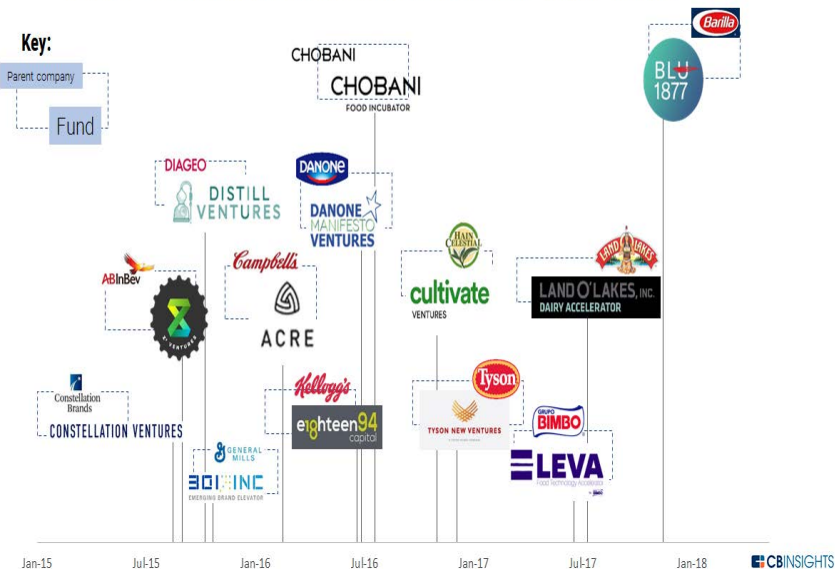
Figure 3: Startup Deal Activity (AgFunder, 2020)



Food company VC firms

Major food companies' investment vehicles

A timeline of recently launched venture funds/incubators by date of initial announcement



- **FOOD CORPORATES ANNOUNCE STARTUP INITIATIVES**
- Alcohol companies Constellation Brands, AB InBev, and Diageo were slightly ahead of the curve in launching funds.
- Major CPG companies followed, including General Mills, Campbell's, Kellogg's, and Danone.
- These funds operate across various structures.
- Some, such as General Mills' 301 Inc., are managed internally by the corporation;
- others, such as Campbell's Acre Venture Partners, are managed by external investors with the corporation (e.g. Campbell's) as the sole limited partner (LP).

Why VC Investors Are Plowing Record Sums Into Agtech Crunchbase!

Chris Metinko February 10, 2022

AgTech Funding

Includes pre-seed, seed, venture, corporate and private equity funding of venture-backed companies

■ Total \$ Invested

◆ Number of Deals



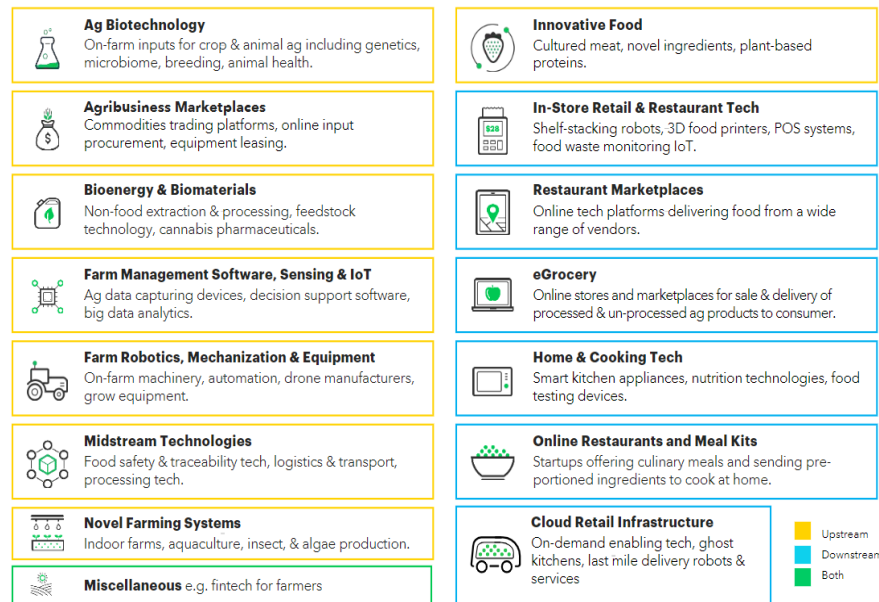
crunchbase news

- Changing buying habits of millennials ref their food's taste, nutrition and sustainability.
 - Vertical farming
 - Controlled environment ag (CEA)
- Agtech 1.0:
 - genetics, pesticides and fertilization,
- Agtech 2.0
 - digitization,
 - data science,
 - alternative farming,
 - ...supply disruptions and
 - labor force access.

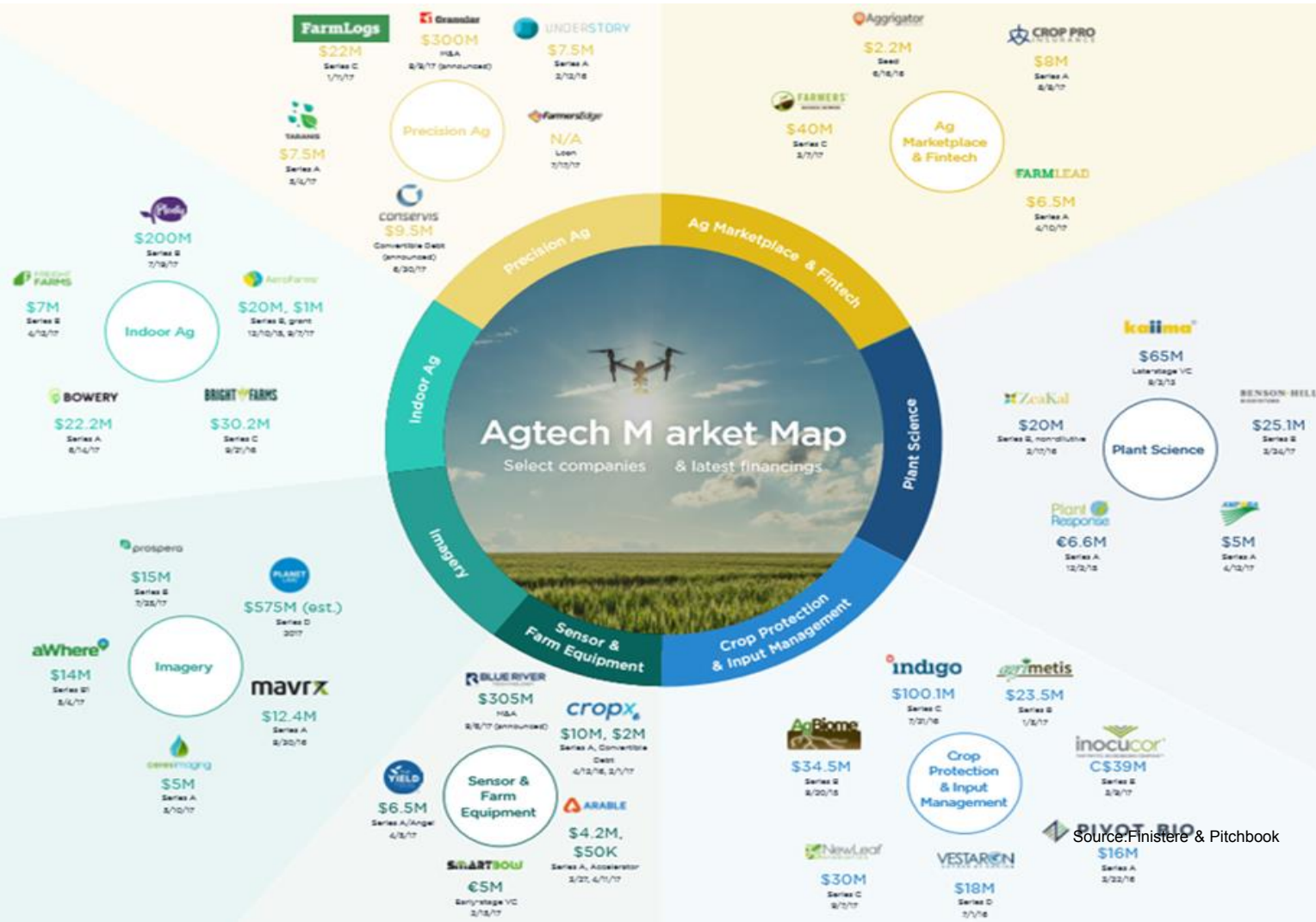
Evolution of Ag Investment

- Until 2015, ag investment was **primarily public securities or farmland** (Wilson & Vetsch, 2020). After this period, **funding evolved to venture capital**.
- Ag is described as a perfect investment given favorable **returns, inflationary hedge, and negative correlation to equities** (Hancock Agricultural Investment Group, 2009).
- Studies suggest **public ag stocks can be high return but with greater volatility** (Wilson & Vetsch, 2020; Chen, Wilson, Larsen, and Dahl, 2015). Therefore, ag should be part of a diversified portfolio.
- Ag is experiencing **new sectors and business models**. Downstream industries are forming while upstream industries are being disrupted.

Figure 2: Agri-FoodTech Categories (AgFunder, 2020)



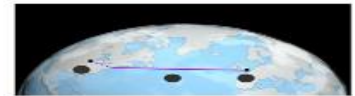
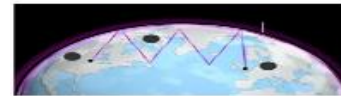
Medley of Technologies in AgTech



Technology

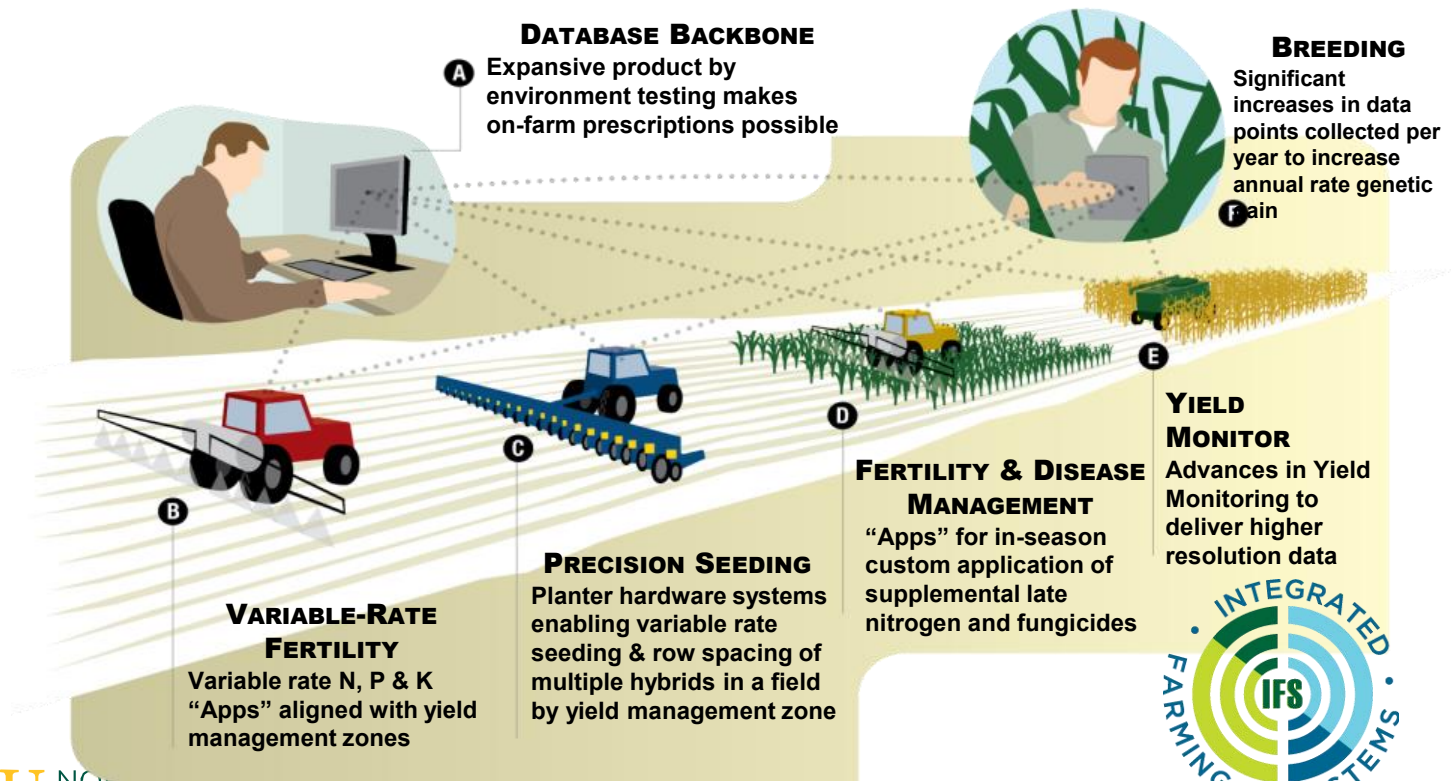
- Breeding technologies
- Reduced chemicals
- Alternative fertilizers
- Precision everything
 - Variable rate tech
 - Sensors
 - Imagery
- Autonomous everything
- Digital everything
- Supply chain coordination

Trading Mechanisms: *Reduced cost, improved accuracy and Increased Speed (33.5 milliseconds reduced to 29)*

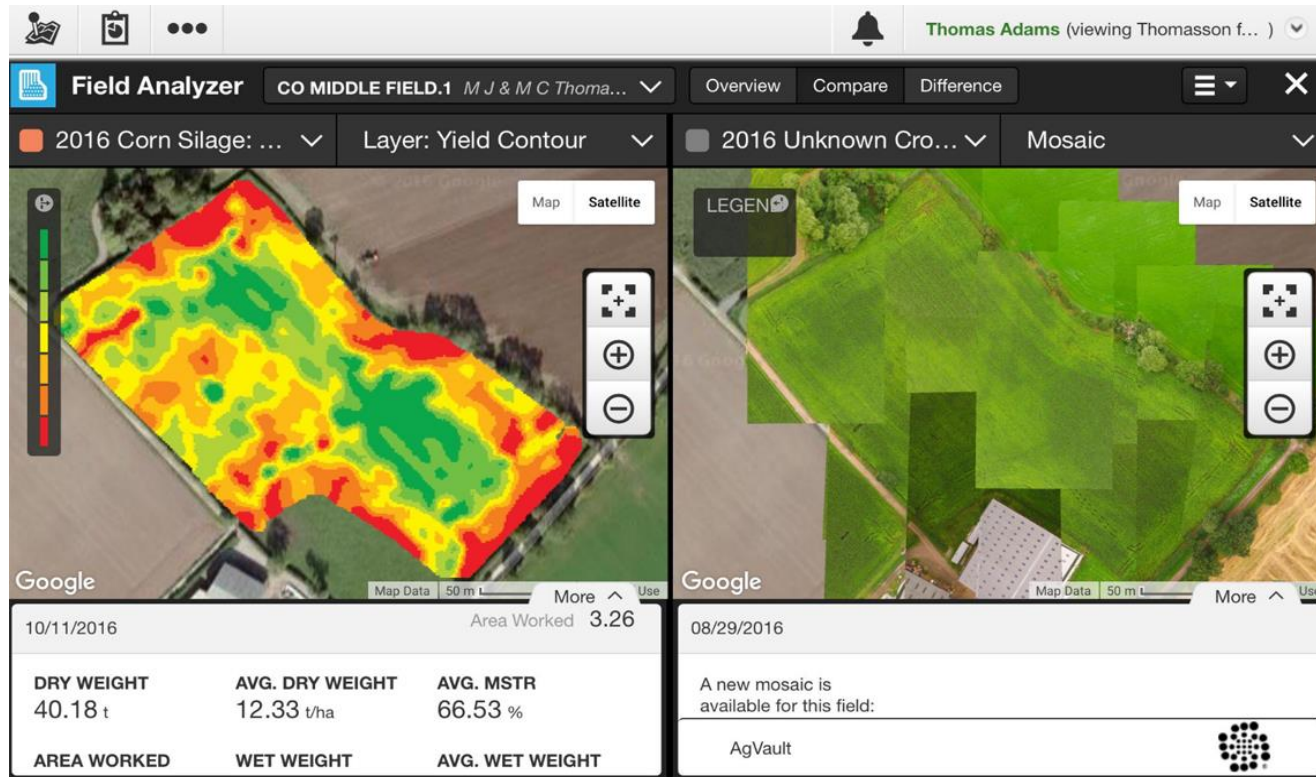


Ag-Informatics! Integrated Farming SystemsSM Would Combine Advanced Seed Genetics, On-farm Agronomic Practices, Software and Hardware Innovations to Drive Yield

(Monsanto: Yield increase=10b/a)



Precise, Valuable Data—real-time, agnostic



NDSU



Tommy Adams @RVTprecision · Oct 11

An @sentera_us QuickTime image taken on 1st Sept compared to yield map 6 weeks later in the @johndeere ops centre clear similarities



5



10



Digital Twin – Spatial Re-characterization--VERGE

Identified damages in one field



Field boundary before February 2022



Field boundary after February 2022



Field Operations Impact – increased miles driven, increased emissions, increased time

Past operational plan



	Past	Current
Track direction	132 deg	132 deg
# of turns	78	175
Distance	33 miles	38 miles

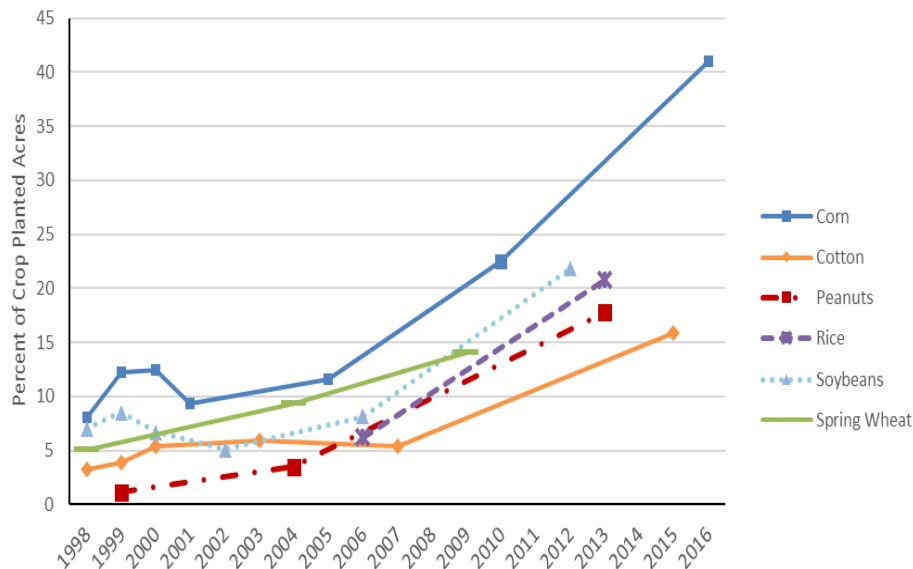
- ❑ Increase operational efficiency
- ❑ Use exclusion zones for autonomous demining.
- ❑ Assessing long-term impact of the craters.
- ❑ Impact → yield and machinery selection.

Current operational plan



VRT in the United States

DAVID SCHIMMELPFENNIG, USDA ERS



Note: Line markers indicate survey years for each crop. **Source:** USDA Economic Research Service estimates using data from the Agricultural Resource Management Survey (ARMS) Phase II.

- **Variable Rate Application**
 - Comes standard with most new large equipment. Utilization is increasing, but has been slow because of complexities
- **Adoption varies by state and crop.**
 - Corn (40%), soybean (25%), and spring wheat (15%) are highest
 - Adoption has grown through time.
- **ROI:** Variable-rate technology (VRT) lowers cost and raises operating profit For corn farms
 - **Cost decrease about \$21/ac**
 - **ROI is estimated 1.1 percent.**
- **Precision ag:** Profit about \$20/acre, but, limit use due to lack of extensive wireless connectivity

EXAMPLE: *Impact of seeding speed on crop yield*

Speed	Plant density	Crop yield	Reduction of EBITDA	Reduction of bonus
km/h	(twins)	t/ha	\$/ha	\$/ha
5	70 (0)	12.2	0	0
7	77 (1)	11.5	125	12

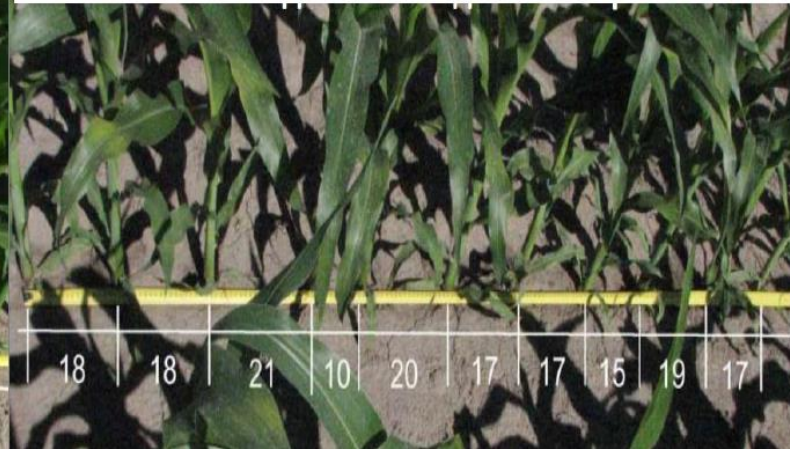
Speed 5 km/h

Even distribution of plants 16-18 cm



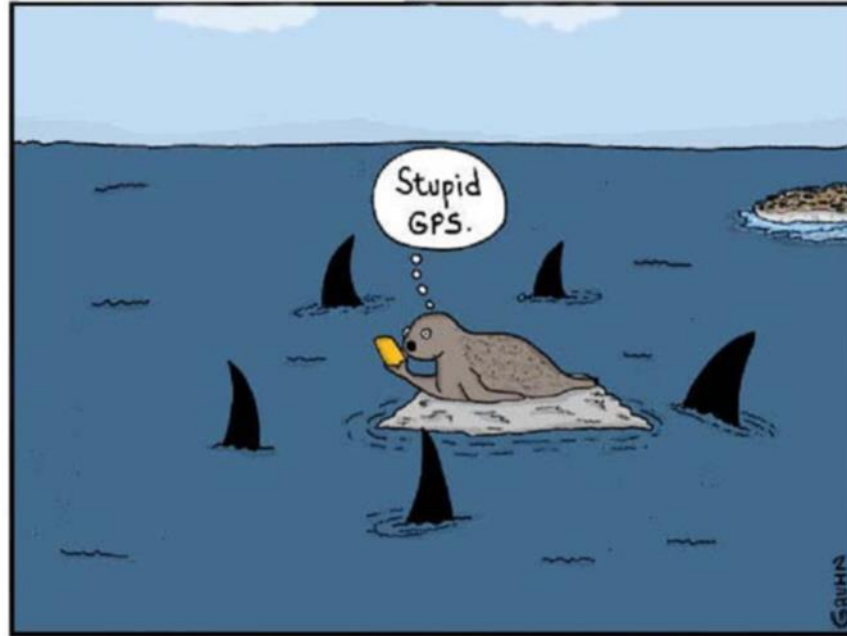
Speed 7 km/h

Uneven distribution of plants 17-20 cm



People are the Main Profit Driver

No technology can replace a good farmer



Seed technology

(increase in breadth and depth of breeding tech)

Evolution of Breeding: progression in time and complexity

In addition to

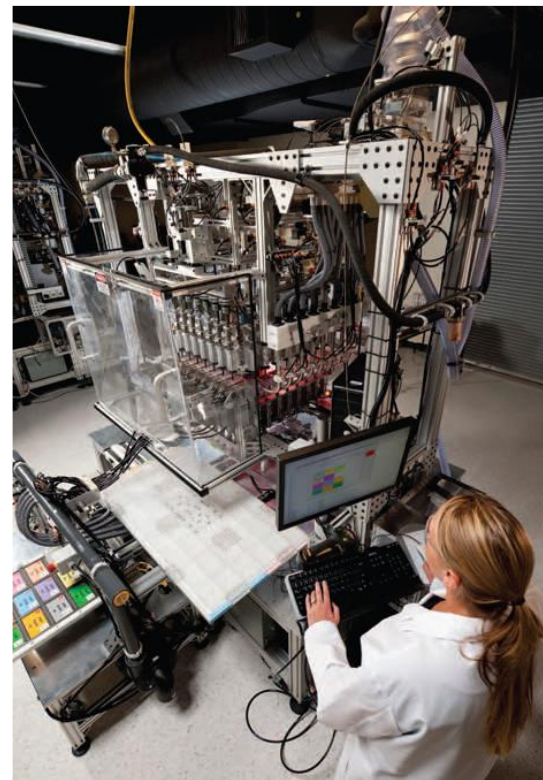
- Conventional Breeding
- Doubled Haploids
- Hybrid
- Traditional Marker Assisted Selection for known genes
- Seed chipping for MAS
- Transgenics (GM)
- Whole Genome Sequencing
- Genomic Selection
- Gene Editing
- Shuttle breeding
- Seed treatments (biologicals)
- etc.

Hi-Throughput Seed Chipper (Monsanto)

Ex of new technology to accelerate breeding and lower costs

- Ex of new technology accelerating breeding and lowering cost
- Patented (other companies are adopting like technologies; and recent patent dispute w/DuPont)
- Determine the genetics of a seed without destroying the seed itself.
- Breeder can plant the seed in a field test and use it in the breeding process to create more seeds of its kind.
- Identifies the best-of-the-best [germplasm](#) (genetics)
- Doubles the rate of improvement in genetic characteristics.

Source: C. Paterson, Monsanto's Innovation, *AgAdvance*, Jan 2013, pp. 36-



Chinese Response: BGI

- Converted Shoe Factory In Shenzhen
- largest genome mapping company in the world,
- Largest facility, a former shoe factory, .
- Two gray buildings, the factory and the dorm
- Salary: \$451/m for graduate trained professionals in bioinformatics



Alternatives to Intense Use of AgChem

Alternative Crop Protection Solutions

- Address impact of glyphosate driven in part by social media
- Alternative to glyphosate and fungicide
- Major buyers specifying nil-trace glyphosate
- Companies
 - **AgriMetis**

Peptide Technology

- Biological opportunity
- Use peptides to target certain pests;
- Companies
 - **Vestaron**
 - **Plant Health Care**

Alternatives to Intense Use of AgChem

Greenlight Biosciences

- RNA for Agriculture
- Substantial
 - loss due to insects, weeds, viruses and fungi that either
 - don't have a current means of control or
 - have developed resistance against traditional pesticides.
- 95% of the pesticides sprayed never reach their target species and vast majority of the chemicals sprayed or applied end up accumulating in our soil, water or food;
- RNA can be utilized to efficiently and specifically target the pest of interest through a natural process known as RNA interference (RNAi).

Others

- Sound Ag
- Benson Hill
- Agrifly
- Granular
- Greenlight
- Guardian

Autonomous Everything

- Groundbreaking
 - April 26 2019
- 40 Acre Autonomous farm
- Driven by
 - Growth in food demand
 - Shortage of labor
 - Software and sensors
 - IOT
 - Etc.
- Numerous companies



Key Players

- Case IH- Tractor
- John Deere/Guss Automation- Tractor/Tillage & Spray System
- Monarch Tractor- Tractor
- New Holland – Tractor
- Nexat- Vehicle w/ Modules
- Raven Industries- Grain Cart
- Solinftec- Sprayer Robot
- Sabanto AG- Tractor
 - CHS Investment
- AGCO- Planter



VERGE: *Combines Imagery, AI and Autonomous*

Groundbreaking innovation in the areas of precision and autonomous agriculture.

IoT Devices



UAVs



Robots



CNH



John Deere

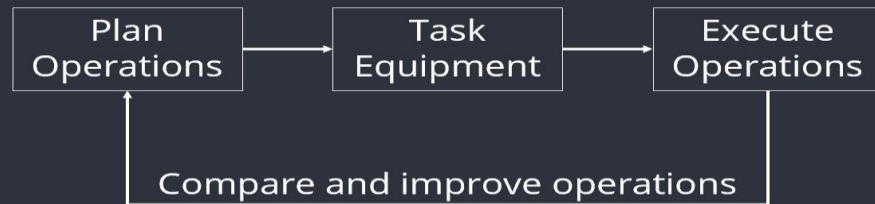


Raven



Autonomous Gap

1. Farmer knowledge and in-field decisions
2. Farm, soil, and equipment characterization
3. Planning precise paths for equipment

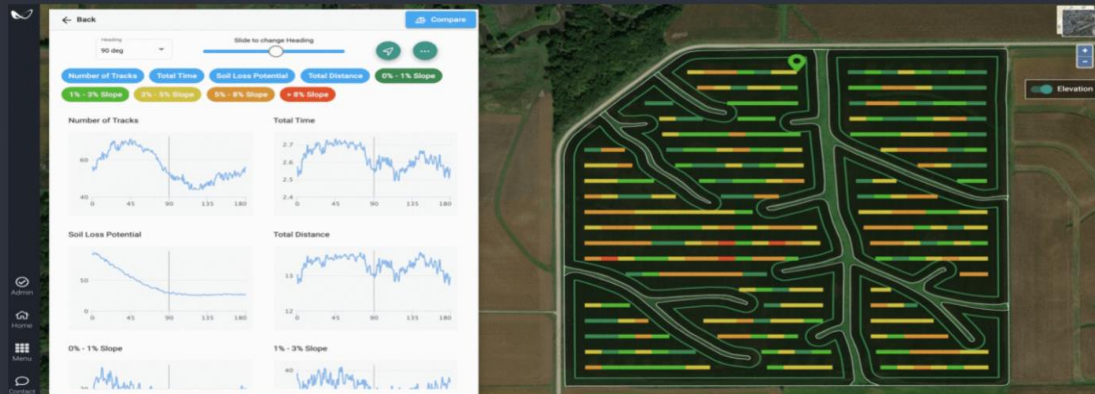


★ Empower farmers to make decisions when they are not in close proximity to their fields.

Verge: *Efficacy Gains*

Launch Pad

An interactive web-based application that simplifies farm operations planning to reduce in-field decision making. We equip farmers with the tools to make informed, timely decisions.



INCREASE
EFFICIENCY



REDUCE
INPUTS



INCREASE NET
INCOME

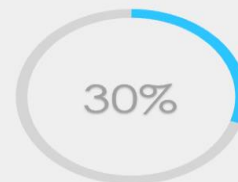


IMPROVE
SUSTAINABILITY



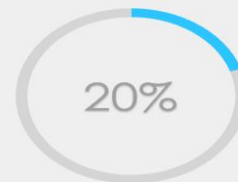
Increase Efficiency

Save time and costs associated with field operations. Reduce the travel in field, maximize coverage, and increase efficiency



Machine Utilization

Increase the equipment working utilization rate, reduce transport and idle time. Get more out of the equipment with preplanned paths.



Reduce Input Costs

Improved planning of operations leads to reducing the number of overlapping passes and optimized use of input and fuel.

Market

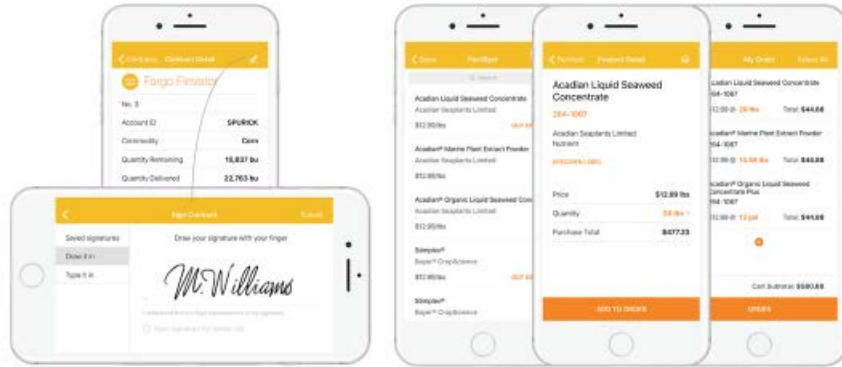
- Machinery: Drones, Self driving tractors, and Seed planting robots
- Estimated Market value \$95 Billion by 2027 with 13.5% CAGR
- Big players buying startups to expedite entry
 - Deere buying Blue River for \$305 Million and Bear Flag for \$250 Million
- Companies: looking into how AI can be utilized to detect and determine field conditions

Case IH will release a limited number of self propelled driverless, robotic Trident dry applicators for regular sale to farmers next year, making it the first major piece of autonomous equipment on the market. The machine was previewed and demonstrated at the Farm Progress Show in Iowa last summer. The company wants real life experience to prove that guidance and control systems are reliable enough for the marketplace and to familiarize farmers with autonomous equipment.

Digitization Everything!

Internet Market Information and Transactions: Make markets more transparent

Bushel (Myriad Mobile)



BUSHEL

E-Sign and Store

14

Grain marketing software

- E-signature \$40/contract vs \$5
- Data sharing/access
- Expanding in several dimensions
- Staff:
 - Started with 3 NDSU staff
 - Now 200+ employees
 - Turned down offers to be acquired
 - Going for Series B round of refinancing

Bushel's Vision

To connect the
grain industry
through digital
infrastructure.

2,000+

*Live grain receiving
locations, ethanol plants,
flour mills, crushing etc.*

40%

of US Grain Origination digitized

All market share statistics from 2019 production

61,000

Monthly Active Users - trailing 6 months

Industry faces increasing complexity and uncertainty with fewer hands

Complexity is worsened by data requirements, duplication, antiquated tools... and if you don't have this data - you are out of luck: NETWORK is critical to exploit economies of scale

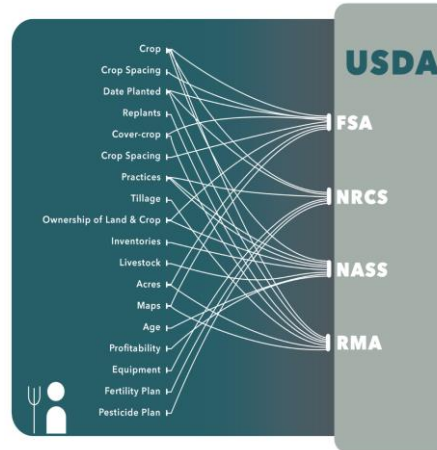
To maximize value, players must make thousands of decisions



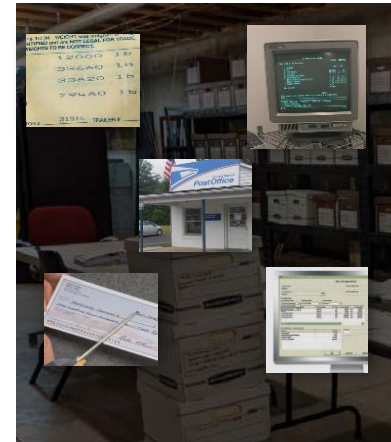
Just one company*:

- 300 grain varieties
- >300 silos
- >7,000 other storage points
- >200,000 transportation options
- >150 agronomic scenarios

Required reporting multiplies duplication



All the while relying on antiquated tools



* Source: McKinsey & Company. [Ag supply-chain optimization and value creation](#)

Integrated suite built by ag people for ag people

Network !



BushelMobile™

- Communicate with Farmers to drive engagement
- Share grain positions with farmers



BushelTrade™

- Manage cash bids and offers
- Hedge management
- Slippage protection



BushelFulfill™

- Ticket & invoice mgmt across commercial counterparties
- Settle grain quicker
- Understand grain positions with your partners



BushelWallet™

- Payments app
- Embedded payments
- Enable grain stakeholders to pay each other in one system



FarmLogs

POWERED BY BUSHEL

- Farm management system
- Automated P&L
- Super Scale Ticket

Bushel Platform

- UI customization

- Microservice infrastructure

- Data standardization

- Built-in collaboration

- Business logic

- Billing

Best in class security

SOC 2 type 2

Powerful integrations

Robust APIs ◦ ~20 ERP and other integrations

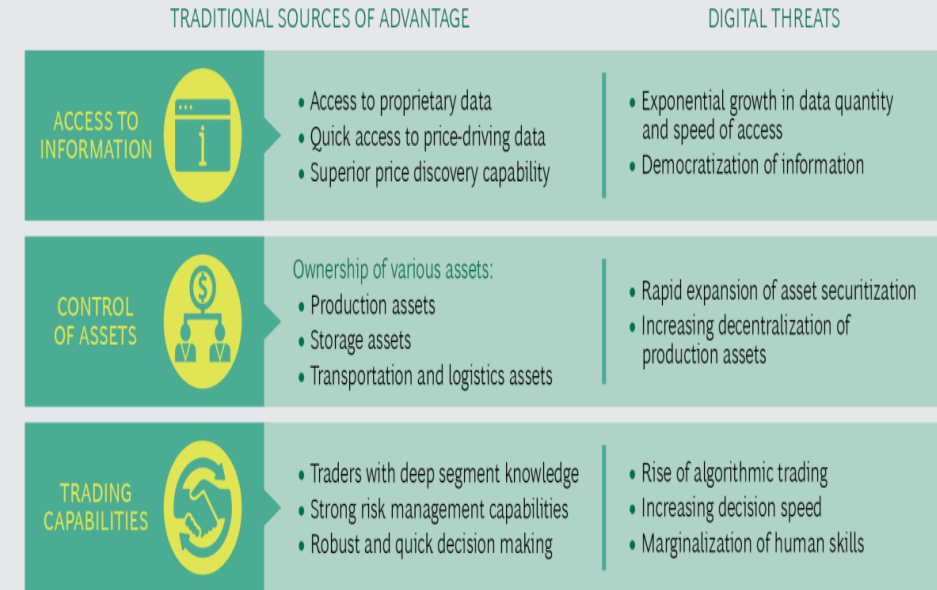
Professional services

Consulting ◦ Custom build ◦ Implementation

Digitization on traditional merchandizing:
Substantial lag vs other sectors and commodities
ref development and adoption of digitization

- Lower per trade profit
- Greater market efficiencies
 - *Lower cost*
 - *Fewer errors*
- Less arbitrage opportunities
- E.g., COVANTIS

EXHIBIT 2 | Digital Forces Are Changing the Sources of Competitive Advantage



Source: BCG analysis.

Digitization everywhere!



Ukraine Has Digitized Its Fighting Forces on a Shoestring

Kyiv's forces networked under Russian attack, achieving a cut-priced 'MacGyver' version of systems the Pentagon has spent decades developing

Ukrainian troops operated a telescopic tower with a remote camera on a Soviet car that was recast to observe and correct fire on the front line near Kharkiv, Ukraine, on Christmas Day. EVGENIY MALOLETKA/ASSOCIATED PRESS

Ag and Fintech

1/27/23, 8:19 AM

The Next Fintech Revolution: Agriculture Finance

FORBES > MONEY > FINTECH

The Next Fintech Revolution: Agriculture Finance

Nik Milanovic Contributor

I write about fintech in society. Founder of This Week in Fintech.

Follow

1

Jan 5, 2023, 11:42am EST

Fintech's next wave will focus on improving the less well-known, **less 'sexy' markets fundamental to the global economy –**

- one of the largest markets primed for disruption is agriculture finance. 2022 saw a quiet but steady rise in fintech products being built for the massive agriculture

Why disrupt agriculture finance to begin with?

- size of the market
- limitations of existing service providers. ...

Applications (suggested)

- Agriculture Lending
- Farm Payments:
- Pricing Data & Commodities Trading
- Insurance
- Marketplace
- Banking

Next technology in Gr. Handling: *Sept 2021: CHS Herman Minn.*

First-of-its-kind automated elevator allows after-hours grain delivery

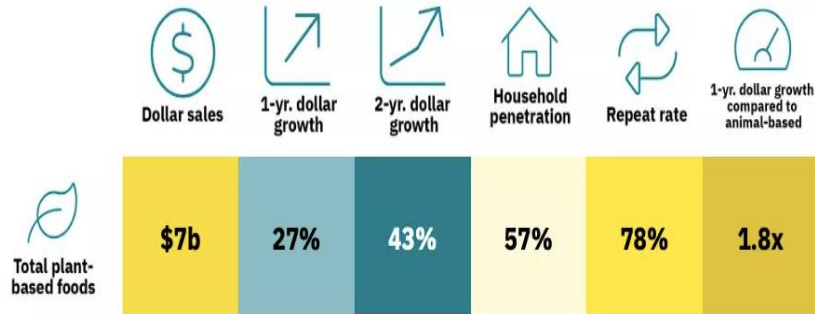
The facility operates like any other grain elevator for deliveries during regular business hours. After hours, RFID key cards, grain trailer ID tags, cameras and other automation systems enable grain delivery without staff present. »



Novel Foods

- High fiber wheat
- Oxidization stability (storability)
- Plant based foods
- Mozza
- ...

Plant based proteins



- Fastest growth in Projected food:
 - Driven by millennials
 - Partly for perceived demand for improved sustainability
- Companies expanding in PBP
 - All major food companies
 - All major commodities processors (Cgl, ADM, Bunge et al)



IPOs + Add to myFT

Oatly's US IPO prospectus highlights risks to its Chinese backer

Swedish vegan milk group planning \$10bn Nasdaq float says it may also list in Hong Kong



Emerging Impactful Ag Technologies (ref grains and oilseeds)		
Technology	Impact	Active/emerging Firms
Encapsulation and nanotechnology	Delivery system that makes biologicals, RNAi, peptides, plant oils, and pheromones work	AgroSpheres , AquaYield
Stacked RNAi traits.	Allow more targeted, less toxic solutions for plant pests and diseases.Extend patent life on a lot of important molecules coming off-patent	AgroSpheres
Soil Sampling	Cheaper, more timely and accurate sampling allows for more targeted application of chemicals and nutrients.	
DNA-sequenced soil data	Predictive models for specific traits, biologicals, inoculants etc, seed placement	
Biological N fixation	Reduces costs, hours on equipment, and increases yields	
Nitrogen fixing	Fixing microbes displacing about 25% of synthetic N in corn, at a cheaper price and better performance. Biologics at scale - allowing producers to do more with less	
Spraying with drones "See and Spray"	Not small drones!, Big drones 90%+ reduction in herbicide for pre and post emerge without giving up efficacy	PivotBio; Chonex Guardian Ag Greeneye Tech (Agco), Blue River (JD), Bilberry(Trimble)
Double cropping in the south	Canola could go on 10 million acres	
Data mgmt platforms	Pull together information collected through sensors, unmanned aerial and ground systems, satellite, variable rate maps, and information.	Project FarmVibes, Microsfot Reserch RealmFive
Autonomy (or, Semi-autonomous)	Labor saving; focuse on unnamed aerial and ground systems and heavy equipment	JD, CNHI, Swarm Robotics, Small Robot Co. Sabanto and Polymath Robotics
Financial Tech (novel fin tech applicati	Stylized insurance, incentives, input rebates, and financial strategies etc.	
Supply chain efficiency	Efficiency in the value chain, digital payments ecosystem, etc.	Bushel
Digital B2B	Launch support functionality leveraging expertise in data management.	Likely Big Digital/Computer Tech firms large tech players

- Survey of AgTech VC's and Developers
 - Which ag technologies will be most impactful in the next 5 years?
 - No edit/rank
- We need them all~!

Elements of Strategy

- Demand for agtech
- Adoption curves
- Real options
- Portfolio of real options

Demand for Ag Technology

Production Traits

- Yield increases
- Cost savings
- Reduced variability in yield and cost
- Labor saving
- Convenience
 - Eg 'atm'
 - Digital/mobile transactions
 - Very interesting. Thanks. One issue you may want to add is demographics. Farmers continue to be getting older, Mexicans are not as welcome, and the opioid crisis is destroying the small communities. My question is what will we do with our farms 10-15 years from now? If not AgTech, what other alternatives do we have? And if you're not up to speed on AgTech, will you get leapfrogged by your competitors?

Post-Production Technology

- End-use quality: *highly differentiated*
- Product quality
 - Consistency
 - Clean label
 - Healthy
 - Millennials
 - Safety
 - Etc.

Dynamics of AgTech

- **Demand for AgTech is robust**
- **Technology must have value, relative to competing technologies**
 - 5c/ vs 1's\$
- **Excessive entry (ease of entry)/new development**
 - Rationalization
 - PLC
- **Challenges to AgTech development**
 - High fixed cost, low marginal cost (ruinous competition)
 - Estimating demand (and competition) for something that doesn't exist!
 - Drought tolerant corn, wheat; frost tolerant wheat; etc.

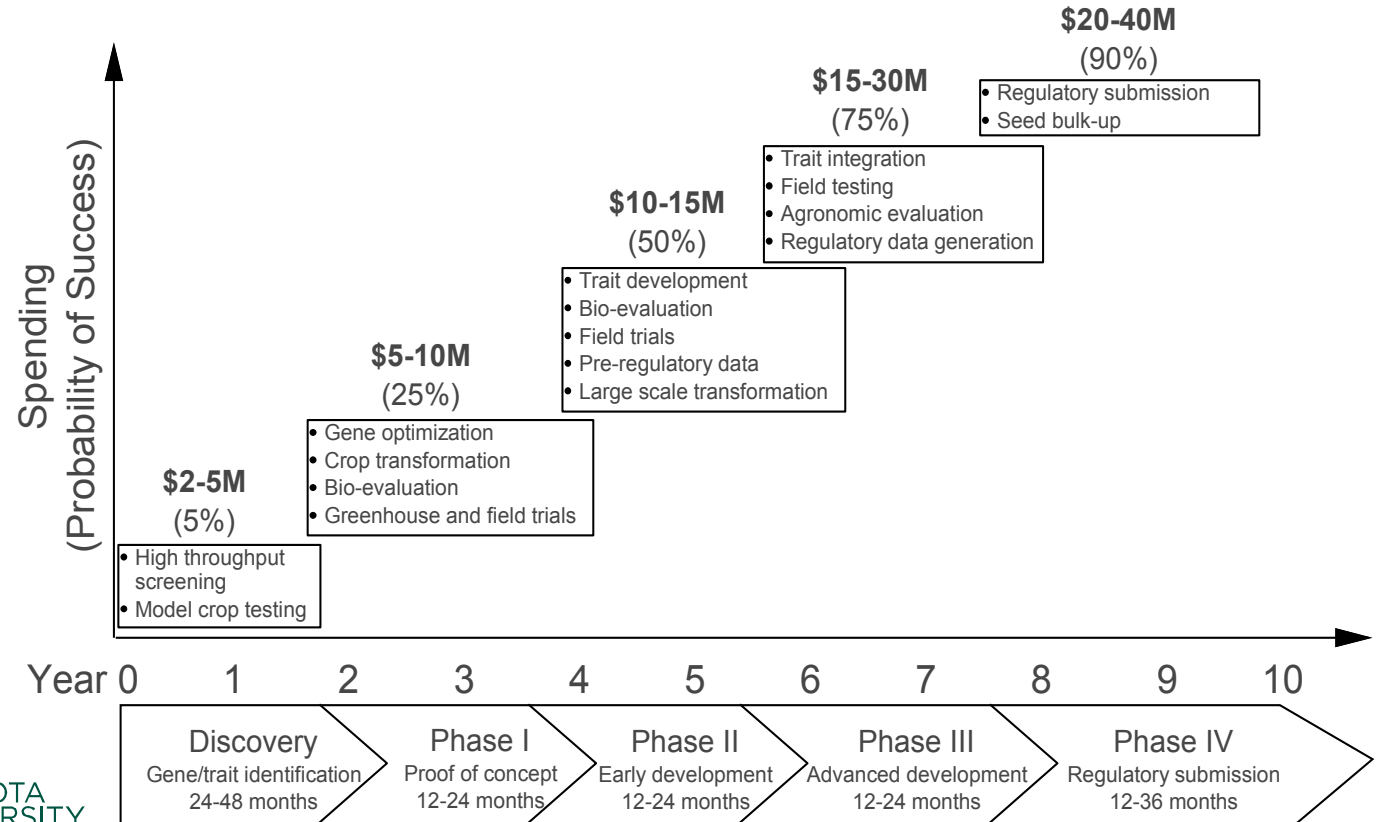
Strategic Issues and AgTech



- **Opportunities for economic analysis**
 - Adoption/diffusion/penetration
 - Bundling vs unbundling
 - Economics of development strategy (real options)
 - Strategy as a portfolio of real options
 - Partnering terms
 - Shapely value
 - Licensing strategies
 - Real options for lisc terms
 - Re-financing strategies vs divestiture to 'strategic'

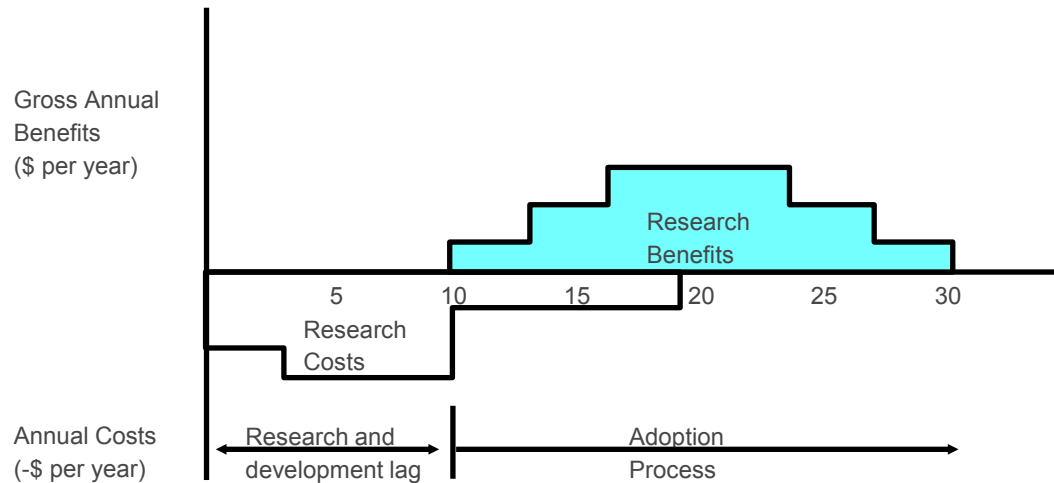
Phases of Ag tech Product Development

Below for AgBiotech, but concept is similar for other technologies



*Numbers (time duration, spending, and probability of success) are all estimates. The actual for individual projects could vary.

Flows of Biotech Research and Development Benefits and Costs Over Time



Source: Alston et al. 2000.

ROI on Ag Research (public)

Figure 1, and this reflects a 95% confidence interval between 13 to 37%.

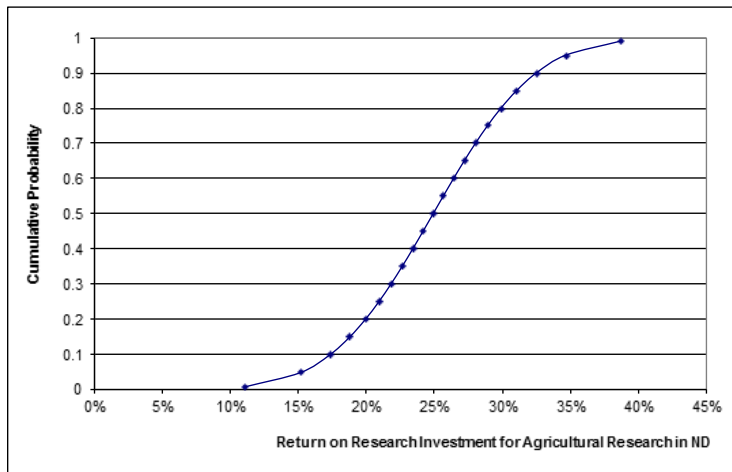
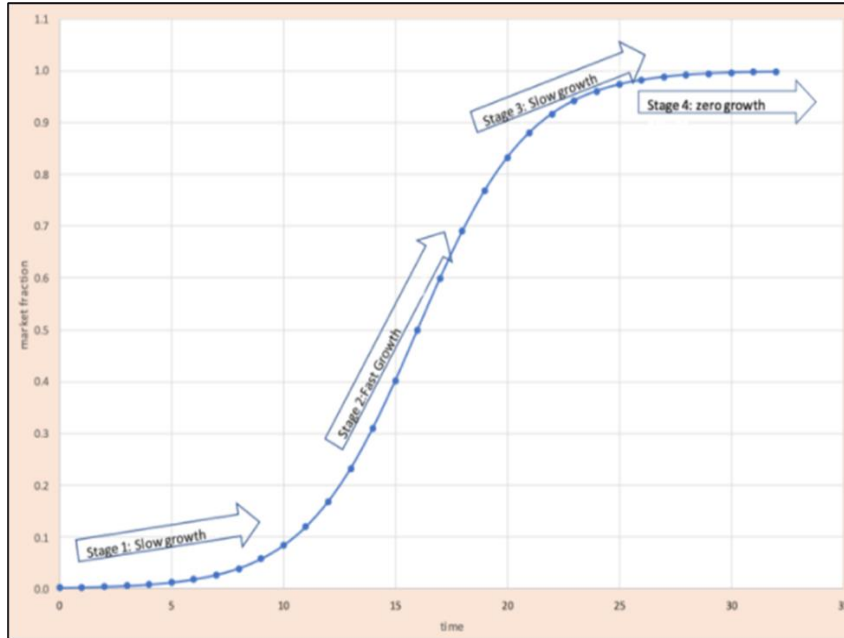


Figure 1. Estimated Cumulative Distribution for Return on Investment in North Dakota.

- **ROI on investing in ag research is superb**
 - ND: 24% ROI
 - USDA studies corroborate this value
 - Recent SCAB initiative: 34% (Dr. Nganje et al, forthcoming)

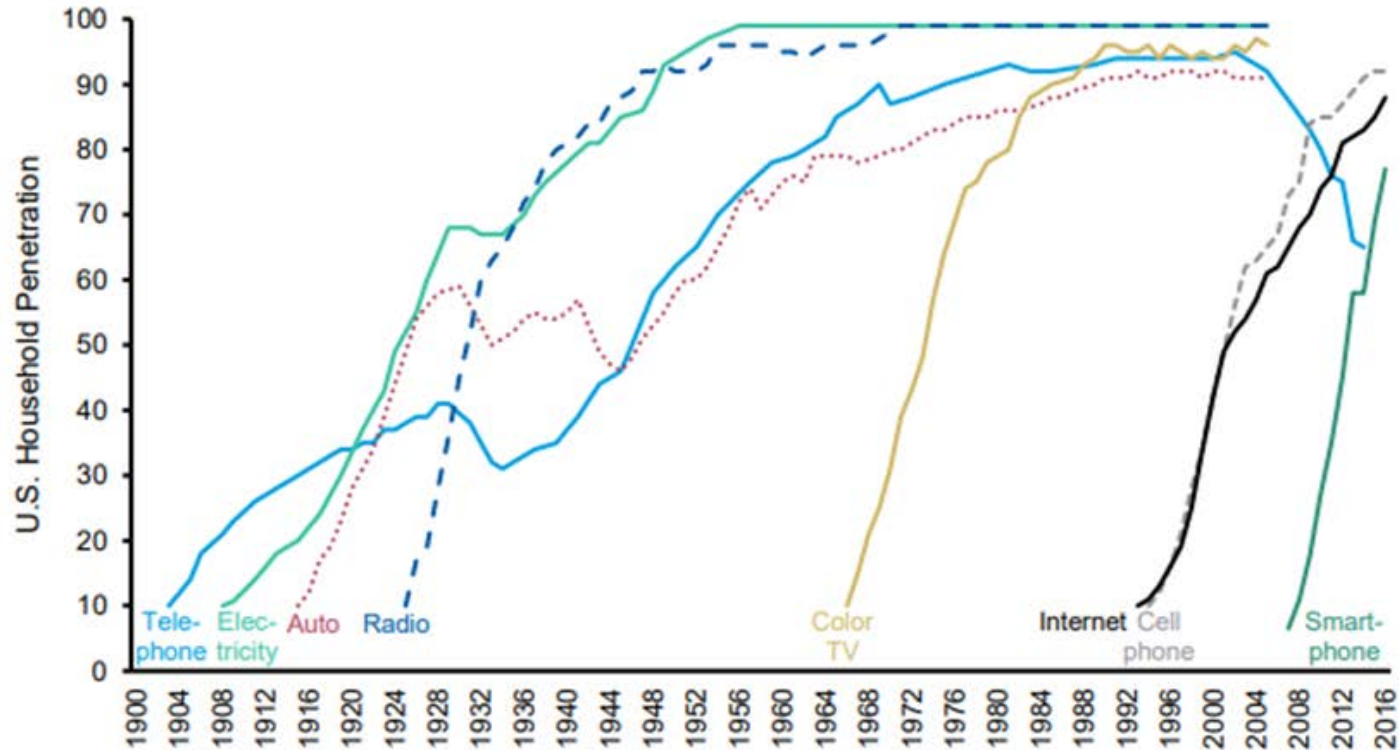
Adoption Curves: new product market adoption Stages of market development



- Phases on commercialization and adoption
- Highly uncertain
- Huge impacts on project NPV's
- Examples below

Diffusion and adoption of technology products: Faster adoption in Recent Technologies

(Mauboussin and Callahan 2021).

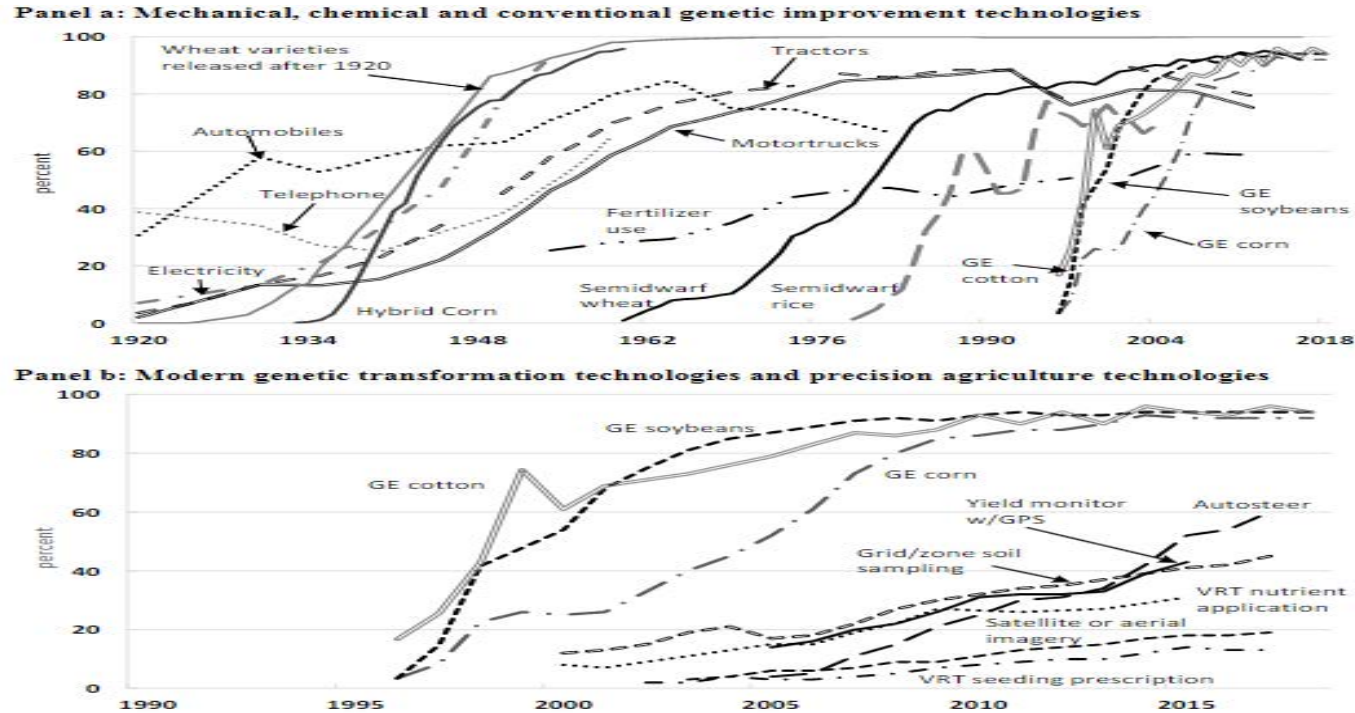


Source: Asymco.

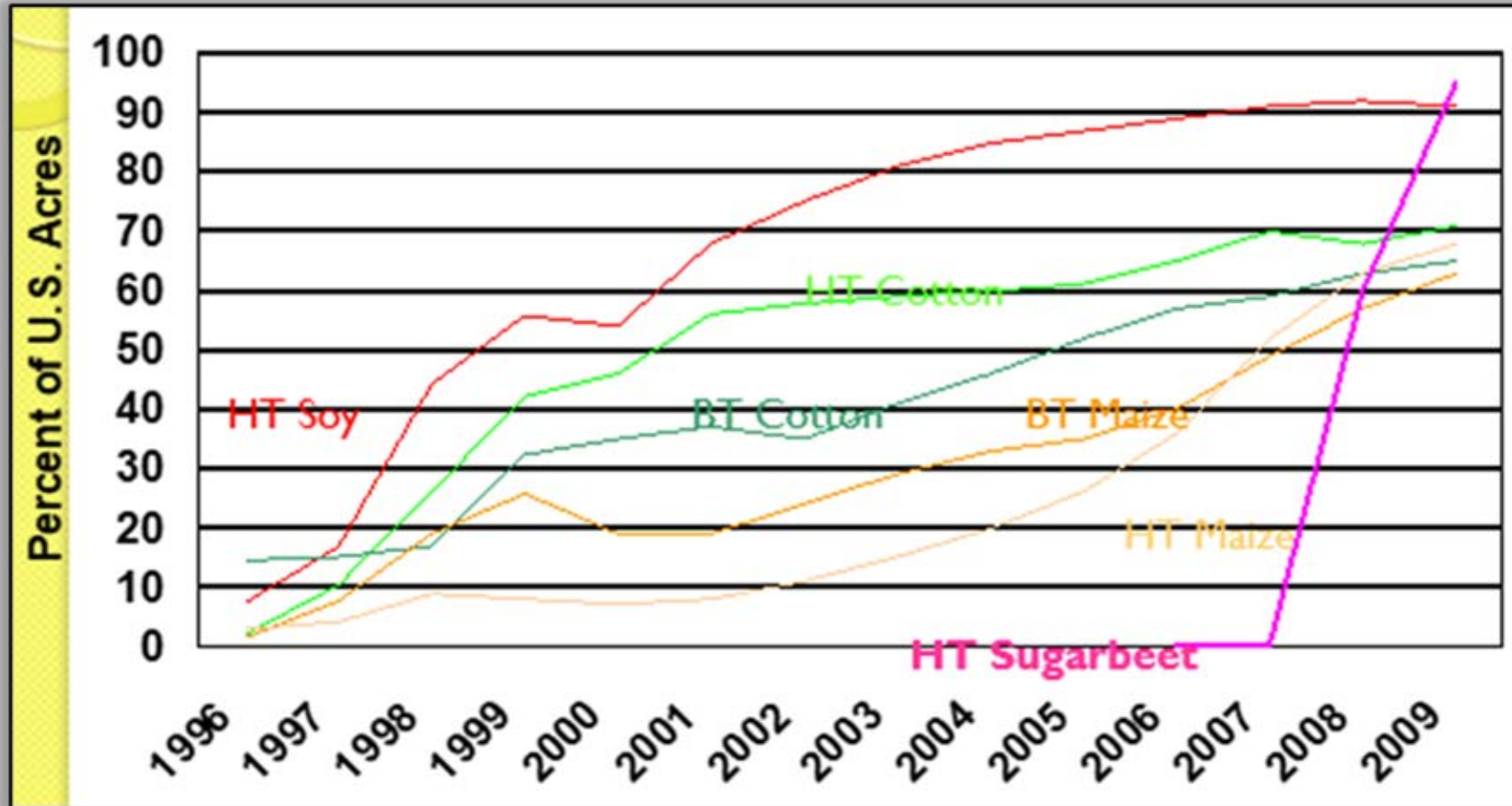
Note: Telephone data for 2006-2008 estimated using 2005 and 2009 values and assuming an equal change per year.

AgTech Innovation Dilemma

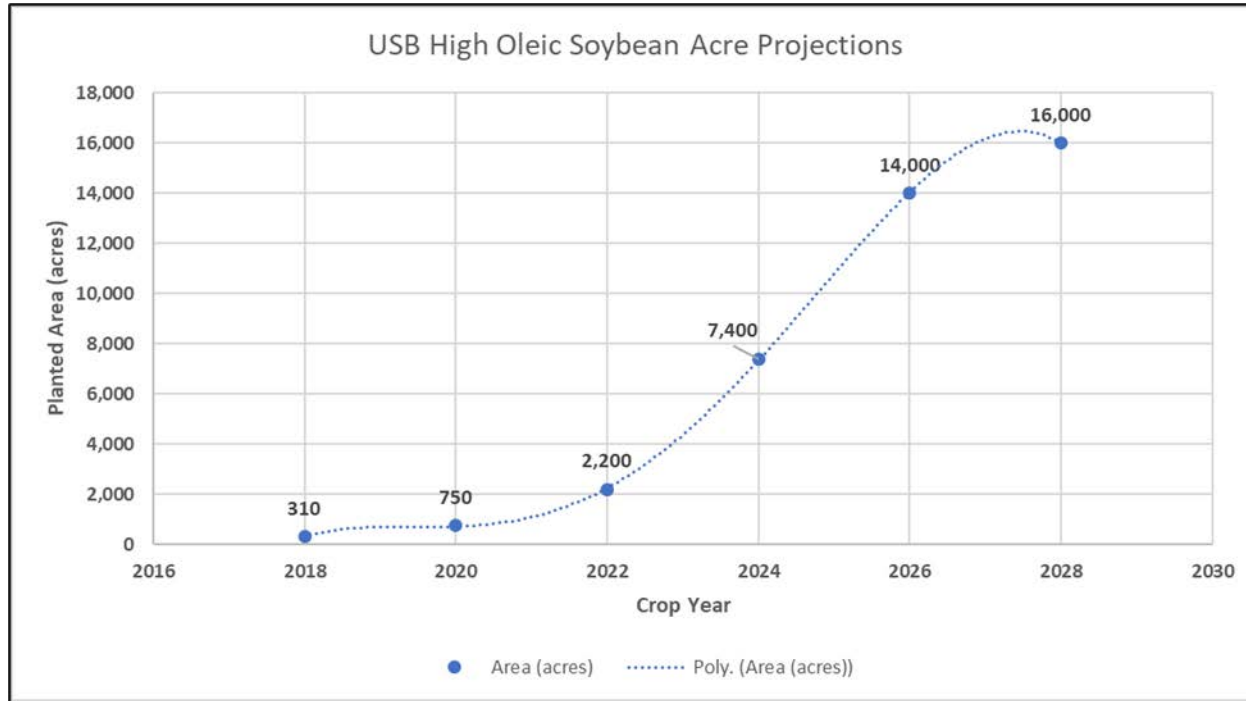
Figure 12: AgTech Adoption in U.S. (Alston & Pardey, 2020)



US biotech trait adoption (authors calculations).



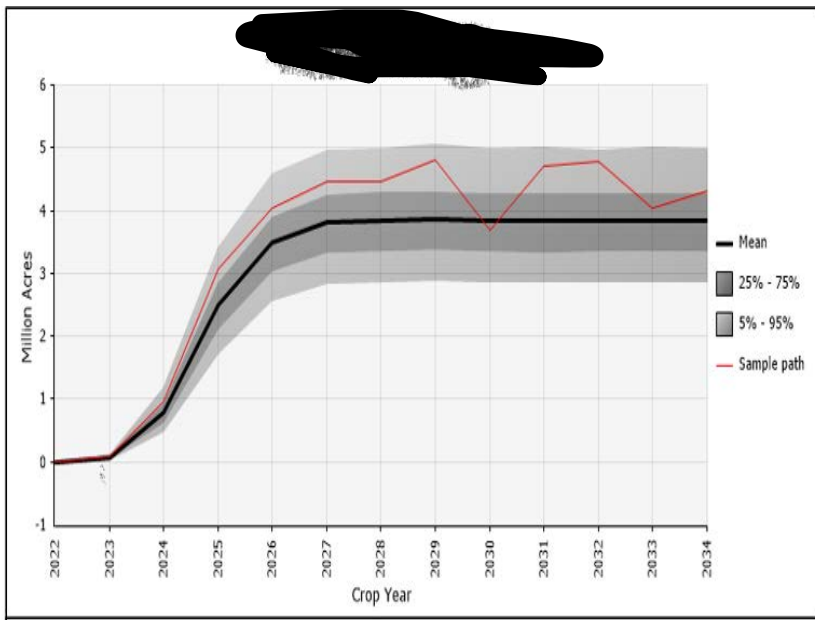
Market penetration for high oleic soybean market (source: United Soybean Board)



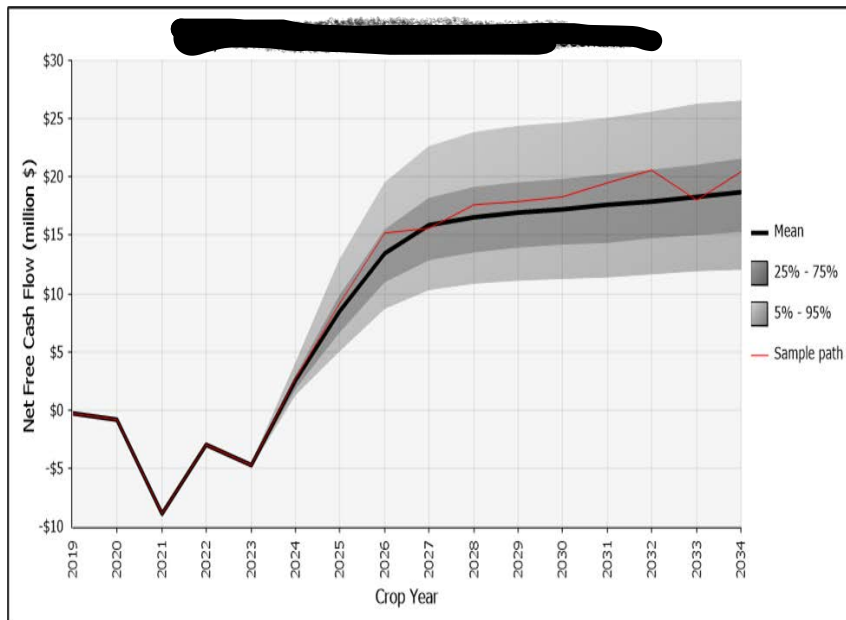
Adoption Curves and EBITDA

Derived and Implemented in NPV Models Using Monte *Carlo Simulations to Capture Risks*

Adoption Curve



Net Free Cash Flows



Lesson for Tech Developers

ROI Metric

- **Importance:** Should the tech be adopted?
- Farmers confront:
Multiple competing technologies
- **ROI!**

Ex Sentara--next

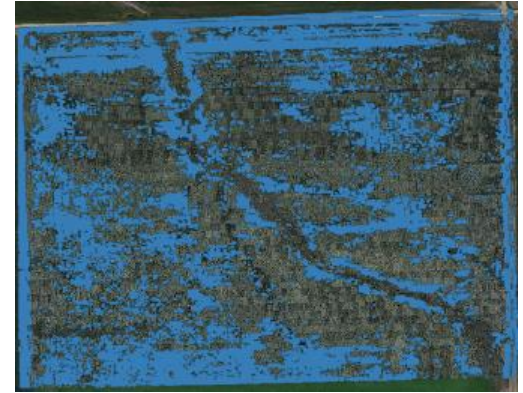
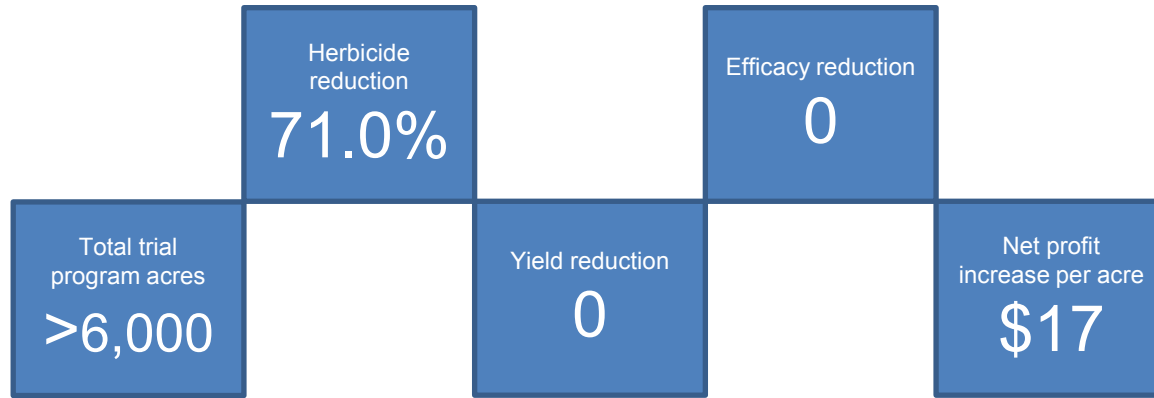
- Conduct studies to indicate the ROI of adoption
 - Internal or 3rd party
 - Credible
 - Replica table
- Not dissimilar from University Field Trials

Issues in AgTech

- “Cool” products doesn’t mean they’ll sell
- Must have a double digit ROI for producers
 - AgTech entrepreneurs have tough time conveying potential ROI



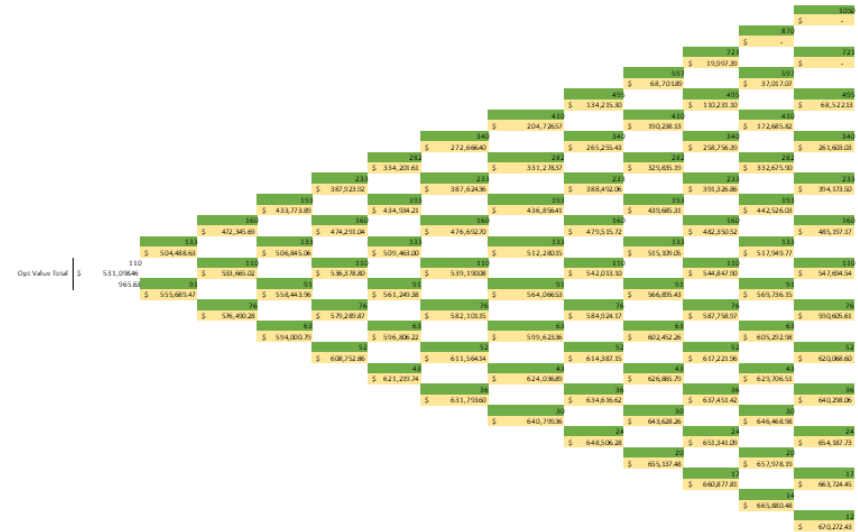
Ex: Sentara Weed detection and mapping



- High-precision weed mapping enables chemical reductions up to 71%
- Grower receives economic benefit; revenue/margin shift from chemistry to digital
- Enables multi-mode treatment scenarios that deliver improved grower outcomes and motivate adoption of higher-margin premium products
- **Average accuracy is 96.9% with a standard deviation of 3.31%**

Real Options and R&D for AgTech

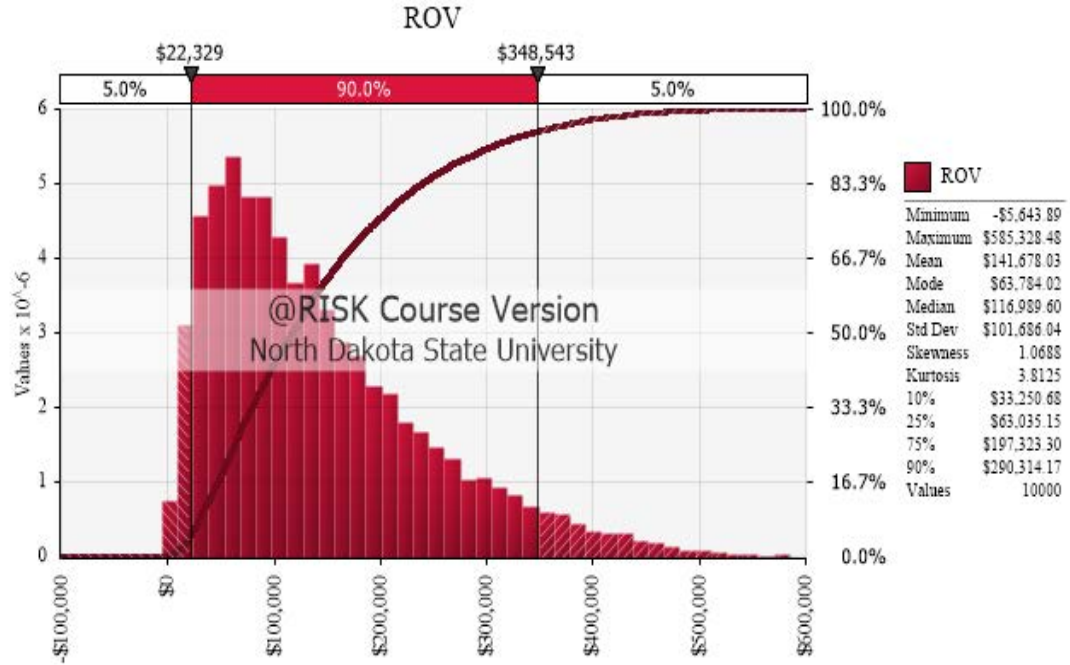
- Important features are uncertainties that are resolved through time, and, options
 - Research managers have options that can be pursued throughout the duration of the project.
- Investing in R&D is a call option and valued as a real option
 - Incur a cost for future opportunities, uncertainty and options
 - Invest over time
 - Option to
 - continue,
 - abandon or
 - Wait
 - othe



Ex: Mean Simulation Results of Valuation Using Real Option Value

- Mean value is **\$141.2** million
- “fat-tail” upside given a maximum value of \$595.3 million.
- 90% confidence interval that the value of product 1 is between \$22.3 million and \$348.5 million.
- Standard deviation is \$101.7 million, offering high volatility of results.

Figure 19: Mean ROV of Product 1 (Thousands



- DCV: **\$18 million**

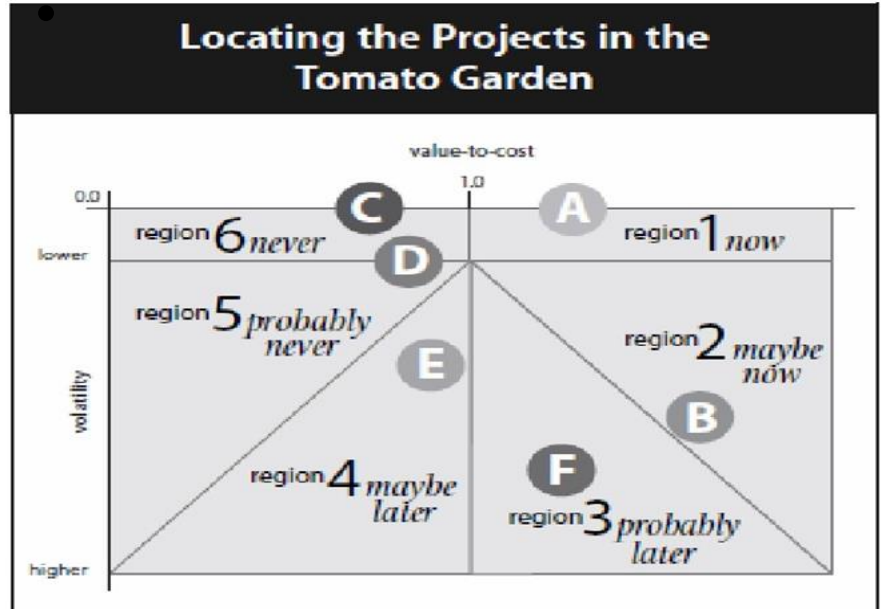
Strategic options: *Strategies for Technology Development*

Concept: *Tech dev as a real option (call)*

- Strategic options
- Model used to incorporate 'strategic options'
 - Options that can be exercised, conditional on continuing
 - Compare:
 - Risk and returns
 - On multiple competing/complementary projects
- **Tomato Gardens:** Compare risk and return, and use these to prioritize path forward

Portfolio of strategic options

See Luerhman, *Strategy as a Portfolio of Real Options* (HBR)



Sharing Profits: Easy! Shapely Value [SV] illustration

Independent 3 players: A, B, C

- $V\{A\}=6$,
- $v\{B\}=12$,
- $v\{C\}=18$;
- Total: 36

Coalition 1: 2 combinations

- $v\{A, B\}=21$;
- $v\{A, C\}=27$;
- $v\{B, C\}=36$;

Coalition 3: 3 partners

- $v\{A, B, C\}=90$ Grand Coalition:
 - A should get 23,
 - B should get 30.5,
 - C should get 36

$$\begin{aligned}
 \phi_A(v) &= \sum_K (v(K) - v(K \setminus \{A\})) \frac{(k-1)!(n-k)!}{n!} \\
 &= (v(\{A\}) - v(\{\emptyset\})) \frac{(1-1)!(3-1)!}{3!} + (v(\{A, B\}) - v(\{B\})) \frac{(2-1)!(3-2)!}{3!} + \\
 &\quad (v(\{A, C\}) - v(\{C\})) \frac{(2-1)!(3-2)!}{3!} + (v(\{A, B, C\}) - v(\{B, C\})) \frac{(3-1)!(3-3)!}{3!} \\
 &= \frac{1}{3} * 6 + \frac{1}{6} * (21 - 12) + \frac{1}{6} * (27 - 18) + \frac{1}{3} * (90 - 36) = 23
 \end{aligned}$$

$$\begin{aligned}
 \phi_B(v) &= \sum_K (v(K) - v(K \setminus \{B\})) \frac{(k-1)!(n-k)!}{n!} \\
 &= (v(\{B\}) - v(\{\emptyset\})) \frac{(1-1)!(3-1)!}{3!} + (v(\{A, B\}) - v(\{A\})) \frac{(2-1)!(3-2)!}{3!} + \\
 &\quad (v(\{B, C\}) - v(\{C\})) \frac{(2-1)!(3-2)!}{3!} + (v(\{A, B, C\}) - v(\{A, C\})) \frac{(3-1)!(3-3)!}{3!} \\
 &= \frac{1}{3} * 12 + \frac{1}{6} * (21 - 6) + \frac{1}{6} * (36 - 18) + \frac{1}{3} * (90 - 27) = 30.5
 \end{aligned}$$

$$\begin{aligned}
 \phi_C(v) &= \sum_K (v(K) - v(K \setminus \{C\})) \frac{(k-1)!(n-k)!}{n!} \\
 &= (v(\{C\}) - v(\{\emptyset\})) \frac{(1-1)!(3-1)!}{3!} + (v(\{A, C\}) - v(\{A\})) \frac{(2-1)!(3-2)!}{3!} + \\
 &\quad (v(\{B, C\}) - v(\{B\})) \frac{(2-1)!(3-2)!}{3!} + (v(\{A, B, C\}) - v(\{A, B\})) \frac{(3-1)!(3-3)!}{3!} \\
 &= \frac{1}{3} * 18 + \frac{1}{6} * (27 - 6) + \frac{1}{6} * (36 - 12) + \frac{1}{3} * (90 - 21) = 36.5
 \end{aligned}$$

Lessons and Outlook

- Robust demand for technology
 - (we need it all!)
- Technology must have value relative to competing technologies
- Numerous strategic issues/opportunities
 - Ripe for economic and strategic analysis

Challenges to AgTech VC's (Wilson interpretation)

- **Lots of money wants to be invested in AgTech**
 - Few projects would be interpreted as 'good projects'
- Tools to vet good vs bad projects
- Proving (demonstrating) irrevocably the value of the technology
 - Technical efficiency, cost savings, ROI, yield increase, cost, value of improved quality
- TimeLine: e.g., 7-12 years
 - 7 years is a short time
- **Inventors Dilemma: Agtech firm choice:**
 - **develop and commercialize internally**
 - w/new outside investors
 - Loosing control
 - Funding:
 - Seed
 - Series A
 - Series B
 - Series C
 - Acquired or go public
 - **Or, sell to a strategic**