

The Underappreciated Economics of Robotics (and spotting associated disruptions)

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A Review of Disruption (known unknowns)

- Industry (& labor) disruption is inevitable (known)
- Technology tends to drive this disruption (unknown)
- Robotics is a special case of this phenomenon
- This type of disruption impacts real world economics

- Reminder about geometric sequences
- Progressive decline in pricing - estimations
- **NEW CONCEPT “MECC”**: Marginal Effective Cost of Consumption (technology + design)

Why we care about the “disruption” frame

- What do VCs fund (in this space), and why?
- What does Marc Andreessen’s claim that ‘software is eating the world’ have to do with robotics?
- Does this impact what should or could be studied?
- Should (can?) researchers use these frames to better identify questions to answer?
- How do regulators and policy-makers use disruption frames to do a better job?

Elements: Rate of Change, Network Effects, Transactions Costs, Externalities, Public Goods & Marginal Cost of Consumption (vs. Production)

Punchline about the “elements”

Rate of Change – fairly obvious

Network Effects – autonomous cars as an example

Transactions Costs – Google Adwords as example

Externalities – “internalizing them” (think sensors)

Public Goods – avoiding/solving them (non-rival, non-excludable)

Marginal Effective Cost of Consumption (vs. Production) – More on that soon

- **A way of jump starting the conversation:**
 - Old, New, Next
 - Nuisance, Materially Impactful, Game Changer
 - “What is the weirdest thing that could happen?”
 - “What if we stretched that analysis out 100 years?”
- **Security (Cybersecurity)**
- **Pricing**
- **Logistics**
- **Production (including Human Capital)**
- **Compliance, Legal, & Liability (IP issues ++)**
- **Service (interaction)**
- **Analytics**

Humans are bad at the intuition around compounding (and geometric sequences *generally*)

Benjamin Franklin's Wisdom

- Money makes money and the money that money makes makes more money
- Future value of an investment

$$FV = C_0 \times (1 + r)^N$$

When betting on doubling a penny everyday for a *month*... [spreadsheet]

What is the most important legal question?

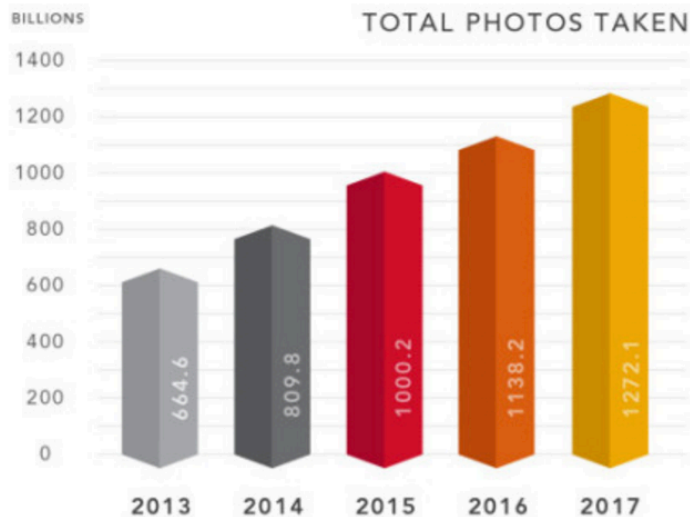
Implications for project/business credibility?

Implications for why researchers miss disruption?

Pixels, Focus, and Convenience



But what about before 2013?



One Trillion
photos will be taken in 2015



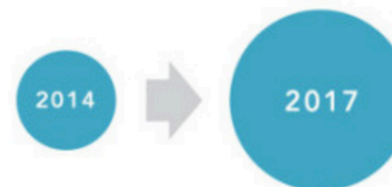
People are taking more photos than ever before, mainly due to the increase in usage and ownership of mobile phones with cameras.



78.8%

By 2017, nearly 80% of all photos will be taken with mobile phones.

4.9 Trillion Photos Stored



The total number of photos stored is expected to grow from 2.7 trillion in 2014 to 4.9 trillion in 2017.

Photography: An example

- Photo taking, processing, sharing
- Concept of diminishing variable cost
- If reduction of variable cost is geometric?
- Digital (camera sensor technology + phones)
- Digital with less expensive storage
- Digital with sharing ability (transmission)
- Digital with auto-sharing ability (Instagram)
- What *digital* does to marginal/variable cost
- At what rate is that changing?
- What happens when it hits zero? (use cases!)
- What happens when cost of consumption = zero?

- **The specifics are interesting but a distraction**
 - MOOCs (Massive Open Online Courses)
 - On Demand, Drop-In customer courses (online)
 - Peer moderated discussions & study groups
 - Cloud based materials & exercises
- **The trends are where the strategy emerges**
 - Digital-Physical blur – decoupled from geography
 - Self directed and time-shifted consumption
 - Crowdsourced feedback and reviews
 - Cost of production (per student) dropping fast
 - **Cost of consumption** (by student) dropping faster
- **Winner take all features promise big disruption (network effects more common now)**

Thinking Harder about Cost of Consumption

- **Distinguishing from Cost of Production**
 - Vehicles and Driving
 - If free (including maintenance) do you drive more?
 - Where is the greater cost of consumption? (Note TESLA – maint)
 - What disruption is, therefore, more powerful? (Note Waze)
- **Isolate the broad opportunity (consumption) costs**
 - Yelp/Google/Trip Advisor Restaurant Reviews
 - Relative (larger) cost (risk) of eating out?
 - Hackers & tool costs/time to learn/scale deployment?
 - Search (research), Storage real costs, analytics (statistics)?
 - Job searching, salary analysis
- **Recognize the user element of design**

Finding Patterns in Any Industry

- **Video games & Entertainment & Drones**
 - Why are smart phone games so popular (if ‘inferior’)?
 - Why do sensors and networking matter?
 - Why “recommended for you” is transformative.
- **Delivery Services, Parking Garages, & Taxis**
 - What “costs” consumers the most in a taxi ecosystem?
 - What does software have to do with delivery pricing?
 - Why are parking garages at risk in San Francisco?
- **Shipping & Trucking**
 - Maersk and the Altona Container Facility (forklift miles)
 - Sleepiness monitors, wind tracking, & traffic predictions?

Understanding Horses & Mules

Rate of Change

Network Effects

Transactions Costs

Externalities

Public Good Effects

Marginal Effective Cost of Consumption (of horses vs. tractors)

But first a quick review of the very fast decline of horses on farms...

Mechanization

1900

Number of work animals
21.6 million

1930

Number of horses, mules
18.7 million

Number of tractors
920,000

1945

Number of tractors
2.4 million

Number of mules and horses used for work power on farm
11.6 million

1960

Number of tractors
4.7 million

Number of horses and mules used for work power on farm
3 million

Note: Data on work animals were no longer collected by the Census after 1960.

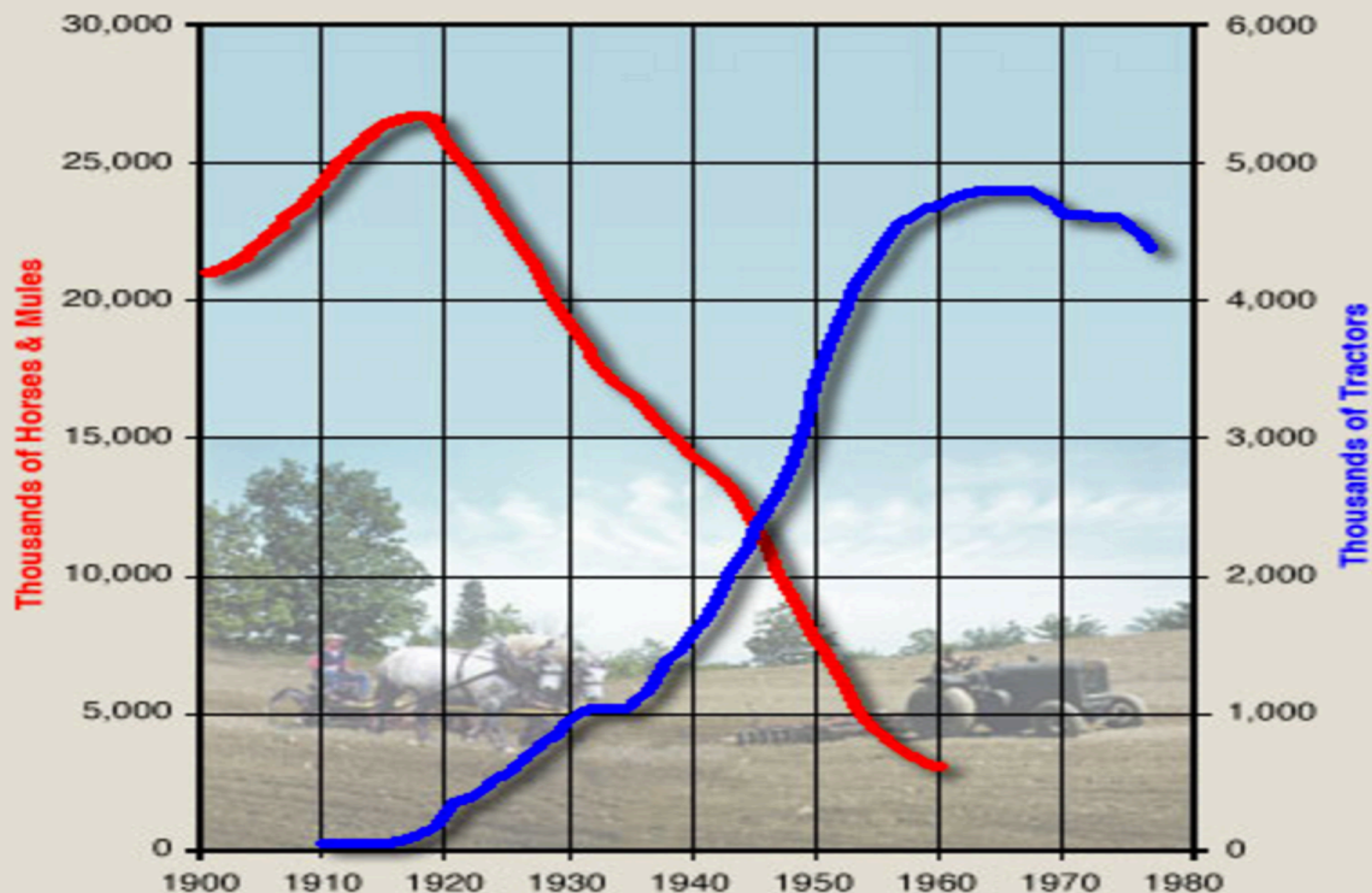
Source: Compiled by Economic Research Service, USDA, using data from *Census of Agriculture* and *Census of the United States*.

U.S. Equine Population During Mechanization of Agriculture and Transportation

Year	Number of Horses and Mules
1900	21,531,635
1905	22,077,000
1910	24,042,882
1915	26,493,000
1920	25,199,552
1925	22,081,520
1930	18,885,856
1935	16,676,000
1940	13,931,531
1945	11,629,000
1950	7,604,000
1955	4,309,000
1960	3,089,000

Source: Adapted from Ensminger (1969).

Tractor Power Overcomes Horse Power in 1945



Animal and tractor power. Data from U.S. Dept. of Commerce.
[Graph based on estimate that one tractor could replace five horses on a farm.]

Exercise: Disruption Elements & Why

Use the following elements of the “horse vs. tractor” analysis (by the farmer) to highlight possible sources of disruption.

Rate of Change

Network Effects

Transactions Costs

Externalities

Public Good Effects

Marginal Effective Cost of Consumption (of horses vs. tractors)

How do you reframe employer/worker?

- **Cost of Production (for labor component) of the employment relationship? WAGES**
- **Are employers buying labor or future output?**
- **Cost of Consumption (for labor component) of the employment relationship? EVERYTHING ELSE**
 - Recruitment
 - Supervision
 - Training
 - What else?
 - Note about the “gig economy” – reduces MECC?
 - Note about “robotics” – reduces MECC?

Labor Displacement & Substitution

- **Transaction Costs Related to Labor Procurement, Fit, and Retention**
 - Search, Recruit, Evaluate, Train, Retain
 - Each labor unit is somewhat unique, case by case review
 - Fit is only partially knowable prior to actual work
 - Skills & performance can vary in both directions over time
 - Duration of suitability (and willingness) is uncertain
 - Network Effects, Interoperability, & Skill Transference
 - Low Human Network Effects, Opposite for Robots
 - Industrial examples & cars: mix/match is sub-optimal
 - Non-competes? (Innovation sharing) – IP protection
 - Training? Cultural influence? Ramp-up times?

Labor Displacement & Substitution - cont

- **Capital Structure & Finance Issues**
 - CAPEX vs. Cash.... (Robots are CAPEX)
 - Implications for borrowing & leverage
 - Flexibility in depreciation
- **If Employer Tax schemes remain the same**
- **Balance Sheets (and Taxes)**
- **Balance Sheet impact**