AEA: Continuing Education - Introduction to Digital Economics and the Economics of Artificial Intelligence

Martin, Chiara, Avi and Catherine

Agenda

Catherine introduces the intellectual history of our field

Agenda

Catherine talks about the basic economic properties of digital data and digital infrastructure and uses the example of the question of whether digital industries are prone to concentration as a lens to think about these economic properties.

Agenda

The Intellectual History of Digital Economics and Artificial Intelligence

Foundations: Economic Properties of Digital Data and Infrastructure - Do they lead to Concentration?

Digital Privacy and Algorithmic Bias

Digital Platforms and Regulation

Digital Economics and the Creative Industries, Retail and Education

Foundations: The Economics of Artificial Intelligence

Artificial Intelligence and Labor Markets

Artificial Intelligence and Innovation

Artificial Intelligence and the Broader Political Economy

Final Thoughts

Catherine talks about the economics of digital privacy and also about the shift of policy concerns to the question of algorithmic bias

Agenda

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Artificial Intelligence and the Broader Political Economy

Final Thoughts

Chiara talks about the current policy debate surrounding digital platform regulation

Agenda

Avi talks about the underlying digital economics of a variety of industries that have been affected by the digital revolution

Agenda

Avi talks about what AI is and why that makes it interesting for economists

Agenda

Avi talks about current research trying to understand how AI may affect labor markets

Agenda

The Intellectual History of Digital Economics and Artificial Intelligence

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Final Thoughts

Avi talks about current research trying to understand how AI relates to the economics of innovation

Agenda

Martin talks about how AI can be a tool for government surveillance and how this affects our understanding of the broader political economy of AI.

Agenda

- The Intellectual History of Digital Economics and Artificial Intelligence
- Foundations: Economic Properties of Digital Data and Infrastructure - Do they lead to Concentration?
- Digital Privacy and Algorithmic Bias
- Digital Platforms and Regulation
- Digital Economics and the Creative Industries, Retail and Education
- Foundations: The Economics of Artificial Intelligence
- Artificial Intelligence and Labor Markets
- Artificial Intelligence and Innovation
- Artificial Intelligence and the Broader Political Economy
- Final Thoughts

Three Key Themes

1. Think about what is different.
2. Central role of the economics of information
3. Economics has a key role in helping navigate uncertainty about inequality, the broader political economy, and concentration of power.

AEA: Continuing Education - Digital Infrastructure and Data: Do they Shape Digital Industries?

Catherine Tucker

Leaders | Regulating the internet giants

The world's most valuable resource is no longer oil, but data

The data economy demands a new approach to antitrust rules

Two ways that we can approach how digital industries may be different

- They are different because of they deal in data and that is somehow different
- They are different because digital infrastructure is somehow different

Plan for this session

- What do we know about data
- What do we know about digital infrastructure
- What does this mean in terms of what digital economics has to predict about concentration

Agenda

Data

Digital Infrastructure

As a starting point it is useful to think what could be different about data

- Digital storage costs have fallen a lot
  - Though in theory that sounds as though it should take us towards entry and competition as this reduces fixed costs
- Digital data is non-rival (but then so is information)

What I think makes digital data interesting..

- The question of whether it is excludable or not? (Blockchain anyone)
- The question of how we make property rights (I will talk about this more tomorrow)?

But there persists an antitrust debate surrounding data

Usually along the lines of data as an essential facility

The role of the essential facilities doctrine

BY MATS A. BERGMAN*

I. Introduction

When the essential facilities doctrine is applied, a dominant firm is compelled to supply a "critical" or "essential" intermediate good to its downstream (or, less often, upstream) competitor(s) at a "nondiscriminatory" price. The effect of the doctrine will be similar to a price regulation of the intermediate good. This will, in turn, enable or promote downstream competition.

When applicable, the doctrine is a powerful instrument in the competition authorities' hands. In an article on the essential facil-

For something to be an essential facility you need...

- Rare
- Valuable
- Non-imitable

The Usual Answer

- Network Effects
- Switching Costs

Network Effects and Market Power: What Have We Learned in the Last Decade?

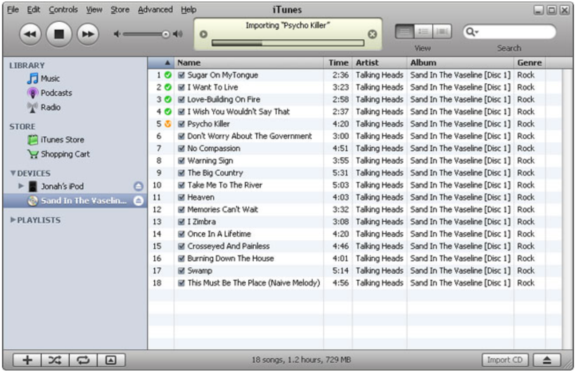
BY CATHERINE TUCKER

Catherine Tucker is the Sloan Distinguished Professor of Management Science at MIT Sloan School of Management, Cambridge, MA, and Research Associate at the National Bureau of Economic Research (NBER).

Network Effects

- Local
- Fragile without switching costs
- Sometimes negative

Switching Costs in a Cloud Based Environment



Lack of economies of scale in data

Instead reframe around the 'cold-start' problem

Home > Management Science > Ahead of Print >

The Editor and the Algorithm: Recommendation Technology in Online News

Christian Peukert, Ananya Sen, Jörg Claussen

Published Online: 17 Oct 2023 | https://doi.org/10.1287/mnsc.2023.4954

Abstract

We run a field experiment to study the relative performance of human curation and automated personalized recommendation technology in the context of online news. We build a simple theoretical model that captures the relative efficacy of personalized algorithmic recommendations and curation based on human expertise. We highlight a critical tension between detailed, yet potentially narrow, information available to the algorithm versus broad (often private), but not scalable, information available to the human editor. Empirically, we show that, on average, algorithmic recommendations can outperform human curation with respect to clicks, but there is significant heterogeneity in this treatment effect. The human editor performs relatively better in the absence of sufficient personal data and when there is greater variation in preferences. These results suggest that reverting to human curation can mitigate the drawbacks of personalized algorithmic

So my opinion (which is not held by all digital economists)

Is that raw data by itself is probably not at the route of our concerns about the digital economy

Agenda

Data

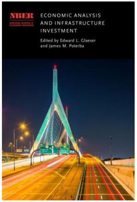
Digital Infrastructure

Best Reference on Digital Infrastructure

Digital Infrastructure

Shane Greenstein

PUBLISHED DATE November 2021 **COPYRIGHT** 2021 **ISBN** 978-0-226-80058-5



CONFERENCE HELD NOVEMBER 15-16, 2019
BOOK: ECONOMIC ANALYSIS AND INFRASTRUCTURE INVESTMENT
BOOK EDITORS: EDWARD L. GLAESER & JAMES M. POTERBA
PUBLISHER: UNIVERSITY OF CHICAGO PRESS

What determines the supply of innovative digital infrastructure and how does variance in supply shape the performance of digital services? The essay reviews research into the economic impact of deployment, innovation, and adoption of digital infrastructure. It distinguishes between household and business use of access, and describes how and where improvement to digital infrastructure benefits both suppliers and users. Despite its importance for economic performance, digital infrastructure operates at a distinctive and evolving boundary between public and private, which frames many research questions. The essay focuses on the experience in the United States and it covers the global experience when possible, stressing policy-relevant research questions. A large number of unanswered questions can benefit from economic analysis.

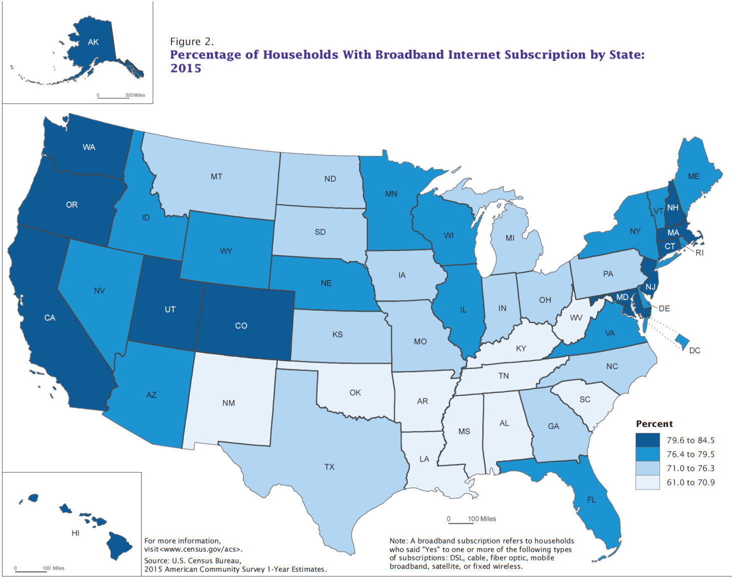
You will learn a lot about history and technology

- Root servers, fiber, broadband lines, networking switches and routers, content delivery networks, cloud facilities, and cellular towers

Useful Facts

- In 2001, 50% of US households had internet and that was via dial up. In 2007, 50% used broadband.
- 80% of US households have broadband. This is less than other developed nations.
- 75% of US households have a smartphone.
- 2% of US households in 2018 still use dial up.

Figure 2.
Percentage of Households With Broadband Internet Subscription by State: 2015

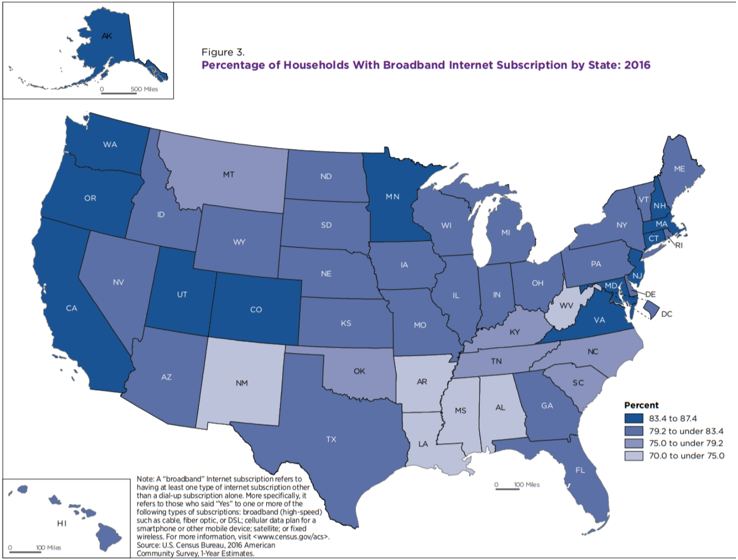


For more information, visit<www.census.gov/acs>.

Source: U.S. Census Bureau, 2015 American Community Survey 1-Year Estimates.

Note: A broadband subscription refers to households who said "Yes" to one or more of the following types of subscriptions: DSL, cable, fiber optic, mobile broadband, satellite, or fixed wireless.

Figure 3.
Percentage of Households With Broadband Internet Subscription by State: 2016



Note: A "broadband" Internet subscription refers to having at least one type of internet subscription other than a dial-up subscription alone. More specifically, it refers to those who said "Yes" to one or more of the following types of subscriptions: broadband (high-speed) such as cable, fiber optic, or DSL; cellular data plan for a smartphone or other mobile device; satellite; or fixed wireless. For more information, visit <www.census.gov/acs>.
Source: U.S. Census Bureau, 2016 American Community Survey, 1-Year Estimates.

Rosston and Wallsten (2019) study 'Internet Essentials'. But not much research

Fixed Broadband Deployment Data: Jun, 2018 Status V1

Wireline

View Data | Visualize | Export | API | ...

All facilities-based broadband providers are required to file data with the FCC twice a year (Form 477) on where they offer Internet access service at speeds exceeding 200 kbps in at least one direction. Fixed providers file lists of census blocks in which they can or do offer service to at least one location, with additional information about the service. Data

More

Updated
October 29, 2019

About this Dataset

Updated
October 29, 2019

Data Last Updated
October 29, 2019

Metadata Last Updated
October 29, 2019

Date Created
September 3, 2019

Views
3,740

Downloads
352

Data Provided by
(none)

Dataset Owner
Alireza Shadman

Contact Dataset Owner

Common Core

Bureau Code	356:00
Program Code	000:000

Topics

Category	Wireline
Tags	fcc, wcb, broadband, 2017

Licensing and Attribution

License	Public Domain U.S. Government
Source Link	https://www.fcc.gov/economics-analytics/industry-analysis-division/form-477-resources

What's in this Dataset?

Rows
69.5M

Columns
17

An understanding of this infrastructure is important to understand identification

- The study of the internet has been hindered by our not very convincing Instruments
  - College students
  - Topography
  - Rail lines
- Switch network IV sounds convincing
- Self-publicity - placement of cellphone towers connected to historic church placement

Can we learn things from digital infrastructure more generally about government and infrastructure

- That digital infrastructure has ‘happened’ swiftly, with very little government intervention.
- Furthermore, the US pathway for digital infrastructure has dominated worldwide

Where to next in this literature

- Too much focus on the economics of broadband in the literature
- Not enough research on
  - Content Distribution Networks
  - Cellular
  - Cloud Computing

I might frame this as the switch away from traditional infrastructure

- Switch to cloud computing allowed Pandora to run analyzed of the effectiveness of ad campaigns in 4 minutes rather than 2 hours.
- Switch to private firms controlling the (lack of) infrastructure.

The cloud added approximately $214 billion in value-added to U.S. GDP in 2017. The cloud added approximately 2.15 million jobs in 2017. In approximately 15 years since 2002, the cloud economy has nearly tripled in size.
However, very little studied

Bringing this back to though to the question of competition economics

- Nothing I have said about infrastructure suggests any concern from a tradition industrial organization perspective.
- Economics of scale, scope and so on.

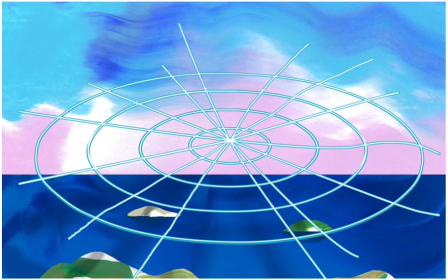
And Yet....

‘A sufficiently successful social platform is experienced as a piece of infrastructure’

The New York Times Magazine

ON TECHNOLOGY

What if Platforms Like Facebook Are Too Big to Regulate?



All this is to say that a sufficiently successful social platform is experienced, much like Uber, as a piece of infrastructure. Except, instead of wrapping its marketplace around a city's roads, Facebook makes a new market around communication, media and civil society. This, from a founder's perspective, is an electrifying outcome. But this cultural metastasis has led to a swift and less-than-discriminate backlash. Already, calls for regulating the largest internet platforms are growing louder while remaining tellingly vague.

Should economists join in this new digital platforms as ‘infrastructure’ debate?

Regulating Informational Infrastructure: Internet Platforms as the New Public Utilities

K. Sabeel Rahman
July 2018
Cite as: 2 GEO. L. TECH. REV. 234 (2018)

It’s not easy being an Internet giant. Once the darlings of the innovation economy, the major technology companies—Amazon, Google/Alphabet, and Facebook—have in recent months found themselves suddenly on the back foot. From the firestorm surrounding the proliferation of “fake news” and hate speech on Facebook and YouTube, to Google’s long-burning dispute with Yelp over the former’s alleged skewing of search results to favor its own products, to Amazon’s various disputes with publishers and retailers alike, the technical wizardry, convenience, and efficiency promised by these firms no longer seems benign.

Punchline

From my perspective the interesting political economy questions and policy interest come not from the data-foundation of digital industries but the fact that digital industries are often based around information

AEA: Continuing Education - Digital Privacy and Algorithmic Bias

Catherine Tucker

Agenda

Challenges to Studying Privacy as an Economist

The History of the Economics of Privacy

Outstanding Questions

Algorithmic Bias

Punchline

In Depth

Challenges to Studying Privacy as an Economist

- Modeling it is Hard
- Bound Up in Technological Change

What is Privacy?

My Favorite Definition: Freedom from Unwarranted Intrusion

CAN PRIVACY BE JUST ANOTHER GOOD?

JOSEPH FARRELL*

In Depth

Challenges to Studying Privacy as an Economist

- Modeling it is Hard
- Bound Up in Technological Change

First steps

HARVARD

LAW REVIEW.

VOL. IV. DECEMBER 15, 1890. NO. 5.

THE RIGHT TO PRIVACY.

"It could be done only on principles of private justice, moral fitness, and public convenience, which, when applied to a new subject, make common law without a precedent; much more when received and approved by usage."

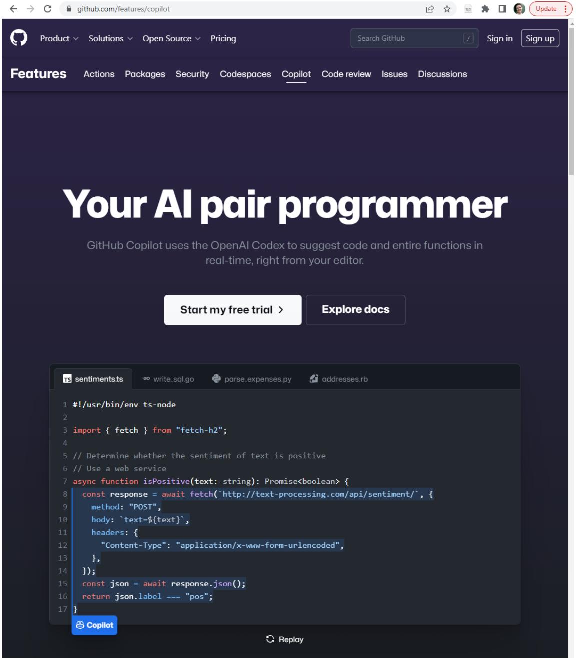
WILLES, J., in Millar v. Taylor, 4 Burr. 2303, 2312.

THAT the individual shall have full protection in person and

A Shift in Costs of Data Storage

- In 2001, 1 GB cost $19.70 to store.
- In 2010, 1 GB cost $0.06 to store.
- In 2022, 1 GB cost $0.0023/GB to store.

A Shift in Costs in Data-Driven Technologies



All These Mean That How We Model And Think About Privacy is Constantly Changing

Agenda

Challenges to Studying Privacy as an Economist

The History of the Economics of Privacy

Outstanding Questions

Algorithmic Bias

Punchline

Journal of Economic Literature 2016, 54(2), 442–492
http://dx.doi.org/10.1257/jel.54.2.442

The Economics of Privacy†

ALESSANDRO ACQUISTI, CURTIS TAYLOR, AND LIAD WAGMAN*

This article summarizes and draws connections among diverse streams of theoretical and empirical research on the economics of privacy. We focus on the economic value and consequences of protecting and disclosing personal information, and on consumers' understanding and decisions regarding the trade-offs associated with the privacy and the sharing of personal data. We highlight how the economic analysis of privacy evolved over time, as advancements in information technology raised increasingly nuanced and complex issues. We find and highlight three themes that connect diverse insights from the literature. First, characterizing a single unifying economic theory of privacy is hard, because privacy issues of economic relevance arise in widely diverse contexts. Second, there are theoretical and empirical situations where the protection of privacy can both enhance and detract from individual and societal welfare. Third, in digital economies, consumers' ability to make informed decisions about their privacy is severely hindered because consumers are often in a position of imperfect or asymmetric information regarding when their data is collected, for what purposes, and with what consequences. We conclude the article by highlighting some of the ongoing issues in the privacy debate of interest to economists. (*JEL* D82, D83, G20, I10, L13, M31, M37)

Share Some Ideas About Good Research Topics for Researchers

Not in any way intended to be exhaustive.

Agenda

Challenges to Studying Privacy as an Economist

The History of the Economics of Privacy

Outstanding Questions

Algorithmic Bias

Punchline

In Depth

Breakdown

- Outstanding Questions
  - The Value of Privacy
    - Let's Measure Some Benefits to Privacy Regulation
    - Measuring Privacy Preferences
    - Privacy Preferences and Contextual Integrity
    - Privacy Preferences and Information Security Concerns
    - Time-Inconsistency in Privacy Preferences
  - Markets and Privacy
  - The Spread of Privacy Protective Technologies
  - Algorithmic Privacy
  - The Broader Economy and Privacy

I am completely guilty of this

THE UNIVERSITY OF CHICAGO PRESS JOURNALS

Home > Innovation Policy and the Economy > Volume 12

PREVIOUS ARTICLE

NEXT ARTICLE

FREE

Privacy and Innovation

Avi Goldfarb and Catherine Tucker

Rotman School of Management, University of TorontoMIT Sloan School of Management and NBER

Abstract | Full Text | PDF

Sections

More

Abstract

Information and communication technologies now enable firms to collect detailed and potentially intrusive data about their customers both easily and cheaply. Privacy concerns are thus no longer limited to government surveillance and public figures' private lives. The empirical literature shows that privacy regulation may affect the extent and direction of data-based innovation. We also show that the impacts of privacy regulation can be extremely heterogeneous. We therefore argue that digitization has made privacy policy a part of innovation policy.

Privacy Regulation Might Halt The Spread of Data Associated With Unfounded Stigma

- Mental Health
- Reproductive Health
- Past Crimes

Privacy Regulation Might Halt The Spread of Data Associated With Addiction

- Health
- Spending
- Gambling

But if we want to measure more global benefits to privacy regulation we need to model consumer tastes for privacy better

Breakdown

So Far

F

Valuing Intrinsic and Instrumental Preferences for Privacy

Tesary Lin

Published Online: 13 May 2022 | https://doi.org/10.1287/mksc.2022.1368

Abstract

I empirically separate two components in a consumer's privacy preference. The intrinsic component is a "taste" for privacy, a utility primitive. The instrumental component comes from the consumer's anticipated economic loss from revealing his private information to the firm and arises endogenously from a firm's usage of consumer data. Combining an experiment and a structural model, I measure the revealed preferences separately for each component. Intrinsic preferences have seemingly small mean values, ranging from $0.14 to $2.37 per demographic variable. Meanwhile, they are highly heterogeneous across consumers and categories of data: The valuations of consumers at the right tail often exceed the firm's valuation of consumer data. Consumers' self-selection into data sharing depends on the respective magnitudes and correlation between the two preference components and often deviates from the "low types are more willing to hide" argument. Through counterfactual analysis, I show how this more nuanced selection pattern changes a firm's inference from consumers' privacy decisions and its data-buying strategy.

And Also

Athey, Susan, Christian Catalini, and Catherine Tucker. The digital privacy paradox: Small money, small costs, small talk. No. w23488. National Bureau of Economic Research, 2017.

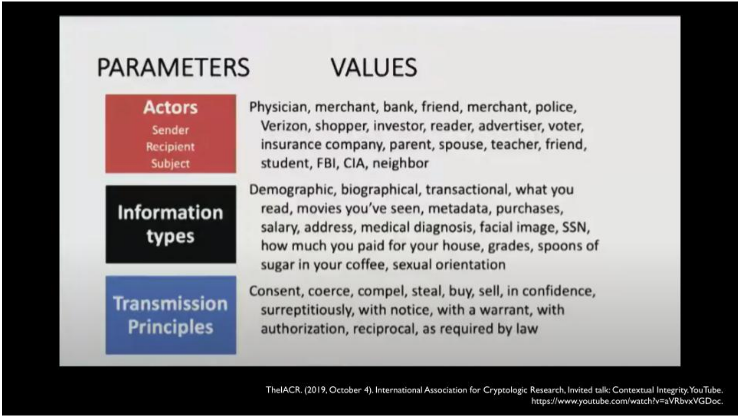
What This Tells Me We Need

Papers with individual-level privacy choice data over time across difference dimensions. Without that it is hard to make much progress given our current tool kit. (But even this would suffer truncation)

Breakdown

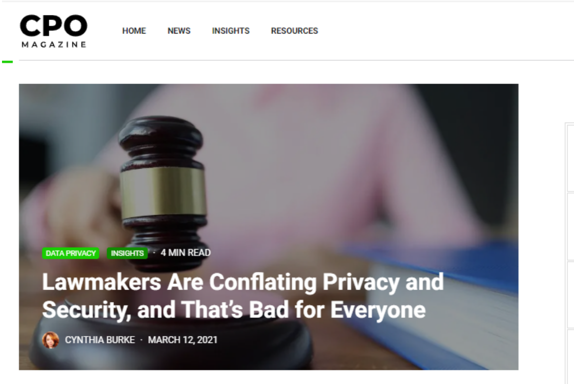
The Theory of Contextual Integrity May Give Us Insights into How To Model Heterogeneity of Privacy Preferences Across Domains, Times and Individuals

Contextual Integrity Theory: Helen Nissenbaum



Breakdown

Can This Framework Help Us Distinguish Between Information Security and Privacy Concerns?



Breakdown

American Economic Review: Papers & Proceedings 2012, 102(3): 349–353
http://dx.doi.org/10.1257/aer.102.3.349

Shifts in Privacy Concerns†

By Avi Goldfarb and Catherine Tucker*

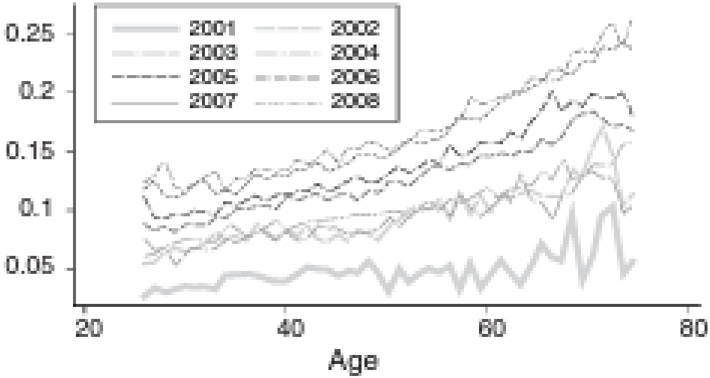


Figure 1. Fraction Refusing to Reveal Income by Age and Year

Inferences From Data Created In Your Youth

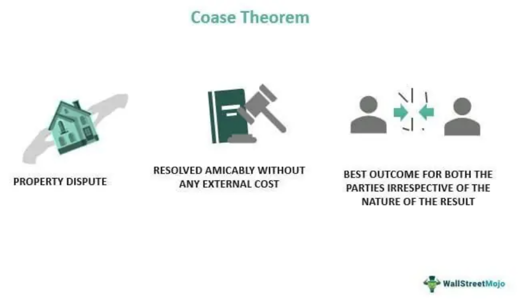
In Depth

Outstanding Questions

- The Value of Privacy
- Markets and Privacy
  - Property Rights and Privacy
  - Individual Data Markets
  - Competitive Dynamics and Privacy
- The Spread of Privacy Protective Technologies
- Algorithmic Privacy
- The Broader Economy and Privacy

Breakdown

All Economists When Asked to Comment on Privacy



But are Property Rights Easy to Define?

- Beyond Binary Data
- Spillovers
- Inferences Rather than Data

Breakdown

Outstanding Questions

- The Value of Privacy
- Markets and Privacy
  - Property Rights and Privacy
  - Individual Data Markets
  - Competitive Dynamics and Privacy
- The Spread of Privacy Protective Technologies
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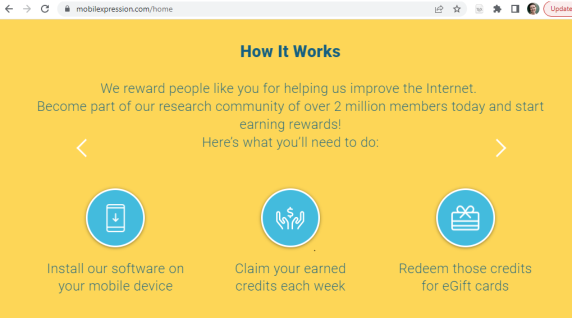
- The Broader Economy and Privacy

Why haven’t Individual Data Markets worked?



One obvious explanation is asymmetric information and moral hazard

Another explanation is that data is just very cheap

technical.ly/startups/how-drunk-mode-app-became-data-location-company-x-mode-social/

Technical.ly

STARTUPS

Feb. 27, 2020 12:45 pm

How Drunk Mode, an app for the inebriated, became data location company X-Mode Social

The Reston, Virginia-based company pivoted from an earlier app known as a "condom for your phone" and is now working to drive data collection to be "a more transparent, privacy-conscious industry."

Breakdown

Outstanding Questions
- The Value of Privacy
- Markets and Privacy
  - Property Rights and Privacy
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  - Competitive Dynamics and Privacy
- The Spread of Privacy Protective Technologies
- Algorithmic Privacy
- The Broader Economy and Privacy

Privacy & Market Concentration: Intended & Unintended Consequences of the GDPR

57 Pages • Posted: 15 Nov 2019 • Last revised: 22 Sep 2022

Garrett Johnson
Questrom School of Business

Scott Shriver
University of Colorado at Boulder - Department of Marketing

Samuel Goldberg
Stanford Institute for Economic Policy Research

Date Written: September 21, 2022

Abstract

We show that websites' vendor use falls after the European Union's General Data Protection Regulation (GDPR), but that market concentration also increases among technology vendors that provide support services to websites. We collect panel data on the web technology vendors selected by more than 27,000 top websites internationally. The week after the GDPR's enforcement, website use of web technology vendors falls by 15% for EU residents. Websites are relatively more likely to retain top vendors, which increases the concentration of the vendor market by 17%. Increased concentration predominantly arises among vendors that use personal data such as cookies, and from the increased relative shares of Facebook and Google-owned vendors, but not from website consent requests. Though the aggregate changes in vendor use and vendor concentration dissipate by the end of 2018, we find that the GDPR impact persists in the advertising vendor category most scrutinized by regulators. Our findings shed light on potential explanations for the sudden drop and subsequent rebound in vendor usage.

Keywords: Privacy, GDPR, Competition, Web Technology, Regulatory compliance

JEL Classification: D04, K21, L11, L22, L51, L86, M30, M38, O38

Suggested Citation:

Let’s Look at the Dynamics Elsewhere

Global EdTech and Smart Classrooms Market Report 2022-2027 Featuring Leading Players - Apple, Cisco, Blackboard, IBM, Dell EMC, Google, Microsoft, Oracle, SAP, & Instructure - ResearchAndMarkets.com

ugust 04, 2022 08:37 AM Eastern Daylight Time

UBLIN--(BUSINESS WIRE)--The "Global EdTech and Smart Classrooms Market by Hardware (Interactive splays, Interactive Projectors), Education System Solution (LMS, TMS, DMS, SRS, Test Preparation, earning & Gamification), Deployment Type, End User and Region - Forecast to 2027" report has been dded to **ResearchAndMarkets.com's** offering.

lobal EdTech and Smart lassrooms Market by ardware (Interactive Displays, teractive Projectors), ducation System Solution (LMS, TMS, DMS, SRS, Test Preparation, Learning & Gamification), Deployment Type, End User and Region -

The publisher forecasts the global EdTech and smart classrooms market to grow from USD 125.3 billion in 2022 to USD 232.9 billion by 2027, at a Compound Annual Growth Rate (CAGR) of 13.2%

The major factors driving the growth of the EdTech and smart classrooms market include growing adoption of eLearning solutions, impact of COVID-19 pandemic and growing need for online teaching-learning models to continue education system in lockdown.

In Depth

Breakdown

Let’s Move Beyond Studies of Ad Blocking and Move to the Firm

Product Category Descriptions

Privacy program management – solutions designed specifically for the privacy office.

Assessment managers tend to automate different functions of a privacy program, such as operationalizing privacy impact assessments, locating risk gaps, demonstrating compliance and helping privacy officers scale complex tasks requiring spreadsheets, data entry and reporting.

Consent managers help organizations collect, track, demonstrate and manage users’ consent.

Data mapping solutions can come in manual or automated form and help organizations determine data flows throughout the enterprise.

Data subject request solutions help organizations facilitate inquires made by individuals who wish to exercise their data rights. These can include requests involving the right to access, rectification, portability and erasure.

Incident response solutions help companies respond to a data breach incident by providing information to relevant stakeholders of what was compromised and what notification obligations must be met.

Privacy information managers provide organizations with extensive and often automated information on the latest privacy laws around the world.

Website scanning is a service that primarily checks a client’s website to determine what cookies, beacons and other trackers are embedded to help

Enterprise privacy management – solutions designed to service the needs of the privacy office alongside the overall business needs of an organization.

Activity monitoring helps organizations determine who has access to personal data and when it is being accessed or processed. These solutions often come with controls to help manage activity.

Data discovery tends to be an automated technology that helps organizations determine and classify what kind of personal data they possess to help manage privacy risk and compliance.

Deidentification/Pseudonymity solutions help data scientists, researchers and other stakeholders derive value from datasets without compromising the privacy of the data subjects in a given dataset.

Enterprise communications are solutions that help organizations communicate internally in a secure way to avoid embarrassing or dangerous leaks of employee communications.

Breakdown

Costs of Regulation or Privacy Enhancing?

2022 Privacy Tech VENDOR REPORT

By IAPP Staff Writer Alex LaCasse

The IAPP presents its sixth annual "Privacy Tech Vendor Report." In previous editions, the report examined the growth and trends of the privacy technology marketplace year over year. This issue, the IAPP lists 364 privacy technology vendors, each featured in the directory section of this report.

In the last six years, privacy tech has become a critical industry offering solutions for an ever-evolving global regulatory system that places a greater emphasis on user privacy. A key takeaway is that while the privacy tech industry has grown exponentially, it stands on the precipice of a fundamental sea change, facing possible consolidation and specialization geared toward specific customer solutions.

This year's "Privacy Tech Vendor Report" finds the industry at a crossroads of sorts. As privacy has shifted from an afterthought to a necessity within the last decade, the conversation today regarding its place in product development has evolved from the abstract to the technical implementation of an array of solutions.

"Companies are now moving toward understanding what their privacy tech

Chief Strategy Officer Mark Thompson, CIPP/E, CIPM, CIPT, FIP. "For the vendors that have 'got it right,' there is a clear opportunity to differentiate from the pack by showing an enhanced understanding of customer needs and how their products help solve these challenges."

Astrachain co-founder and CEO Yosra Jarraya said the privacy tech marketplace has grown past the point of solely playing catch-up with the implementation and enforcement of privacy laws around the world. Instead, it now looks to build comprehensive technical solutions to big-picture data security concerns.

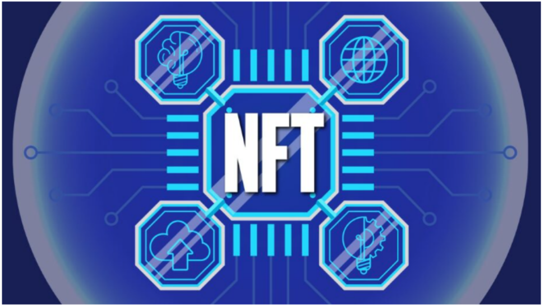
> *Companies are now moving toward understanding what their privacy tech requirements are, and I can't say enough about how that was just not a thing, even a few years ago.*

Breakdown

Perhaps you can do better that me here....

Cryptoeconomy: NFTs could be the way to data privacy

Por *staff* -04/08/2022



"Anything that you post on the internet isn't yours anymore." A lot of us who grew up in the age of the internet heard that a lot because it's virtually true. Once you post something online, any and everybody can download it, manipulate it and you have no control over it. **However, this might be changing with the introduction of NFTs as the next resource for digital identity management and data privacy.**

In Depth

Outstanding Questions

- The Value of Privacy
- Markets and Privacy
- The Spread of Privacy Protective Technologies
- Algorithmic Privacy
  - Inferential Privacy
- The Broader Economy and Privacy

Breakdown

Outstanding Questions

- The Value of Privacy
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- Algorithmic Privacy
  - Inferential Privacy
- The Broader Economy and Privacy

Do we care about data privacy or inferential privacy?

Private traits and attributes are predictable from digital records of human behavior

Michal Kosinski[a,1], David Stillwell[a], and Thore Graepel[b]

[a]Free School Lane, The Psychometrics Centre, University of Cambridge, Cambridge CB2 3RQ United Kingdom; and [b]Microsoft Research, Cambridge CB1 2FB, United Kingdom

Edited by Kenneth Wachter, University of California, Berkeley, CA, and approved February 12, 2013 (received for review October 29, 2012)

We show that easily accessible digital records of behavior, Facebook Likes, can be used to automatically and accurately predict a range of highly sensitive personal attributes including: sexual orientation, ethnicity, religious and political views, personality traits, intelligence, happiness, use of addictive substances, parental separation, age, and gender. The analysis presented is based on a dataset of over 58,000 volunteers who provided their Facebook Likes, detailed demographic profiles, and the results of several psychometric tests. The proposed model uses dimensionality reduction for preprocessing the Likes data, which are then entered into logistic/linear regression to predict individual psychodemographic profiles from Likes. The model correctly discriminates between homosexual and heterosexual men in 88% of cases, African Americans and Caucasian Americans in 95% of cases, and between Democrat and Republican in 85% of cases. For the personality trait "Openness," prediction accuracy is close to the test-retest accuracy of a standard personality test. We give examples of associations between attributes and Likes and discuss implications for online personalization and privacy.

social networks | computational social science | machine learning | big data | data mining | psychological assessment

browsing logs (11–15). Similarly, it has been shown that personality can be predicted based on the contents of personal Web sites (16), music collections (17), properties of Facebook or Twitter profiles such as the number of friends or the density of friendship networks (18–21), or language used by their users (22). Furthermore, location within a friendship network at Facebook was shown to be predictive of sexual orientation (23).

This study demonstrates the degree to which relatively basic digital records of human behavior can be used to automatically and accurately estimate a wide range of personal attributes that people would typically assume to be private. The study is based on Facebook Likes, a mechanism used by Facebook users to express their positive association with (or "Like") online content, such as photos, friends' status updates, Facebook pages of products, sports, musicians, books, restaurants, or popular Web sites. Likes represent a very generic class of digital records, similar to Web search queries, Web browsing histories, and credit card purchases. For example, observing users' Likes related to music provides similar information to observing records of songs listened to online, songs and artists searched for using a Web search engine, or subscriptions to related Twitter channels. In contrast to these other sources of information, Facebook Likes are unusual in that they are currently publicly available by default. However

Inferential Privacy Makes Real The Question of The Unpredictability of Algorithmic Progress

In Depth

Breakdown

Technology

Amazon to Bring Same-Day Delivery to Roxbury After Outcry

- Largely black Boston neighborhood was excluded from service
- Illinois Congressman wants FTC to investigate delivery areas

Photographer: David Paul Morris/Bloomberg

By Spencer Soper
April 26, 2016 at 5:19 PM EDT *Updated on April 26, 2016 at 8:22 PM EDT*

The Mirror of Privacy Policy: Data Deserts

Breakdown

Outstanding Questions

- The Value of Privacy
- Markets and Privacy
- The Spread of Privacy Protective Technologies
- Algorithmic Privacy
- The Broader Economy and Privacy
  - Privacy and Inequality
  - The Political Economy of Government Surveillance
  - Privacy and Trade

AI-tocracy
Martin Beraja, Andrew Kao, David Y. Yang, and Noam Yuchtman
NBER Working Paper No. 29466
November 2021
JEL No. E00,L5,L63,O25,O30,O40,P00

ABSTRACT

Can frontier innovation be sustained under autocracy? We argue that innovation and autocracy can be mutually reinforcing when: (i) the new technology bolsters the autocrat's power; and (ii) the autocrat's demand for the technology stimulates further innovation in applications beyond those benefiting it directly. We test for such a mutually reinforcing relationship in the context of facial recognition AI in China. To do so, we gather comprehensive data on AI firms and government procurement contracts, as well as on social unrest across China during the last decade. We first show that autocrats benefit from AI: local unrest leads to greater government procurement of facial recognition AI, and increased AI procurement suppresses subsequent unrest. We then show that AI innovation benefits from autocrats' suppression of unrest: the contracted AI firms innovate more both for the government and commercial markets. Taken together, these results suggest the possibility of sustained AI innovation under the Chinese regime: AI innovation entrenches the regime, and the regime's investment in AI for political control stimulates further frontier innovation.

Added Inducement

Government Surveillance and Internet Search Behavior

53 Pages • Posted: 23 Mar 2014 • Last revised: 15 Mar 2017

Alex Marthews
Digital Fourth / Restore The Fourth

Catherine E. Tucker
Massachusetts Institute of Technology (MIT) - Management Science (MS)

Date Written: February 17, 2017

Abstract

This paper displays data from the US and its top 40 trading partners on the search volume of select keywords from before and after the surveillance revelations of June 2013, to analyze whether Google users' search behavior changed as a result. The surveillance revelations are treated as an exogenous shock in information about how closely users' internet searches were being monitored by the US government. Each search term was independently rated for its degree of privacy sensitivity along multiple dimensions. Using panel data, our results suggest that search terms that were deemed both personally-sensitive and government-sensitive were most negatively affected by the PRISM revelations, highlighting the interplay between privacy concerns relating to both the government and the private individual. Perhaps surprisingly, the largest `chilling effects' were not found in countries conventionally treated as intelligence targets by the US, but instead in countries that were more likely to be considered allies of the US. We show that this was driven in part by a fall in searches on health-related terms. Suppressing health information searches potentially harms the health of search engine users and, by reducing traffic on easy-to-monetize queries, also harms search engines' bottom line. In general, our results suggest that there is a chilling effect on search behavior from government surveillance on the Internet, and that government surveillance programs may damage the profitability of US-based internet firms relative to non-US-based internet firms.

Keywords: surveillance, Snowden, prism, chilling effects, international trade

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  - Privacy and Trade

F.C.C. Readies Vote on Banning New Huawei and ZTE Devices

The vote, which is expected to pass, is required by a law that President Biden signed last year.

Give this article

Jessica Rosenworcel, the F.C.C. chairwoman, said the agency "remains committed to protecting our national security by ensuring that untrustworthy communications equipment is not authorized for use within our borders." Pool photo by Jonathan Newton

By David McCabe and Cecilia Kang
Oct. 13, 2022 Updated 2:33 p.m. ET

https://www.protocol.com/bulletins/pri...

protocol

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Biden hopes privacy appeals for EU citizens will save data flows

The president is signing an order implementing the details of an agreement with the EU to replace Privacy Shield.

Agenda

Challenges to Studying Privacy as an Economist

The History of the Economics of Privacy

Outstanding Questions

Algorithmic Bias

Punchline

Outline

Some notes on the framing of the issue

- How the privacy debate has moved from privacy to data-based discrimination to algorithmic bias

The debate on privacy harms has moved on to algorithmic discrimination

Home > Management Science > Vol. 65, No. 7 >

Algorithmic Bias? An Empirical Study of Apparent Gender-Based Discrimination in the Display of STEM Career Ads

Anja Lambrecht, Catherine Tucker

Published Online: 10 Apr 2019 | https://doi.org/10.1287/mnsc.2018.3093

Abstract

We explore data from a field test of how an algorithm delivered ads promoting job opportunities in the science, technology, engineering and math fields. This ad was explicitly intended to be gender neutral in its delivery. Empirically, however, fewer women saw the ad than men. This happened because younger women are a prized demographic and are more expensive to show ads to. An algorithm that simply optimizes cost-effectiveness in ad delivery will deliver ads that were intended to be gender neutral in an apparently discriminatory way, because of crowding out. We show that this empirical regularity extends to other major digital platforms.

The FTC Echoes This

BILLING CODE: 6750-01-P

FEDERAL TRADE COMMISSION

16 CFR Part 464

Trade Regulation Rule on Commercial Surveillance and Data Security

AGENCY: Federal Trade Commission.

ACTION: Advance notice of proposed rulemaking; request for public comment; public forum.

SUMMARY: The Federal Trade Commission ("FTC") is publishing this advance notice of proposed rulemaking ("ANPR") to request public comment on the prevalence of commercial surveillance and data security practices that harm consumers. Specifically, the Commission invites comment on whether it should implement new trade regulation rules or other regulatory alternatives concerning the ways in which companies (1) collect, aggregate, protect, use, analyze, and retain consumer data, as well as (2) transfer, share, sell, or otherwise monetize that data in ways that are unfair or deceptive.

Why might algorithms be biased?

- Biased Programmers
- Biased training data
- Bias is learned from humans interacting with the algorithm

What can economists do to inform the algorithmic bias debate

- Explore areas where we can understand the mechanism which might explain algorithmic bias (**?**)
- Point out counterfactual thinking and the existing economics literature (**?**)

Agenda

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Returning to the idea of what is different: Punchline

1. data persistence
2. data spillovers
3. data repurposing

What questions are open for the field

1. Are there ways of measuring privacy preferences?
2. Do consumers value personalize advertising?
3. Do consumers distinguish between data privacy and data security?
4. Do consumers have hyperbolic discounting when it comes to future data use? How can we characterize uncertainty over data reuse?
5. Is there any win on the idea of ‘privacy competition’ Or is there always a tradeoff between privacy and competition?
6. Do sectoral or unified approaches to privacy competition work better?
7. What about privacy-protective technologies? Transaction costs or worthwhile?
8. Please study government surveillance

If I get to this final slide in our allotted time I literally won't believe it

But thank you a lot for listening and can't wait for your thoughts and ideas about where the field should go

cetucker@mit.edu

Regulation *of* and *with* Digital Platforms: An Empirical Perspective

Chiara Farronato (Harvard, CEPR, NBER)

AEA Continuing Education

San Antonio

January 8, 2024

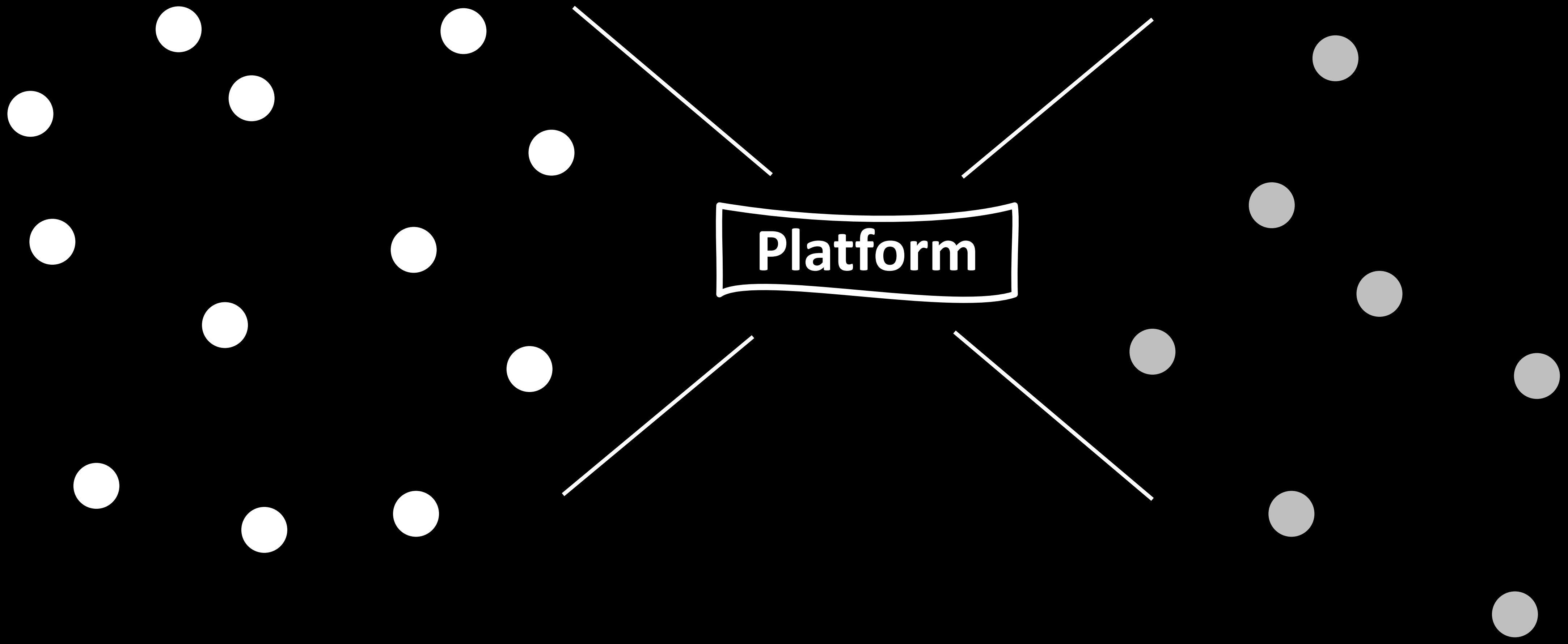
https://www.ebayinc.com/stories/news/meet-the-buyer-of-the-broken-laser-pointer/

Regulating Digital Platforms

Definitions:

- *Regulating:*
  - *Consumer protection: ensure consumers are protected from risky transactions.*
  - *Antitrust: protect consumers from abuses of dominant positions.*
- *Digital Platforms (very loose definition):*
  - *Enable interactions between two or more side of users (multi-sided platforms).*
  - *Facilitate search, matching (incl. payment), trust.*
  - *They are not all MAAMA.*

Digital Platforms as Information Aggregators



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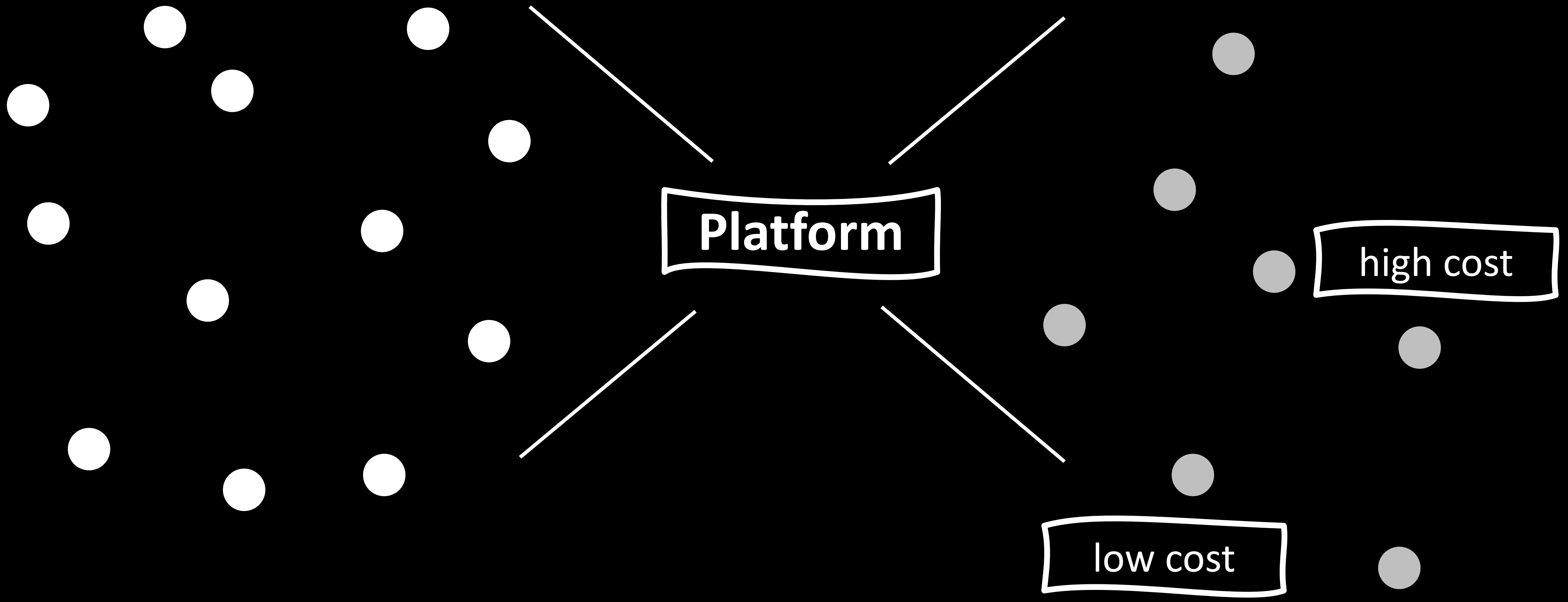

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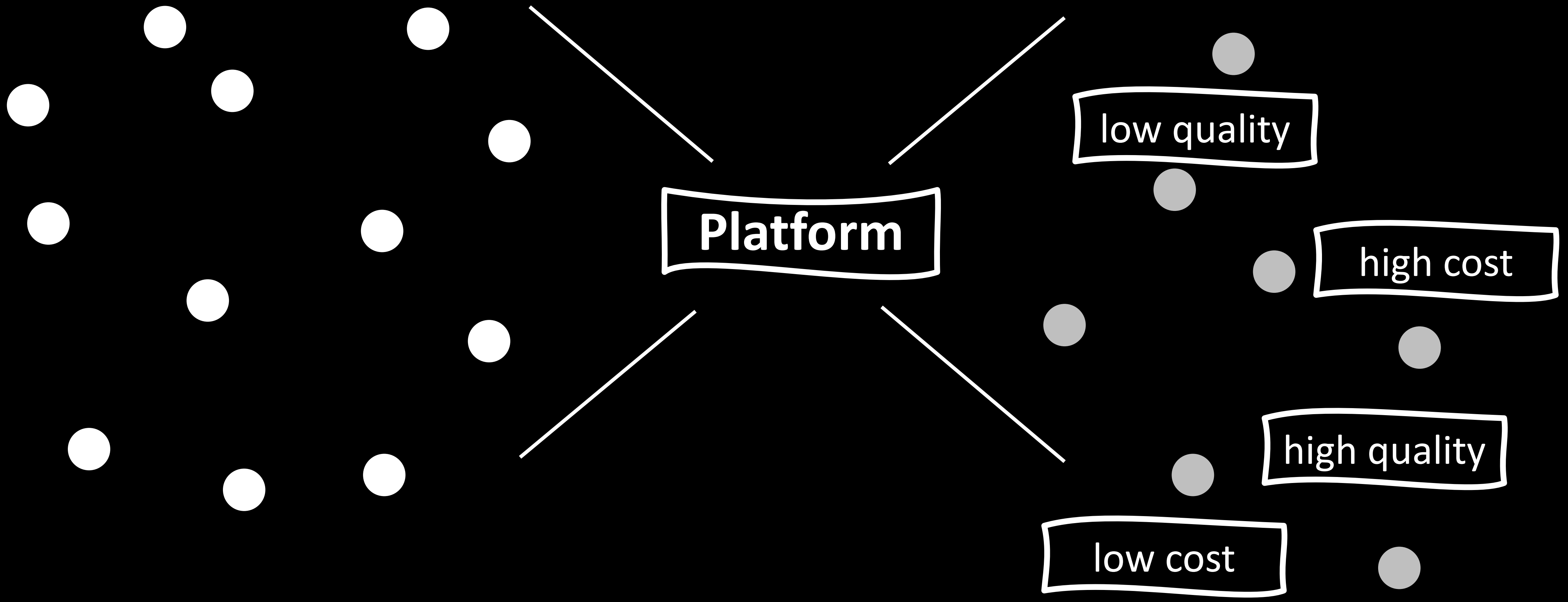

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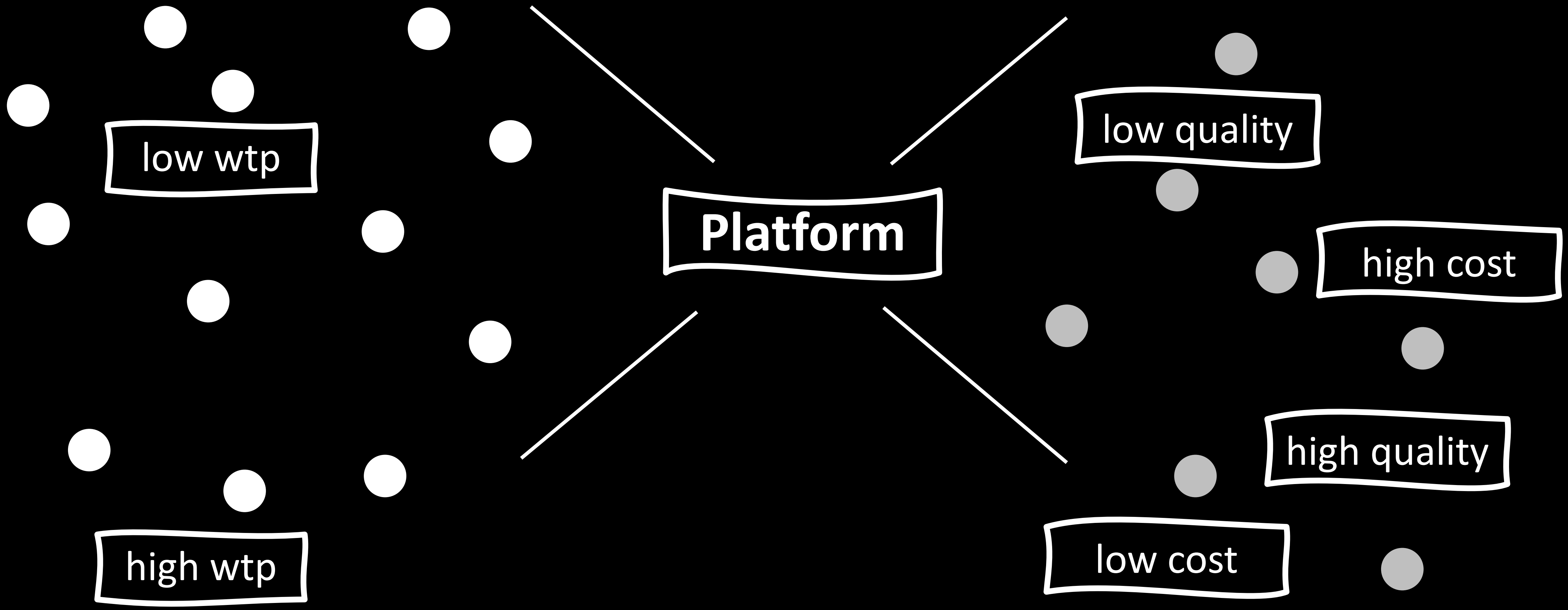

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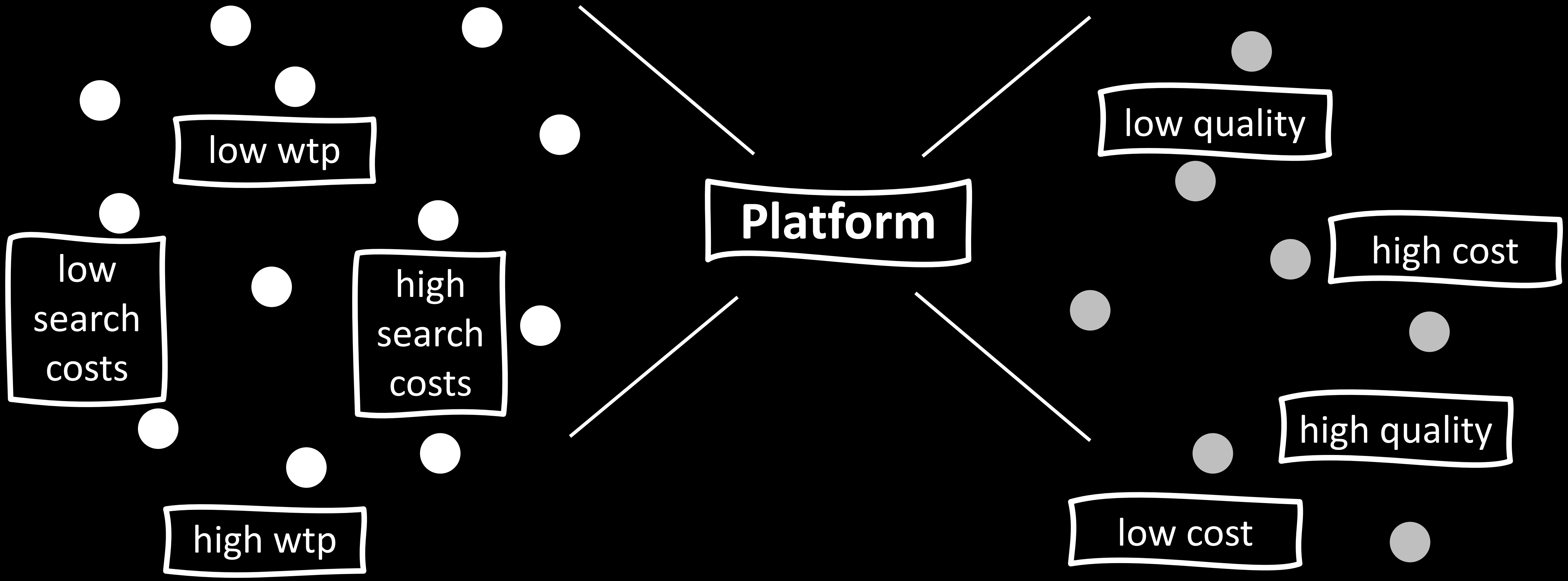


Part 1:

Regulating Consumer Protection *With* the Help of Digital Platforms.

Part 2:

Antitrust Regulation *Of* Digital Platforms.

Part 1:

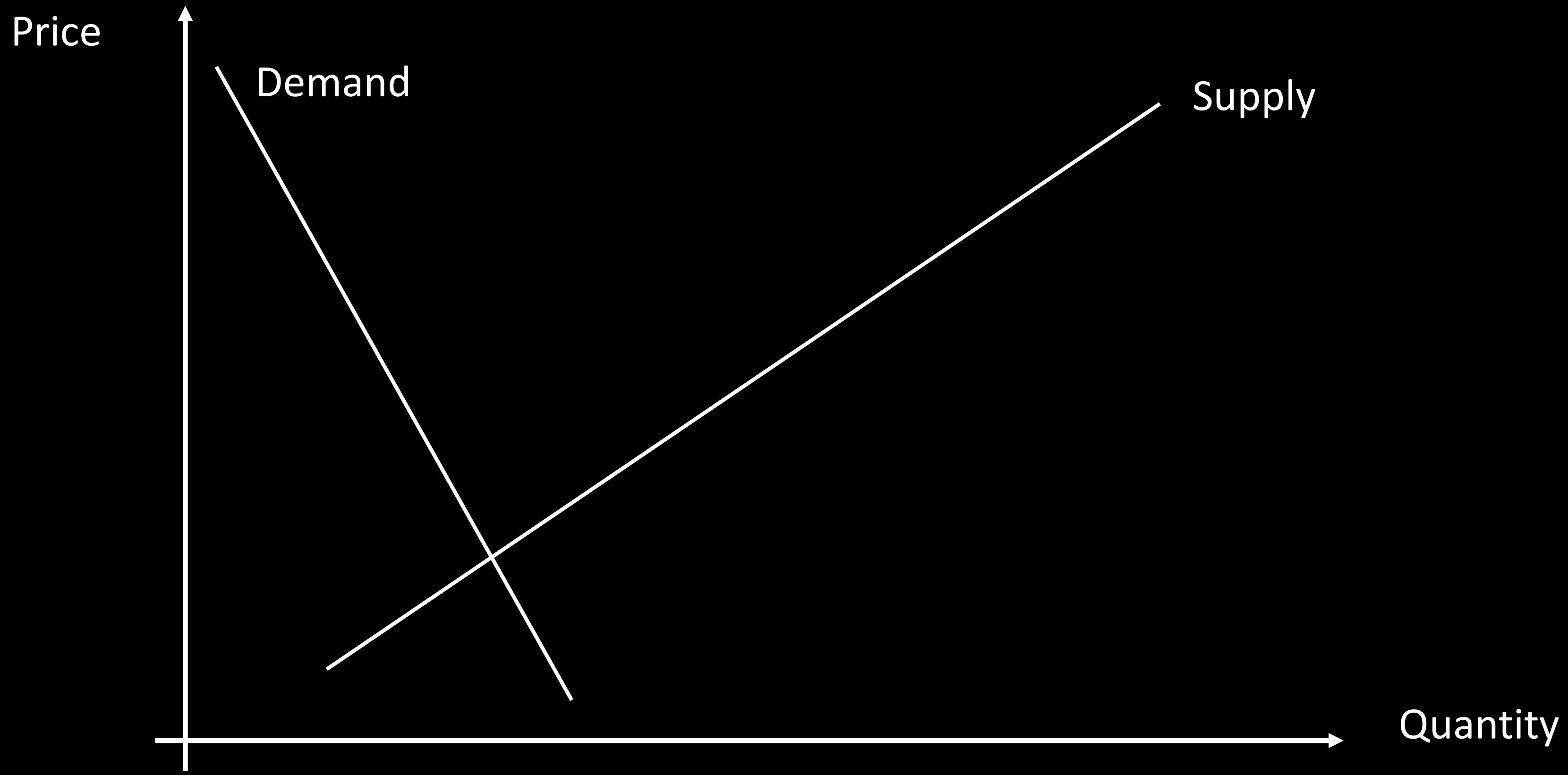
Regulating Consumer Protection *With* the Help of Digital Platforms.

Consumer Protection

- Most digital platforms enter existing markets, which are already subject to regulation…
  - Occupational Licensing.
  - Certifications.
  - Health and Safety Inspections.

Consumer Protection

- Most digital platforms enter existing markets, which are already subject to regulation… designed to address asymmetric information.



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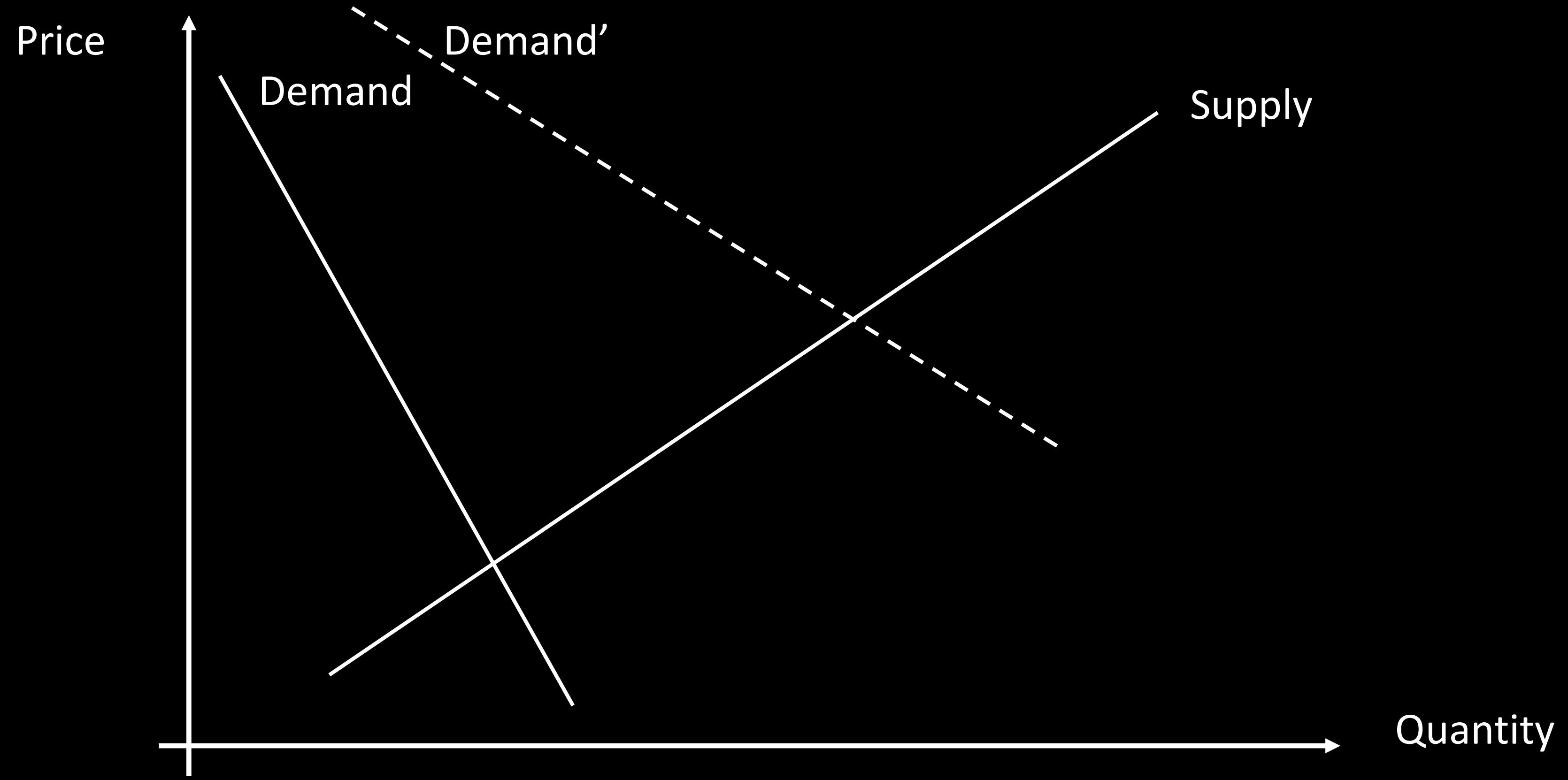

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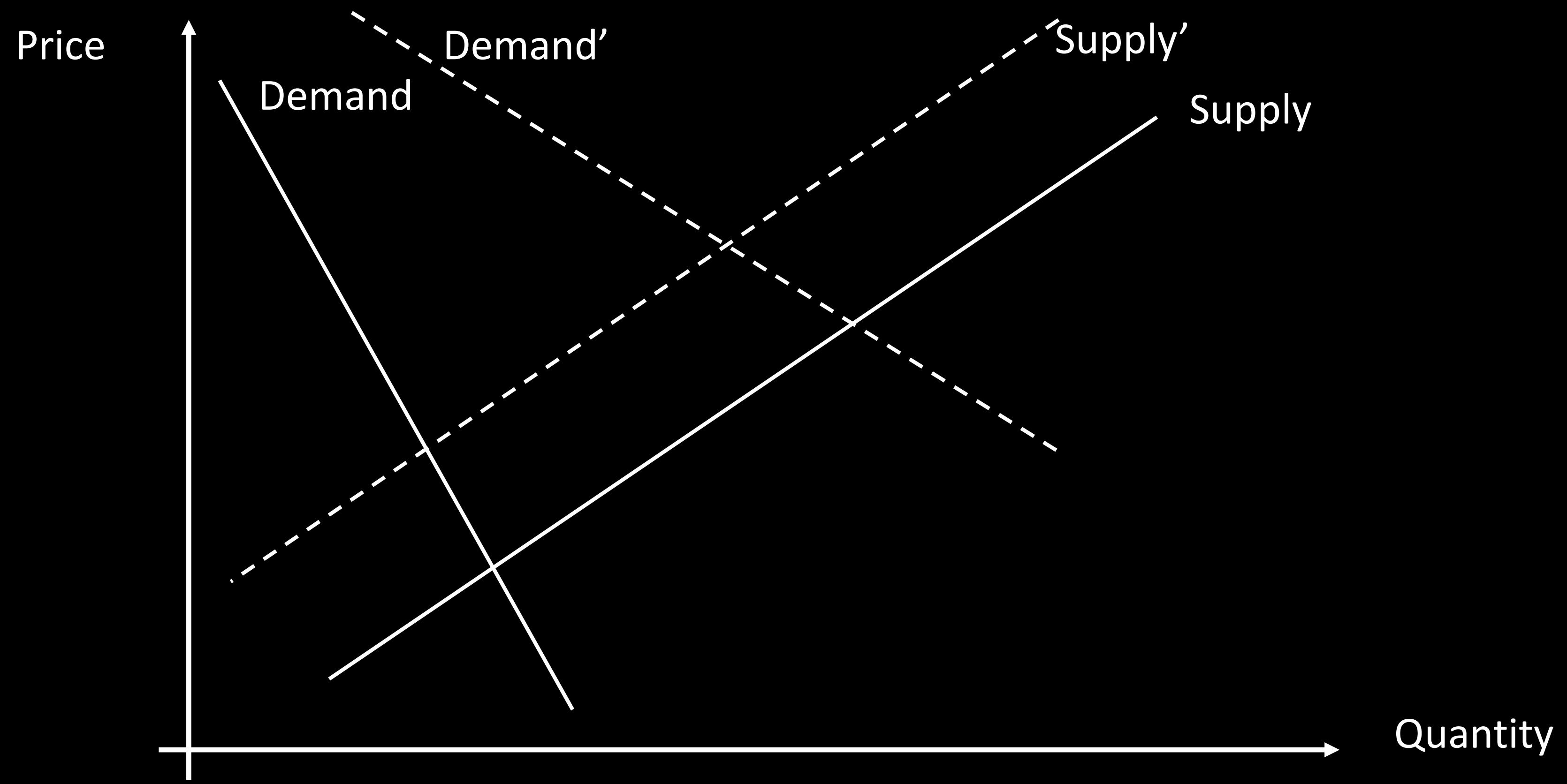

Consumer Protection

- Given it already exists, we could simply extend existing regulation to "online providers." E.g.:
  - Extend safety/accessibility regulation for hotels to Airbnb hosts.
  - Extend taxi medallion requirements for taxis to Uber/Lyft drivers.

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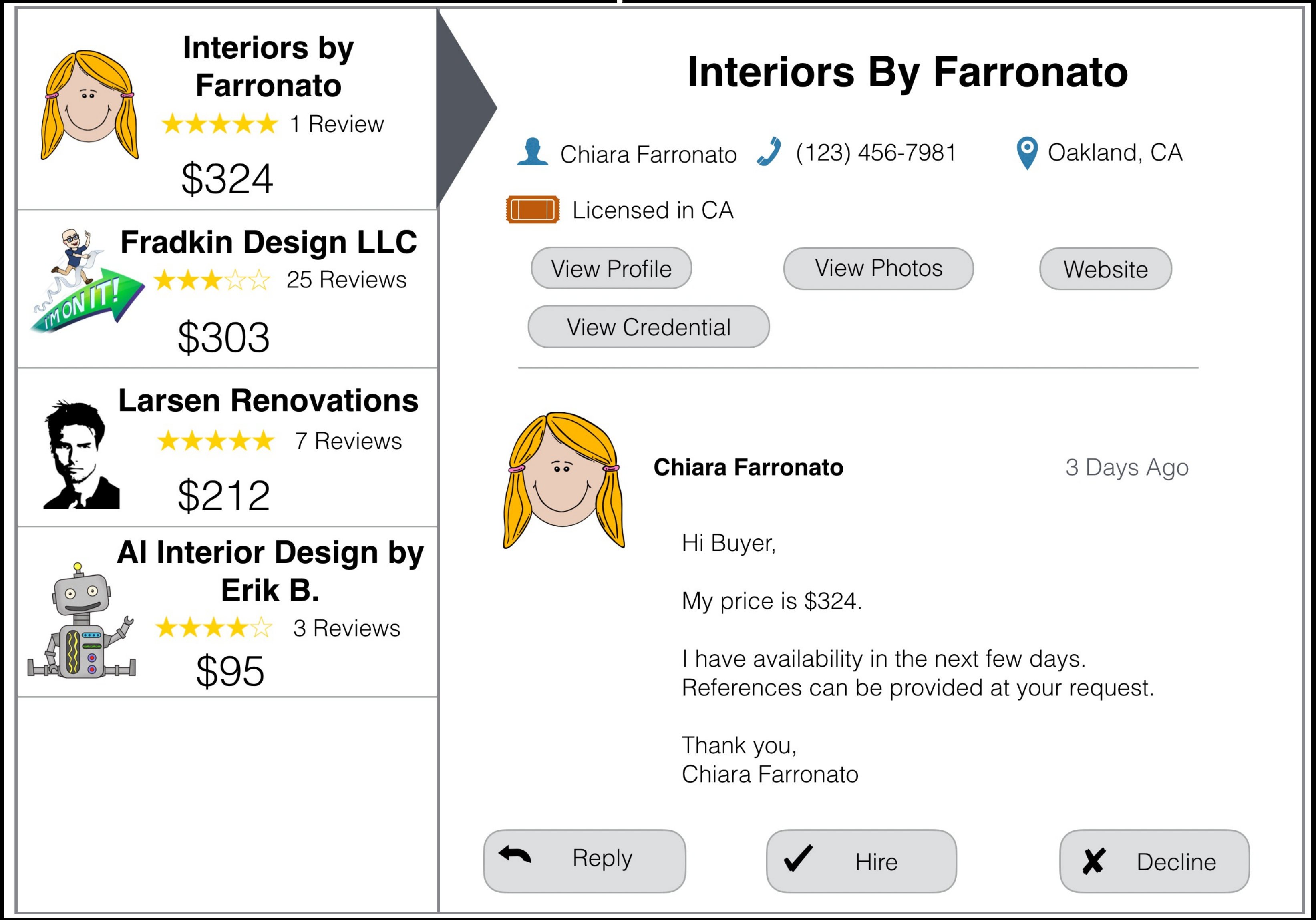
1. Is existing regulation justified in the first place?
2. Does fundamentally different supply warrant different regulation?
3. What other options are available to address asymmetric information?

1.Is Existing Regulation Justified in the First Place?

- Online platforms are becoming the primary way of finding professionals in many industries:
  - Platforms track transactions and reviews.
  - Platforms provide a new way to measure the effects of existing regulation.

<u>Consumer Protection in an Online World: An Analysis of Occupational Licensing (‘23, joint work with Fradkin, Larsen, and Brynjolfsson)</u>

Platform for Home Improvement Services



Signaling Value of Licenses v. Reviews

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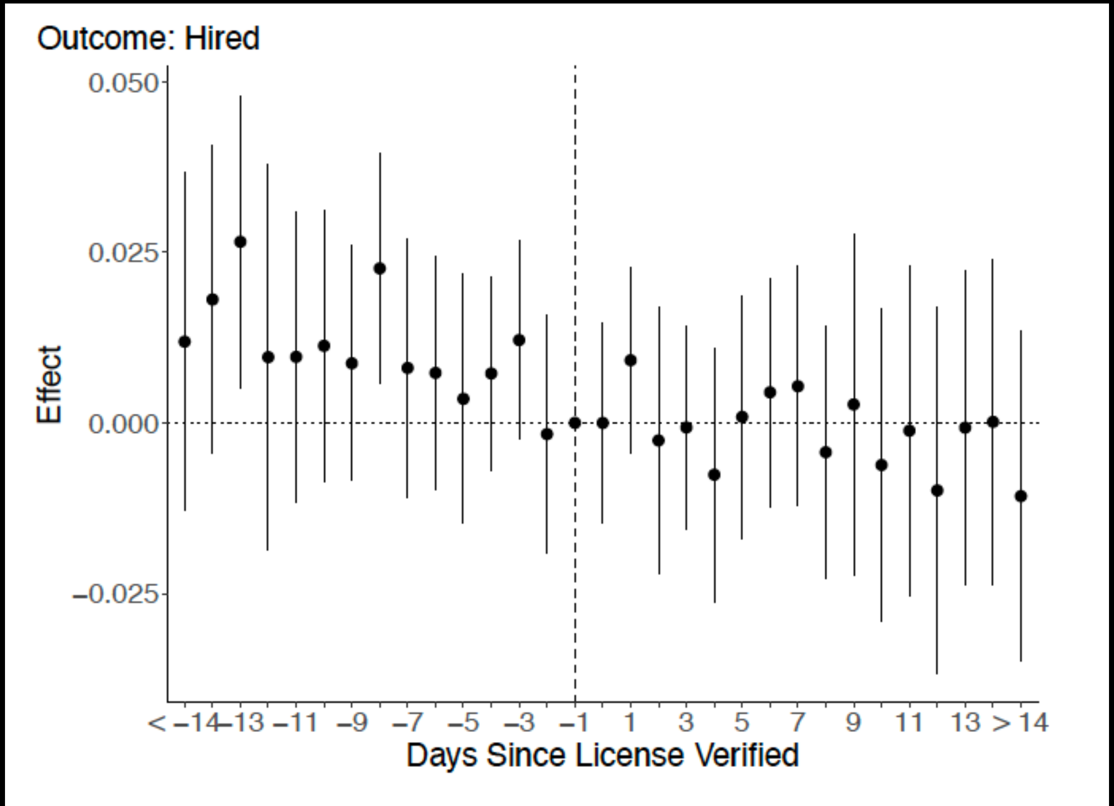
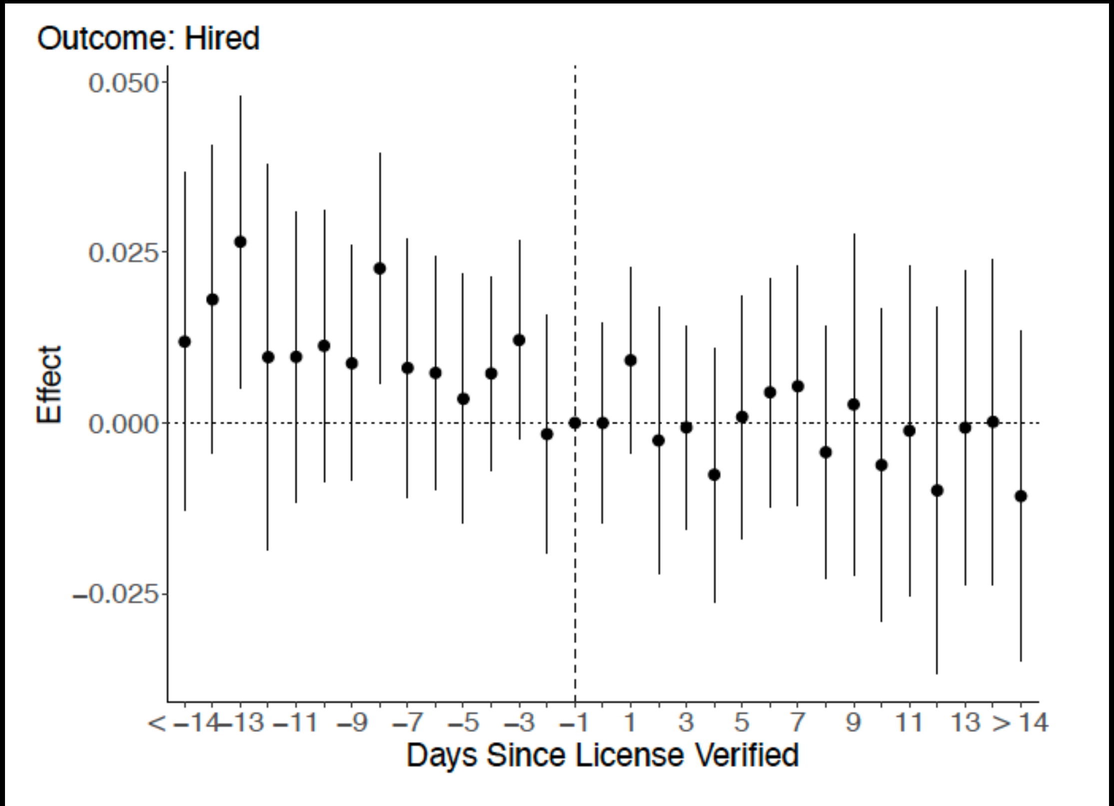
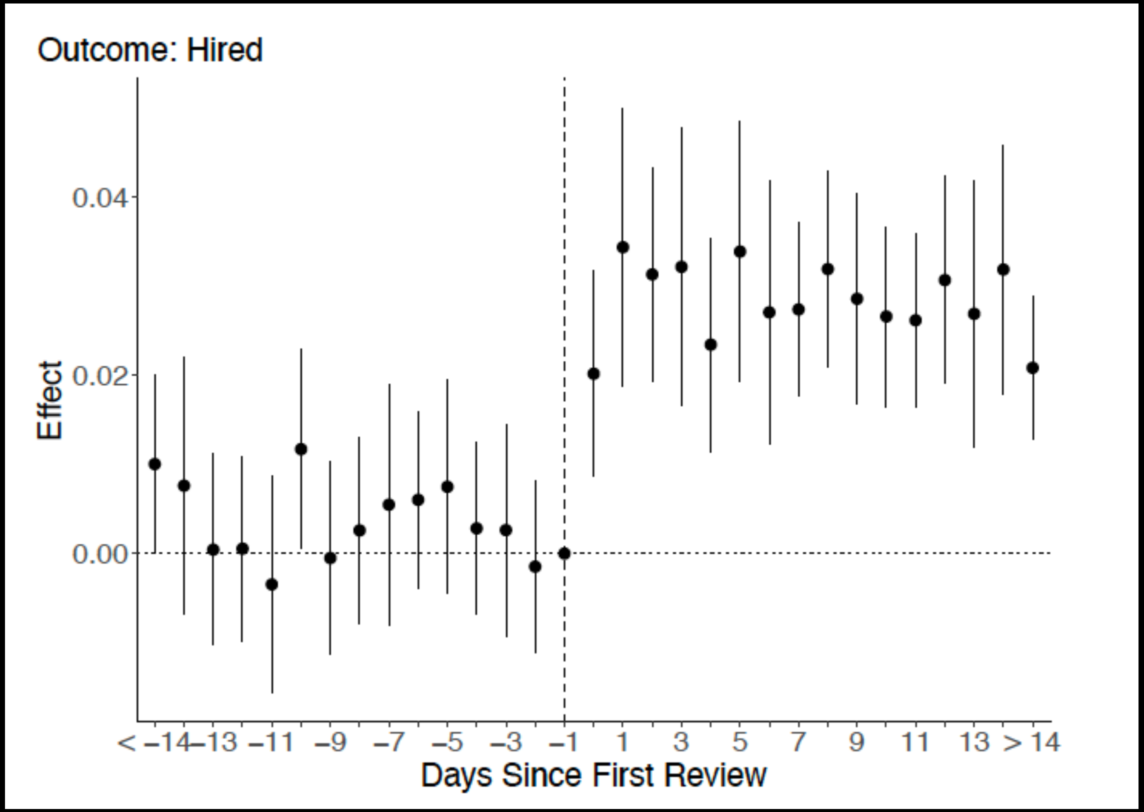


Signaling Value of Licenses v. Reviews





Equilibrium Effects of Licensing Stringency

- Exploit variation in licensing laws across US states and home improvement occupations.

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- Effect of more stringent licensing regulation on:
  - Demand:
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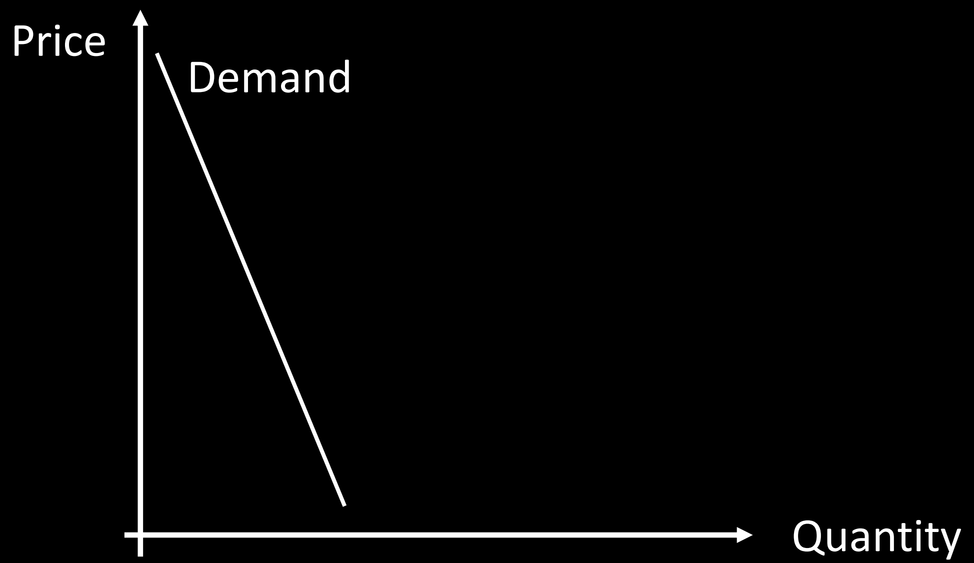

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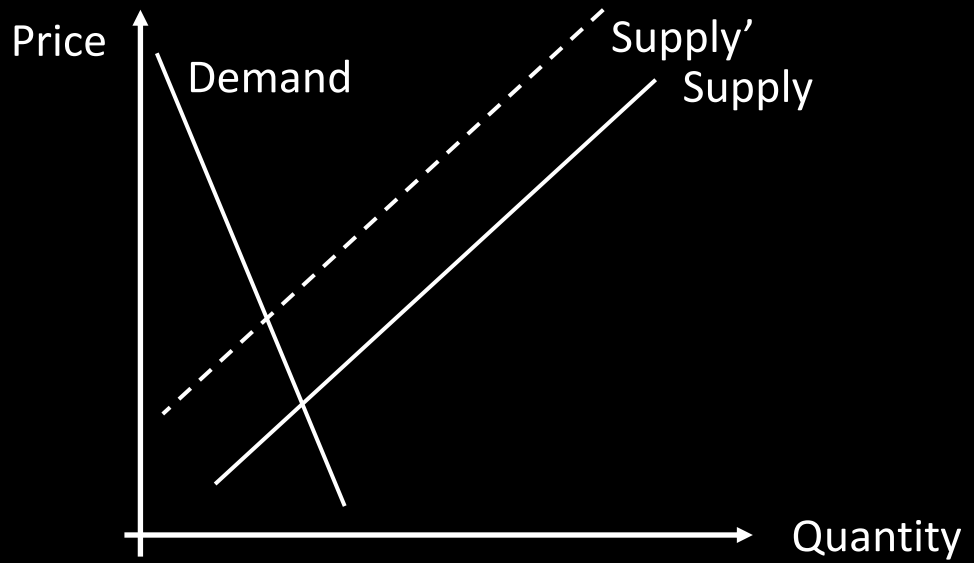

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- Open Q:
  - How can we better measure quality dimensions we should care about?
  - Which requirements (school, on job training) have largest net benefits?

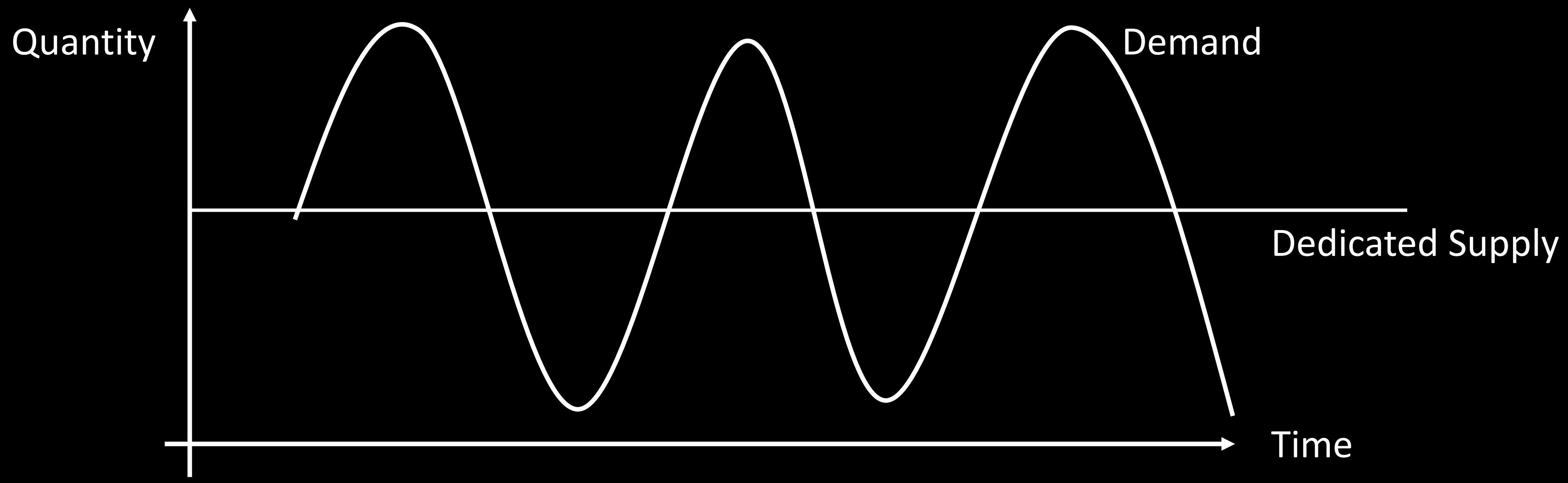
2.Does Fundamentally Different Supply Warrant Different Regulation?

- Existing regulation is designed for “professional providers.”
- This tends to generate “dedicated supply:”
  - Hotels whose rooms are available ~365 days a year;
  - Taxis who are available in ~8-hour shifts.

<u>The Welfare Effects of Peer Entry: The Case of Airbnb and the Accommodation Industry (‘22, joint with Fradkin)</u>

The Accommodations Market Before Airbnb

The Accommodations Market Before Airbnb



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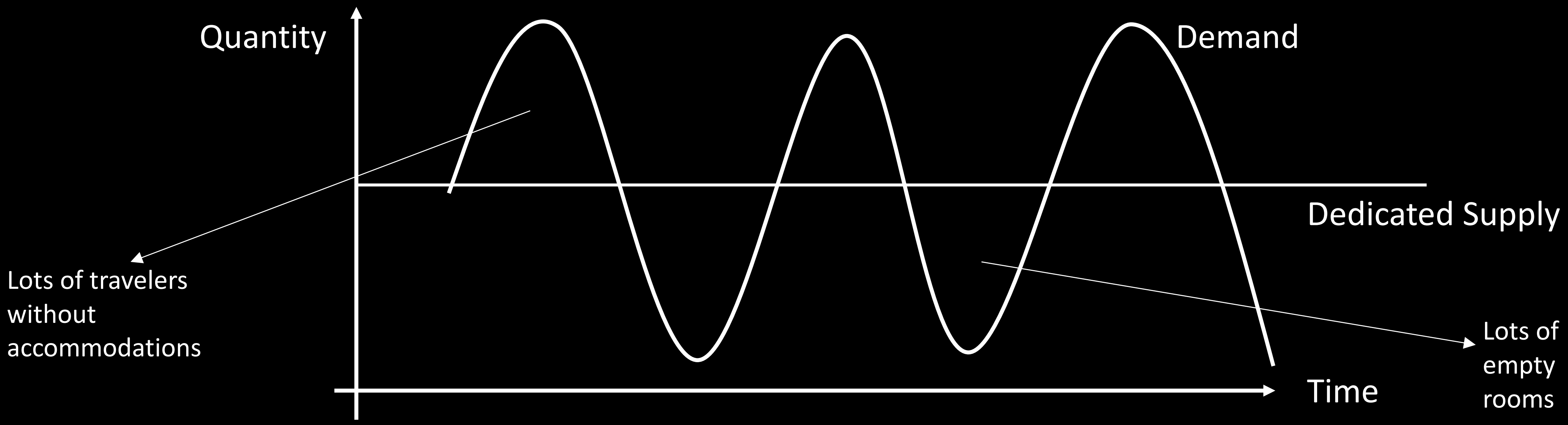

Airbnb Facilitates Entry of “Flexible Supply”

- Flexible supply is responsive to demand fluctuations, by entering when demand is high and contracting when demand is low.

- Large welfare benefits for consumers, by expanding choice set and reducing prices in periods when demand is highest and dedicated capacity is sold out.

Open Q: How to Adapt Regulation to a Mix of Flexible & Dedicated Supply?

- How should we design a two-part regulatory system while maintaining fair competition?

- How do we distinguish between “flexible” and “dedicated” supply?
  - In some cities, home-sharing hosts are subject to fewer restrictions than hotels but cannot rent to travelers for more than a few nights a year.
  - In others, ridesharing drivers are subject to fewer restrictions than taxi drivers, but also cannot perform the same pick-up/drop-offs as taxis (e.g., airports).

3. Other Options to Address Asymmetric Information?

- Existing regulation often relies on *experts' evaluations* of providers' quality.
- Can digital traces/online reputation substitute experts (Shapiro, 1986)?

<u>Consumer Reviews and Regulation: Evidence from NYC Restaurants ('23, joint with Zervas)</u>

Role of Online Reviews in Informing Consumers about Restaurant Hygiene

Peter C.
Fairfax, VA
1 friend
9 reviews

1/3/2013

halfway finishing my pho , FOUND COCKROACH inside the pho broth and had big fight with server(seems like one of the owner) after he insist on me paying for the pho.. not even apologying , told me I still have to pay for other pho which I can almost guess that it was made from same dirty pot..
WILL DEFINITELY CALL HEALTH DEPT. and most DEFINITELY they wont see me again!
freakin, disgusting S#$&!

Useful **11** Funny **2** Cool

Role of Online Reviews in Informing Consumers about Restaurant Hygiene

- On one hand:
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- On the other hand:
  - Online reviews can be informative about some hygiene dimensions (pests and food handling practices) but not others (worker hygiene).
- Open Q:
  - How can we leverage useful quality information to improve regulatory monitoring (i.e., achieve same quality with less expert effort or increasing quality with same expert effort)?

Part 2:

Antitrust Regulation *Of* Digital Platforms.

What Makes Digital Platforms Different?

Confluence of:

- Marginal and distribution costs ~ 0.
- Strong economies of scale and scope.
- Increasing marginal returns to data.
- Strong network effects.

Taken from Scott-Morton et al., 2019, “Committee for the Study of Digital Platforms,” Report, Stigler Center for the Study of of the Economy and the State. (*Stigler report*)

What Makes Digital Platforms Different?

Confluence of:

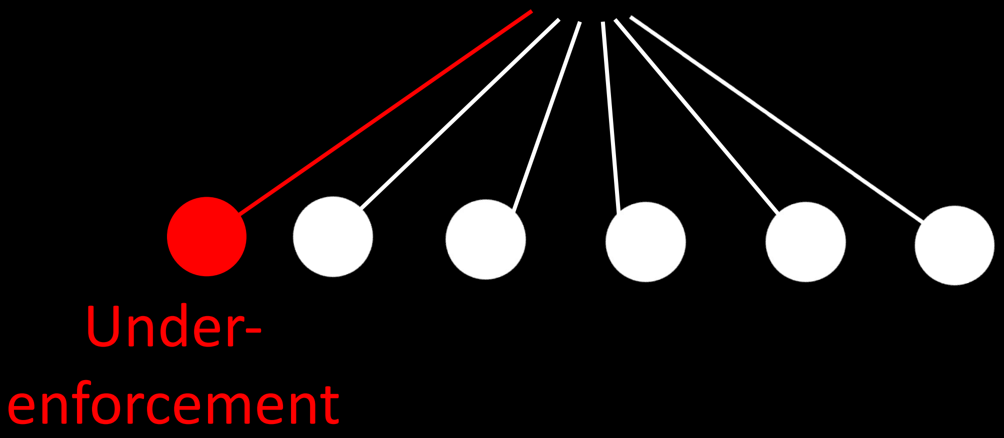
- Marginal and distribution costs ~ 0.
- Strong economies of scale and scope.
- Increasing marginal returns to data.
- Strong network effects.
  - Outside of the Big 5, unlikely to be strong enough to justify concentration of activity on a single platform (“Dog Eat Dog: Balancing Network Effects and Differentiation in a Digital Platform Merger,” ‘22, with Fong and Fradkin).
  - Treat the Big 5 as “public utilities” (Tirole, ‘14)

Taken from Scott-Morton et al., 2019, “Committee for the Study of Digital Platforms,” Report, Stigler Center for the Study of of the Economy and the State. (*Stigler report*)

Antitrust Regulation of Digital Platforms until Recently

Under-
enforcement

Antitrust Regulation of Digital Platforms going Forward



Incredibly Exciting Time to Study Platform Antitrust, but How?

- We need more work quantifying the trade-offs of various policy recommendations.
- Platforms are information aggregators, so they have plenty of data to look at.

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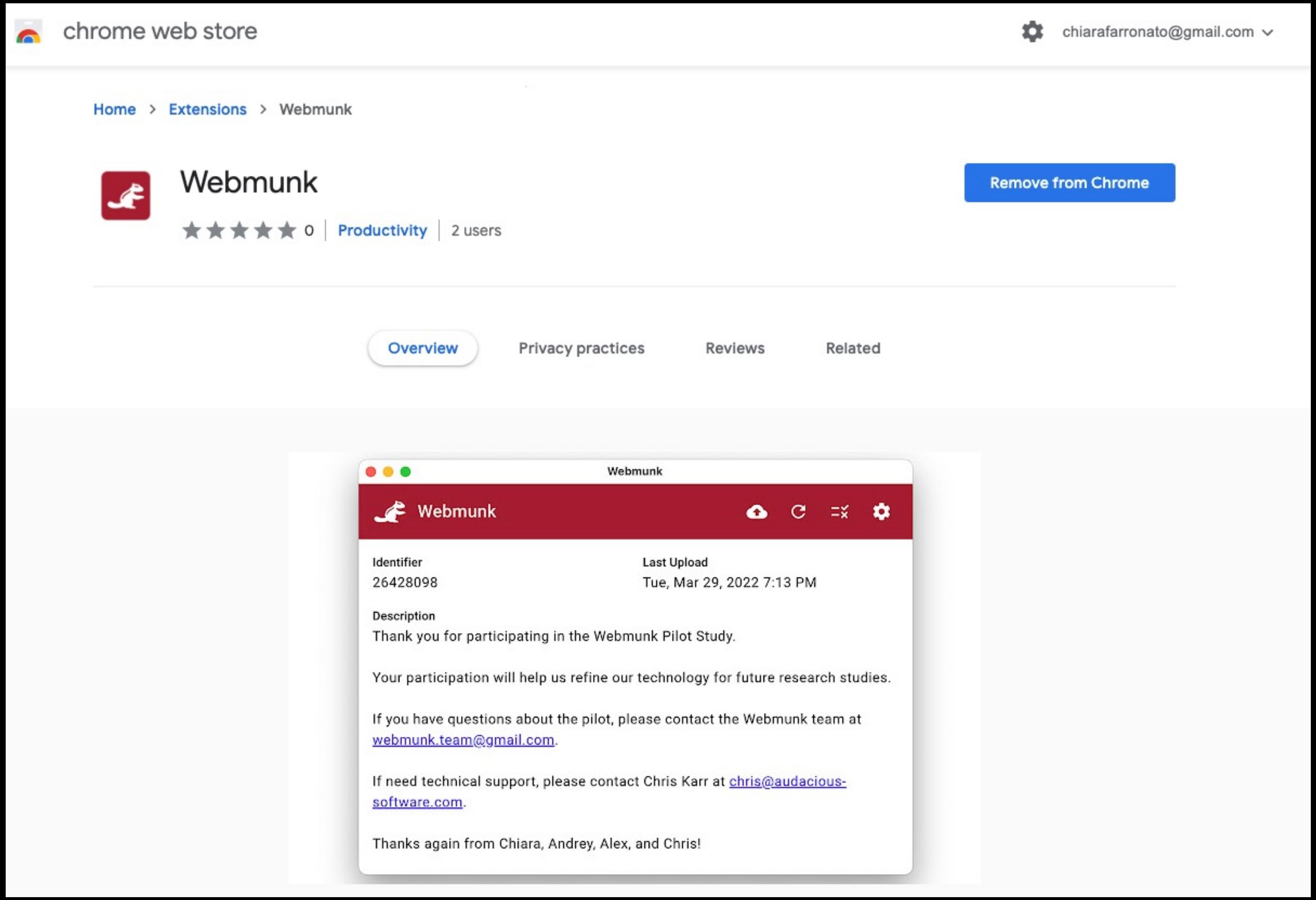
- Try knocking on Amazon's door: "I'd like to use your data to study whether you give priority to your products…"

Webmunk: A New Tool for Studying Online Behavior and Digital Platforms

A browser extension that can:

- Manipulate your browsing experience;
- Track your browsing behavior;
- Prompt you to complete additional tasks.



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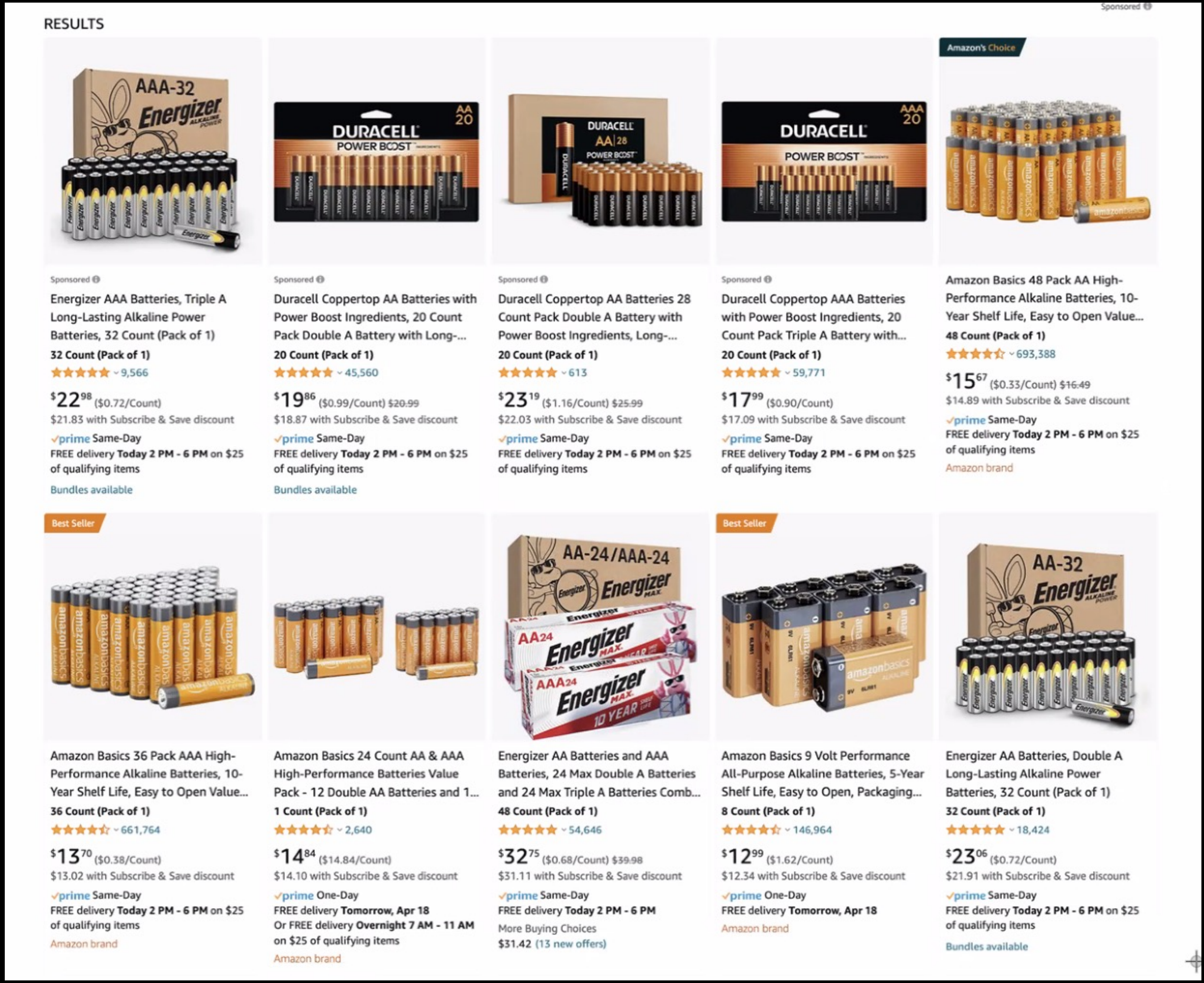

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10116956	https://www.amazon.com/s?k=contigo+coffee+trave...	2022-11-29	1666.7917	1473.0730	B09RNB862W
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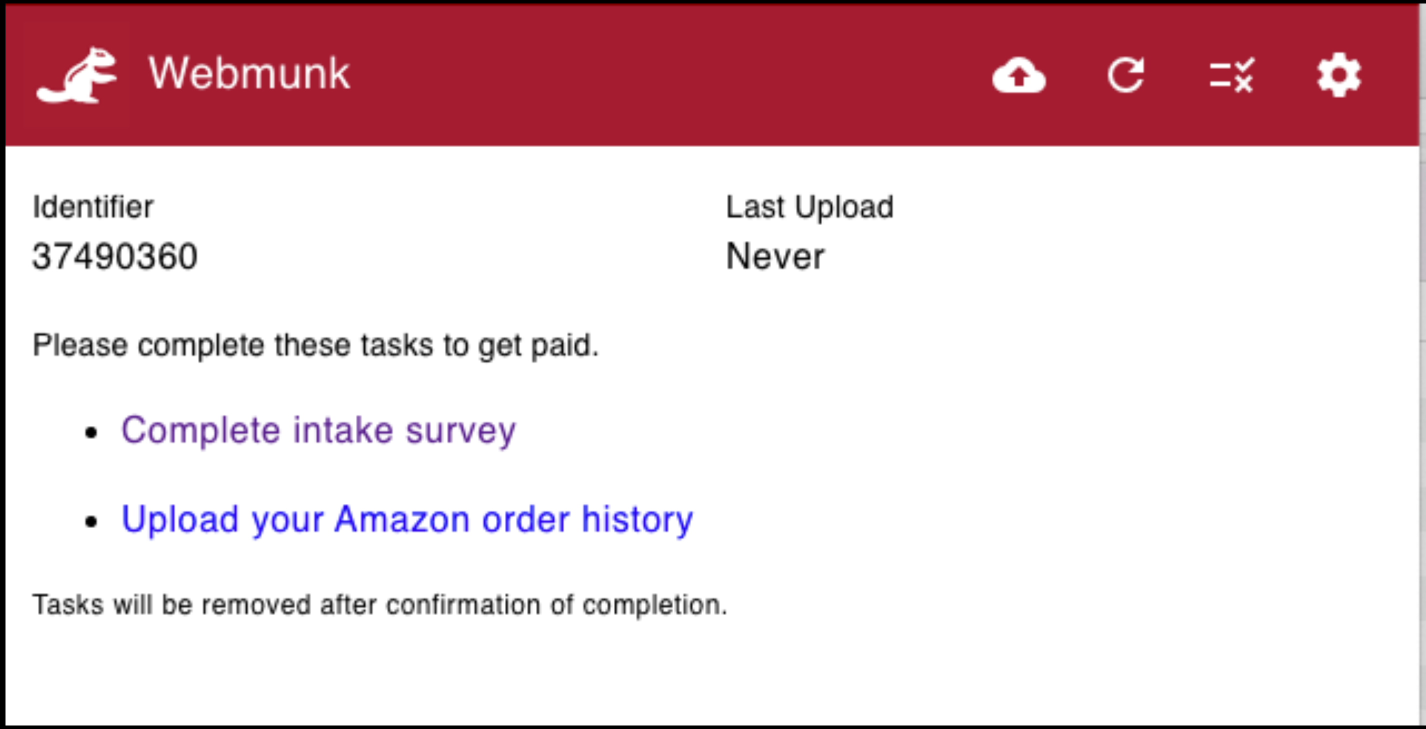
10116956	https://www.amazon.com/s?k=contigo+coffee+trave...	2022-11-29	2124.1250	258.0729	B09RNBH8PJ

Webmunk

A browser extension that can:

- Manipulate your browsing experience;
- Track your browsing behavior;
- **<u>Prompt you to complete additional tasks.</u>**



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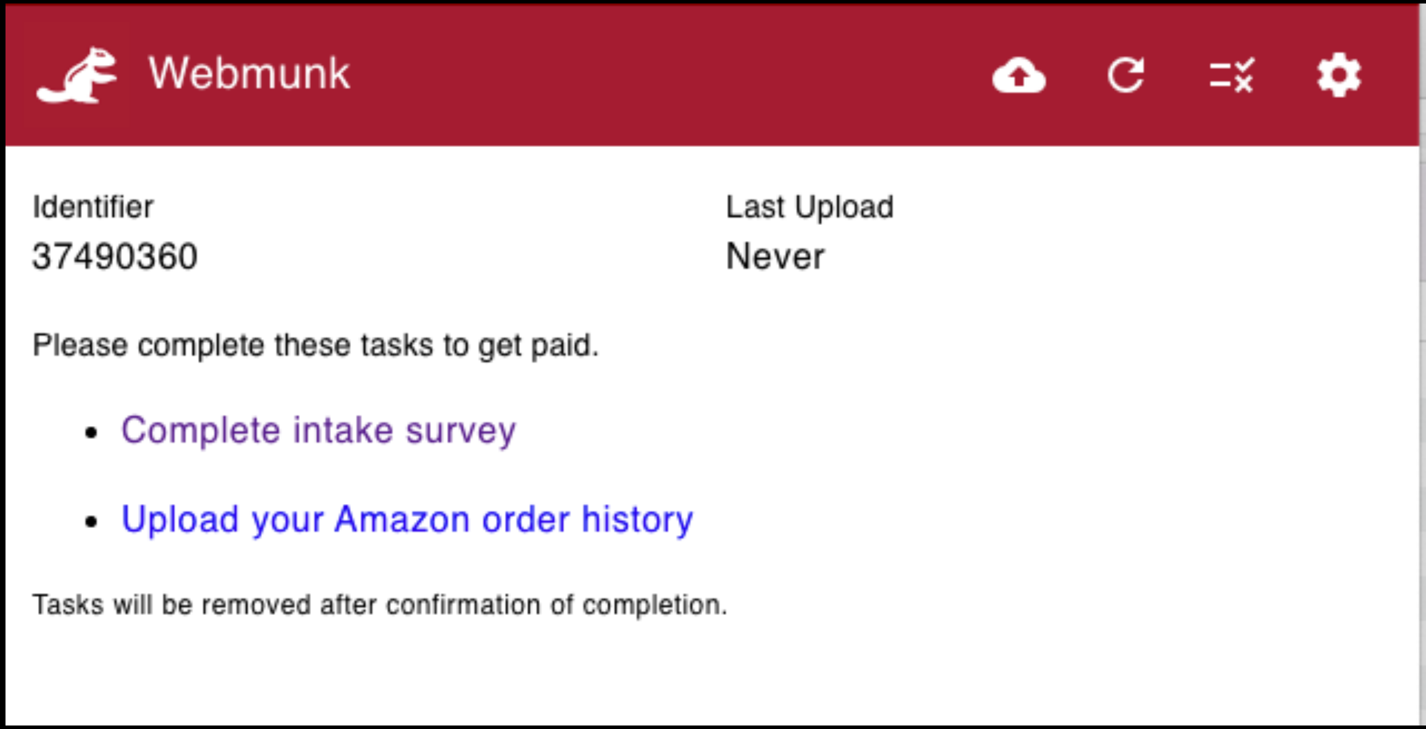

webmunk.org

First Application of Webmunk: Self-Preferencing at Amazon: Evidence from Search Rankings ('23, with Fradkin and MacKay)

Recruited participants through Facebook:

- Ask them to install Webmunk and keep it installed for a few weeks.
- ~3k Amazon searches by ~180 users (currently expanded to ~1,200).

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Descriptives highlight how search results and their position are key for product discovery:

- 46% of product pages are reached through a search results page (11% of product pages are reached from outside Amazon);
- In 72% of searches, consumers do not click past the first page;
- (based on scroll position data) half of the products on a full results page are actually seen.

How Does Amazon Rank Products?

How Does Amazon Rank Products?

- Strongest predictors of higher position:
  - Prime eligibility
  - Number of ratings
  - Best Seller badge
  - Sponsored

How Does Amazon Rank Products?

- Strongest predictors of higher position:
  - Prime eligibility
  - Number of ratings
  - Best Seller badge
  - Sponsored
  - … and Amazon Brand

	Rank (1)	Rank (2)	Rank (3)
Amazon Brand	-6.670***	-4.396***	-4.649***
	(0.261)	(0.219)	(0.219)
Sponsored	-15.740***	-16.749***	-16.733***
	(0.103)	(0.135)	(0.135)
Major Brand			-1.761***
			(0.188)
Search Spell FE	Yes	Yes	Yes
Additional Controls		Yes	Yes
R^2	0.388	0.424	0.424
Observations	1,827,253	1,827,253	1,827,253
Mean of Y	35.3	35.3	35.3
Sample	All	All	All
Carousels	Search Has		
Amazon Brand	All		

Why do we care how Amazon Ranks Products?

Digital Markets Act:

- Applies to large “gatekeepers” who operate one or more “core platform services” (e.g. search, social networks, os,…).
- <u>*Ex-ante*</u> obligations based on 2 principles:
  - **Contestability** (give market a chance at competition): e.g., interoperability
  - **Fairness** (competition based on merits): e.g., no self-preferencing, no combining data across services.

Why do we care how Amazon Ranks Products?

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  - **Fairness** (competition based on merits): e.g., no self-preferencing, no combining data across services.
- Is the priority given to Amazon brands evidence of self-preferencing?
  - Not necessarily.

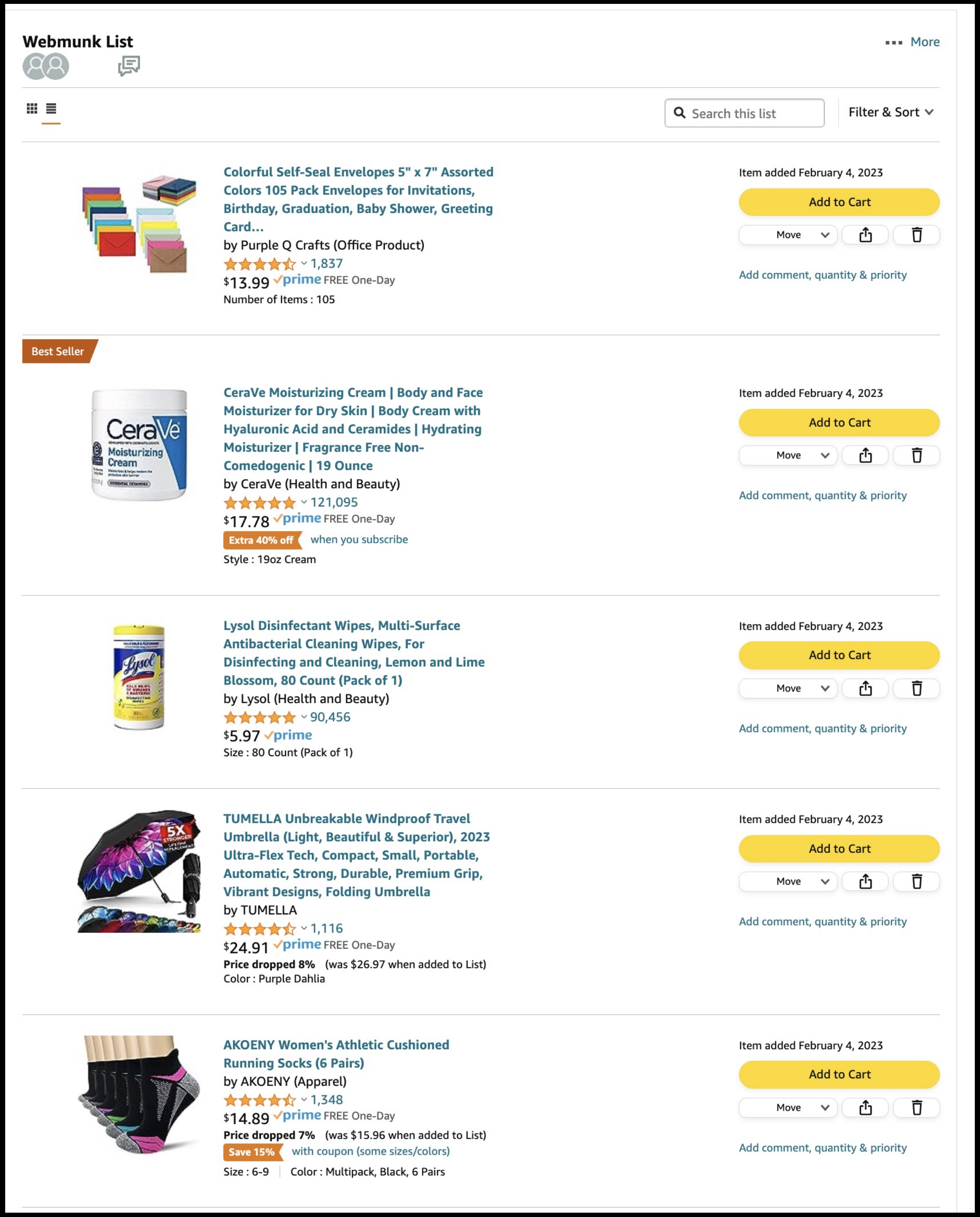
How Do We Test for Self-Preferencing?

- Aguiar et al. (‘21) and Reimers et al. (‘23): A platform is biased in favor of a product if the product attains **smaller success** conditional on **ex-ante assessment.**
  - **Ex-ante assessment:** product rank
  - **Success:** demand

Back to Webmunk (in progress, with Fradkin and MacKay)

Ask participants to perform incentivized shopping tasks:

- Search for products in pre-specified categories;
- Pick one product to add to “Webmunk Wishlist;”
- With high probability:
    - We buy a product on their wishlist;
    - Give them $50-price as additional compensation.



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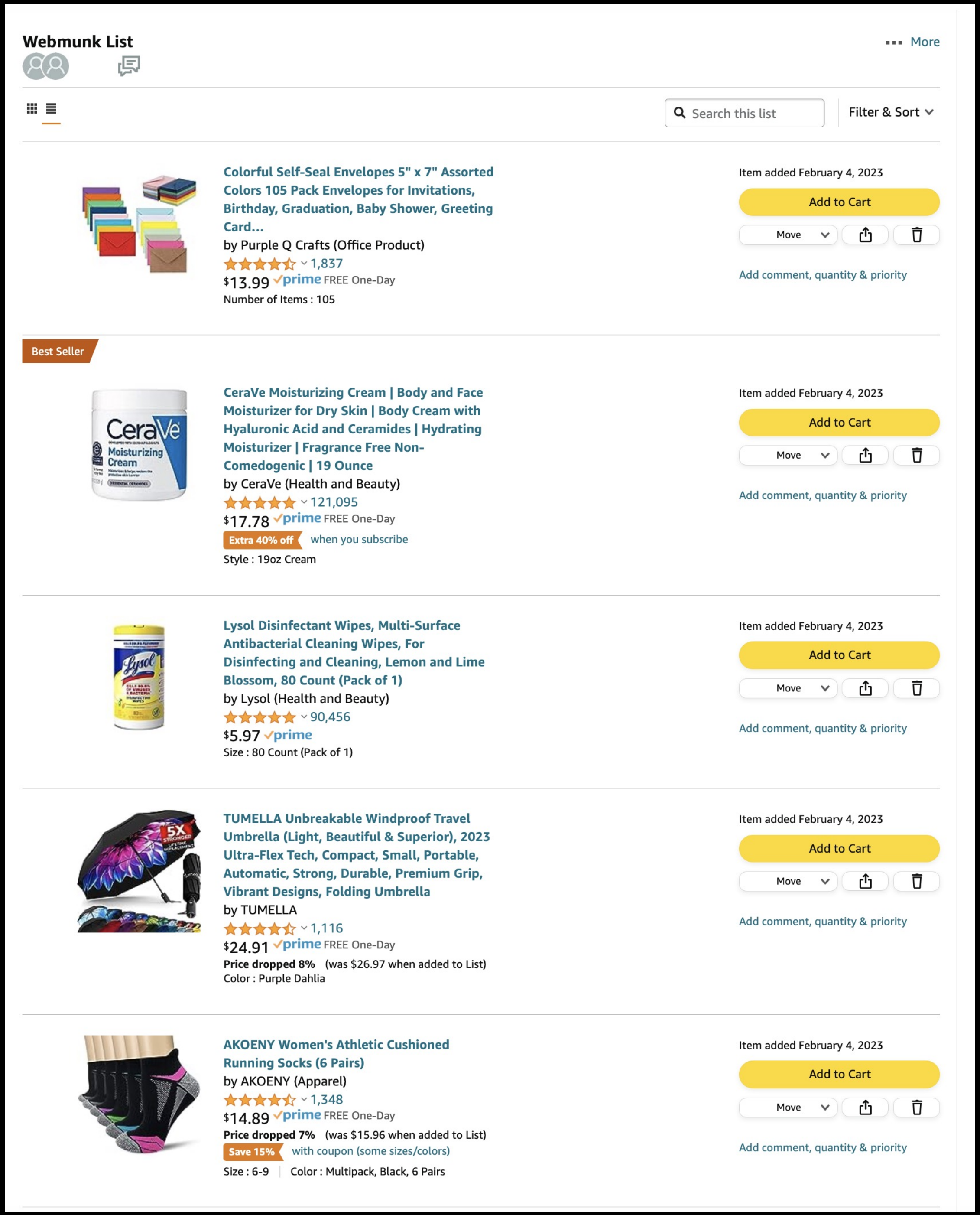
- Search for products in pre-specified categories;
- Pick one product to add to “Webmunk Wishlist;”
- With high probability:
  - We buy a product on their wishlist;
  - Give them $50-price as additional compensation.
- Amazon branded products are ~4% of the products listed and ~8% of the products chosen.



Testing for Self-Preferencing

	Is Product Purchased			
	(1)	(2)	(3)	(4)
Amazon Brand				
Search Rank				
Sample	Control Group	All	All	All
R^2	0.039	0.038	0.039	0.048
Observations	119,548	350,061	350,061	350,061
Search fixed effects	Yes	Yes	Yes	Yes
Search Rank (Assigned) fixed effects				Yes
Search Rank fixed effects				Yes

Testing for Self-Preferencing

	Is Product Purchased			
	(1)	(2)	(3)	(4)
Amazon Brand				
Search Rank	-0.002***			
	(0.000)			
Sample	Control Group	All	All	All
R^2	0.039	0.038	0.039	0.048
Observations	119,548	350,061	350,061	350,061
Search fixed effects	Yes	Yes	Yes	Yes
Search Rank (Assigned) fixed effects				Yes
Search Rank fixed effects				Yes

Testing for Self-Preferencing

	Is Product Purchased			
	(1)	(2)	(3)	(4)
Amazon Brand	0.007			
	(0.005)			
Search Rank	-0.002***			
	(0.000)			
Sample	Control Group	All	All	All
R^2	0.039	0.038	0.039	0.048
Observations	119,548	350,061	350,061	350,061
Search fixed effects	Yes	Yes	Yes	Yes
Search Rank (Assigned) fixed effects				Yes
Search Rank fixed effects				Yes

Testing for Self-Preferencing

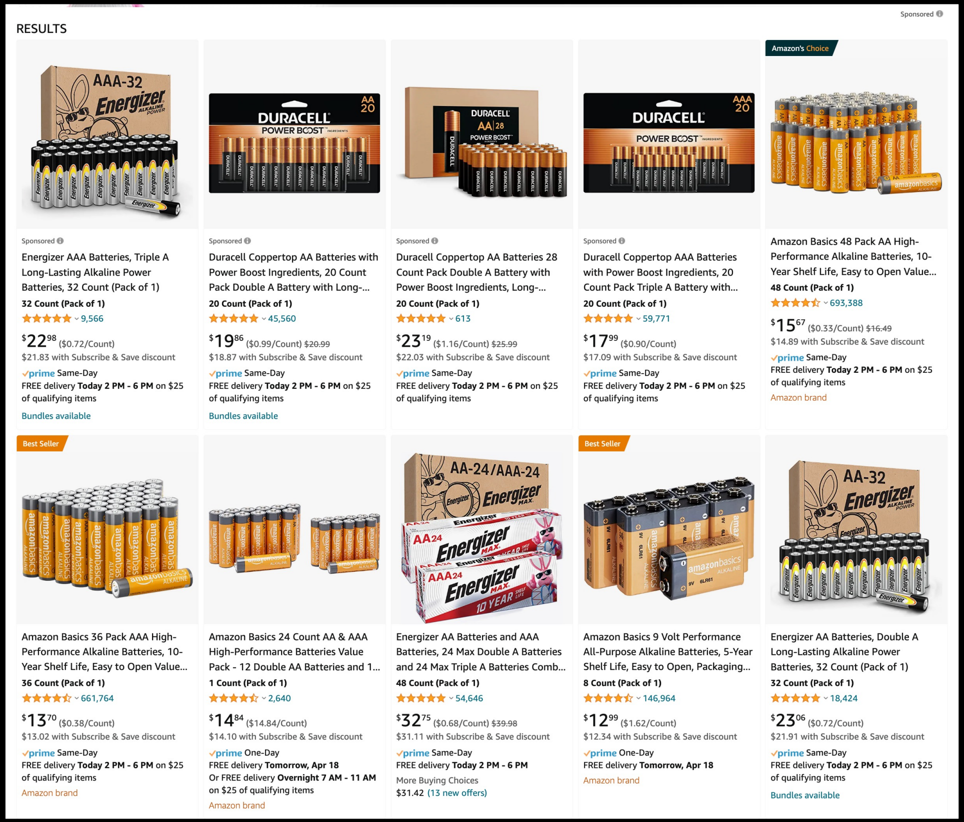
	Is Product Purchased			
	(1)	(2)	(3)	(4)
Amazon Brand	0.007	0.013**	0.039***	0.008
	(0.005)	(0.004)	(0.009)	(0.004)
Search Rank	-0.002***	-0.002***	-0.002***	
	(0.000)	(0.000)	(0.000)	
			-0.001***	
			(0.000)	
Sample	Control Group	All	All	All
R^2	0.039	0.038	0.039	0.048
Observations	119,548	350,061	350,061	350,061
Search fixed effects	Yes	Yes	Yes	Yes
Search Rank (Assigned) fixed effects				Yes
Search Rank fixed effects				Yes

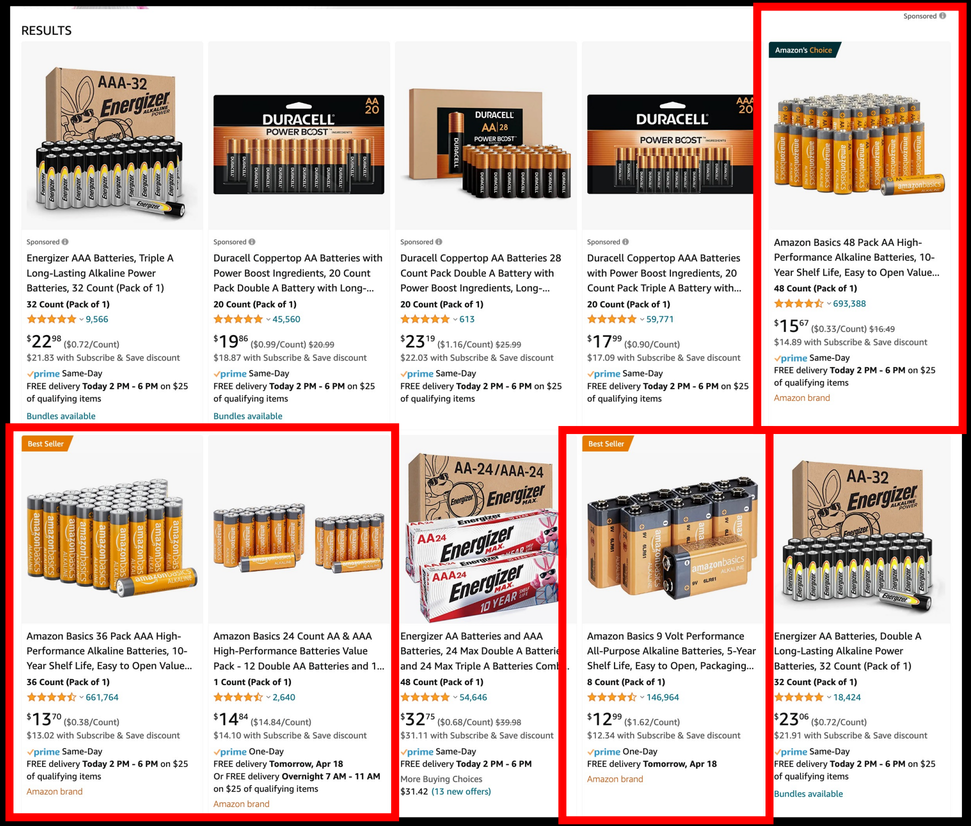
Test suggests that platform is neutral or even biased against Amazon brands.

Is that enough?

- Dynamic “self-preferencing” could be difficult to detect in a cross-section (e.g., strategies allowing Amazon brands to accumulate more reviews than comparably similar third-party products).

Webmunk as a tool to run online experiments




RESULTS
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1 Count (Pack of 1)
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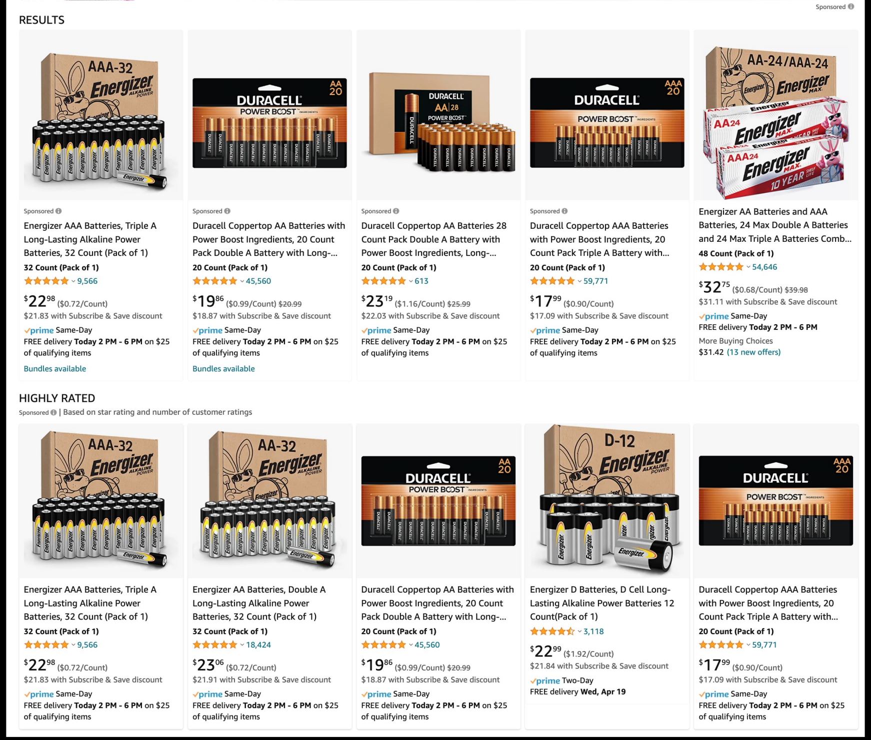
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3,118
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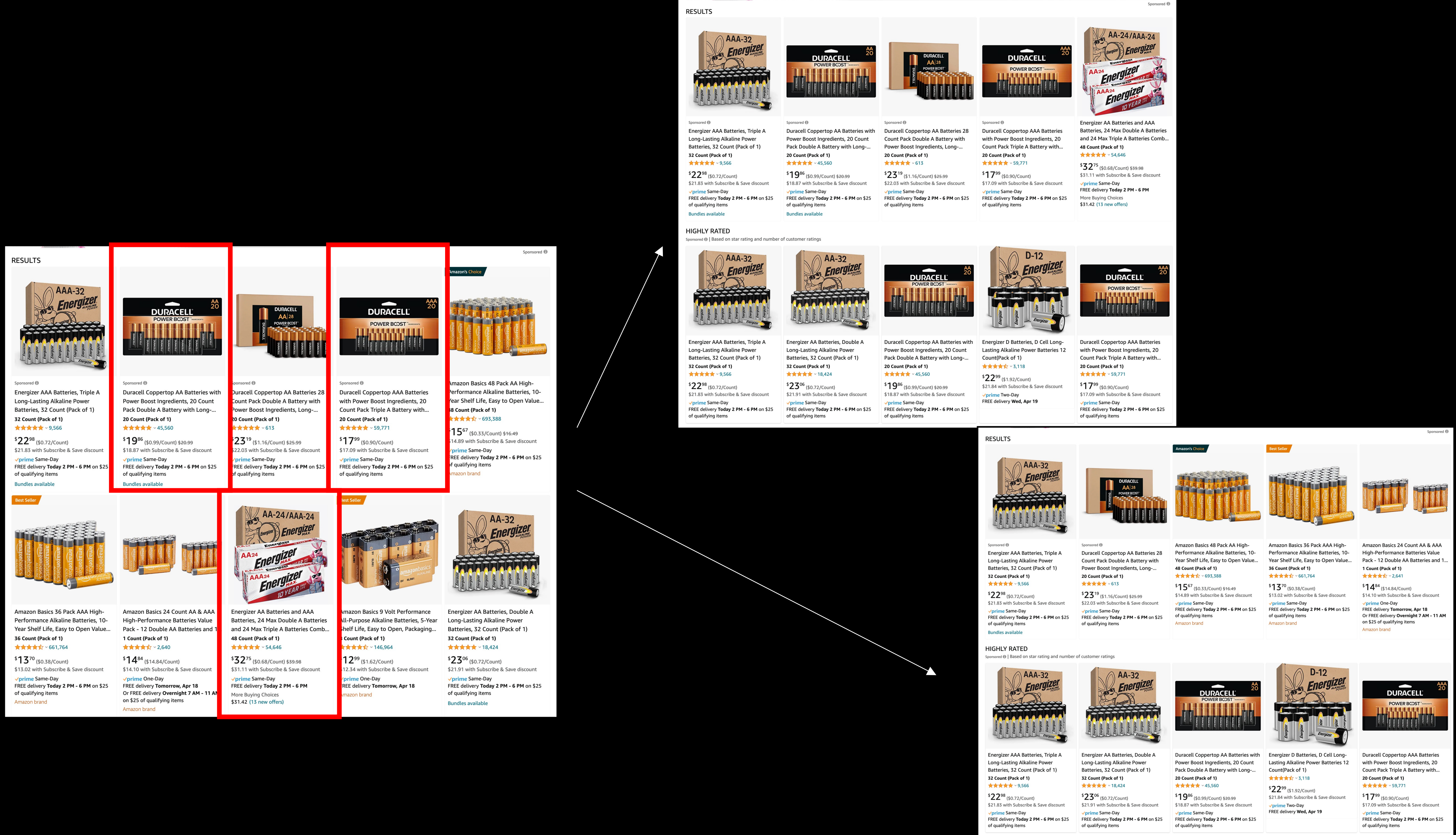
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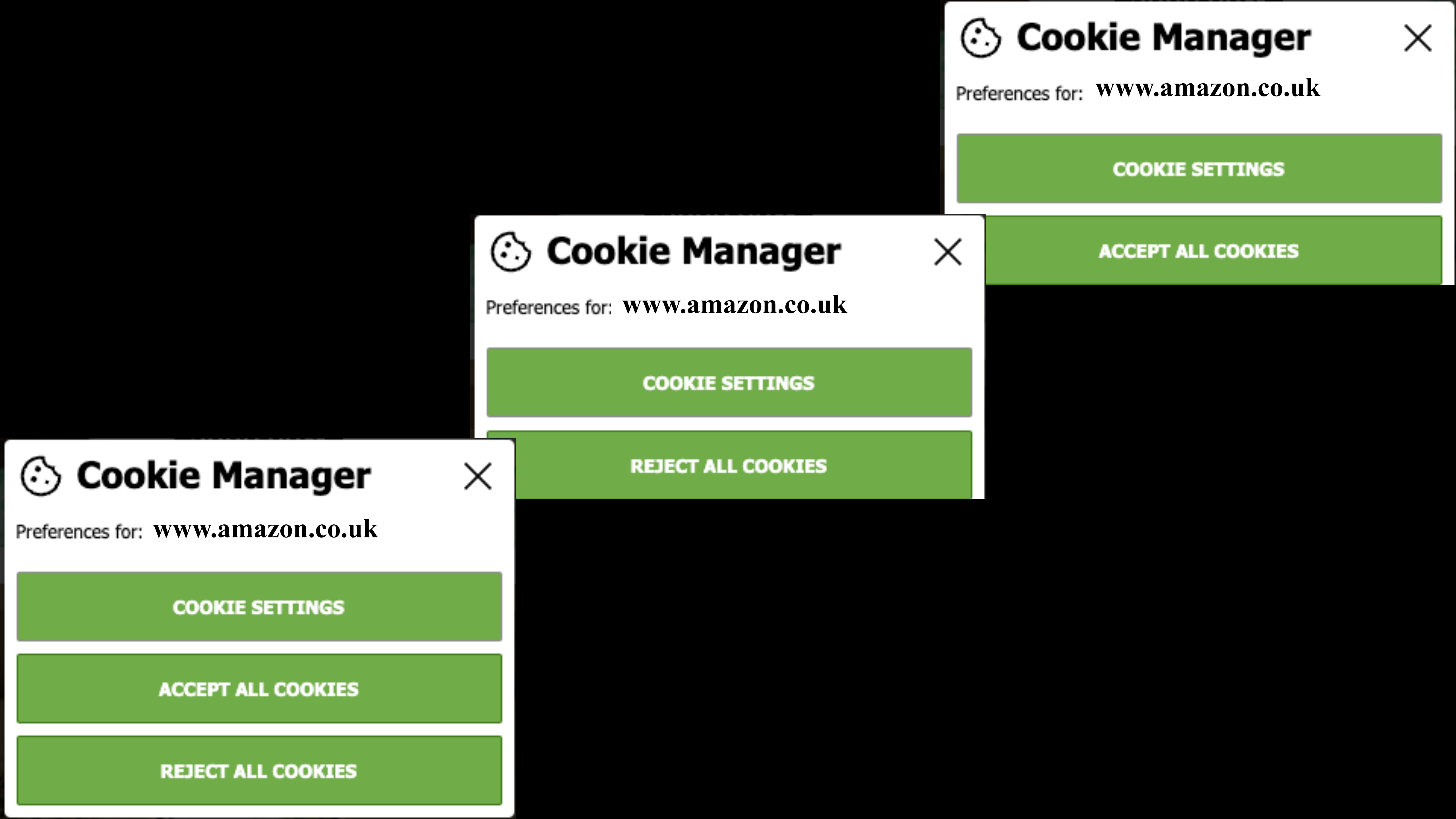
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Preferences for: www.amazon.co.uk
COOKIE SETTINGS
ACCEPT ALL COOKIES
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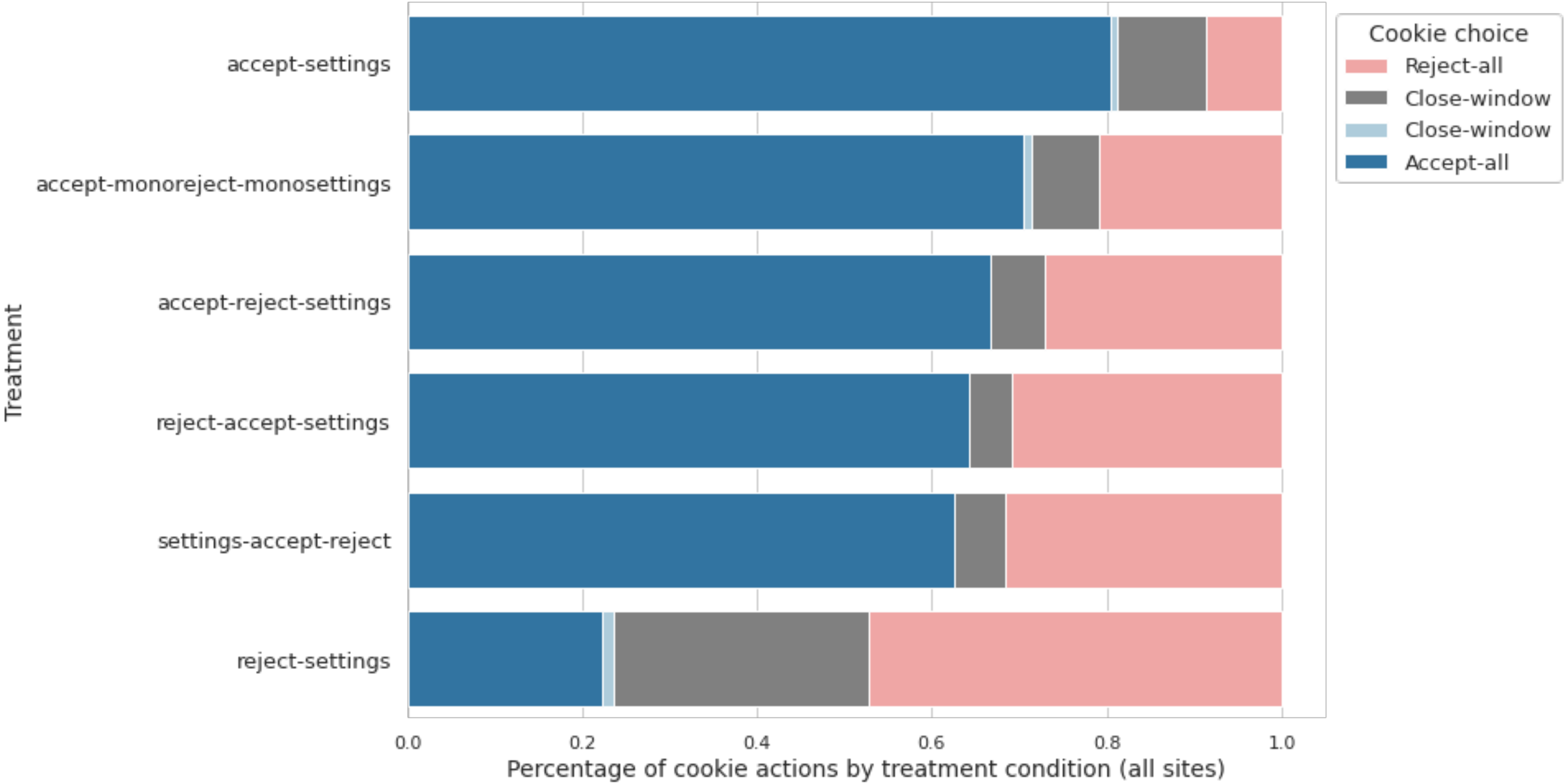


Cookie choice
Reject-all
Close-window
Close-window
Accept-all
Treatment
accept-settings
accept-monoreject-monosettings
accept-reject-settings
reject-accept-settings
settings-accept-reject
reject-settings
0.0
0.2
0.4
0.6
0.8
1.0
Percentage of cookie actions by treatment condition (all sites)

Concluding Remarks

Digital platforms collect, aggregate, and redistribute valuable data:

- (consumer protection) regulation WITH platforms
  - Online reputation as partial alternative to ex-ante screening mechanisms such as occupational licensing or ongoing monitoring such as health and safety inspections.

- (antitrust) regulation OF platforms
  - Incredibly exciting time to study platform antitrust.
  - We need more creative ways of collecting data.
  - Look out for policy changes (and don’t just focus on the unintended consequences ☺)

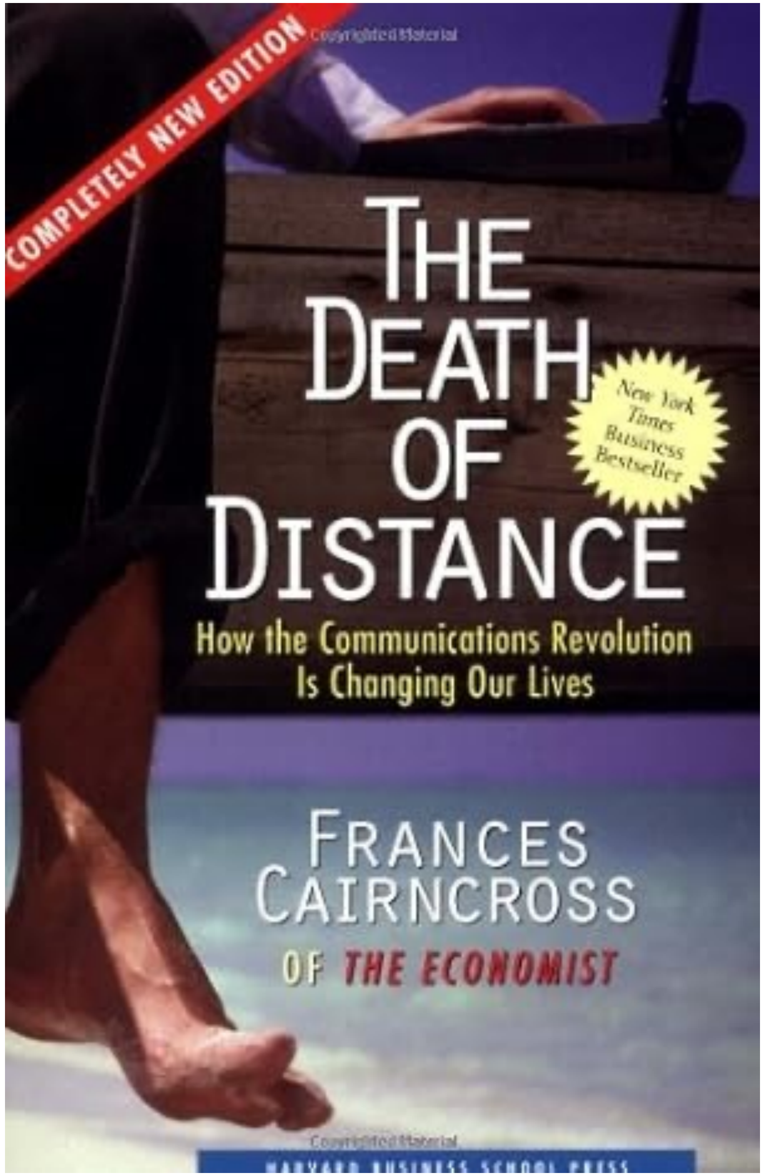
Thank you.

cfarronato@hbs.edu

[And thanks to my co-authors in these papers & ongoing work: Andrey Fradkin, Erik Brynjolfsson, Jessica Fong, Chris Karr, Bradley Larsen, Tesary Lin, Alexander MacKay, Giorgos Zervas]

Digital Economics in retail, entertainment, (and higher education)

Geography and digital economics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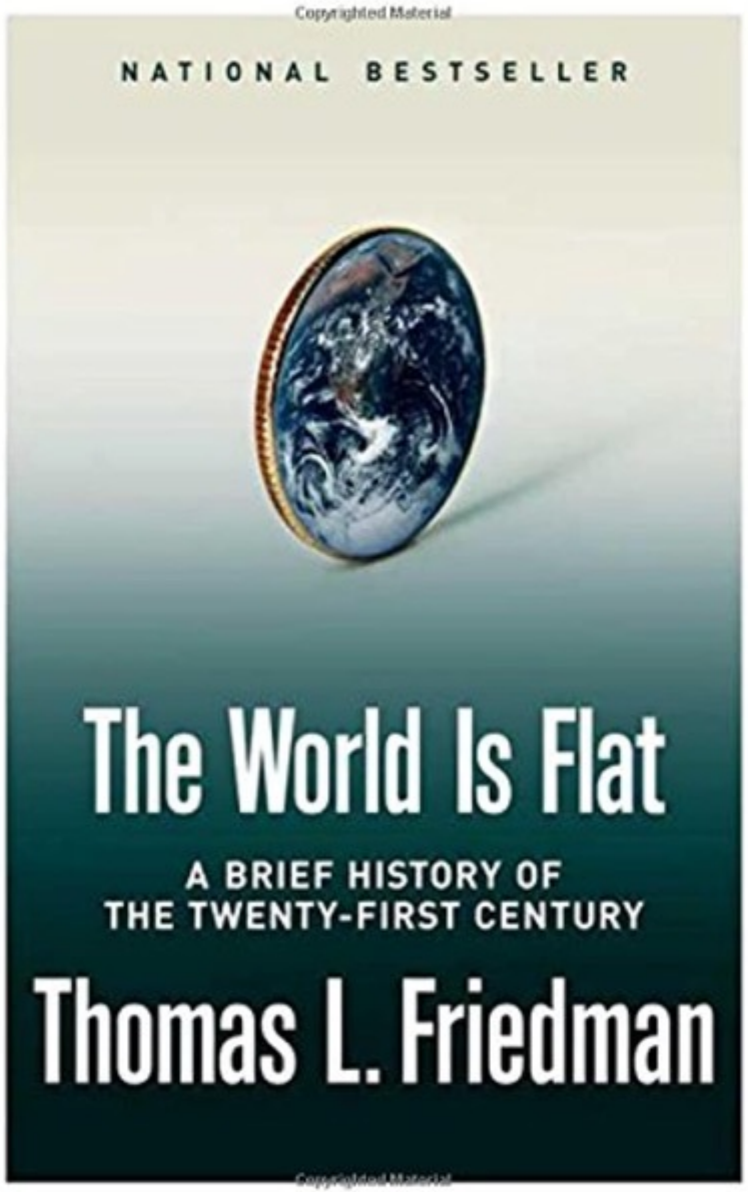
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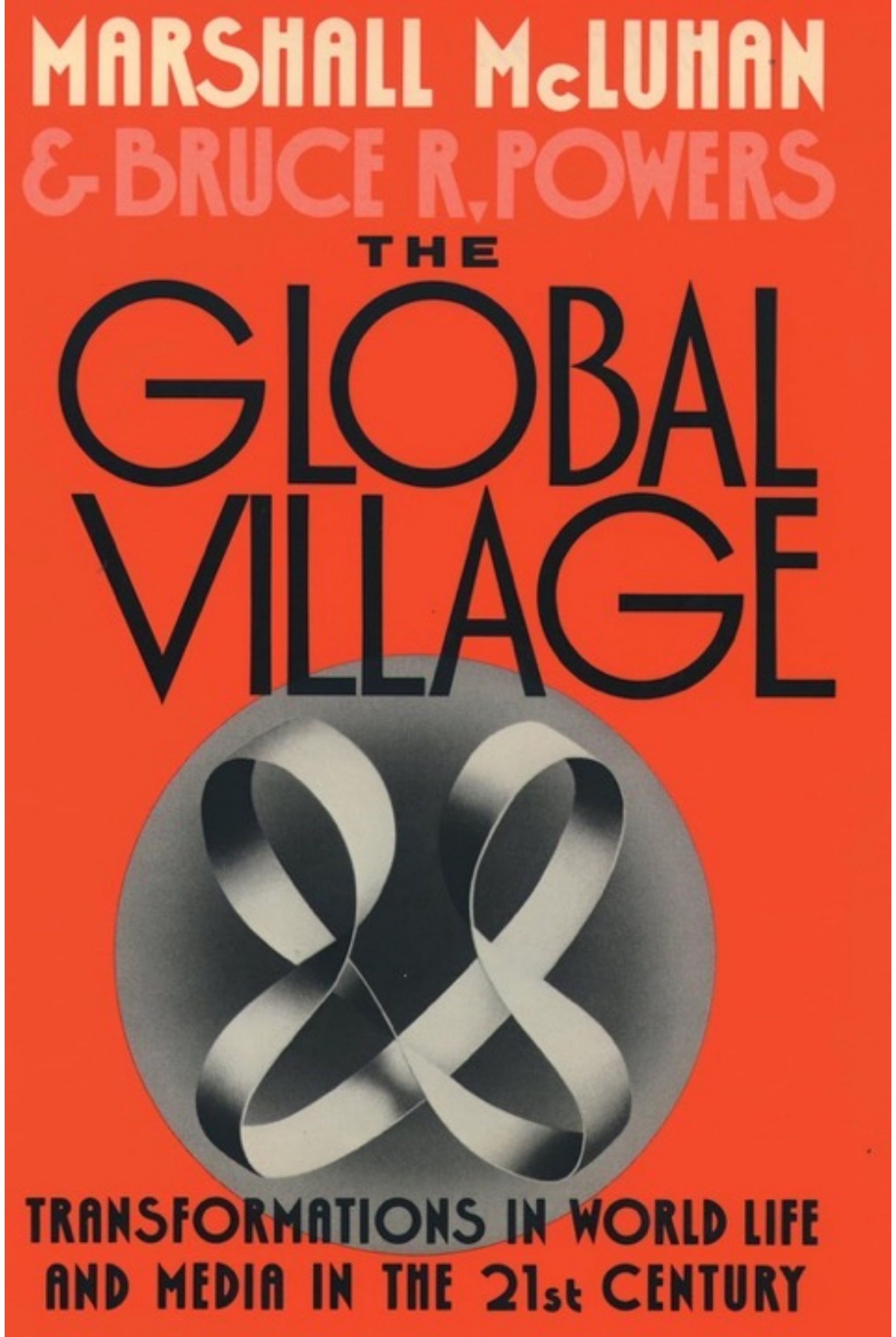
Thomas L. Friedman

2005



Intraindustry Specialization and the Gains from Trade

Paul R. Krugman
Massachusetts Institute of Technology

Several recent empirical studies of trade suggest that *interindustry* specialization and trade, which reflect the conventional forces of comparative advantage, are also accompanied by *intraindustry* specialization, which reflects scale economies and consumers' taste for a diversity of products. This paper develops a simple model which illustrates this argument. Two main results are developed. First, the nature of trade depends on how similar countries are in their factor endowments. As countries become more similar, the trade between them will increasingly become intraindustry in character. Second, the effects of opening trade depend on its type. If intraindustry trade is sufficiently dominant, the advantages of extending the market will outweigh the distributional effects, and the owners of scarce as well as of abundant factors will be better off.

Over the years, many empirical students of international trade have argued that trade among the industrial countries cannot adequately be explained by conventional theories of comparative advantage. One might summarize this empirical critique by pointing to three aspects of world trade which seem to contradict received theory. First, much of world trade is between countries with similar factor endowments. Second, a large part of trade is intraindustry in character—that is, it consists of two-way trade in similar products. Finally, much of the expansion of trade in the postwar period has taken place without

This research was supported by a grant from the National Science Foundation. An earlier version of this paper, "International Trade and Income Distribution: A Reconsideration," was presented at the NBER Summer Institute in International Studies, Cambridge, Massachusetts, July 1979.

[*Journal of Political Economy*, 1981, vol. 89, no. 5]

Key forces

- Cost of transporting information falls.
- This cost becomes similar for long distance and short distance transportation of information.

Is distance dead?

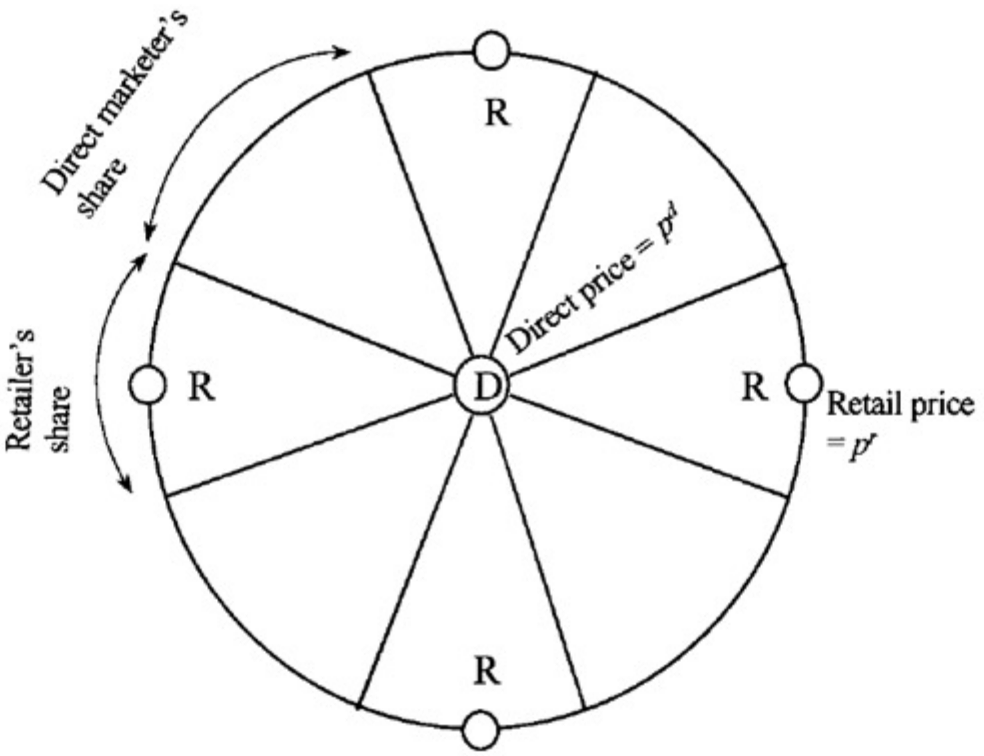
- In retail: e.g. Brynjolfsson, Hu, and Rahman (2009)
- In trade of digital goods: e.g. Blum and Goldfarb (2006)
- In exchange rate pass-through: e.g. Gorodnichenko and Talavera (2017)
- In finance: e.g. Eichengreen, Lafarguette, and Mehl (2016)
- In business internet use: Forman, Goldfarb, and Greenstein (2005)

But cyberspace is not a real place

Offline options matter

Balasubramanian's (1998) adaptation of a Salop model

Figure 1 Spatial setting of the circular market



MARKETING SCIENCE/Vol. 17, No. 3, 1998

Offline options affect online purchasing

- Clothing: Brynjolfsson, Hu, and Rahman (2009)
- Books: Forman, Ghose, and Goldfarb (2009)

Preference minorities

diapers.com

Choi and Bell (2011)

ELSEVIER

Journal of Urban Economics

Volume 56, Issue 1, July 2004, Pages 1-24

Geography and the Internet: is the Internet a substitute or a complement for cities?

Todd Sinai, Joel Waldfogel

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Abstract

We study the tendency to connect to the Internet and the online and offline shopping behavior of connected persons. We document that larger markets have more locally-targeted online content and that individuals are more likely to connect in markets with more local online content, suggesting the Internet is a complement to cities. Yet, holding local online content constant, people are less likely to connect in larger markets, indicating that the Internet is also a substitute for cities. Finally, we find that individuals connect to overcome local isolation, in the form of racial isolation or distance to retail stores.

Offline options can create awareness

- Clothing: Wang and Goldfarb (2017)
- Glasses: Bell, Galleno, and Moreno (2018)

Governments are local

IN A WORLD WITHOUT BORDERS: THE IMPACT OF TAXES ON INTERNET COMMERCE*

AUSTAN GOOLSBEE

The rapid rise in sales over the Internet and the fact that most Internet buyers pay no sales tax has ignited a considerable debate over taxes and the Internet. This paper uses new data on the purchase decisions of approximately 25,000 online users to examine the effect of local sales taxes on Internet commerce. The results suggest that, controlling for observable characteristics, people living in high sales taxes locations are significantly more likely to buy online. The results are quite robust and cannot be explained by unobserved technological sophistication, shopping costs, or other alternative explanations. The magnitudes in the paper suggest that applying existing sales taxes to Internet commerce might reduce the number of online buyers by up to 24 percent.

I. INTRODUCTION

The extraordinary growth of the Internet in the last few years has led some to speak of the birth of a world without borders, a place where free communication, competitive markets, and extensive comparison shopping are a matter of course (see *The Economist* [1997a] and Hof [1998]). This apparent lack of geography in cyberspace, however, has raised some difficult problems regarding

Government policy

- Taxes:
  - Goolsbee (2000)
  - Ellison and Ellison (2009)
  - Anderson et al (2011)
  - Einav et al (2014)
- Copyright policy:
  - Gomez Herrera and Martens (2014)
- Privacy policy:
  - Goldfarb and Tucker (2011);
  - Goldberg, Johnson, and Shriver (2022)
  - etc.
- Etc.

Trust is easier locally

JOURNAL ARTICLE

Dividing Online and Offline: A Case Study

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Ginger Zhe Jin, Andrew Kato

The Review of Economic Studies, Volume 74, Issue 3, July 2007, Pages 981–1004,
https://doi.org/10.1111/j.1467-937X.2007.00434.x
Published: 01 July 2007 **Article history** ▾

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Abstract

Every new method of trade offers an opportunity for economic agents to compare its costs and benefits relative to the status quo. Such comparison motivates sorting across market segments and reshapes the whole marketplace. The Internet provides an excellent example: it introduces substantial search cost savings over brick and mortar retail stores but imposes new obstacles for sellers to convey quality. Using sports card trading as a case study, we provide empirical evidence on (1) the sorting of product quality between the online and offline segments, (2) the changes for retail outlets after the Internet came into place, and (3) how supporting industries such as professional grading and card manufacturing adapted to take advantage of the new market.

The Geography of Trade in Online Transactions: Evidence from eBay and MercadoLibre

Ali Hortaçsu

F. Asís Martínez-Jerez

Jason Douglas

AMERICAN ECONOMIC JOURNAL: MICROECONOMICS
VOL. 1, NO. 1, FEBRUARY 2009
(pp. 53-74)

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Abstract

We analyze geographic patterns of trade between individuals using transactions data from eBay and MercadoLibre, two large online auction sites. We find that distance continues to be an important deterrent to trade between geographically separated buyers and sellers, though to a lesser extent than has been observed in studies of non-Internet commerce between business counterparties. We also find a strong "home bias" for trading with counterparties located in the same city. Further analyses suggest that location-specific goods such as opera tickets, cultural factors, and the possibility of direct contract enforcement in case of breach may be the main reasons behind the same-city bias. (JEL D44, F11, R12)

Spatial correlation in tastes (local culture)

ELSEVIER

Journal of International Economics
Volume 70, Issue 2, December 2006, Pages 384-405

Does the internet defy the law of gravity?

Bernardo S. Blum, Avi Goldfarb

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Abstract

We show that gravity holds in the case of digital goods consumed over the Internet that have no trading costs. Therefore trade costs cannot fully account for the effects of distance on trade. In particular, we show that Americans are more likely to visit websites from nearby countries, even controlling for language, income, immigrant stock, etc. Furthermore, we show that this effect only holds for taste-dependent digital products, such as music, games, and pornography. For these, a 1% increase in physical distance reduces website visits by 3.25%. For non-taste-dependent products, such as software, distance has no statistical effect.

	(1)	(2)
	Taste Dependent[#]	Not Taste Dependent[##]
ln(distance)	-3.248	-0.979
	(0.757)**	(0.628)
ln(gdp)	0.131	0.375
	(0.439)	(0.440)
ln(# hosts)	-0.313	2.738
	(1.066)	(0.916)**
English	0.402	0.804
	(0.411)	(0.432)+
ln(gdp per capita)	0.518	2.177
	(0.795)	(0.870)*
Observations	184	230
LL	-218.71	-214.65

Standard errors in parentheses
All regressions include category fixed effects
+ significant at 10% * significant at 5%; ** significant at 1%

Spatial correlation in tastes (local culture)

- Local website visits
  - Blum and Goldfarb (2006)
- Local news
  - Sinai and Waldfogel (2004)
- Local language
  - Gandal (2006)

Social networks are disproportionately local

JOURNAL OF URBAN ECONOMICS **43**, 136–156 (1998)
ARTICLE NO. UE962031

Information Technology and the Future of Cities

Jess Gaspar

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Received October 7, 1996; accepted November 11, 1996

Will improvements in information technology eliminate face-to-face interactions and make cities obsolete? In this paper, we present a model where people make contacts and choose a mode of interaction: meeting face-to-face or communicating electronically. Cities are a means of reducing the fixed travel costs involved in face-to-face interactions. When telecommunications technology improves, there will be two opposing effects on cities and face-to-face interactions. First, some relationships that would have been face-to-face will be conducted electronically. Second, the increase in frequency of contact between individuals caused by improvements in telecommunications technology may result in more face-to-face interactions. If the second effect dominates, telecommunications improvements will complement both face-to-face interactions and cities. Our empirical work suggests that telecommunications may be a complement to, or at least not a strong substitute for, cities and face-to-face interactions.

Social networks are disproportionately local

- Online as a complement to face-to-face
  - Hypothesis: Gaspar and Glaeser (1998)
  - In academic research: Agrawal and Goldfarb (2008)
  - In crowdfunding: Agrawal, Catalini, and Goldfarb (2015)
- Trust in local connections
  - Forman, Ghose, and Weisenfeld (2008)

Geography and digital economics

Cyberspace is not a real place

Digital economics and the entertainment industry

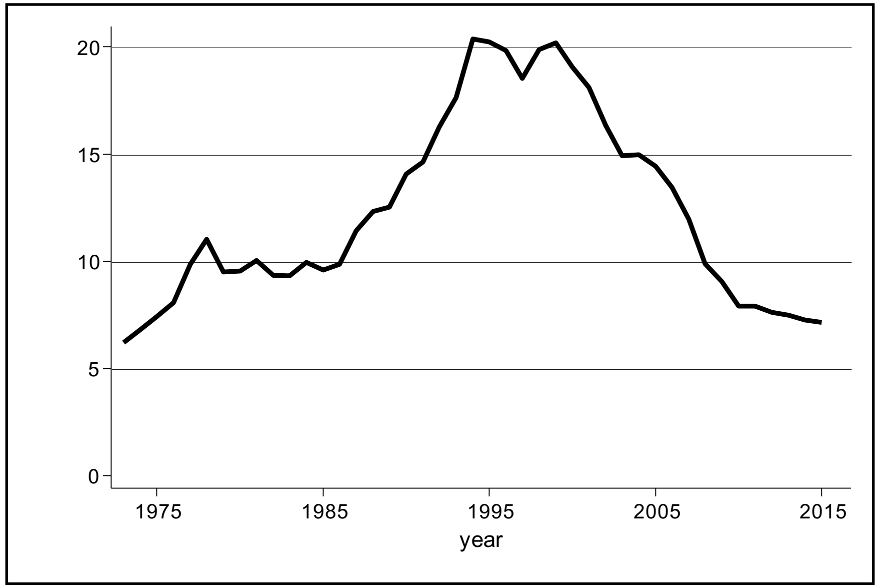
(Draws heavily on work and slides of Joel Waldfogel)

The economics of copyright

- Piracy vs file sharing

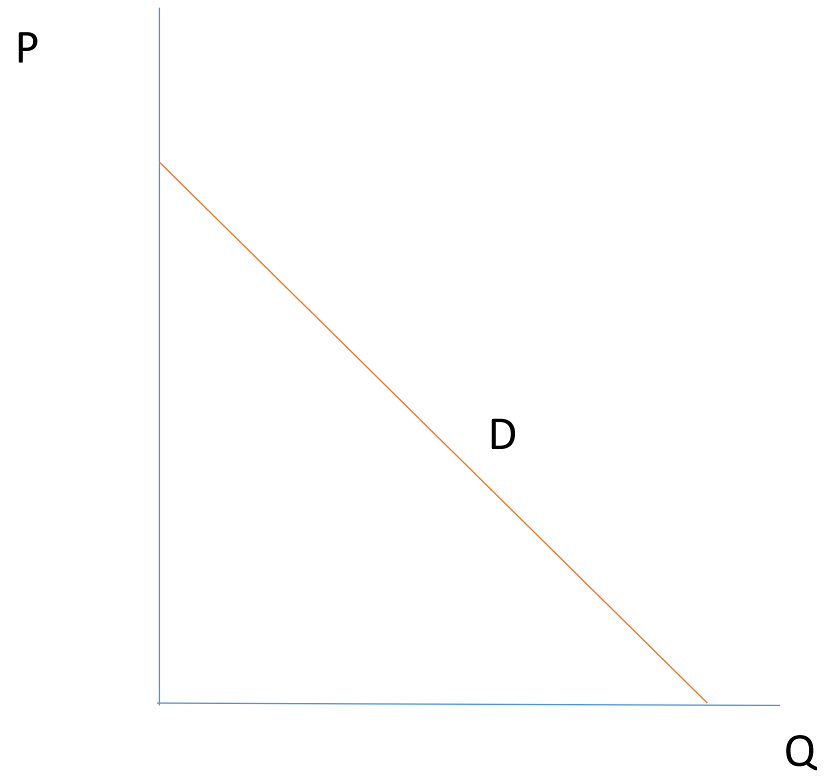
- A massive literature shows that the internet affected revenues of copyright protected industries. Overall, the evidence suggests that revenue declined.
    - Rob & Waldfogel (2006); Smith & Telang (2009); Zentner (2006); Oberholzer-Gee & Strumpf (2007); etc.

Impact of digital technology on music revenues

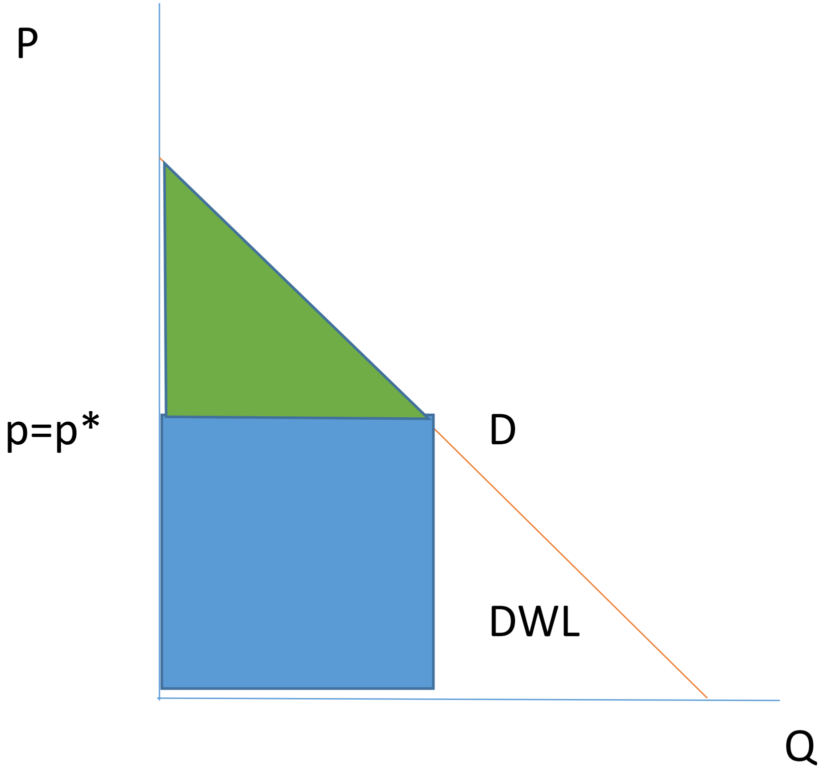


- Figure 2.1: RIAA Total Value of U.S. Music Shipments, 1973-2015

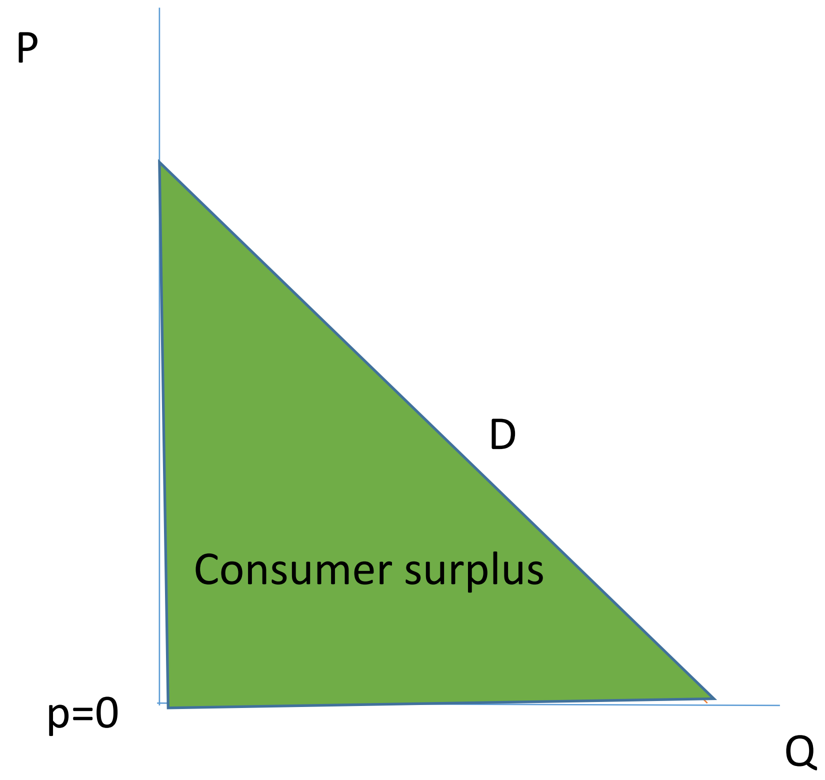
The economics of copyright



The economics of copyright



The economics of copyright

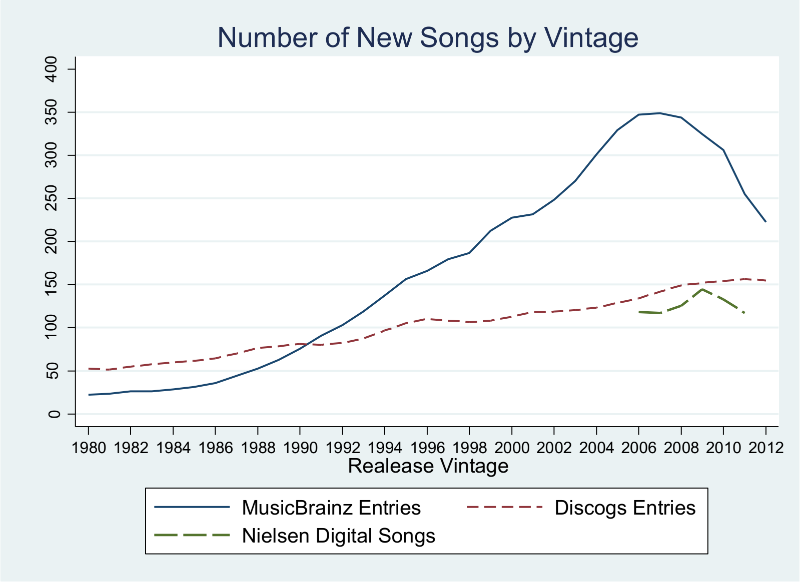


Digital economics and copyright

- Cultural products are expensive and risky
  - $100 million per MPAA movie
  - Recording industry is very investment-intensive
- Without protection, hard to finance creativity
- Copyright grants creators monopoly rights to provide incentives for creative activity
- Monopoly is bad, but we accept the bad (higher prices, reduced consumption) to get a continued flow of new products
- ***Digitization reduces effective protection, and many believe we need stronger enforcement***

On the other hand…

- Falling costs of production, distribution, promotion
  - Easier to bring new products to market without the investment and permission of traditional intermediaries
- Production: feasible with inexpensive equipment (e.g. GarageBand, etc.)
- Distribution: $10 to make your song available on iTunes via CD Baby
- And the number of new products has exploded

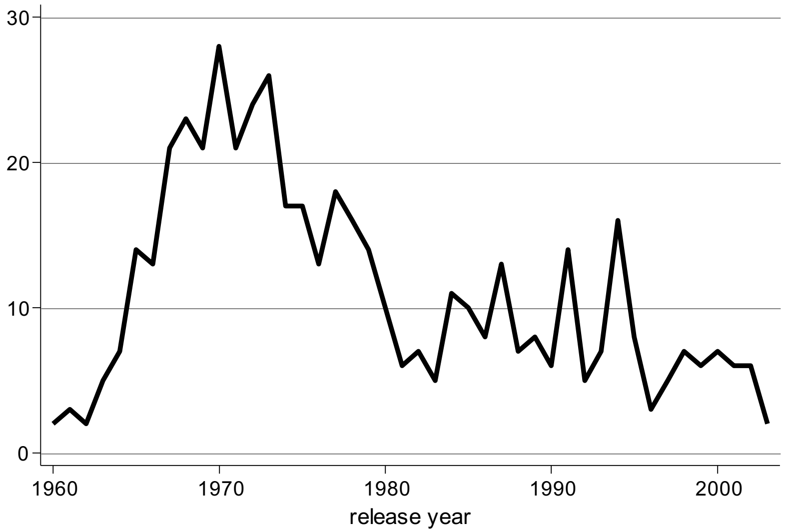


- Tripling in # of new products
  - Nielsen: 35k in 2000, 100k in 2010

How would we know whether copyright is "working" after digitization?

- Standard question ("what's happening to revenue of incumbent firms?") would be sufficient if costs were constant
  - Piracy – by reducing revenue – threatens to curtail creation
- But cost reduction may render lower revenue sufficient
  - We have experienced offsetting shocks: horse race
- ***Better – hard – question: "what has happened to the quantity and quality of cultural products under digitization?"***

Is the new music good compared with the old? (critics)



Number of Albums from the Rolling Stone 500 Released Each Year

Is the new music good compared with the old? (critics)

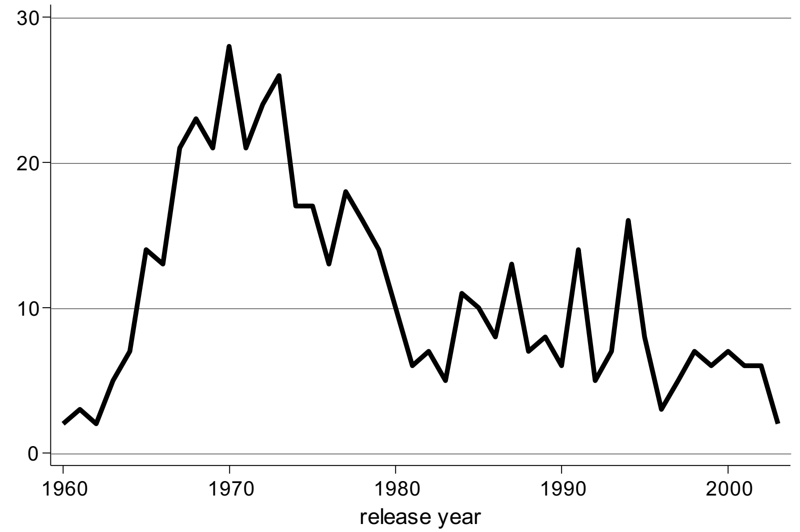
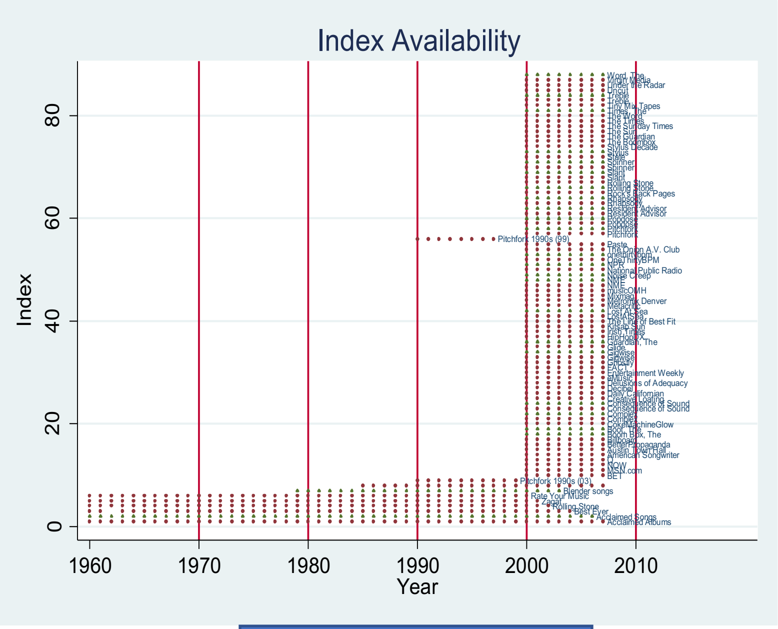


Figure 2.2: Number of Albums from the Rolling Stone 500 Released Each Year



- Regression:

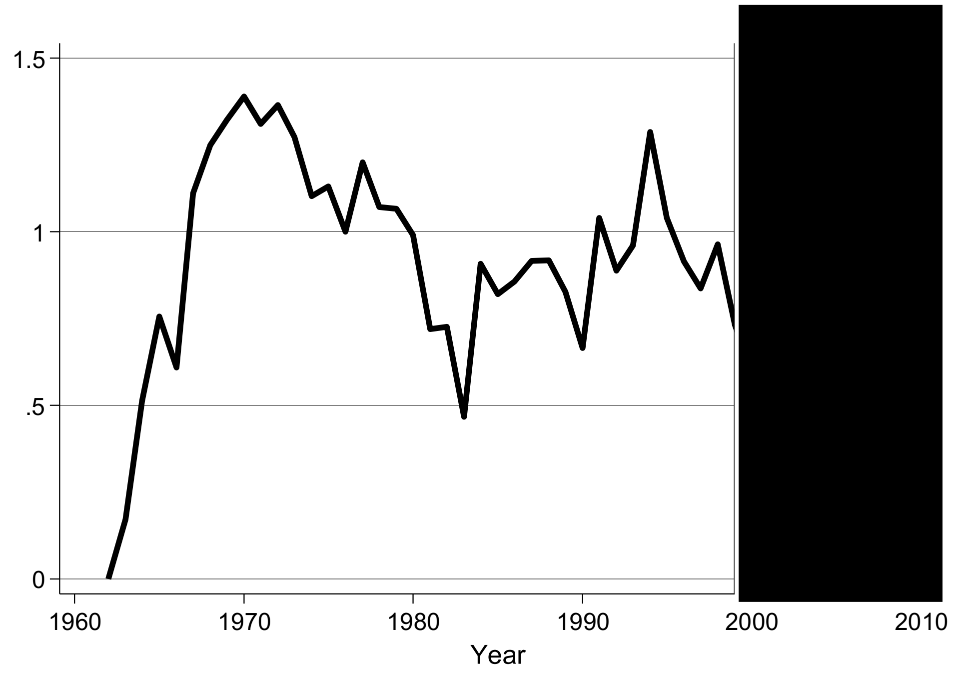
$$\ln\left(y_{it}\right) = \mu_i + \theta_t + \epsilon_{it}$$

- Plot θ's

"Splice" together to create overall index, covering pre- and post-Napster era.

What happens to the critic-based quality index?

Voila: quality does not fall after Napster



Index is falling prior to Napster

Post-Napster constancy is, if anything, a relative increase

Figure 2.4: Music Quality Index Based on Critics
Source: Waldfogel (2012).

Usage-based indices: **airplay** and **sales**

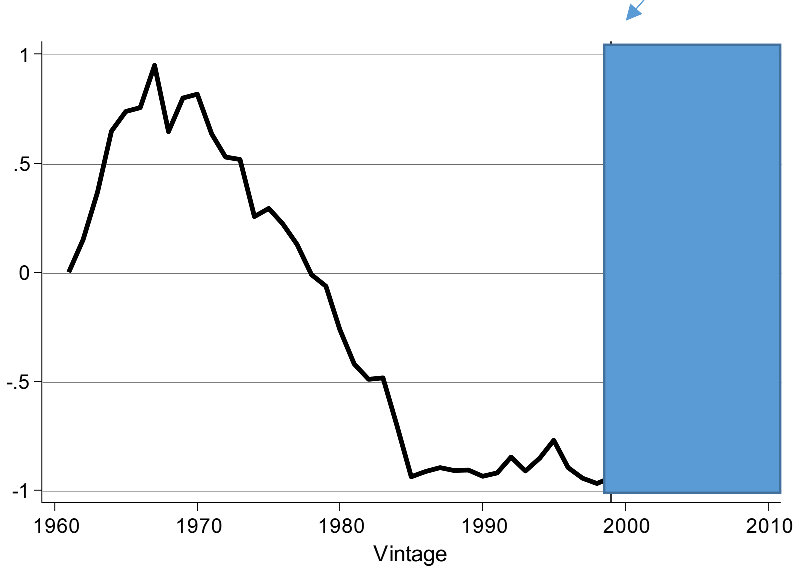


Figure 2.5: Music Quality Index Based on U.S. Airplay

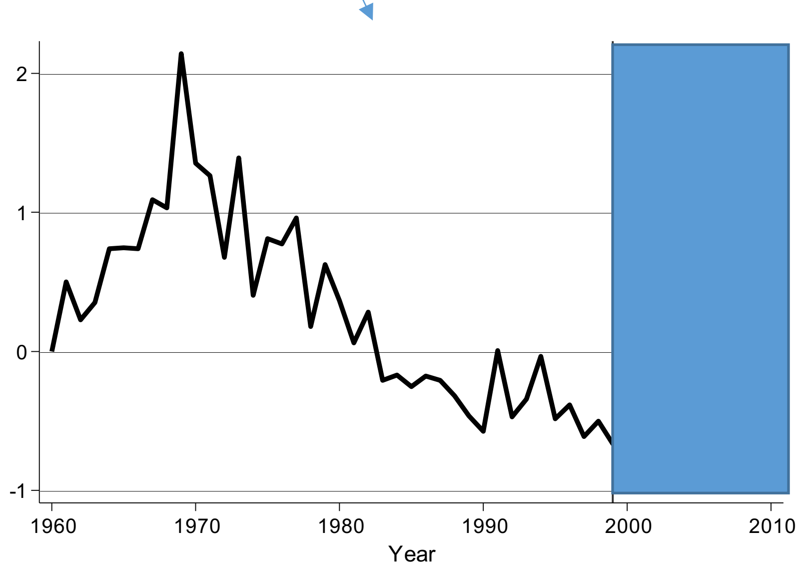


Figure 2.6: Music Quality Index Based on RIAA Sales Data

How might digitization increase total surplus from the entertainment industry?

- Investors make guesses about work's marketability
- Greenlight if expected revenue exceeds the cost
- If the number of new works rises (say, because of lower cost of production) then:

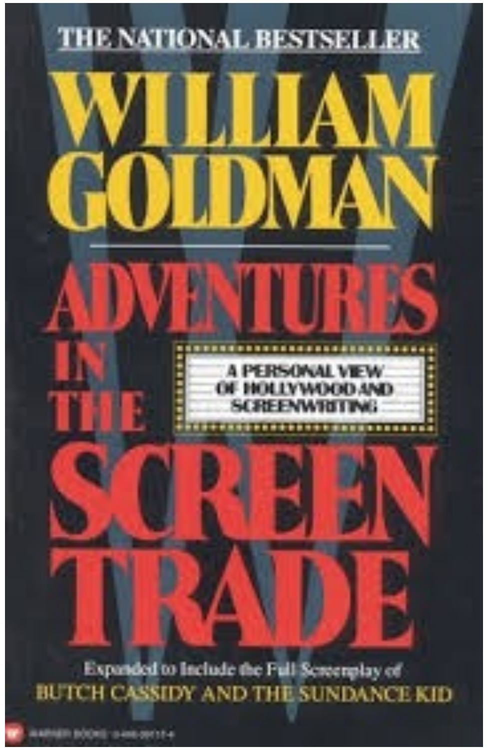
- ***What happens to the volume of "good" work available to consumers?***

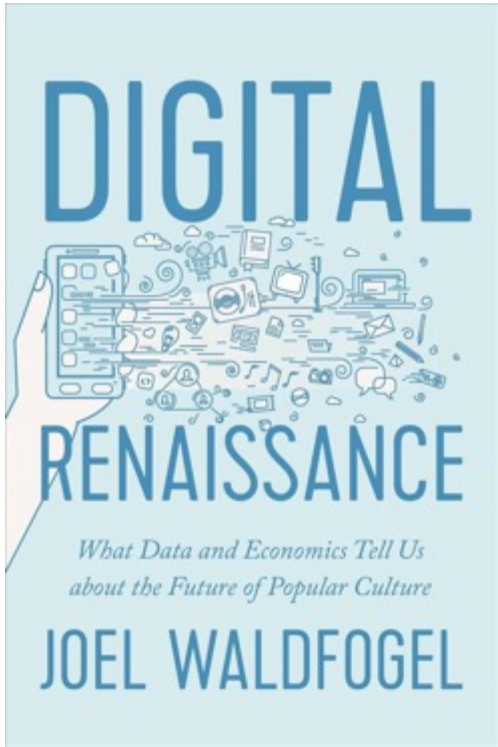
Suppose marketability were predictable

- Then reduction in *cost* brings more products
- But they are of modest quality: *new threshold* < expected revenue (*"quality"*) < *old threshold*

Might digitization *improve* quality?

- What does cost reduction do when "nobody knows anything"?

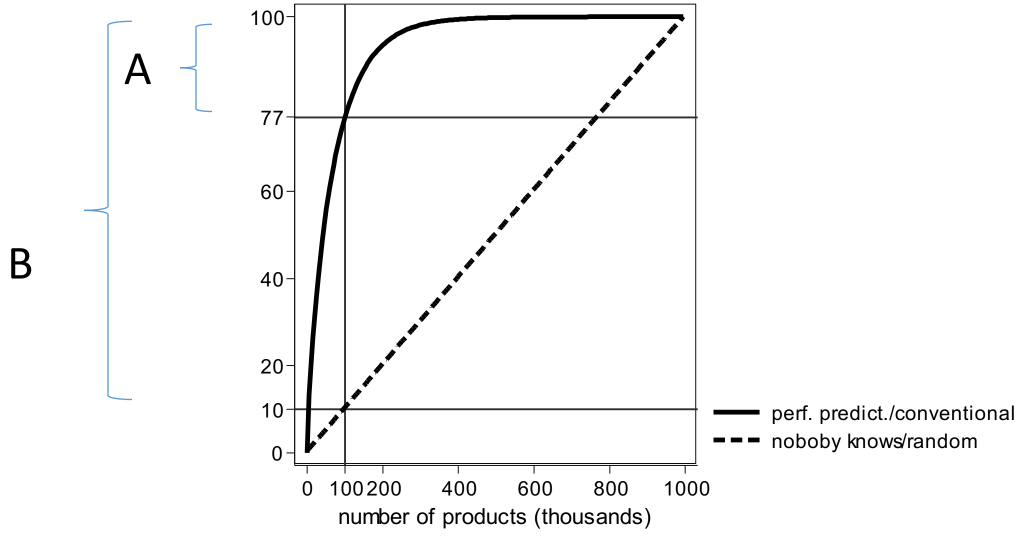




Aguiar and Waldfogel (2018 JPE)

We explore the consequence of quality unpredictability for the welfare benefit of new products, using recent developments in recorded music as our context. We quantify the effects of new music on welfare using an explicit structural model of demand and entry with potentially unpredictable product quality. On the basis of plausible forecasting models of expected appeal, a tripling of the choice set according to expected quality adds substantially more consumer surplus as the usual long-tail benefits from a tripling of the choice set according to realized quality.

New view: digitization allows more new products



With unpredictability, this is like taking draws from an urn

Suppose no predictability. Literally "nobody knows anything." Then benefit grows linearly in # of products

What's the benefit of tripling the number of new products?

Standard answer: A
Waldfogel's answer: B

We all know A is big. How big is B/A?

TABLE 5
Counterfactual Results

Regime	ΔCS	ΔCS Ratio	ΔRev	ΔRev Ratio	ΔTC	ΔTC Ratio	ΔW	ΔW Ratio
Perfect foresight	.51	1	.51	1	−5.18	1	6.20	1
Imperfect predictability	10.09	19.82	10.09	19.82	−51.55	9.96	71.72	11.57
No predictability	152.42	299.48	153.16	300.93	800.16	−154.54	−494.58	−79.82

Note.—ΔCS is the change in CS from the tripling of the vintage 2011 products made possible by digitization. The three regimes differ by which products are in the counterfactual (no-digitization) choice set. Perfect foresight adds products with the lowest realized quality, while imperfect predictability adds products with the lowest expected quality. The no-predictability regime adds products that are as good, on average, as the products that would be available without digitization. ΔCS Ratio reports ΔCS relative to the perfect foresight estimate that corresponds to the traditional long tail; ΔRev, ΔTC, ΔW, and the corresponding ratios are defined analogously. TC is the fixed cost per product times the number of entering products.

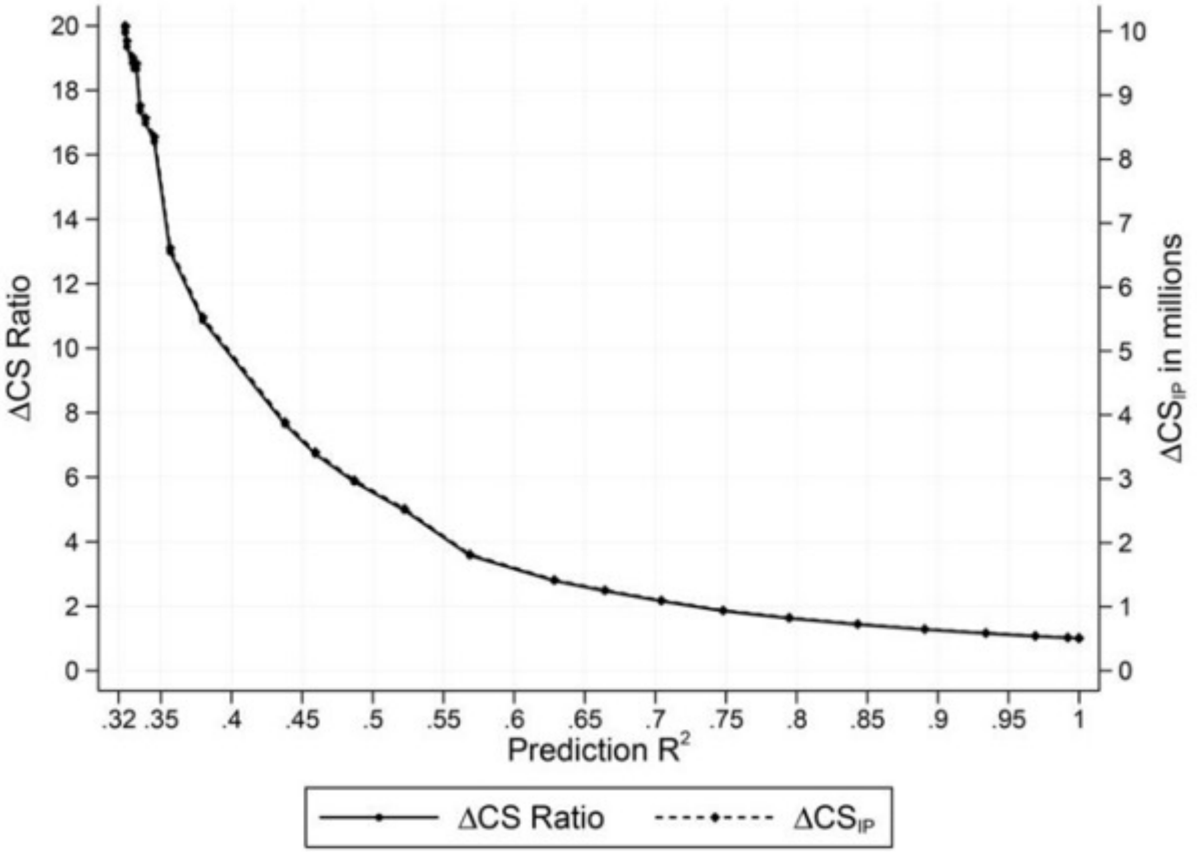


FIG. 3.—ΔCS ratio, ΔCS_{IP}, and prediction R^2

Education

These forces are coming for education

- Work thus far is somewhat limited.
- Role of geography and communication in research.
- Role of low marginal costs of production and distribution in teaching.

Role of low transport costs in research

American Economic Review 2008, 98:4, 1578–1590
http://www.aeaweb.org/articles.php?doi=10.1257/aer.98.4.1578

Restructuring Research: Communication Costs and the Democratization of University Innovation

By Ajay Agrawal and Avi Goldfarb*

We examine the effect of a decrease in collaboration costs resulting from the adoption of Bitnet (an early version of the Internet) on university research collaboration in engineering. Our interest in this question stems not from a concern about either Bitnet or engineering research specifically, but rather about the broader question of how changes in collaboration costs may affect the structure of knowledge production. Exploiting the variation in year of adoption and publication output over time in the 270 universities that published in seven top electrical engineering journals from 1981 to 1991, we find that a Bitnet connection did seem to facilitate a general increase in multi-institutional collaboration (by 40 percent, on average). At the same time, not all adopters benefited equally. Overall, Bitnet seems to have facilitated a disproportionate increase in the role of middle-tier universities, particularly those co-located with top-tier institutions.

The non-uniform effect of Bitnet across university pairs offers insight into the nature of collaborative knowledge production. A researcher deciding whether to add a collaborator to a project will do so if the benefit exceeds the cost such that the returns from collaboration are positive for both parties. Due to the way in which knowledge is produced, a technology shock like the introduction of Bitnet might affect the returns to collaboration differently, depending on characteristics of collaborating pairs, such as the quality of the institutions and the geographic distance between them. Indeed, our finding that certain university pair types benefited disproportionately from Bitnet adoption enables us to make inferences about the relative benefits and costs of collaboration across pair types.

For instance, we examine whether the returns to Bitnet adoption were mediated by pair quality. One might expect that pairs comprised of two top-tier universities would benefit most since individually these institutions produced the highest volume of research and thus had the most on which to collaborate. However, we find that top-tier/middle-tier pairs benefited most from adoption. These results suggest that the most salient effect of Bitnet may have been to facilitate gains from trade through the increased use of underutilized research equipment or the heightened specialization of research tasks.[1]

* Agrawal: Rotman School of Management, University of Toronto, 105 St. George St., Toronto, Canada, M5S 3E6, and NBER (ajay.agrawal@rotman.utoronto.ca); Goldfarb: Rotman School of Management, University of Toronto, 105 St. George St., Toronto, Canada, M5S 3E6 (e-mail: agoldfarb@rotman.utoronto.ca). We thank Pierre Azoulay, Iain Cockburn, Wes Cohen, Shane Greenstein, Scott Stern, two anonymous referees, and especially Ig Horstmann, as well as numerous seminar participants, for useful comments. We also thank Raghav Misra, Swapnil Kotecha, Cara Saunders, and Alex Oettl, all of whom provided excellent research assistance. Errors and omissions are our own. This research was funded by the Social Sciences and Humanities Research Council of Canada (grants 410-2004-1770 and 538-02-1013). Their support is gratefully acknowledged.

[1] With respect to the latter, the intuition is similar in spirit to models that examine trade between developed and developing countries (e.g., Avinash K. Dixit and Victor D. Norman 1980; Elhanan Helpman and Paul Krugman 1985). Many of these models show that the type of trade in equilibrium (i.e., developed-developed or developed-developing) will depend on the nature of the specialization and on the size of the economies. While we focus on specialization to explain our results, we acknowledge it is only one possible mechanism for differences of the observed effect of Bitnet across qualities. Other possibilities include monitoring (George P. Baker and Thomas N. Hubbard 2003) and heterogeneity in research interests (Tanya S. Rosenblat and Markus M. Mobius 2004). The aim of this paper is not to identify the particular mechanism, but to empirically measure the impact of Bitnet connection on different types of collaborations.

Journal of Economic Perspectives—Volume 35, Number 2—Spring 2021—Pages 191–216

The Rise of Research Teams: Benefits and Costs in Economics

Benjamin F. Jones

Economics research is increasingly a team activity: economists increasingly coauthor their papers, and these coauthored papers have a large and increasing impact advantage. This "rise of teams" raises issues for individual researchers and for the field. On the one hand, coauthorship brings benefits, allowing individuals to combine perspectives, knowledge, skills, and effort in fruitful ways. But it also imposes costs; for example, coauthorship divides and obscures credit among the participants, which can undermine individual career progression. This paper synthesizes recent literature to weigh the benefits and costs of research teams. The findings provide guidance to individual researchers themselves, and the institutions that support them, in fostering high-impact research and productive research careers.

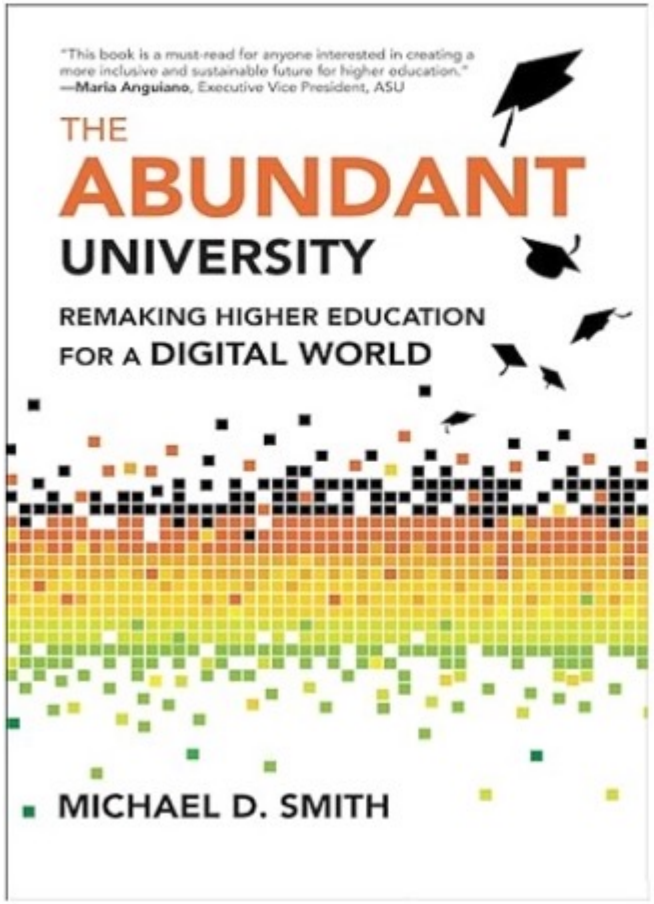
The paper begins by documenting the rapid rise of team authorship in economics. For example, while papers with two or more authors constituted only 19 percent of economics journal articles in 1960, this share rose to 44 percent in 2000 and 74 percent in 2018. Moreover, team-authored papers in economics have increasing impact advantages over solo-authored papers. By 2010, a team was three times more likely to produce a highly cited paper than a solo author, an advantage that has grown steadily with time. These shifts appear not only within every subfield of economics, but also in virtually all fields of science, social science, and patenting.

■ *Benjamin F. Jones is Gordon and Llura Gund Family Professor of Entrepreneurship and Professor of Strategy, Kellogg School of Management at Northwestern University, Evanston, Illinois, and Research Associate, National Bureau of Economic Research, Cambridge, Massachusetts. His email address is bjones@kellogg.northwestern.edu.*

For supplementary materials such as appendices, datasets, and author disclosure statements, see the article page at https://doi.org/10.1257/jep.35.2.191.

Role of low marginal costs of production and distribution in teaching.

- Thus far, little empirical impact on higher ed., and little systematic economic research on k-12.
- Hypothesis is that the best teachers will be able to scale.
- Global competition.



Journal of Economic Literature 2019, 57(1), 3–43
https://doi.org/10.1257/jel.20171452

Digital Economics†

Avi Goldfarb and Catherine Tucker*

Digital technology is the representation of information in bits. This technology has reduced the cost of storage, computation, and transmission of data. Research on digital economics examines whether and how digital technology changes economic activity. In this review, we emphasize the reduction in five distinct economic costs associated with digital economic activity: search costs, replication costs, transportation costs, tracking costs, and verification costs. (*JEL* D24, D83, L86, O33, R41)

1. *What Is Digital Economics?*

Digital technology is the representation of information in bits. This reduces the cost of storage, computation, and transmission of data. Research on digital economics examines whether and how digital technology changes economic activity.

Understanding the effects of digital technology does not require fundamentally new economic theory. However, it requires a different emphasis. Studying digital economics starts with the question of "what is different?" What is easier to do when information is represented by bits rather than atoms? Digital technology often means that costs may constrain economic actions. Therefore, digital economics explores how standard economic models change as certain costs fall substantially and perhaps approach zero. We emphasize how this shift in costs can be divided into five types:

(i) Lower search costs

(ii) Lower replication costs

(iii) Lower transportation costs

(iv) Lower tracking costs

(v) Lower verification costs

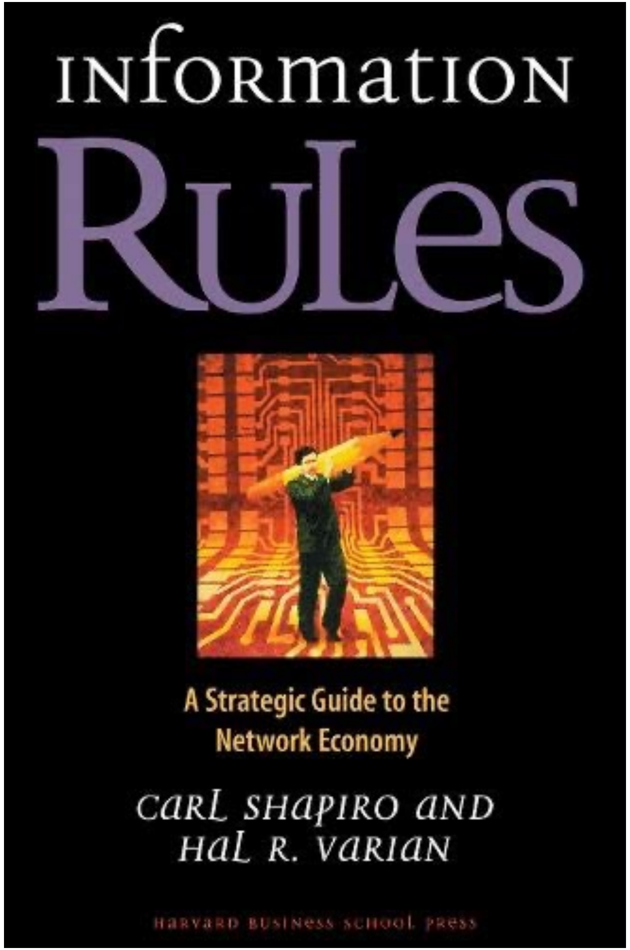
Search costs are lower in digital environments, enlarging the potential scope and quality of search. Digital goods can be replicated at zero cost, meaning they are often non-rival. The role of geographic distance changes as the cost of transportation for digital goods and information is approximately zero. Digital technologies make it easy to track any one individual's behavior. Last, digital verification can make it easier to certify the reputation and trustworthiness of any one individual, firm, or organization in the

* Goldfarb: University of Toronto and NBER. Tucker: Massachusetts Institute of Technology Sloan School of Management and NBER. We thank Andrey Fradkin and Kristina McElheran for helpful comments. We are grateful to the Sloan Foundation for its support of the NBER Digitization Initiative, which built the research community around which this review is based.

† Go to https://doi.org/10.1257/jel.20171452 to visit the article page and view author disclosure statement(s).


1995?

New Economy



Journal of Economic Literature 2019, 57(1), 3–43
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Digital Economics[†]

AVI GOLDFARB AND CATHERINE TUCKER*

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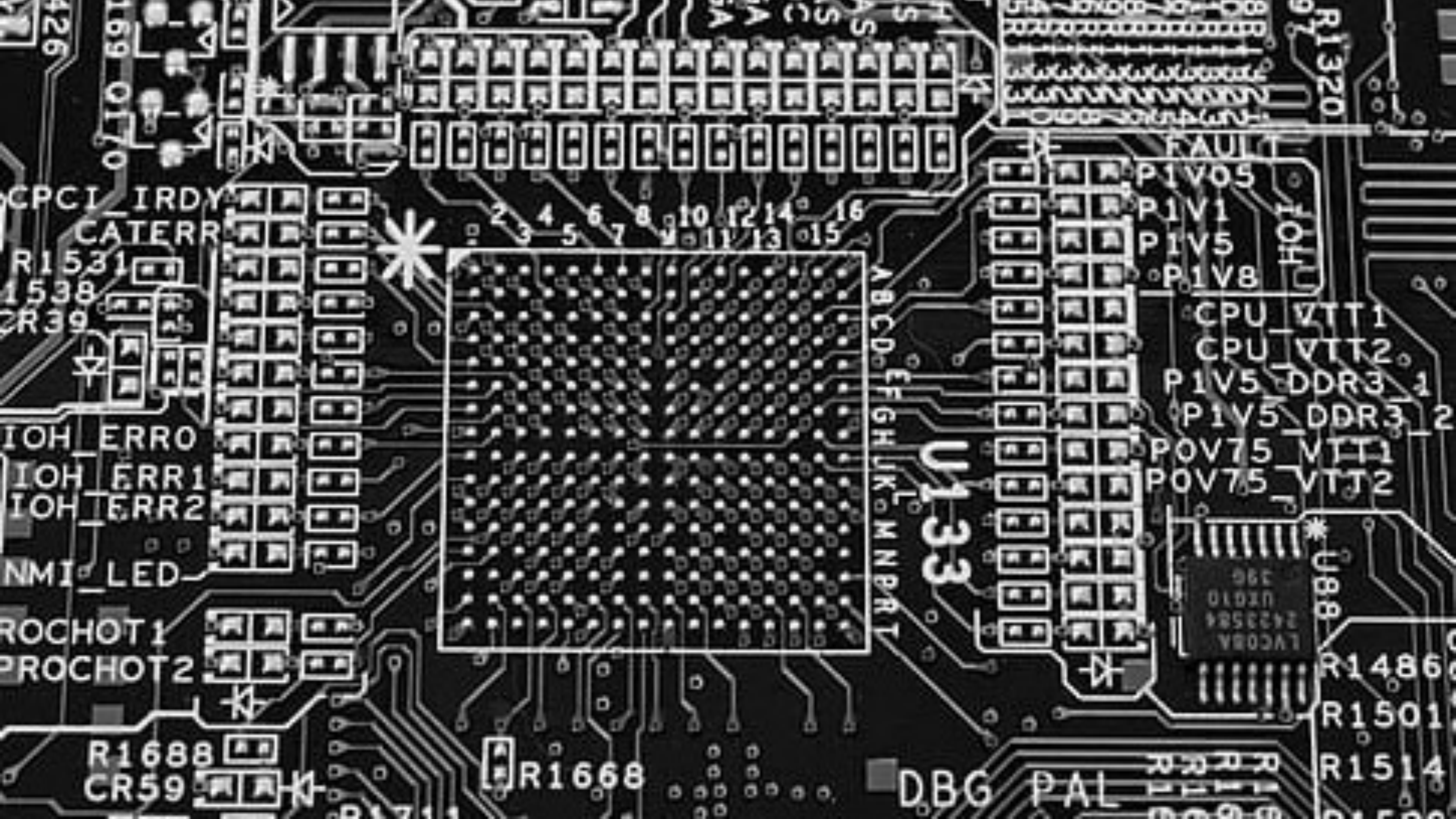
CPCI_IRDY
CATERR
R1531
CR39
IOH_ERR0
IOH_ERR1
IOH_ERR2
NMI_LED
PROCHOT1
PROCHOT2
R1688
CR59
R1668
DBG PAL
U133
FAULT
P1V05
P1V1
P1V5
P1V8
IOH
CPU_VTT1
CPU_VTT2
P1V5_DDR3_1
P1V5_DDR3_2
P0V75_VTT1
P0V75_VTT2
U88
R1486
R1501
R1514
R1320

The Changing Structure of Innovation in Computing: Sources of and Threats to the Dominant U.S. Position

Timothy F. Bresnahan

The computer industry is remarkable for the pace of its technical change over the last half century and for the pace of its organizational change during the 1990s. From its inception in the 1940s, the industry has been characterized by rapid and sustained technical change. Major breakthroughs leading to new uses have punctuated continuous product innovation serving existing uses better each year. For decades, established sellers experienced success based on the persistence of key interface standards linking their proprietary technology to users' and complementors' investments. Much of that success arose from these firms' ability to coordinate and direct the wide variety of different technologies—components, systems, software, and

The Journal of Economic History

Two Centuries of Productivity Growth in Computing

Published online by Cambridge University Press: **21 March 2007**

William D. Nordhaus

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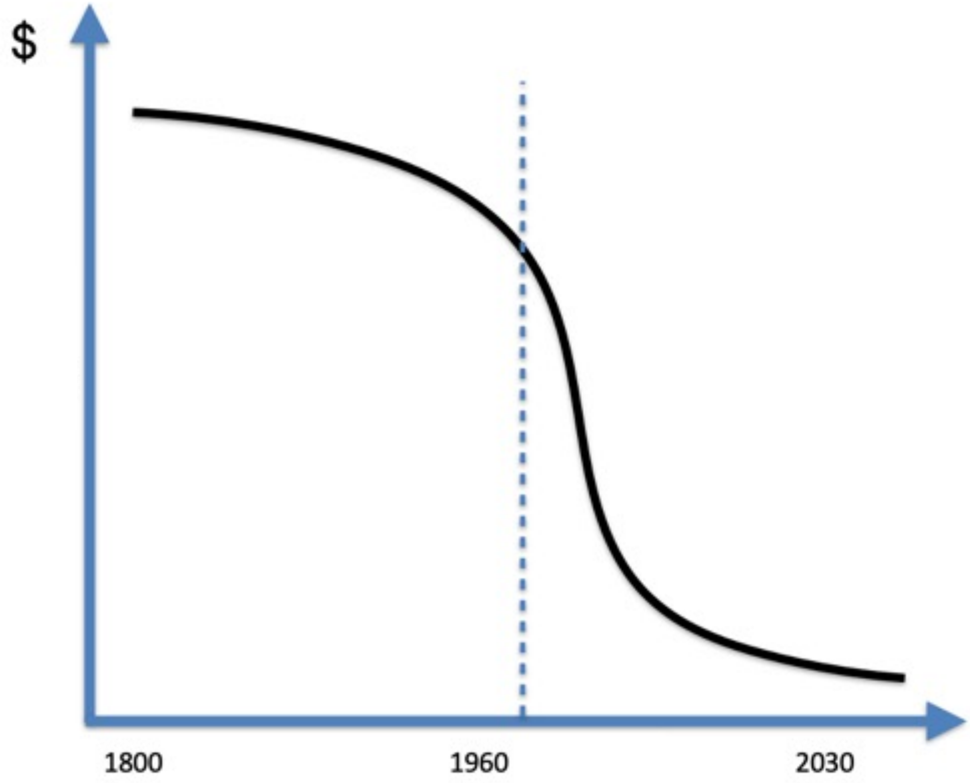
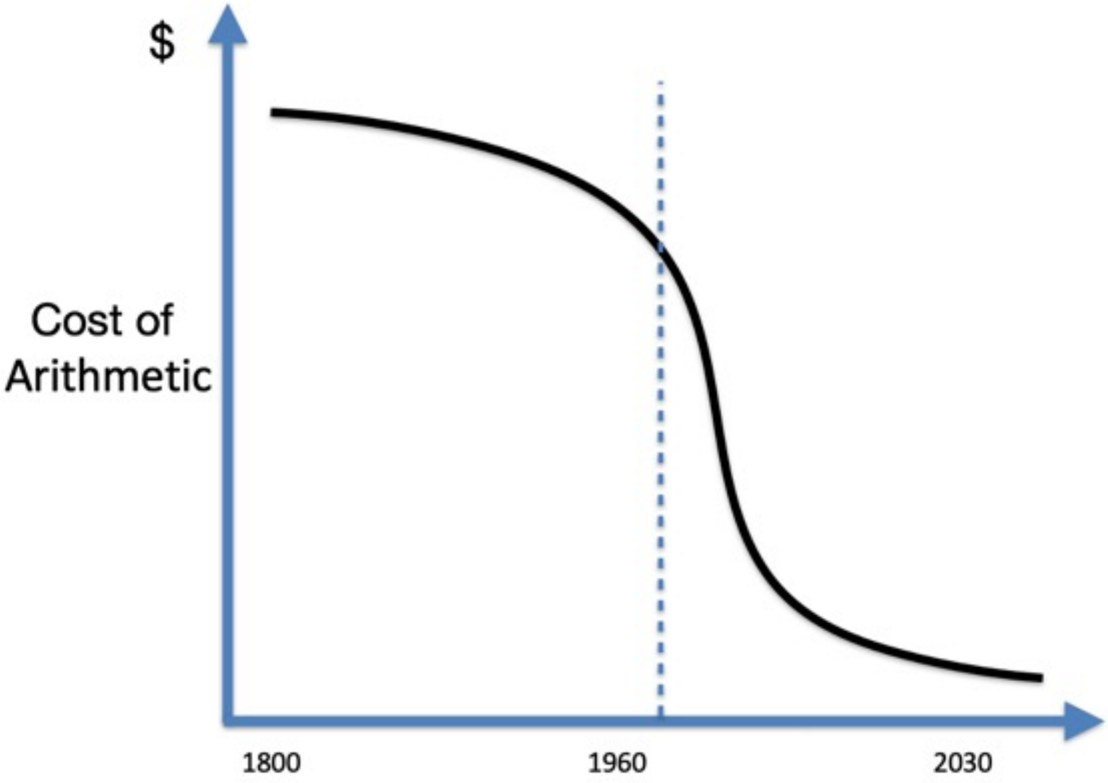
Abstract

The present study analyzes computer performance over the last century and a half. Three

Semiconductors

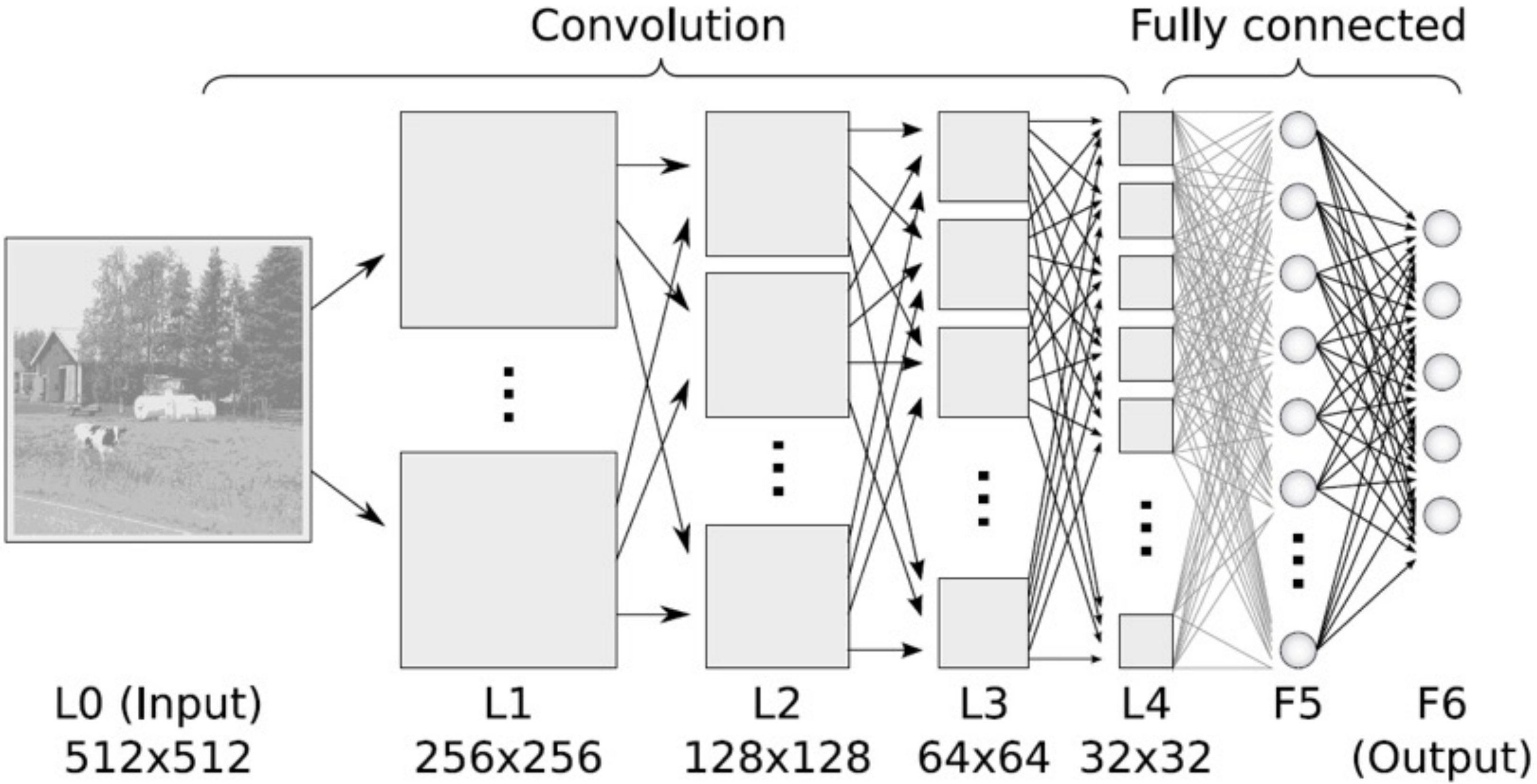


Semiconductors



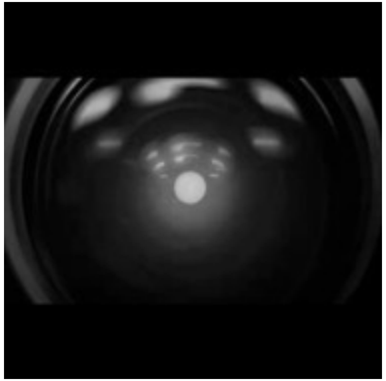
Expanding Range of Use of an Input

Expanding Range of Use of an Input



Source: https://www.ais.uni-bonn.de/deep_learning/

What is Artificial Intelligence?



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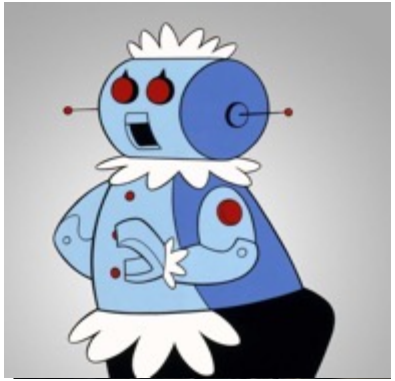

Defining Artificial Intelligence

- Oxford English Dictionary definition: “the theory and development of computer systems able to perform tasks normally requiring human intelligence.”

- A moving target!

Comment Daniel Kahneman

I want to end on a story. A well-known novelist wrote me some time ago that he's planning a novel. The novel is about a love triangle between two humans and a robot. What he wanted to know is how the robot would be different from the people.

I proposed three main differences. One is obvious: the robot will be much better at statistical reasoning and less enamored with stories and narratives than people are. The other is that the robot would have a much higher emotional intelligence. The third is that the robot would be wiser. Wisdom is breadth. Wisdom is not having too narrow a view. That is the essence of wisdom; it's broad framing. A robot will be endowed with broad framing. I say that when it has learned enough, it will be wiser than we people because we do not have broad faming. We are narrow thinkers, we are noisy thinkers, and it is very easy to improve upon us. I do not think that there is very much that we can do that computer will not eventually be programmed to do.

Automation

- A process is automatic if it is performed without human assistance.

- Automation occurs when a process previously performed by humans becomes automatic.

- Fear of massive job losses largely driven by the potential of AI to automate processes.

Microsoft's (2019) System of Intelligence

2

The Technological Elements of Artificial Intelligence

Matt Taddy

AI = Domain Structure + Data Generation + General Purpose ML

Domain Structure	Data Generation	General Purpose ML
Business Expertise	Reinforcement Learning	Deep Neural Nets
Structural Econom[etr]ics	Big Data Assets	Video/Audio/Text
Relaxations and Heuristics	Sensor/Video Tracking	OOS + SGD + GPUs

Figure 1: AI systems are self-training structures of ML predictors that automate and accelerate human tasks.

- Domain structure "allows you to break a complex task into composite tasks that can be solved with ML"
- Data generation in AI systems "requires an active strategy to keep a steady stream of new and useful information flowing into the composite learning algorithms"
- **"The current instance of AI is ML-driven. ML algorithms are implanted in every aspect of AI."**

American Economic Review: Papers & Proceedings 2015, 105(5): 491–495
http://dx.doi.org/10.1257/aer.p20151023

Prediction Policy Problems[†]

By JON KLEINBERG, JENS LUDWIG, SENDHIL MULLAINATHAN, AND ZIAD OBERMEYER[*]

Empirical policy research often focuses on causal inference. Since policy choices seem to depend on understanding the counterfactual—what happens with and without a policy—this tight link of causality and policy seems natural. While this link holds in many cases, we argue that there are also many policy applications where causal inference is not central, or even necessary.

Consider two toy examples. One policymaker facing a drought must decide whether to invest in a rain dance to increase the chance of rain. Another seeing clouds must decide whether to take an umbrella to work to avoid getting wet on the way home. Both decisions could benefit from an empirical study of rain. But each has different requirements of the estimator. One requires causality: Do rain dances cause rain? The other

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I. Predicti

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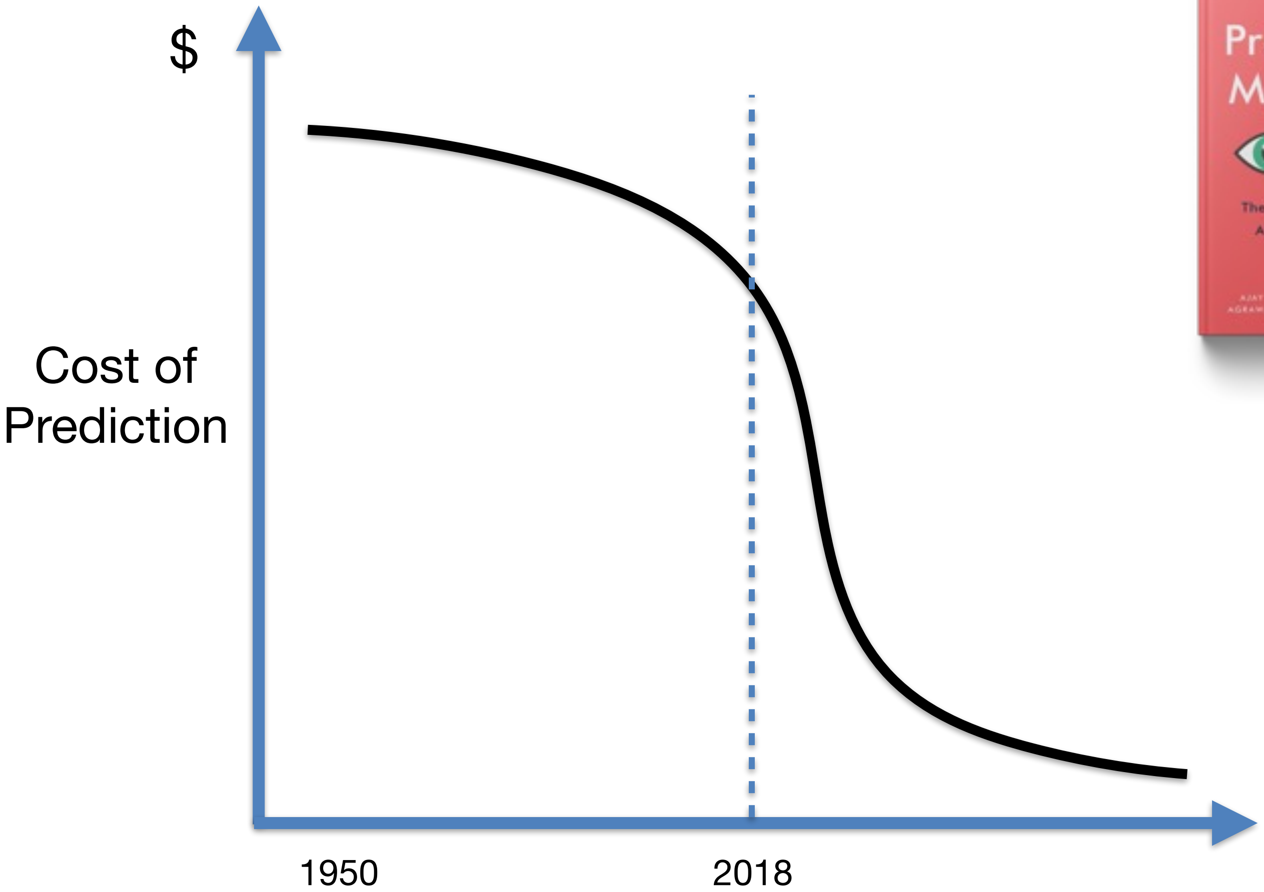
HUMAN DECISIONS AND MACHINE PREDICTIONS*

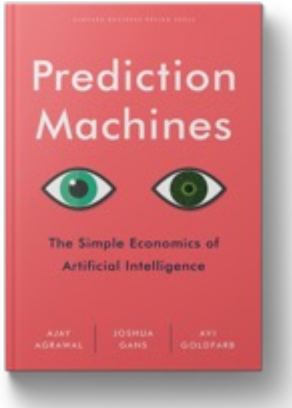
JON KLEINBERG
HIMABINDU LAKKARAJU
JURE LESKOVEC
JENS LUDWIG
SENDHIL MULLAINATHAN

Can machine learning improve human decision making? Bail decisions provide a good test case. Millions of times each year, judges make jail-or-release decisions that hinge on a prediction of what a defendant would do if released. The concreteness of the prediction task combined with the volume of data available makes this a promising machine-learning application. Yet comparing the algorithm to judges proves complicated. First, the available data are generated by prior judge decisions. We only observe crime outcomes for released defendants, not for those judges detained. This makes it hard to evaluate counterfactual decision rules based on algorithmic predictions. Second, judges may have a broader set of preferences than the variable the algorithm predicts; for instance, judges

PREDICTION:
Using information that you *do* have to generate information that you *don't* have

Artificial Intelligence



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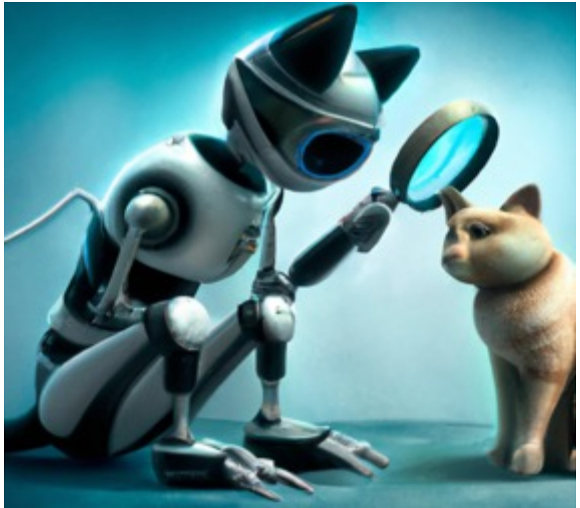
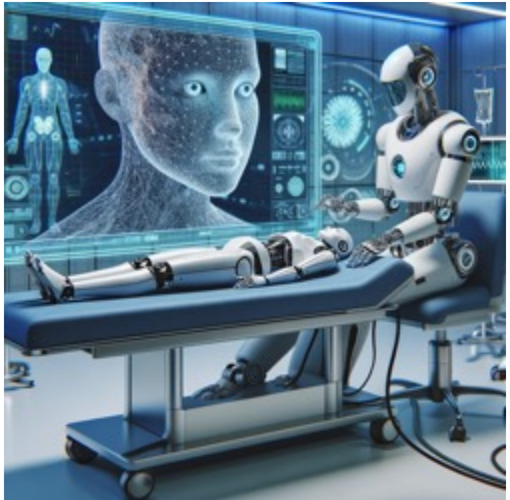



OpenAI

A

How will AI affect productivity and inequality?

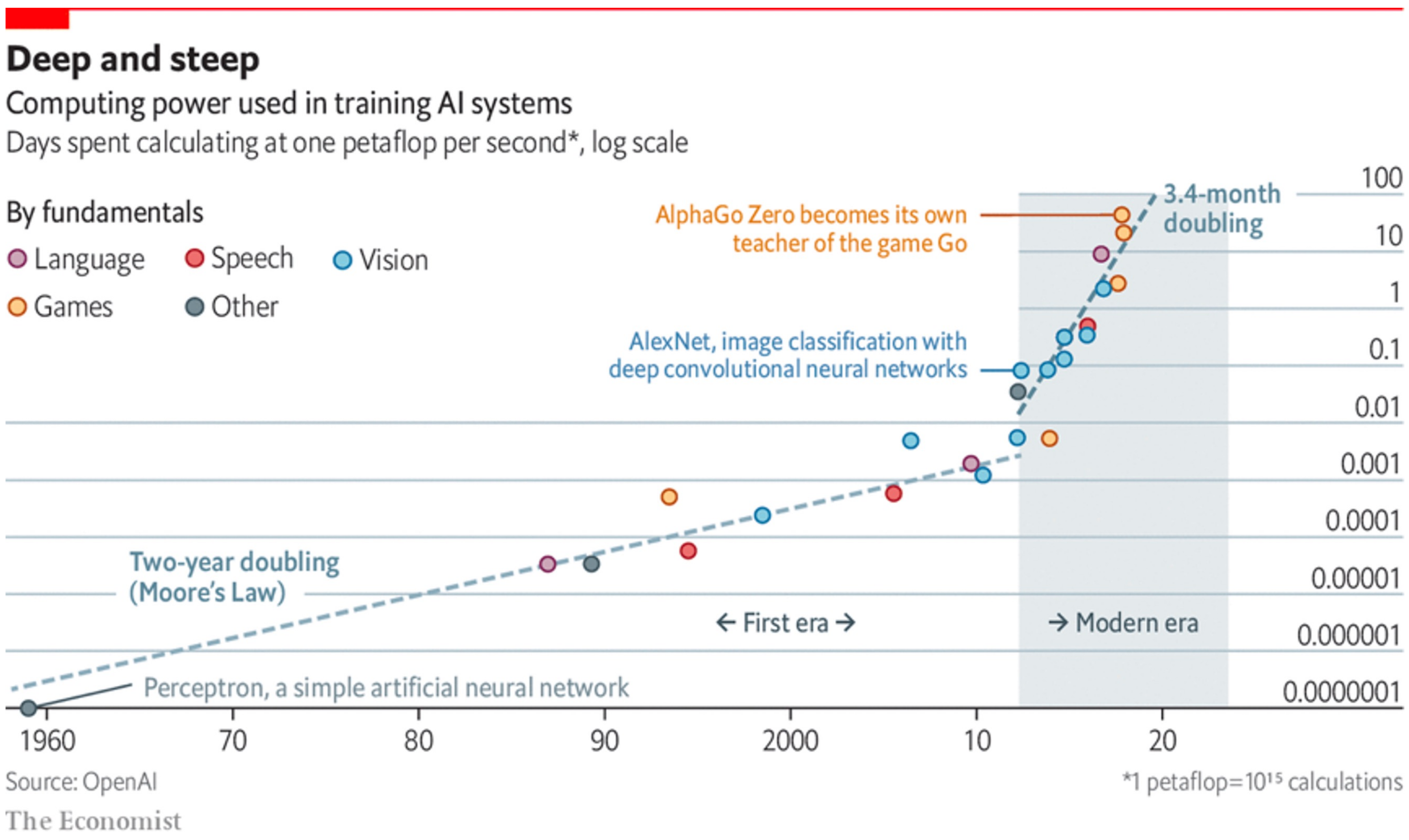
Artificial Intelligence (AI) has the potential to significantly affect productivity and inequality in multiple ways, and many of these effects are interconnected.

Productivity

1. **Automation of Routine Tasks:** AI can automate routine tasks, which can greatly enhance productivity. This is true in various sectors like manufacturing, where robots can work 24/7, and services, where AI can handle tasks such as customer inquiries or data analysis.
2. **Intelligent Assistance:** AI can provide intelligent assistance to human workers, helping them to be more efficient and effective. For example, AI can help doctors diagnose diseases, architects design buildings, or teachers personalize learning.
3. **Innovation:** AI can help drive innovation, creating new products, services, and ways of doing things. This can lead to increased productivity across the economy.

Inequality

1. **Job Displacement:** While AI can increase productivity, it can also lead to job



Deep and steep
Computing power used in training AI systems
Days spent calculating at one petaflop per second*, log scale
By fundamentals
Language
Speech
Vision
Games
Other
AlphaGo Zero becomes its own teacher of the game Go
3.4-month doubling
AlexNet, image classification with deep convolutional neural networks
Two-year doubling (Moore's Law)
← First era →
→ Modern era
Perceptron, a simple artificial neural network
100
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0.01
0.001
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1960
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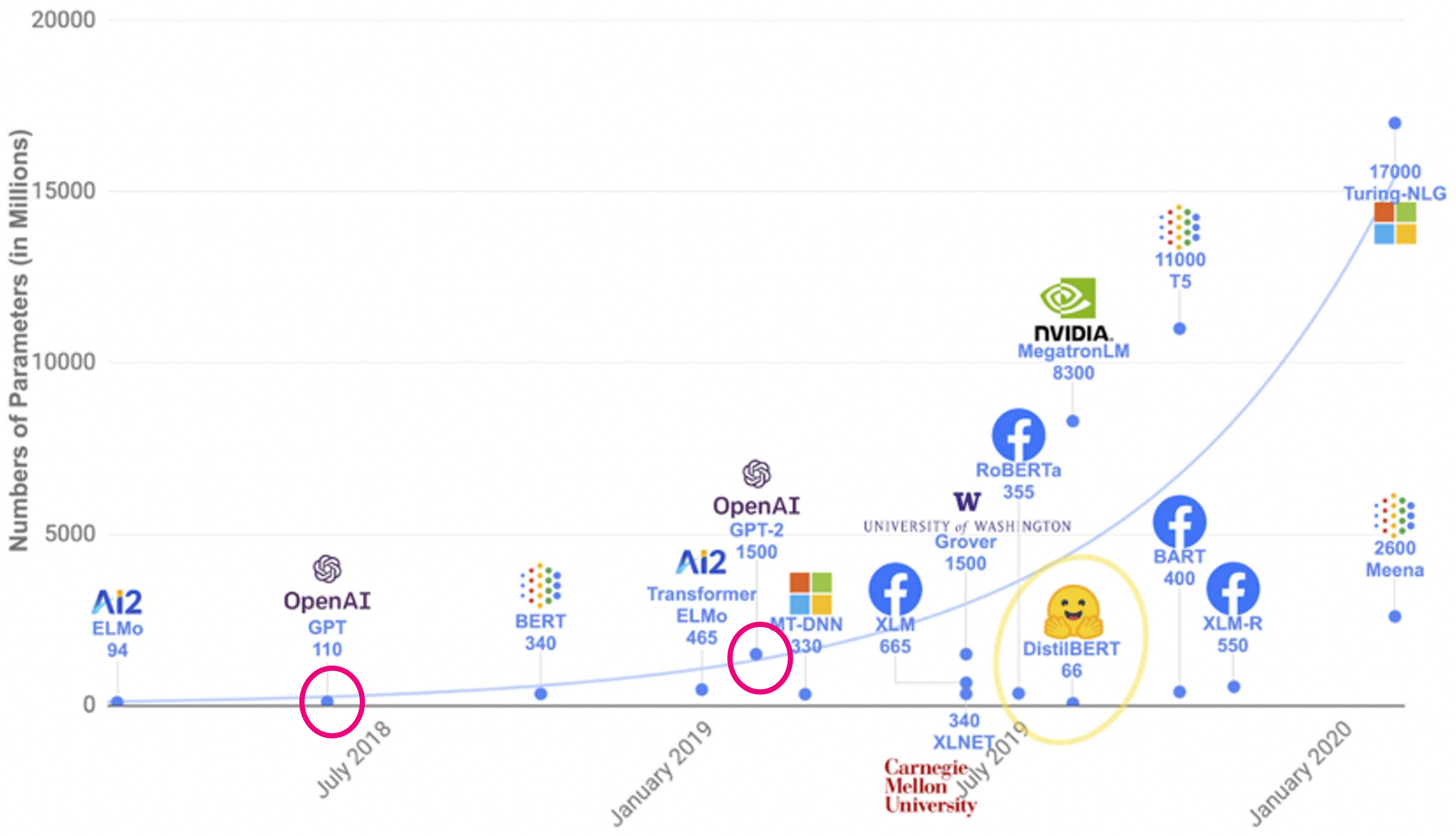
Source: OpenAI
*1 petaflop=10^15 calculations
The Economist



Numbers of Parameters (in Millions)
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July 2018
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July 2019
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Transformer
ELMo
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OpenAI
GPT-2
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MT-DNN
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XLM
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UNIVERSITY of WASHINGTON
Grover
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XLNET
Carnegie
Mellon
University
RoBERTa
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NVIDIA
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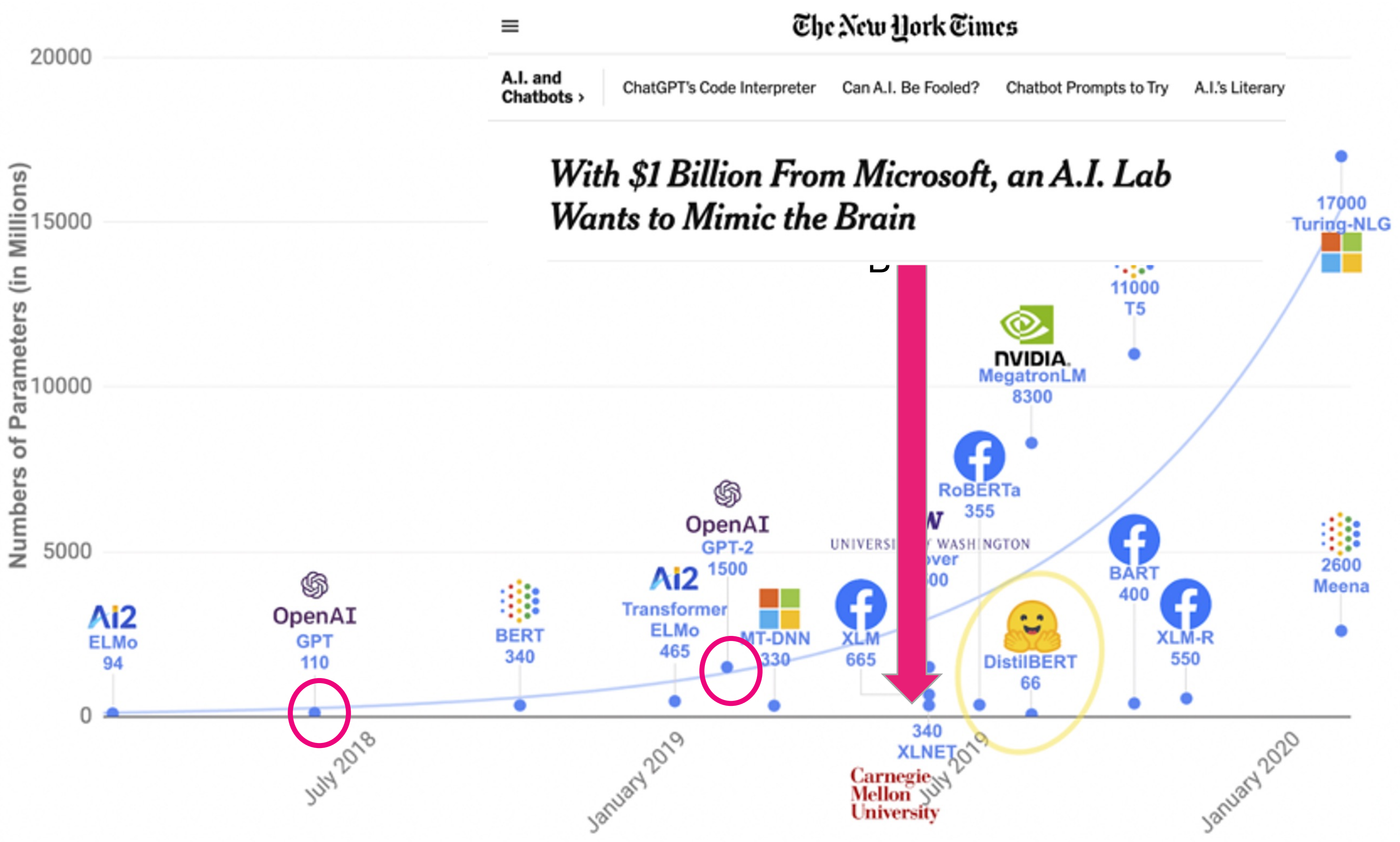
Meena


The New York Times
A.I. and Chatbots ›
ChatGPT's Code Interpreter
Can A.I. Be Fooled?
Chatbot Prompts to Try
A.I.'s Literary
With $1 Billion From Microsoft, an A.I. Lab Wants to Mimic the Brain
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January 2019
July 2019
January 2020
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BERT
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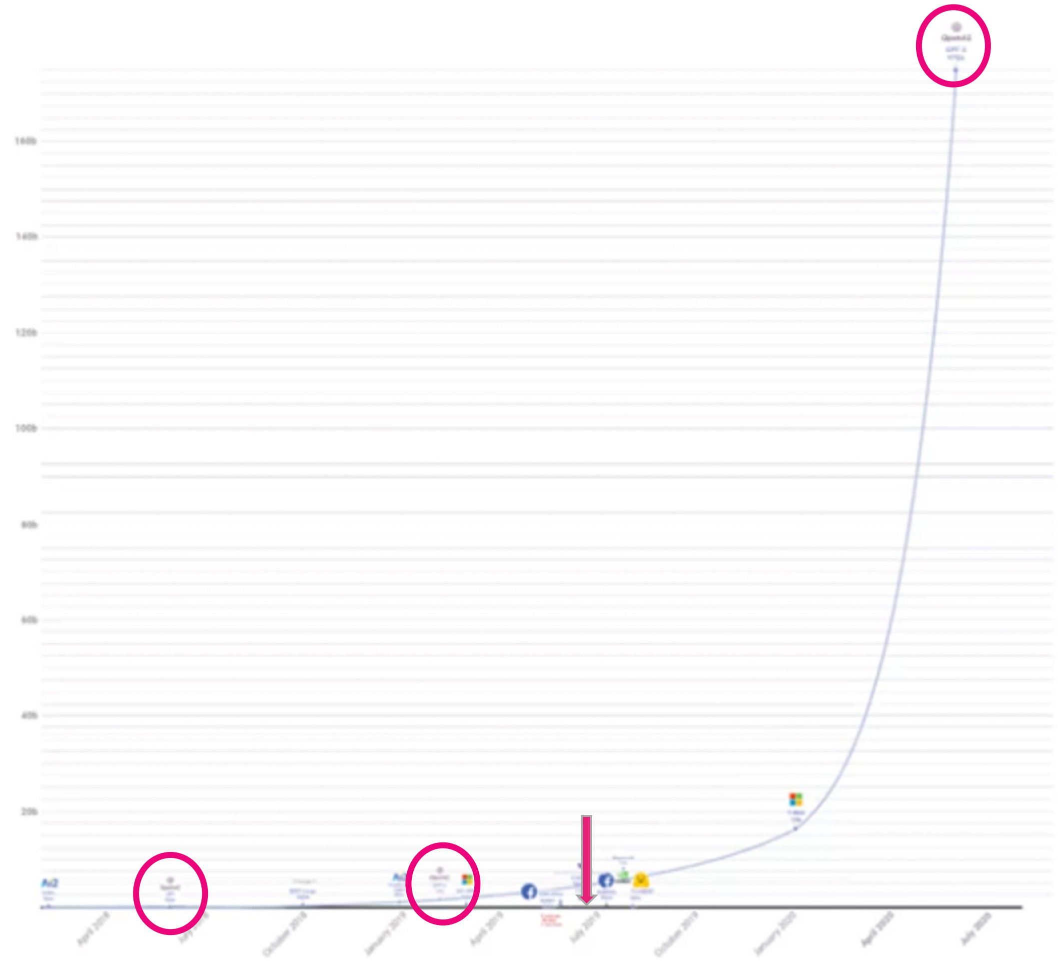
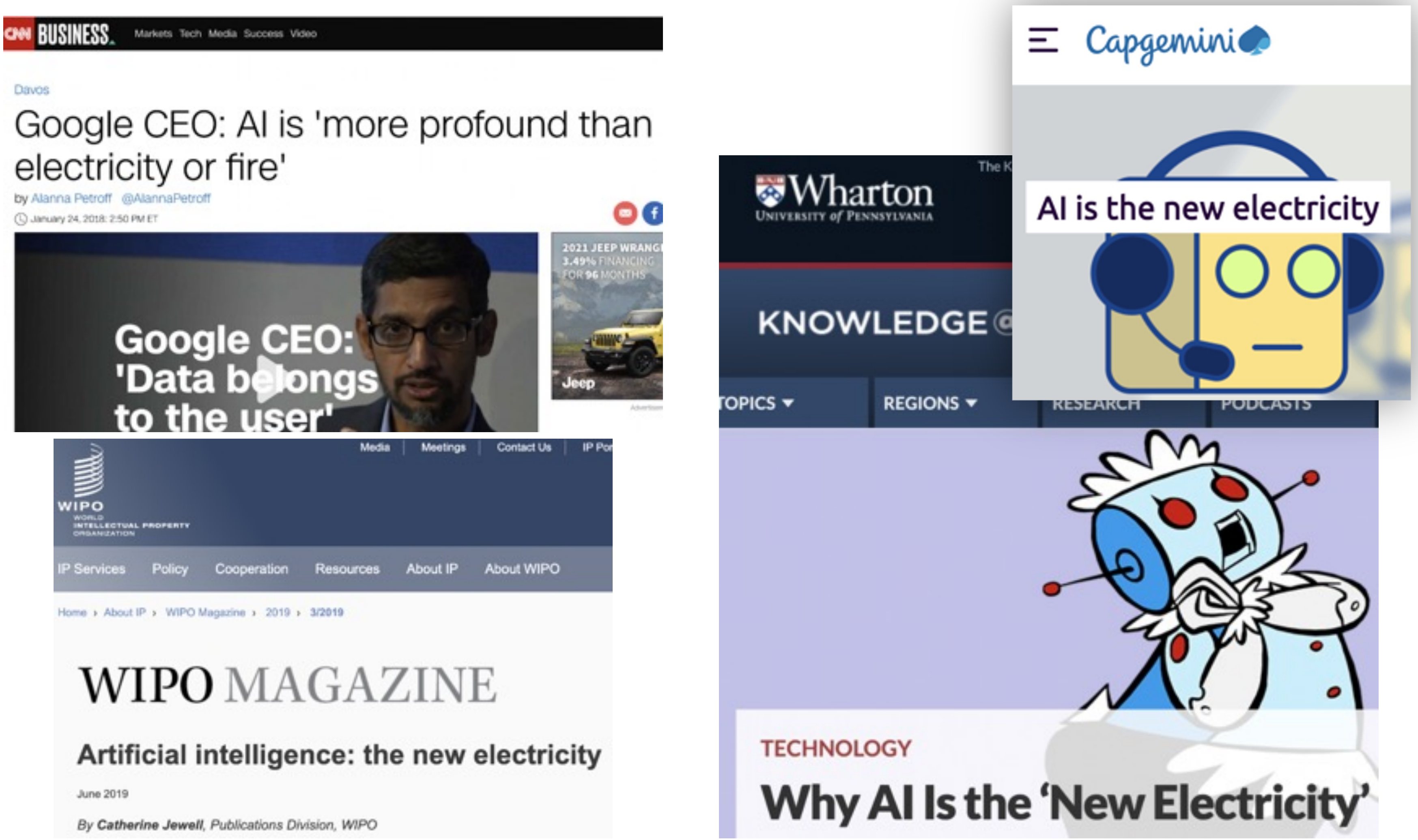
Meena

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by Alanna Petroff @AlannaPetroff
January 24, 2018: 2:50 PM ET
Google CEO: 'Data belongs to the user'
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3.49% FINANCING FOR 96 MONTHS
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Artificial intelligence: the new electricity
June 2019
By Catherine Jewell, Publications Division, WIPO
Wharton
UNIVERSITY of PENNSYLVANIA
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TECHNOLOGY
Why AI Is the 'New Electricity'
Capgemini
AI is the new electricity

The Journal of Economic History

Article contents

Abstract

References

From Shafts to Wires: Historical Perspective on Electrification

Published online by Cambridge University Press: **03 March 2009**

Warren D. Devine Jr

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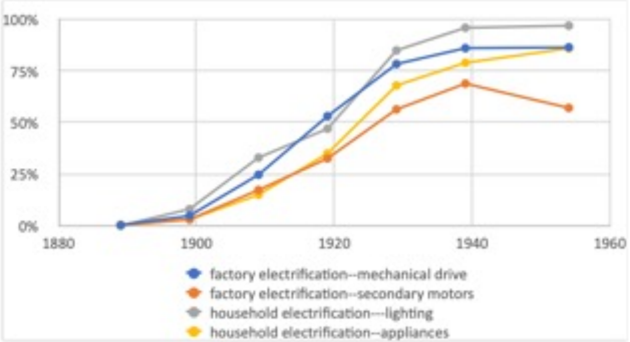
Abstract

The shift from steam to electric power in manufacturing is recounted. Between 1880 and 1930 the production and distribution of mechanical power rapidly evolved from water and steam prime movers with shaft and belt drive systems to electric motors that drove individual machines. The use of electricity reduced the energy required to drive machinery, but more important, enabled industry to obtain greater output per unit of capital and labor input.Reduced energy needs and increased productivity in manufacturing influenced the relationship between energy consumption and gross national product in the first three decades of the twentieth century.



The Dynamo and the Computer: An Historical Perspective on the Modern Productivity Paradox

By PAUL A. DAVID*

Many observers of recent trends in the industrialized economies of the West have been perplexed by the conjecture of rapid technological innovation with disappointingly slow gains in measured productivity. A generation of economists who were brought up to identify increases in total factor productivity indexes with "technical progress" has found it quite paradoxical for the growth accountants' residual measure of "the advance of knowledge" to have vanished at the very same time that a wave of major innovations was appearing—in microelectronics, in communications technologies based on lasers and fiber optics, in composite materials, and in biotechnology. Disappointments with "the computer revolution" and the newly dawned "information age" in this regard have been keenly felt. Indeed, the notion that there is something anomalous about the prevailing state of affairs has drawn much of its appeal from the apparent failure of the wave of innovations based on the microprocessor and the memory chip to elicit a surge of growth in productivity from the sectors of the U.S. economy that recently have been investing so heavily in electronic data processing equipment (see, for example, Stephen Roach, 1987, 1988; Martin Baily and Robert Gordon, 1988). This latter aspect of the so-called "productivity paradox" attained popular currency in the succinct formulation attributed to Robert Solow: "We see the computers everywhere but in the productivity statistics."

If, however, we are prepared to approach the matter from the perspective afforded by the economic history of the large technical systems characteristic of network industries, and to keep in mind a time-scale appropriate for thinking about transitions from established technological regimes to their respective successor regimes, many features of the so-called productivity paradox will be found to be neither so unprecedented nor so puzzling as they might otherwise appear.

I

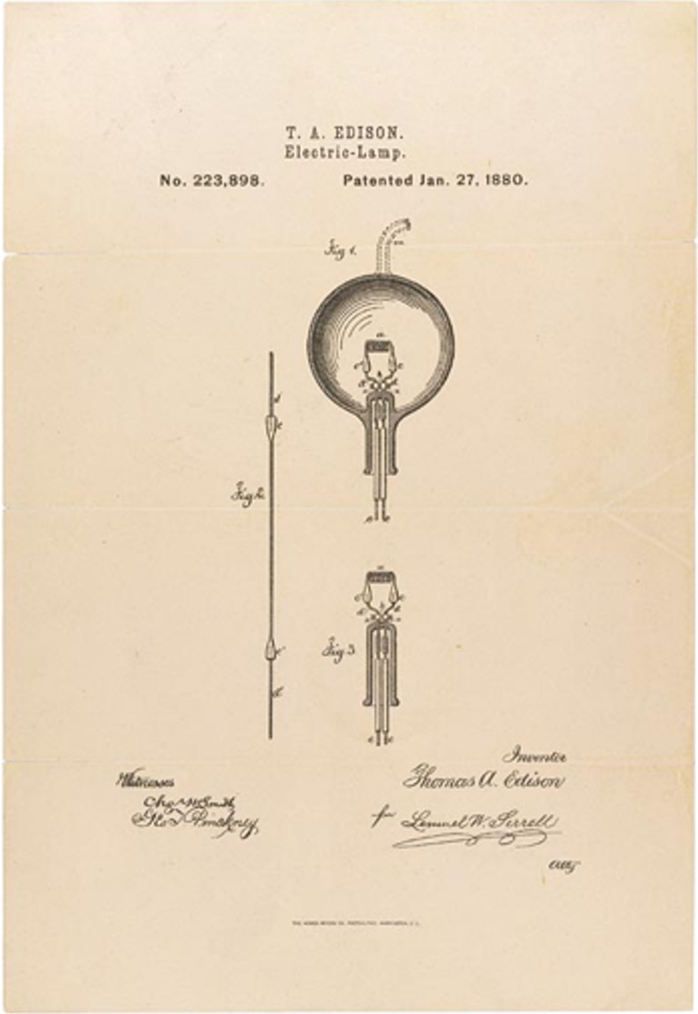
My aim here simply is to convince modern economic analysts (whether perplexed by the productivity slowdown, or not) of the immediate relevance of historical studies that trace the evolution of techno-economic regimes formed around general purpose engines.[1] The latter, typically, are key functional components embodied in hardware that can be applied as elements or modular units of the engineering designs developed for a wide variety of specific operations or processes. Accordingly, they are found ubiquitously distributed throughout such systems when the latter have attained their mature, fully elaborated state. James Watt's (separate condenser) steam engine design springs to mind readily as an example of an innovation that fulfilled this technological role in the first industrial revolution. My particular line of argument will be better served, however, by directing notice to the parallel between the modern computer and another general purpose engine, one that figured prominently in what sometimes is called the "second Industrial Revolution"—namely, the electric dynamo. (But, see also Herbert Simon, 1986.)

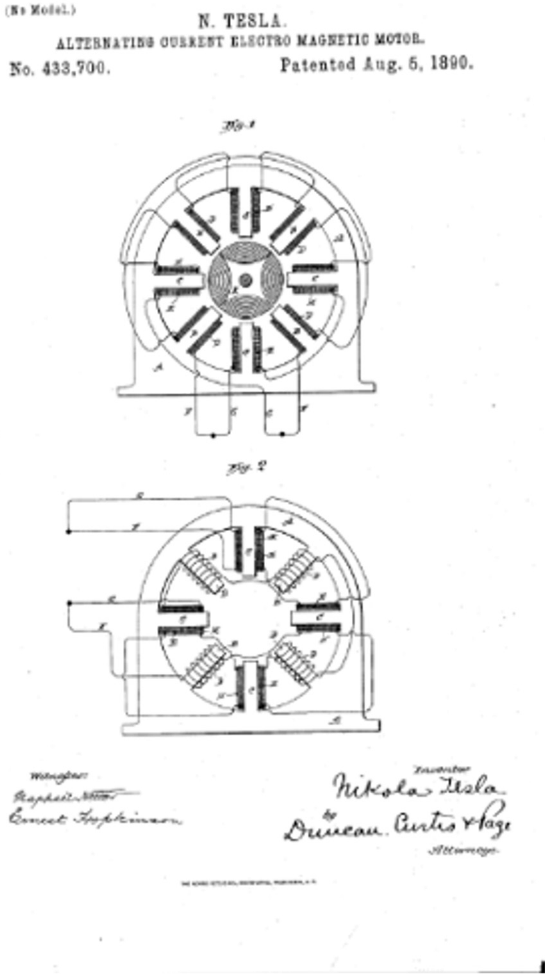
Although the analogy between information technology and electrical technology

*Department of Economics, Encina Hall, Stanford University, Stanford, CA 94305.

Discussions with Paul Rhode were particularly helpful early in the research. I am grateful for comments from Steve Broadberry, Jonathan Cave, Nick Crafts, among the participants in the Economic History Summer Workshop held at Warwick University, July 10–28, 1989; from Timothy Taylor; and from Shane Greenstein, Avner Greif, Edward Steinmueller, and other participants in the Technology and Productivity Workshop at Stanford, October 1989.

[1]This paper draws upon material developed in a longer work—my 1989 paper.


T. A. EDISON.
Electric-Lamp.
No. 223,898.
Patented Jan. 27, 1880.
Fig 1.
Fig 2
Fig 3
Witnesses
Inventor
Thomas A. Edison
Lemuel W. Serrell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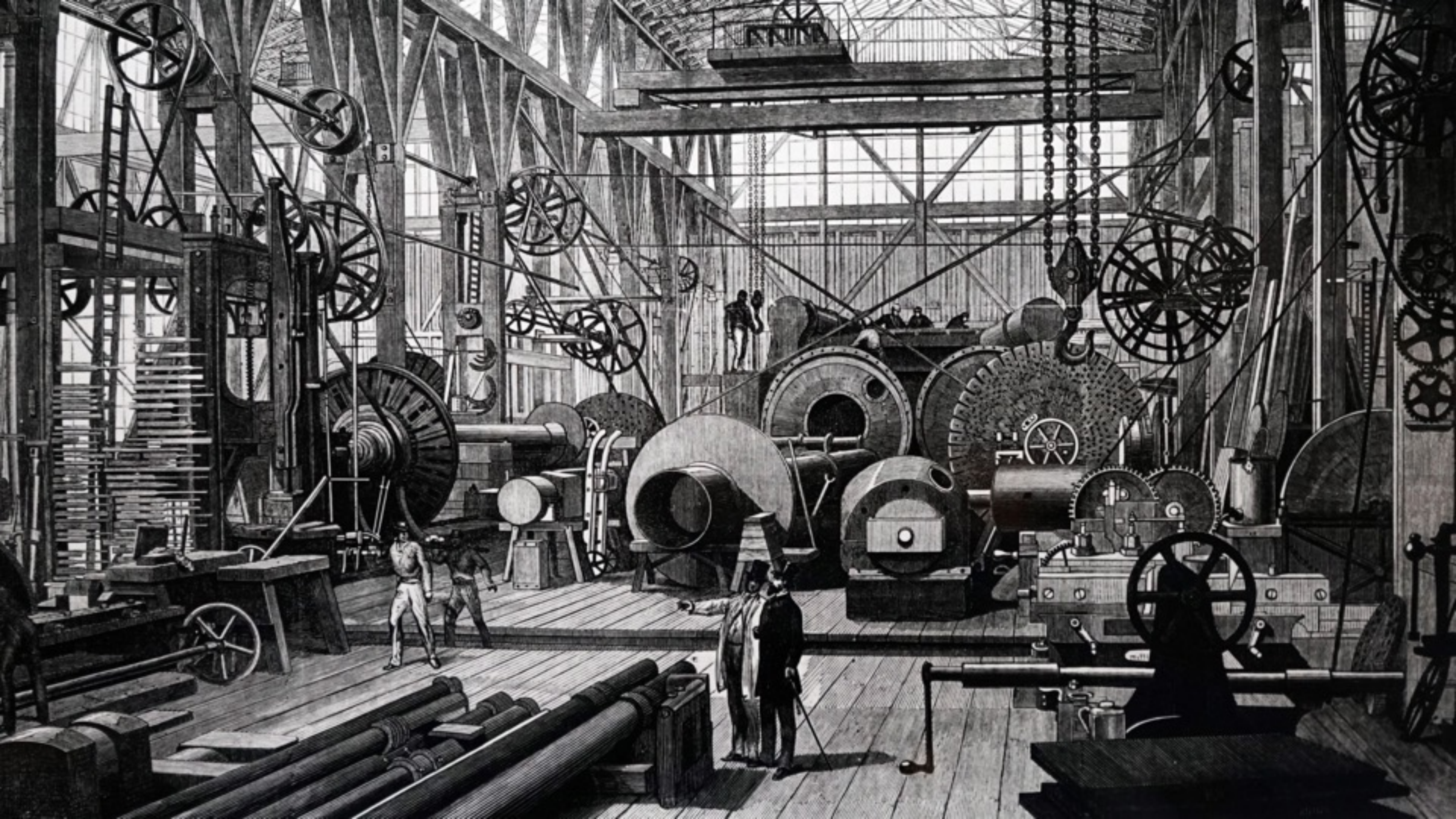
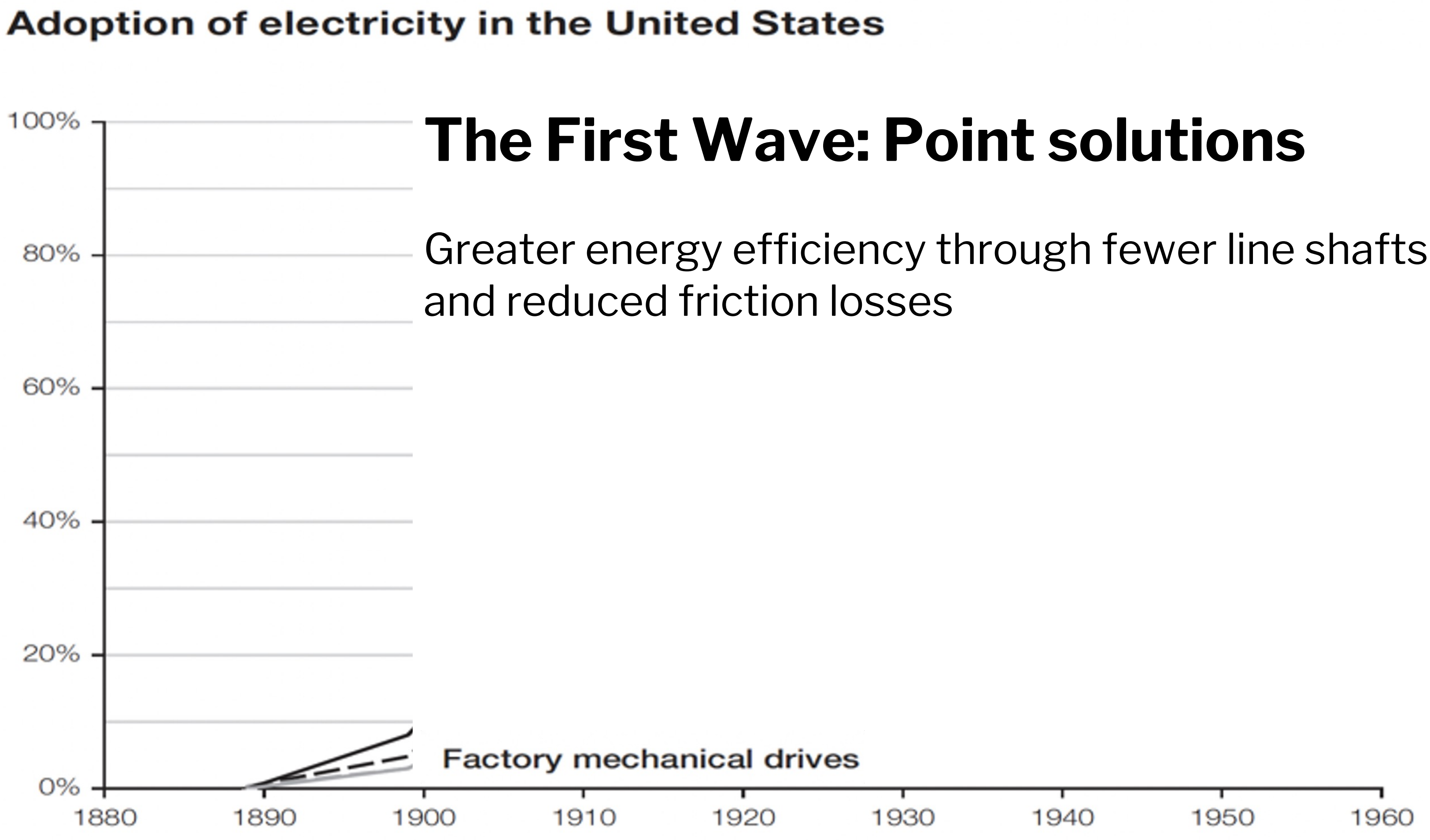
N. TESLA.
ALTERNATING CURRENT ELECTRO MAGNETIC MOTOR.
No. 433,700.
Patented Aug. 5, 1890.
Fig. 2
Witnesses
Ernest Hopkinson
Inventor
Nikola Tesla
by
Duncan Curtis & Page
Attorneys





The First Wave: Point solutions

Greater energy efficiency through fewer line shafts and reduced friction losses

The Second Wave

Flexible machine placement

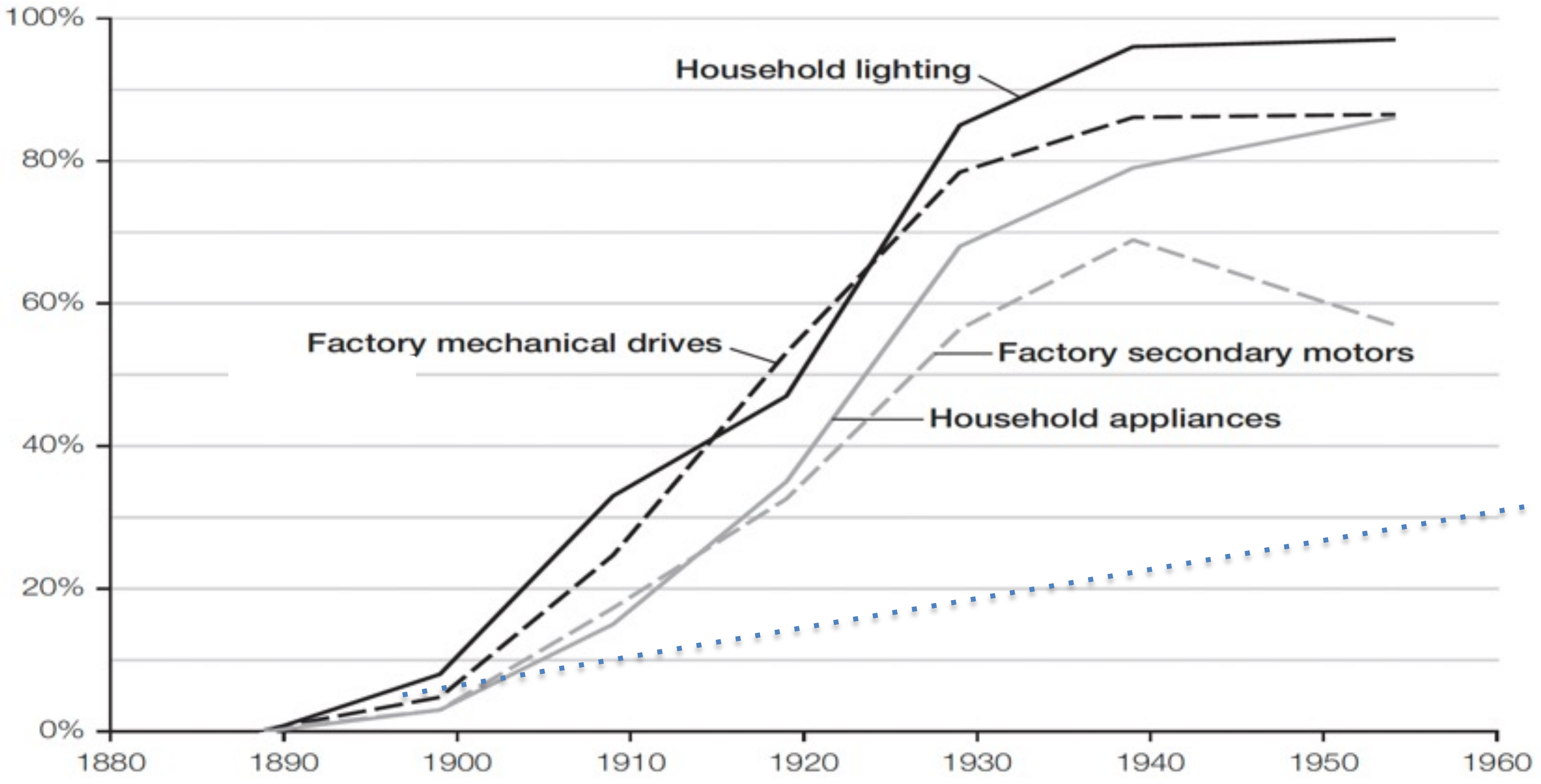
Lighter construction

Single story

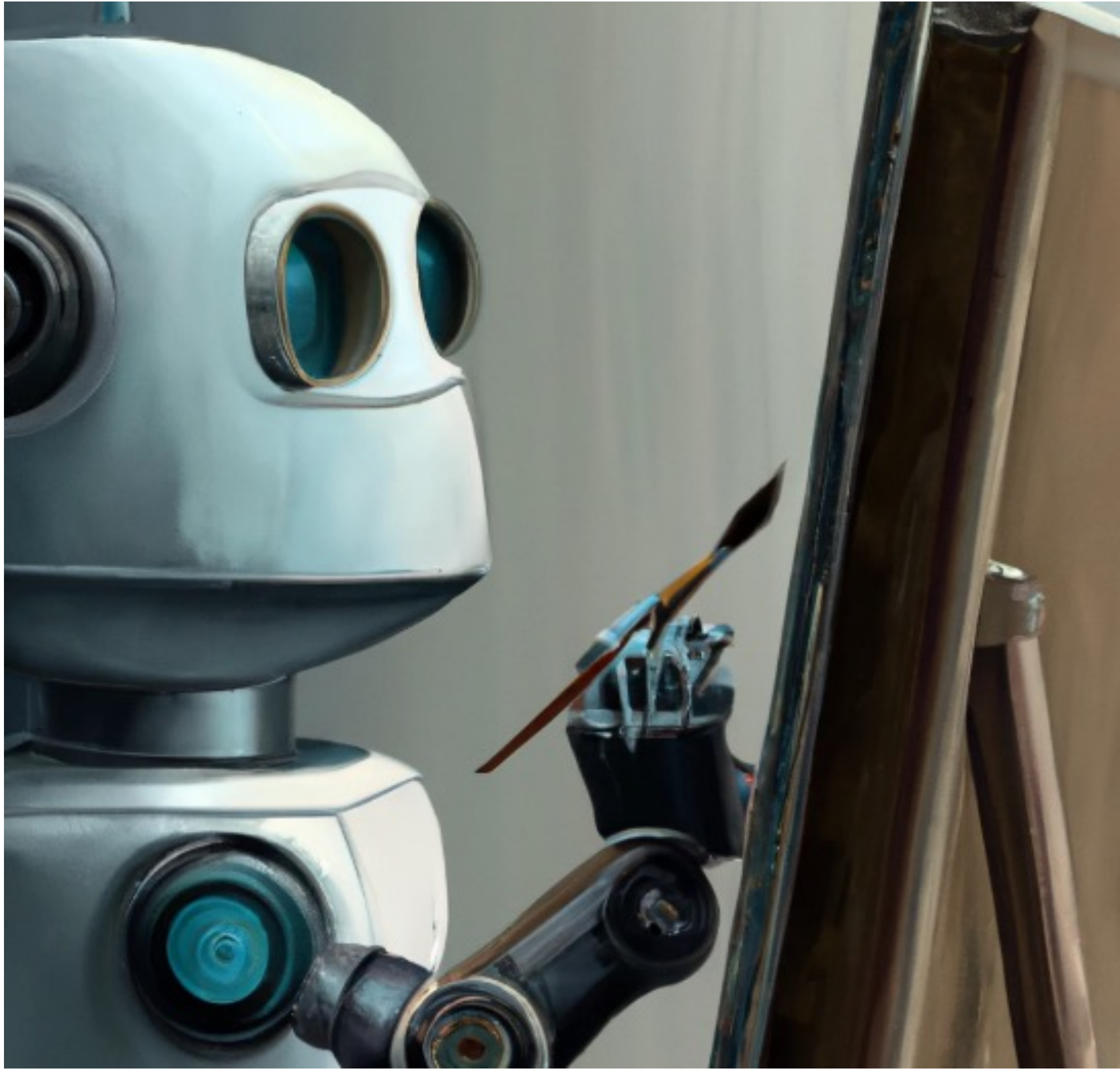
Modular production

Warren D. Devine Jr, 1983, "From Shafts to Wires: Historical Perspective on Electrification," *Journal of Economic History* 43(2), 347–72.

Adoption of electricity in the United States



THE BETWEEN TIMES



What is a General Purpose Technology (GPT)?

ELSEVIER

Journal of Econometrics 65 (1995) 83–108

JOURNAL OF Econometrics

General purpose technologies 'Engines of growth'?

Timothy F. Bresnahan*[a,c], M. Trajtenberg[b,c]

[a] *Department of Economics, Stanford University, Stanford, CA 94305, USA*
[b] *Tel-Aviv University, Tel-Aviv, Israel*
[c] *NBER*

What is a GPT?

- Intersection of micro (economics of innovation) and macro (economics of growth)
- Examples: The steam engine, electrification, computers, etc.
  - They are rare!
- The long run impact on productivity and society is large.
- The productivity impact of GPTs takes time.
  - GPT means slow growth today and fast growth tomorrow.
- Co-invention in the application (“using”) industry is key. It pushes against decreasing returns to the innovation through a **positive feedback loop** with the producing industry.

Co-invention

TIMOTHY BRESNAHAN
Stanford University

SHANE GREENSTEIN
University of Illinois

Technical Progress and Co-invention in Computing and in the Uses of Computers

WHY DO SOME technologies offer opportunities for widespread economic change? Purely technical progress is rarely sufficient to make an invention economically important. Users, through their own experimentation and discovery, make technology more valuable. We call this activity co-invention to distinguish it from original invention. Co-invention is potentially complex and uncertain, and it can be a bottleneck in technical progress. Yet the complementarity between inventions by users and by technologists can benefit a wide range of economic activities. Understanding co-invention is a key to understanding the economic payoff to invention in new information technologies today.[1]

We would like to thank the National Science Foundation, the Institute for Government and Public Affairs at the University of Illinois, the National Bureau of Economic Research Project on Industrial Technology and Productivity, the Center for Economic Policy Research at Stanford University, the Stanford Computer Industry Project, and the Sloan Foundation for financial support. We also thank Ron Borzekowski, Victoria Danilchouk, Harumi Ito, and Mike Mazzeo for their research assistance. Comments at the Brookings microeconomics conference, notably from David Brownstone, Kenneth Flamm, and the editors of this volume, have been very helpful.

1. In the past two centuries general purpose technologies and associated co-invention have helped drive economic growth. These "macro-inventions" (Mokyr, 1990) are rare, important, and slow to come into use. Bresnahan and Trajtenberg (1995) suggest that co-invention by users of a general purpose technology is a key source of Romerian increasing returns. Von Hippel (1988) discusses users' role more generally. For the uncertainty and experimentation surrounding the early stages of the co-invention process, see Rosenberg (1996). The importance of co-invention in information technology has led several authors (Freeman and Soete, 1990; David, 1990) to make comparisons to historically important general purpose technologies.

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informs
http://dx.doi.org/10.1287/mnsc.1110.1460

Three-Way Complementarities: Performance Pay, Human Resource Analytics, and Information Technology

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Erik Brynjolfsson, Lynn Wu
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{erikb@mit.edu, lynnwu@mit.edu}

We test for three-way complementarities among information technology (IT), performance pay, and human resource (HR) analytics practices. We develop a principal–agent model examining how these practices work together as an incentive system that produces a larger productivity premium when the practices are implemented in concert rather than separately. We assess our model by combining fine-grained data on human capital management (HCM) software adoption over 11 years with detailed survey data on incentive systems and HR analytics practices for 189 firms. We find that the adoption of HCM software is greatest in firms that have also adopted performance pay and HR analytics practices. Furthermore, HCM adoption is associated with a large productivity premium when it is implemented as a system of organizational incentives, but has less benefit when adopted in isolation. The system of three-way complements produces disproportionately greater benefits than pairwise interactions, highlighting the importance of including all three complements. Productivity increases significantly when the HCM systems "go live" but not when they are purchased, which can be years earlier. This helps rule out reverse causality as an explanation for our findings.

Key words: incentive systems; information technology; performance pay; human resource analytics; complementarity; enterprise systems; ERP; productivity; production function; principal-agent model
History: Received October 15, 2010; accepted August 12, 2011, by Sandra Slaughter, information systems. Published *online* in *Articles in Advance* March 9, 2012.

1. Introduction

As information technology (IT) investments grew in the 1980s and 1990s, substantial variation emerged in both the returns to IT investments (Brynjolfsson and Hitt 1995, Devaraj and Kohli 2003, Melville et al. 2004, Aral and Weill 2007) and the effectiveness of incentive compensation plans across firms (Ichniowski and Shaw 2003). We propose that these two phenomena are related and that the performance benefits of IT and incentive schemes depend on one another.

Successful incentive systems rely on the ability to monitor and manage employee performance accurately to appropriately reward those who excel. Some information technologies are specifically designed to help firms observe, measure, document, track, and manage performance accurately and transparently, and therefore complement such incentive practices. We develop an analytical model that illustrates this complementarity and demonstrate how the copresence of IT and incentive practices can explain variation in both the returns to IT and the effectiveness of performance pay contracts and human resource (HR) analytics practices that monitor and provide feedback on performance.

We argue that effective incentive practices are made up of a tightly knit incentive "system" that combines performance pay with both HR analytics practices and suitable IT software. We hypothesize that adopting performance pay and HR analytics practices without the information technologies that enable them lessens the incentives offered by performance pay and the insights gained from analysis, and that performance monitoring and management technologies implemented without performance pay and HR analytics are also less effective. Our goal is to examine the complementarities among IT, HR analytics, and performance pay to determine whether these practices can be effectively implemented piecemeal or rather must be introduced as a three-way "system of practices" (Milgrom and Roberts 1990).

To explore these propositions, we narrow our investigation to the adoption of a specific technology—human capital management (HCM) solutions found in typical enterprise resource planning (ERP) systems. These "process-enabling technologies" represent

1

Artificial Intelligence and the Modern Productivity Paradox
A Clash of Expectations and Statistics

Erik Brynjolfsson, Daniel Rock, and Chad Syverson

The discussion around the recent patterns in aggregate productivity growth highlights a seeming contradiction. On the one hand, there are astonishing examples of potentially transformative new technologies that could greatly increase productivity and economic welfare (see Brynjolfsson and McAfee 2014). There are some early concrete signs of these technologies' promise, recent leaps in artificial intelligence (AI) performance being the most prominent example. However, at the same time, measured productivity growth over the past decade has slowed significantly. This deceleration is large, cutting productivity growth by half or more in the decade preceding the slowdown. It is also widespread, having occurred throughout the Organisation for Economic Co-operation and Development (OECD) and, more recently, among many large emerging economies as well (Syverson 2017).[1]

In this paper, we review the evidence and explanations for the modern productivity paradox and propose a resolution. Namely, there is no inherent inconsistency between forward-looking technological optimism and backward-looking disappointment. Both can simultaneously exist. Indeed, there are good conceptual reasons to *expect* them to simultaneously exist when the economy undergoes the kind of restructuring associated with transformative technologies. In essence, the forecasters of future company wealth and the measurers of historical economic performance show the greatest disagreement during times of technological change. In this paper we argue and present some evidence that the economy is in such a period now.

Research Policy 52 (2023) 104653

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Could machine learning be a general purpose technology? A comparison of emerging technologies using data from online job postings☆

Avi Goldfarb [a,b], Bledi Taska [c], Florenta Teodoridis [d,*]

[a] University of Toronto, Rotman School of Management, 105 St. George St, Toronto, ON M5S 3E6, Canada
[b] The National Bureau of Economic Research (NBER), 1050 Massachussetts Ave, Cambridge, MA 02138, USA
[c] Burning Glass Technologies, 1 Lewis Wharf, Boston, MA 02110, USA
[d] University of Southern California, Marshall School of Business, 701 Exposition Blvd., Los Angeles, CA 90089, USA

ARTICLE INFO

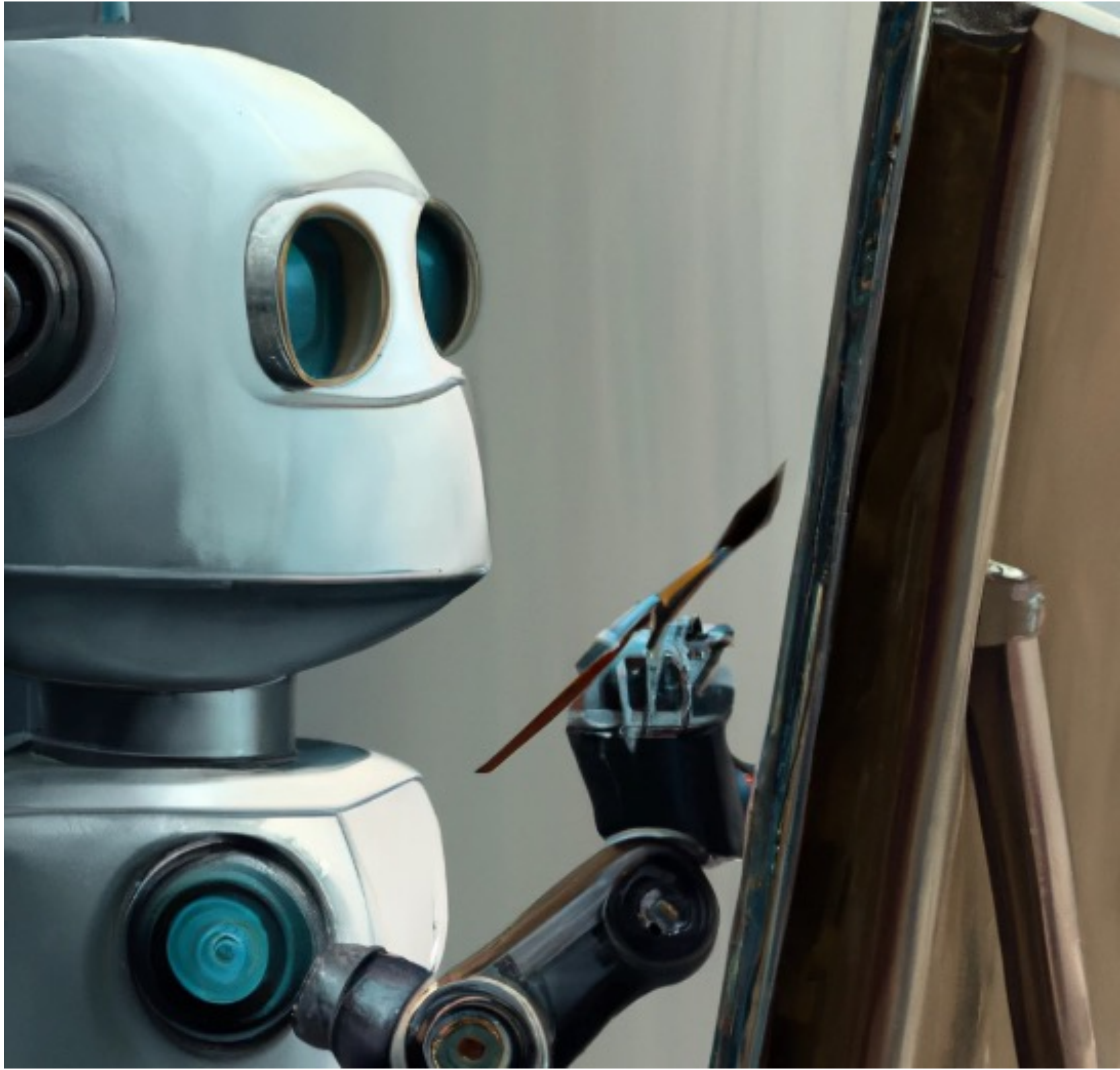
JEL classification:
O30
O31
O32
O33
O39

Keywords:
Artificial intelligence
Machine learning
General purpose technologies
Enabling technologies
Technology adoption
Technology innovation

ABSTRACT

Many emerging technologies have aspects of General Purpose Technologies (GPTs). However, true GPTs are rare and hold potential for large-scale economic impact. Thus, it is important for policymakers and managers to assess which emerging technologies are likely GPTs. We describe an approach that uses data from online job ads to rank emerging technologies on their GPT likelihood. The approach suggests which technologies are likely to have a broader economic impact, and which are likely to remain useful but narrower enabling technologies. Our approach has at least 5 years predictive power distinct from prevailing patent-based methods of identifying GPTs. We apply our approach to 21 different emerging technologies, and find that a cluster of technologies comprised of machine learning and related data science technologies is relatively likely to be a GPT.

THE BETWEEN TIMES



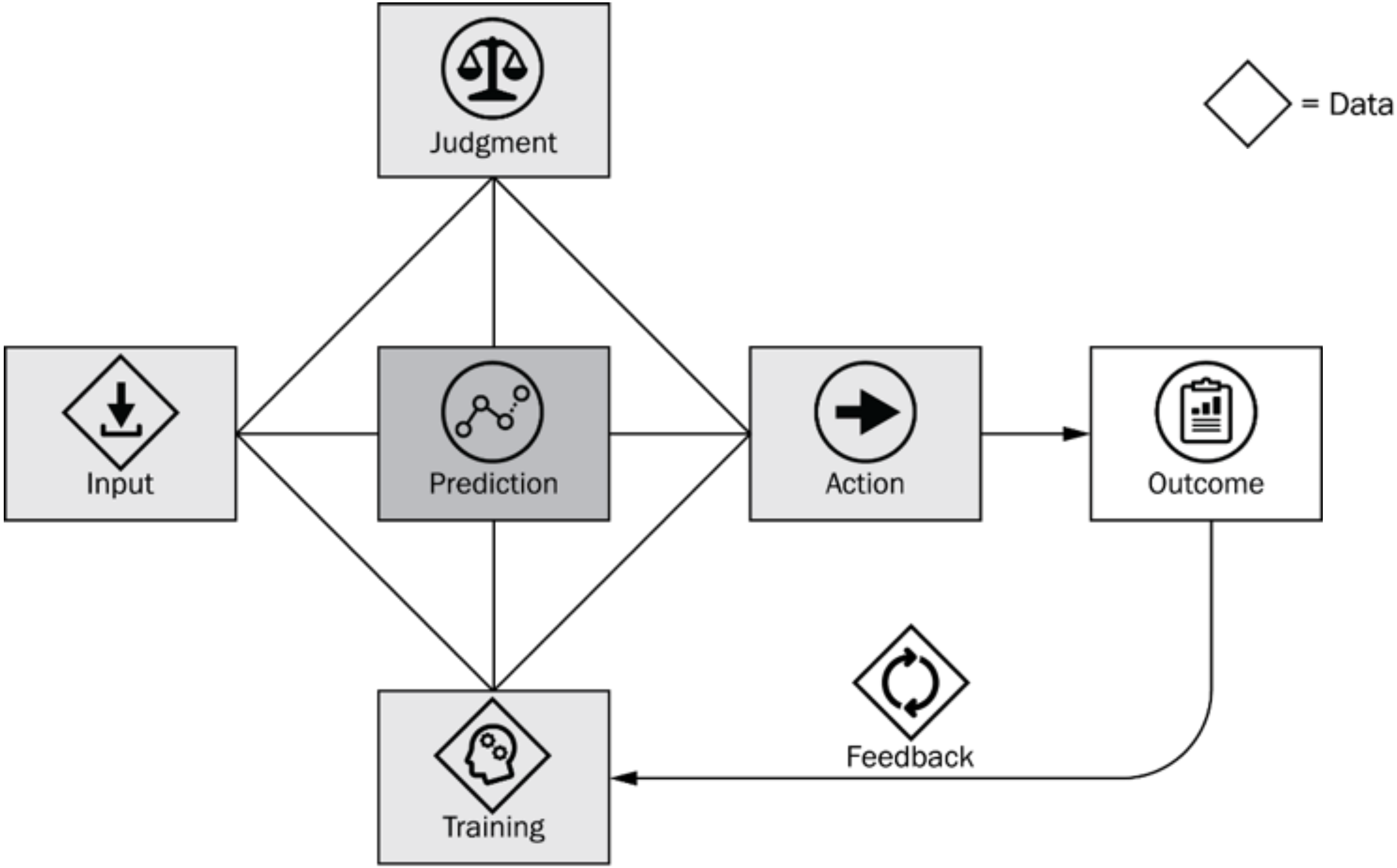
Predictions and Decisions

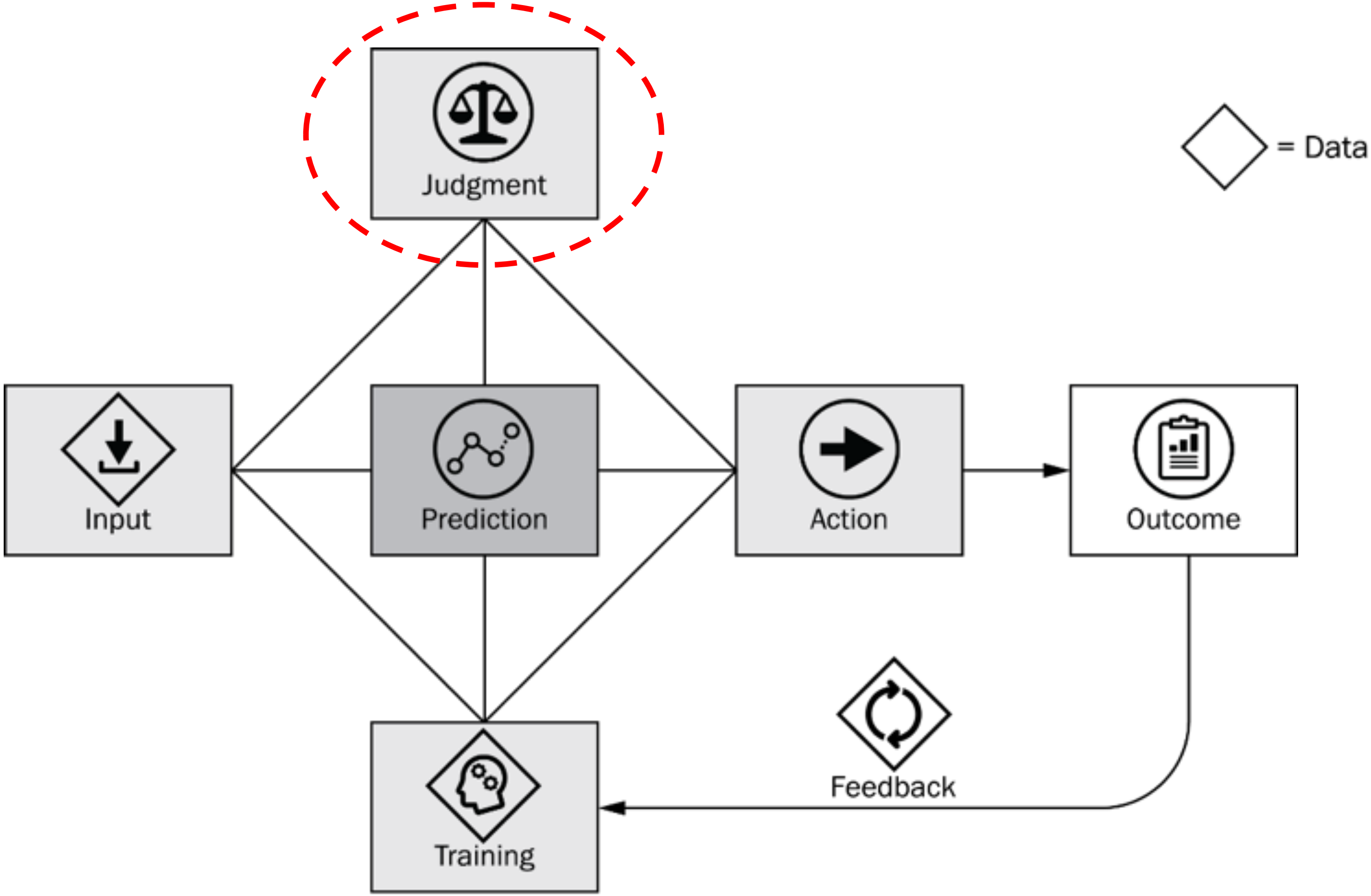
Today's AI is prediction technology

Prediction is valuable because it is an input into decision-making

Decision-making is everywhere

Prediction $\neq$ decision-making


Judgment
= Data
Input
Prediction
Action
Outcome
Feedback
Training



Judgment
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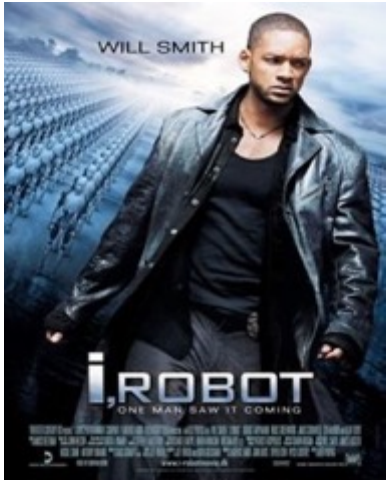
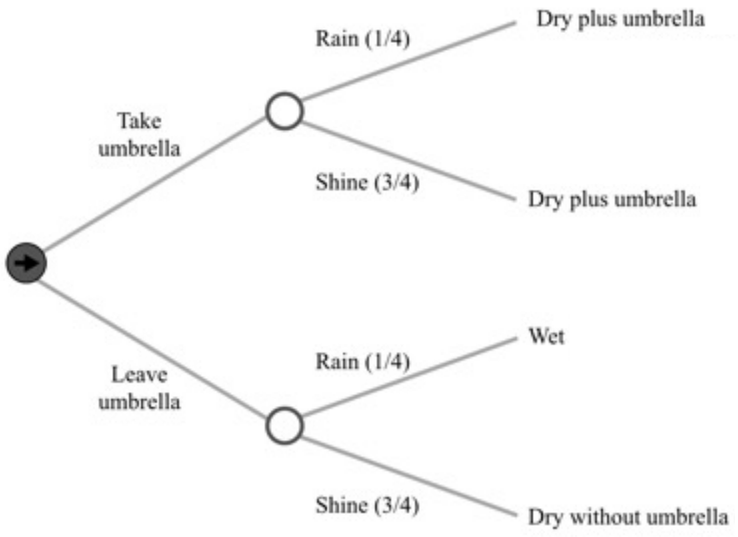
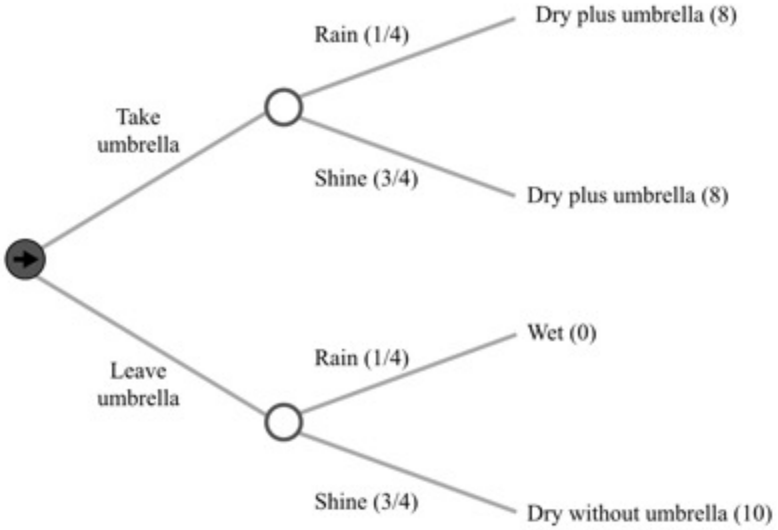

WILL SMITH
I, ROBOT
ONE MAN SAW IT COMING

Judgment is the process of determining what the reward is to a particular action in a particular environment.



Take umbrella
Leave umbrella
Rain (1/4)
Shine (3/4)
Rain (1/4)
Shine (3/4)
Dry plus umbrella
Dry plus umbrella
Wet
Dry without umbrella



Take umbrella
Leave umbrella
Rain (1/4)
Shine (3/4)
Rain (1/4)
Shine (3/4)
Dry plus umbrella (8)
Dry plus umbrella (8)
Wet (0)
Dry without umbrella (10)

Recent AI is all about **prediction**

$$\max_{x \in X} \int u(x,\theta)\, dF(\theta | s)$$

Where does this come from?

Thought
Experience
De gustibus non est disputandum

Judgment *is the process of determining the value of actions in a given state*

The Washington Post
Democracy Dies in Darkness

INNOVATIONS

AI is starting to pick who gets laid off

As layoffs ravage the tech industry, algorithms once used to help hire could now be deciding who gets cut

By Pranshu Verma

February 20, 2023 at 7:00 a.m. EST

THE VERGE TECH REVIEWS SCIENCE CREATORS ENTERTAINMENT VIDEO MORE

POLICY \ REPORT \ US & WORLD

How Amazon automatically tracks and fires warehouse workers for 'productivity'

Documents show how the company tracks and terminates workers

By Colin Lecher | @colinlecher | Apr 25, 2019, 12:06pm EDT

Machines don’t decide

Open questions

- Language and vision are being solved through machine learning.
- These are new types of prediction problems.
- What are the implications for the nature of work, and the necessary complementary inputs?

- Often, the literature on the economics of technology is all about complements. Which complements matter here?

future of life INSTITUTE

Pause Giant AI Experiments: An Open Letter

We call on all AI labs to immediately pause for at least 6 months the training of AI systems more powerful than GPT-4.

View this open letter online.

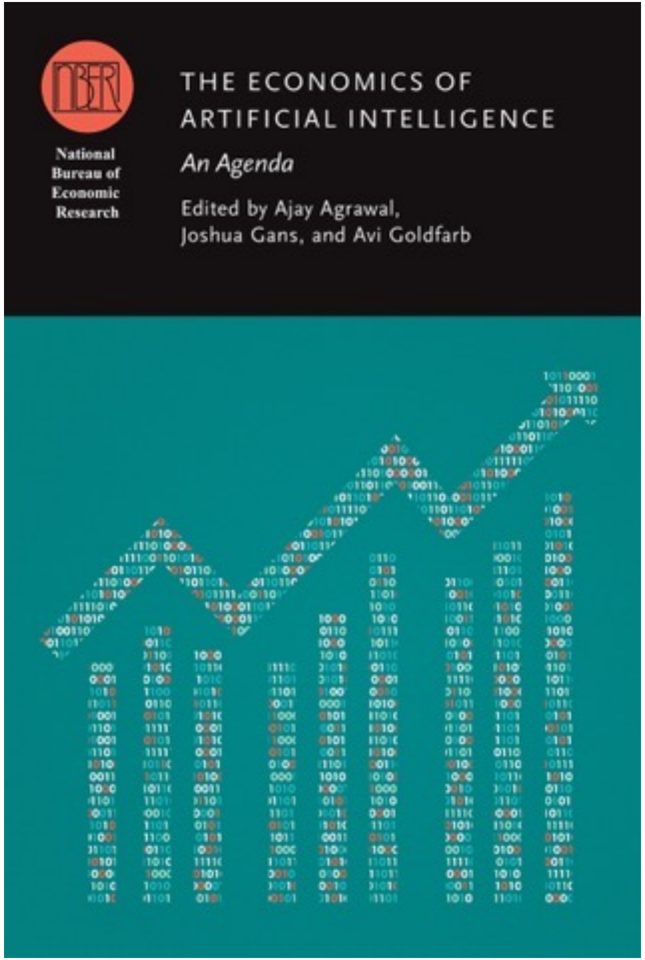
Published	PDF created	Signatures
March 22, 2023	May 5, 2023	27565

AI systems with human-competitive intelligence can pose profound risks to society and humanity, as shown by extensive research[1] and acknowledged by top AI labs.[2] As stated in the widely-endorsed Asilomar AI Principles, *Advanced AI could represent a profound change in the history of life on Earth, and should be planned for and managed with commensurate care and resources.* Unfortunately, this level of planning and management is not happening, even though recent months have seen AI labs locked in an out-of-control race to develop and deploy ever more powerful digital minds that no one – not even their creators – can understand, predict, or reliably control.

"Should we risk loss of control of our civilization? Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?"

"Should we let machines flood our information channels with propaganda and untruth?"

"Should we automate away all the jobs, including the fulfilling ones?"


National Bureau of Economic Research
THE ECONOMICS OF ARTIFICIAL INTELLIGENCE
An Agenda
Edited by Ajay Agrawal, Joshua Gans, and Avi Goldfarb

Potential for a Productivity Boom?

9

Artificial Intelligence and Economic Growth

Philippe Aghion, Benjamin F. Jones, and Charles I. Jones

9.1 Introduction

This chapter considers the implications of artificial intelligence for economic growth. Artificial intelligence (AI) can be defined as "the capability of a machine to imitate intelligent human behavior" or "an agent's ability to

RESEARCH - REPORT

Machines of mind: The case for an AI-powered productivity boom

Martin Neil Baily, Erik Brynjolfsson, and Anton Korinek - Wednesday, May 10, 2023

There is an emerging literature that estimates the productivity effects of AI on specific occupations or tasks. Kalliamvakou (2022) finds that software engineers can code up to twice as fast using a tool called Codex, based on the previous version of the large language model GPT-3. That's a transformative effect. Noy and Zhang (2023) find that many writing tasks can also be completed twice as fast and Korinek (2023) estimates, based on 25 use cases for language models, that economists can be 10-20% more productive using large language models.

future of life INSTITUTE

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"Should we risk loss of control of our civilization?" Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?"

"Should we let machines flood our information channels with propaganda and untruth?"

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“Should we risk loss of control of our civilization? Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?”

“Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?”

14

Artificial Intelligence and Its Implications for Income Distribution and Unemployment

Anton Korinek and Joseph E. Stiglitz

“If progress in AI cannot be halted, our description above suggests mechanisms that may ensure that humans can afford a separate living space and remain viable: because humans start out owning some of the factors that are in limited supply, if they are prohibited from transferring these factors, they could continue to consume them without suffering from their price appreciation.”

“Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?”

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“Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?”

American Economic Journal: Macroeconomics 2021, 13(1): 299–332
https://doi.org/10.1257/mac.20170105

Are We Approaching an Economic Singularity? Information Technology and the Future of Economic Growth†

By William D. Nordhaus*

III. Rapid Technological Change through Superintelligent Innovation

A first possible source of extremely rising economic growth comes from rapid improvements in technology generated by superintelligent agents. This approach can be seen easily using a Cobb-Douglas production function of the form $Y_t = K_t^{\alpha}(A_t L_t)^{1-\alpha}$. Here and below, assume that Y is output, K is capital, L is labor, A is labor-augmenting technology, s is the savings rate, and t is time. For most of the discussion, I assume the savings rate is constant. For a given rate of labor-augmenting technological change of h, the growth of output will be $g \rightarrow n + h$. Singularity quite naturally arises if technological change becomes extremely rapid.

The A.I. Dilemma: Growth versus Existential Risk

Charles I. Jones*
Stanford GSB and NBER

September 12, 2023 — Version 0.7
Preliminary, comments appreciated

Abstract

Advances in artificial intelligence (A.I.) are a double-edged sword. On the one hand, they may increase economic growth as A.I. augments our ability to innovate or even itself learns to discover new ideas. On the other hand, many experts note that these advances entail existential risk: creating a superintelligent entity misaligned with human values could lead to catastrophic outcomes, including human extinction. This paper considers the optimal use of A.I. technology in the presence of these opportunities and risks. Under what conditions should we continue the rapid progress of A.I. and under what conditions should we stop?

“Should we let machines flood our information channels with propaganda and untruth?”

“Should we let machines flood our information channels with propaganda and untruth?”

- The economics are more complicated than popular discourse suggests. Lots of big open questions. Little research to date.

Joshua Gans @joshgans · May 27

This thread illustrates the difference in reaction between economists and other people.

Other people: “Oh no!!! AI is going to cause massive amounts of blackmail.”

Economists: “Well, I guess it will be impossible to blackmail anyone with pictures now.”

Scott Kominers
@skominers

I can't even count how many people have told me the biggest near-term risk of AI is that people will create ways of cloning people's voices to get into their bank accounts.

I always respond "don't you think that then banks might stop accepting verbal phone confirmations?"

4:32 PM · May 27, 2023 · **913** Views

“Should we let machines flood our information channels with propaganda and untruth?”

OVERVIEW

pooling equilibrium

QUICK REFERENCE

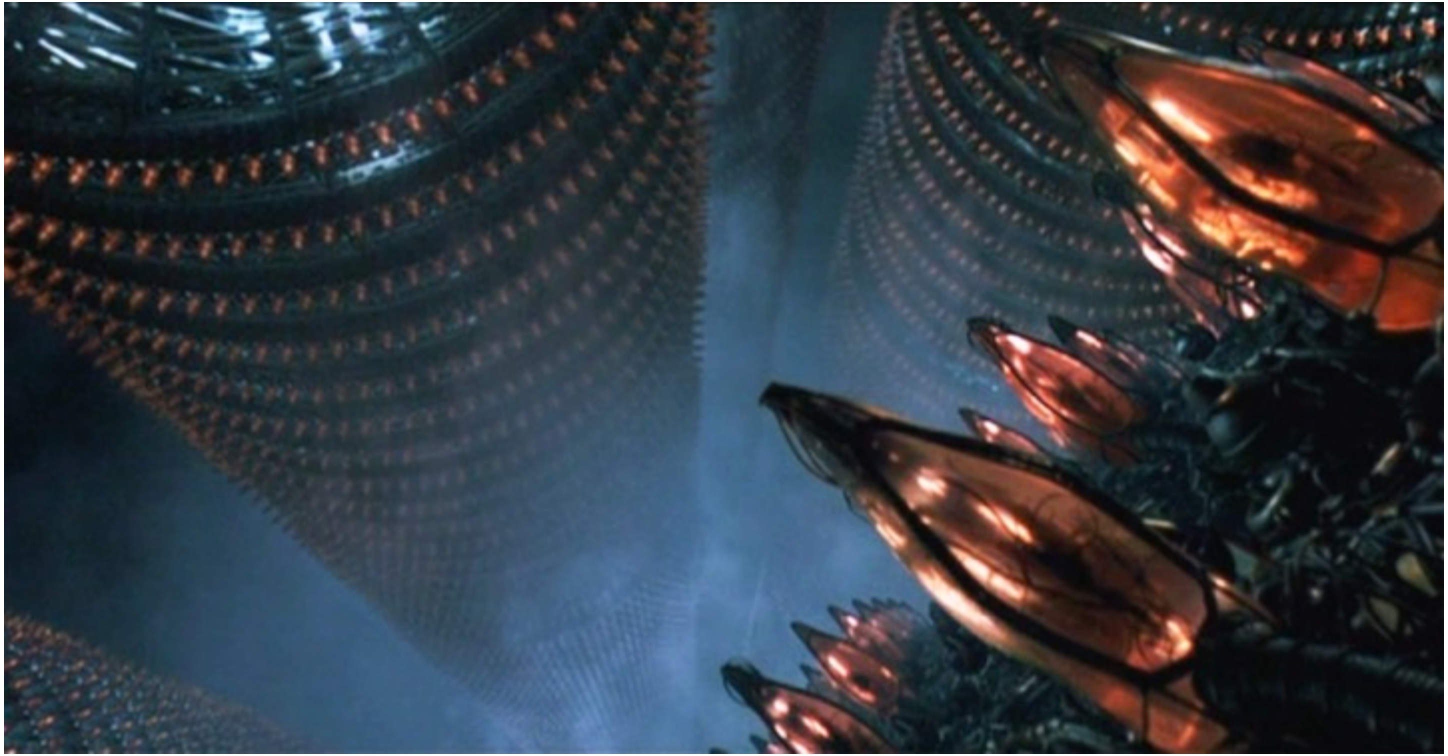
An equilibrium in which agents with differing characteristics choose the same action. For example, in an insurance market a pooling equilibrium involves high-risk and low-risk agents choosing the same insurance contract. See also separating equilibrium.

From: pooling equilibrium in A Dictionary of Economics »

Subjects: Social sciences — Economics

“Should we automate away all the jobs, including the fulfilling ones?”

Wrong question!



9

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"Baumol (1967) observed that sectors with rapid productivity growth, such as agriculture and even manufacturing today, often see their share of gross domestic product (GDP) decline while those sectors with relatively slow productivity growth—perhaps including many services—experience increases. As a consequence, economic growth may be constrained not by what we do well but rather by what is essential and yet hard to improve."

7

Artificial Intelligence, Income, Employment, and Meaning

Betsey Stevenson

The evolution of artificial intelligence (AI) evokes strong emotions in people. Some imagine a dystopia in which people are replaced by machines. Machines will develop the content we read, and the entertainment we enjoy. Artificial intelligence will pick our friends and our politicians, and ultimately take away any sense of human agency. And worst of all, those machines

"There are really two separate questions: there is an employment question, in which the fundamental question is, can we find fulfilling ways to spend our time if robots take our jobs? And there is an income question, can we find a stable and fair distribution of income?."

WHY MIGHT INEQUALITY INCREASE?

The Global Decline of the Labor Share*

Loukas Karabarbounis, Brent Neiman

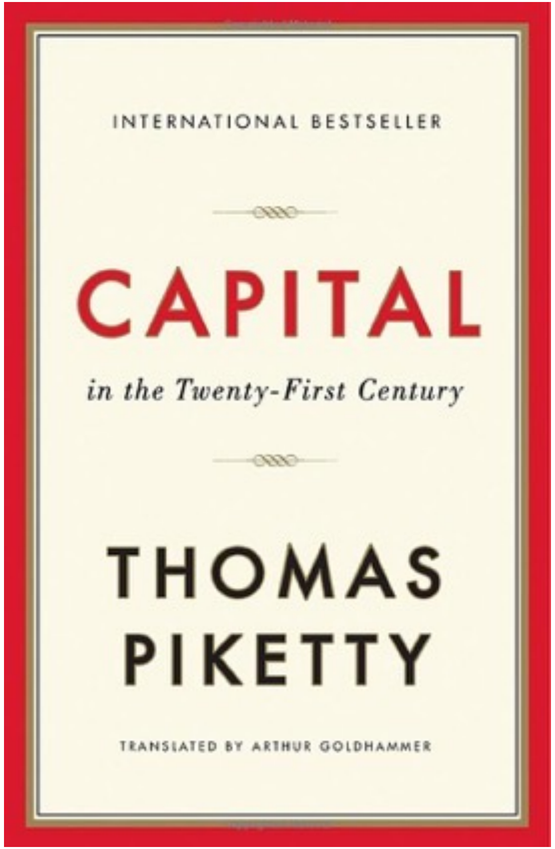
The Quarterly Journal of Economics, Volume 129, Issue 1, February 2014, Pages 61–103,
https://doi.org/10.1093/qje/qjt032
Published: 24 October 2013

PDF | Split View | Cite | Permissions | Share ▾

Abstract

The stability of the labor share of income is a key foundation in macroeconomic models. We document, however, that the global labor share has significantly declined since the early 1980s, with the decline occurring within the large majority of countries and industries. We show that the decrease in the relative price of investment goods, often attributed to advances in information technology and the computer age, induced firms to shift away from labor and toward capital. The lower price of investment goods explains roughly half of the observed decline in the labor share, even when we allow for other mechanisms influencing factor shares, such as increasing profits, capital-augmenting technology growth, and the changing skill composition of the labor force. We highlight the implications of this explanation for welfare and macroeconomic dynamics.

JEL: E21 - Consumption; Saving; Wealth, E22 - Investment; Capital; Intangible Capital; Capacity, E25 - Aggregate Factor Income Distribution



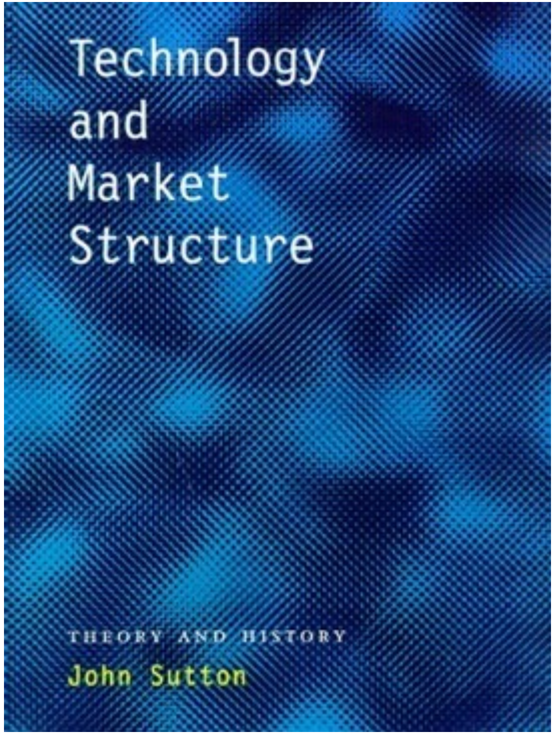
Market Power

Business | Schumpeter

Why tech giants want to strangle AI with red tape

They want to hold back open-source competitors

Brett Ryder



The Digital Markets Act: An economic perspective on the final negotiations

Fiona Scott Morton, Monika Schnitzer, Paul Heidhues, Amelia Fletcher, David Dinielli, Jacques Crémer / 11 Feb 2022

Prohibition of self-preferencing

Self-preferencing occurs where a vertically integrated platform favours its own related services. The draft DMA already includes a prohibition on self-preferencing within ranking services. The current debate is whether this ban should be extended to ‘other settings’.

Such an extension seems attractive in principle, since any sort of self-preferencing can be highly anti-competitive. However, it may prove challenging to enforce in practice. Identifying self-preferencing conduct should be easier in the context of organic rankings, where no payments are made and rankings are designed to be ‘consumer-centric’. It becomes more complex in a context where business users pay (directly or indirectly) for positioning or prominence.

REGULATION (EU) 2022/1925 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 14 September 2022

on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (Digital Markets Act)

(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

THE PROHIBITION OF SELF-PREFERENCING IN THE DMA

ISSUE PAPER

November 2022

Martin Peitz

THE JOURNAL OF INDUSTRIAL ECONOMICS

Original Article | Open Access

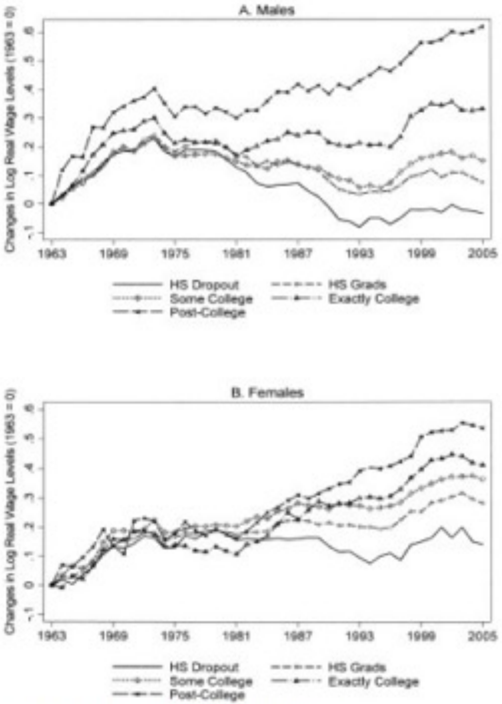
Self-Preferencing in Markets with Vertically Integrated Gatekeeper Platforms*

Jorge Padilla, Joe Perkins, Salvatore Piccolo

First published: 20 May 2022 | https://doi.org/10.1111/joie.12287 | Citations: 7

Computing and the internet increased inequality

Figure 5.—Trends in Composition-Adjusted Real Log Weekly Full-Time Wages by Gender and Education, 1963–2005 (March CPS)



See notes to table 1 for details on samples and data processing.

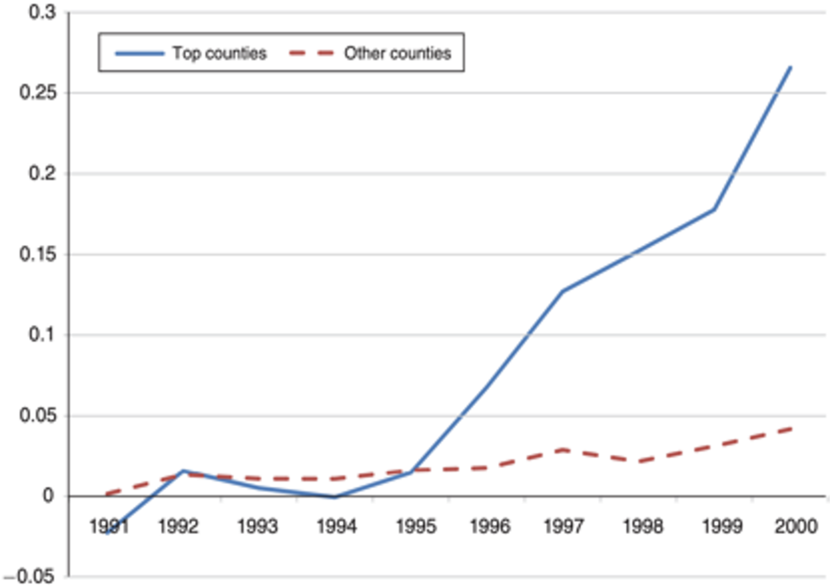
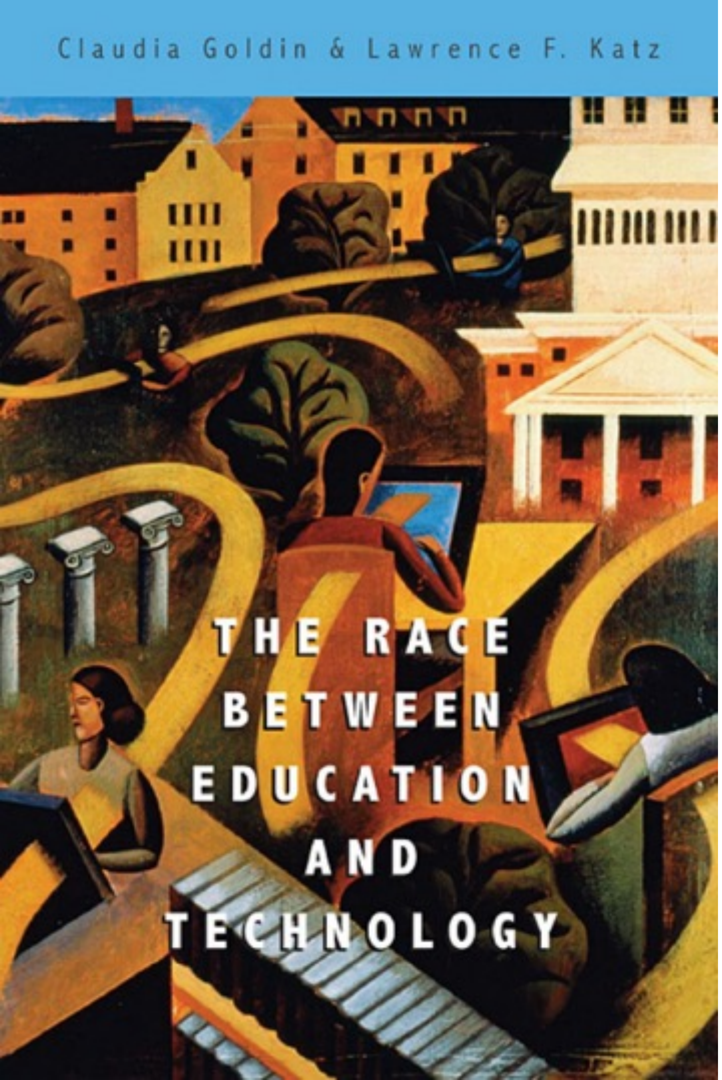


Figure 2. Marginal Effect of Advanced Internet Year-by-Year in Top Counties



TRENDS IN U.S. WAGE INEQUALITY: REVISING THE REVISIONISTS

David H. Autor, Lawrence F. Katz, and Melissa S. Kearney*

Abstract—A recent "revisionist" literature characterizes the pronounced rise in U.S. wage inequality since 1980 as an "episodic" event of the first half of the 1980s driven by nonmarket factors (particularly a falling real minimum wage) and concludes that continued increases in wage inequality since the late 1980s substantially reflect the mechanical confounding effects of changes in labor force composition. Analyzing data from the Current Population Survey for 1963 to 2005, we find limited support for these claims. The slowing of the growth of overall wage inequality in the 1990s hides a divergence in the paths of upper-tail (90/50) inequality—which has increased steadily since 1980, even adjusting for changes in labor force composition—and lower-tail (50/10) inequality, which rose sharply in the first half of the 1980s and plateaued or contracted thereafter. Fluctuations in the real minimum wage are not a plausible explanation for these trends since the bulk of inequality growth occurs above the median of the wage distribution. Models emphasizing rapid secular growth in the relative demand for skills—attributable to skill-biased technical change—and a sharp deceleration in the relative supply of college workers in the 1980s do an excellent job of capturing the evolution of the college/high school wage premium over four decades. But these models also imply a puzzling deceleration in relative demand growth for college workers in the early 1990s, also visible in a recent "polarization" of skill demands in which employment has expanded in high-wage and low-wage work at the

This literature reaches two broad conclusions. First, much of the rise in U.S. earnings inequality during the 1980s appears to be explained by shifts in the supply of and demand for skills combined with the erosion of labor market institutions—including labor unions and the minimum wage—that protected the earnings of low- and middle-wage workers.[2] Second, a number of influential studies argue that the surge of inequality evident in the 1980s reflected an ongoing, secular rise in the demand for skill that commenced decades earlier and perhaps accelerated during the 1980s with the onset of the computer revolution. When this secular demand shift met with an abrupt slowdown in the growth of the relative supply of college-equivalent workers during the 1980s—itself a consequence of slowing educational attainment for cohorts born after 1949 and of smaller entering labor force cohorts—wage differentials expanded

SPECIAL ISSUE REVIEW

Skills, education, and the rise of earnings inequality among the "other 99 percent"

DAVID H. AUTOR Authors Info & Affiliations

SCIENCE • 23 May 2014 • Vol 344, Issue 6186 • pp. 843-851 • DOI: 10.1126/science.1251868

Abstract

The singular focus of public debate on the "top 1 percent" of households overlooks the component of earnings inequality that is arguably most consequential for the "other 99 percent" of citizens: the dramatic growth in the wage premium associated with higher education and cognitive ability. This Review documents the central role of both the supply and demand for skills in shaping inequality, discusses why skill demands have persistently risen in industrialized countries, and considers the economic value of inequality alongside its potential social costs. I conclude by highlighting the constructive role for public policy in fostering skills formation and preserving economic mobility.

The task-based model

Robots and Jobs: Evidence from US Labor Markets

Daron Acemoglu
Massachusetts Institute of Technology

Pascual Restrepo
Boston University

We study the effects of industrial robots on US labor markets. We show theoretically that robots may reduce employment and wages and that their local impacts can be estimated using variation in exposure to robots—defined from industry-level advances in robotics and local industry employment. We estimate robust negative effects of robots on employment and wages across commuting zones. We also show that areas most exposed to robots after 1990 do not exhibit any differential trends before then, and robots' impact is distinct from other capital and technologies. One more robot per thousand workers reduces the employment-to-population ratio by 0.2 percentage points and wages by 0.42%.

American Economic Review 2018, 108(6): 1488–1542
https://doi.org/10.1257/aer.20160696

The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment†

By Daron Acemoglu and Pascual Restrepo*

We examine the concerns that new technologies will render labor redundant in a framework in which tasks previously performed by labor can be automated and new versions of existing tasks, in which labor has a comparative advantage, can be created. In a static version where capital is fixed and technology is exogenous, automation reduces employment and the labor share, and may even reduce wages, while the creation of new tasks has the opposite effects. Our full model endogenizes capital accumulation and the direction of research toward automation and the creation of new tasks. If the long-run rental rate of capital relative to the wage is sufficiently low, the long-run equilibrium involves automation of all tasks. Otherwise, there exists a stable balanced growth path in which the two types of innovations go hand-in-hand. Stability is a consequence of the fact that automation reduces the cost of producing using labor, and thus discourages further automation and encourages the creation of new tasks. In an extension with heterogeneous skills, we show that inequality increases during transitions driven both by faster automation and the introduction of new tasks, and characterize the conditions under which inequality stabilizes in the long run. (*JEL* D63, E22, E23, E24, J24, O33, O41)

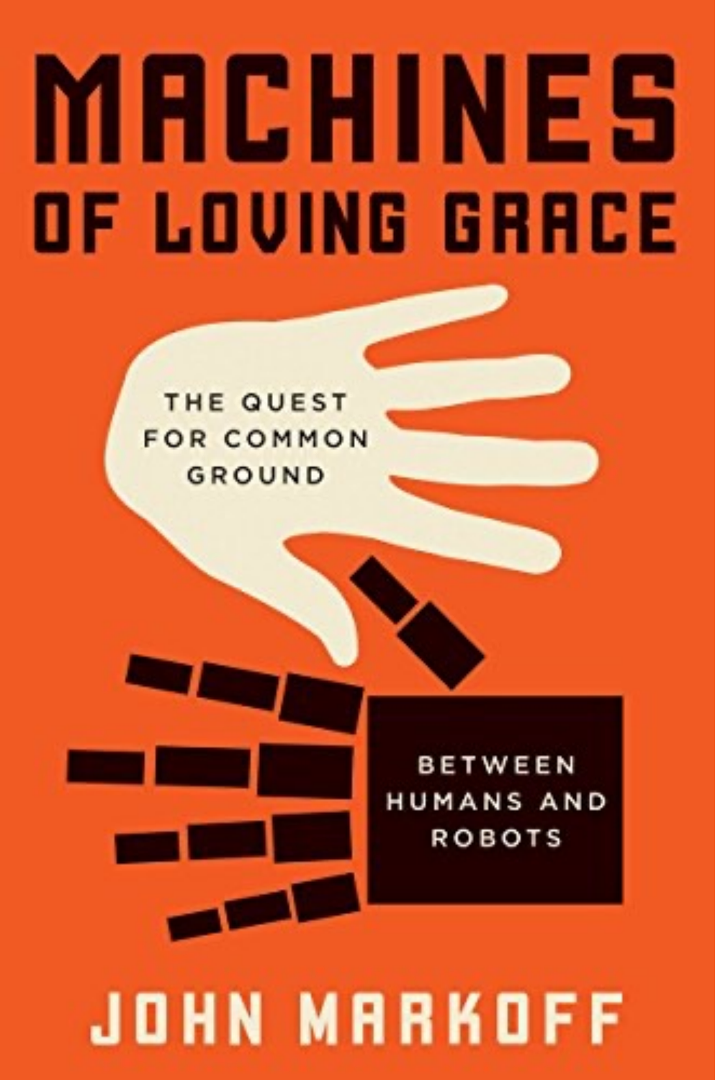
NBER Economics of Artificial Intelligence

Toronto, 26th - 27th September 2019

Panel Discussion on Task-Based and Systems Models

with Timothy Bresnahan, David Autor, and Pascual Restrepo . Video | Slides

MUST INEQUALITY INCREASE WITHOUT REDISTRIBUTION?



Introduction:

One group designed powerful machines that allow humans to perform previously unthinkable tasks, like programming robots for space exploration, while the other works to replace humans with machines, like the developers of artificial intelligence robots to perform the work of doctors and lawyers.

Conclusion:

The solution to the contradiction inherent in AI versus IA lies in the very human decisions of engineers and scientists…who all have intentionally chosen human-centered design.

The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence

Erik Brynjolfsson

In 1950, Alan Turing proposed a test of whether a machine was intelligent: could a machine imitate a human so well that its answers to questions were indistinguishable from a human's? Ever since, creating intelligence that matches human intelligence has implicitly or explicitly been the goal of thousands of researchers, engineers, and entrepreneurs. The benefits of human-like artificial intelligence (HLAI) include soaring productivity, increased leisure, and perhaps most profoundly a better understanding of our own minds. But not all types of AI are human-like – in fact, many of the most powerful systems are very different from humans – and an excessive focus on developing and deploying HLAI can lead us into a trap. As machines become better substitutes for human labor, workers lose economic and political bargaining power and become increasingly dependent on those who control the technology. In contrast, when AI is focused on augmenting humans rather than mimicking them, humans retain the power to insist on a share of the value created. What is more, augmentation creates new capabilities and new products and services, ultimately generating far more value than merely human-like AI. While both types of AI can be enormously beneficial, there are currently excess incentives for automation rather than augmentation among technologists, business executives, and policy-makers.

A good start would be to replace the Turing Test, and the mindset it embodies, with a new set of practical benchmarks that steer progress toward AI-powered systems that exceed anything that could be done by humans alone.

SCIENCE

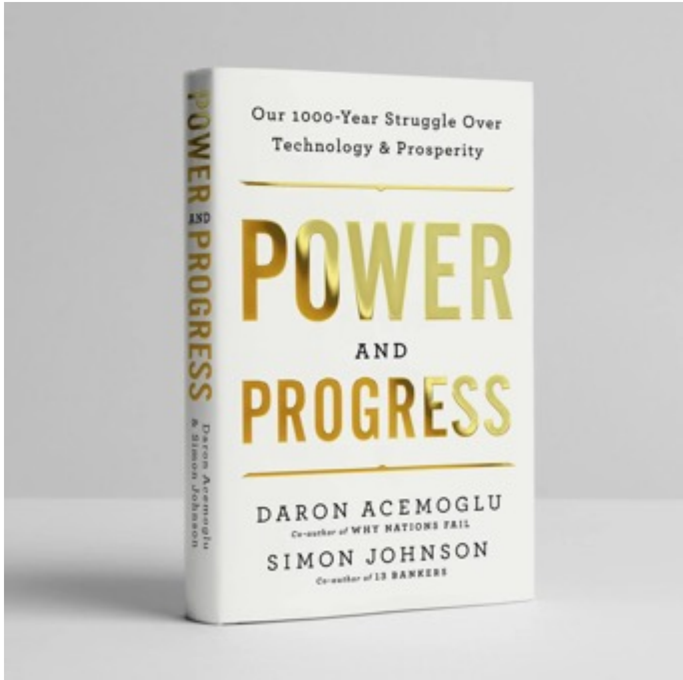
Forum BOSTON REVIEW

AI's Future Doesn't Have to Be Dystopian

AI can be used to increase human productivity, create jobs and shared prosperity, and protect and bolster democratic freedoms—but only if we modify our approach.

Daron Acemoglu

Democracy, Economy, Politics, Redesigning AI, Science and Technology



Current developments, such as they are, go in the direction of automating teachers–for example, by implementing automated grading or online resources to replace core teaching tasks. But **AI** could also **revolutionize** education by **empowering** teachers to adapt their material to the needs and attitudes of diverse students in real time. We **already** **know** that what works for one individual in the classroom may not work for another; different students find different elements of learning challenging. AI in the classroom can make teaching more adaptive and student-centered, generate distinct new teaching tasks, and, in the process, increase the productivity of—and the demand for—teachers.

Harms of AI

Daron Acemoglu

WORKING PAPER 29247 **DOI** 10.3386/w29247 **ISSUE DATE** September 2021

This essay discusses several potential economic, political and social costs of the current path of AI technologies. I argue that if AI continues to be deployed along its current trajectory and remains unregulated, it may produce various social, economic and political harms. These include: damaging competition, consumer privacy and consumer choice; excessively automating work, fueling inequality, inefficiently pushing down wages, and failing to improve worker productivity; and damaging political discourse, democracy's most fundamental lifeblood. Although there is no conclusive evidence suggesting that these costs are imminent or

"damaging competition, consumer privacy and consumer choice; excessively automating work, fueling inequality, inefficiently pushing down wages, and failing to improve worker productivity; and damaging political discourse, democracy's most fundamental lifeblood."

- Some of their writing suggests that they want to change the objectives and philosophy of the entire research field.

- The underlying hypothesis is that if the technical objectives of AI research are changed, then this will steer the economy away from potential loss of jobs, devaluation of skills, inequality, and social discord following from this.

- In this way, society can avoid what Brynjolfsson calls the "Turing Trap", where AI-enabled automation leads to a concentration of wealth and power.

POLICY FORUM

Do we want less automation?

AI may provide a path to decrease inequality

AJAY AGRAWAL, JOSHUA S. GANS, AND AVI GOLDFARB Authors Info & Affiliations

SCIENCE • 13 Jul 2023 • Vol 381, Issue 6654 • pp. 155-158 • DOI: 10.1126/science.adh9429

Impressive achievements made through artificial intelligence (AI) innovations in automating the tasks required in many jobs have reinforced concerns about labor market disruption and increased income inequality. This has motivated calls for change in the direction of AI innovation from being guided by task automation to instead focusing on labor augmentation (1). But task automation and labor augmentation are not polar opposites. Instead, automation of some tasks can lead to augmentation of labor elsewhere. Furthermore, AI automation may provide a path to reversing the trend of increasing income inequality by enabling disproportionate productivity improvements for lower-wage workers, allowing them to perform at levels that would previously require years of education and experience.

GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models

Tyna Eloundou, Sam Manning, Pamela Mishkin, Daniel Rock

We investigate the potential implications of large language models (LLMs), such as Generative Pre-trained Transformers (GPTs), on the U.S. labor market, focusing on the increased capabilities arising from LLM-powered software compared to LLMs on their own. Using a new rubric, we assess occupations based on their alignment with LLM capabilities, integrating both human expertise and GPT-4 classifications. Our findings reveal that around 80% of the U.S. workforce could have at least 10% of their work tasks affected by the introduction of LLMs, while approximately 19% of workers may see at least 50% of their tasks impacted. We do not make predictions about the development or adoption timeline of such LLMs. The projected effects span all wage levels, with higher-income jobs potentially facing greater exposure to LLM capabilities and LLM-powered software. Significantly, these impacts are not restricted to industries with higher recent productivity growth. Our analysis suggests that, with access to an LLM, about 15% of all worker tasks in the US could be completed significantly faster at the same level of quality. When incorporating software and tooling built on top of LLMs, this share increases to between 47 and 56% of all tasks. This finding implies that LLM-powered software will have a substantial effect on scaling the economic impacts of the underlying models. We conclude that LLMs such as GPTs exhibit traits of general-purpose technologies, indicating that they could have considerable economic, social, and policy implications.

Subjects: **General Economics (econ.GN)**; Artificial Intelligence (cs.AI); Computers and Society (cs.CY)

Cite as: arXiv:2303.10130 **[econ.GN]**

(or arXiv:2303.10130v4 **[econ.GN]** for this version)

https://doi.org/10.48550/arXiv.2303.10130

The Impact of AI on Developer Productivity: Evidence from GitHub Copilot

Sida Peng,[1*] Eirini Kalliamvakou,[2] Peter Cihon,[2] Mert Demirer[3]

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[2]GitHub Inc., 88 Colin P Kelly Jr St, San Francisco, USA
[3]MIT Sloan School of Management, 100 Main Street Cambridge, USA

[*]To whom correspondence should be addressed; E-mail: sidpeng@microsoft.com.

Abstract

Generative AI tools hold promise to increase human productivity. This paper presents results from a controlled experiment with GitHub Copilot, an AI pair programmer. Recruited software developers were asked to implement an HTTP server in JavaScript as quickly as possible. The treatment group, with access to the AI pair programmer, completed the task 55.8% faster than the control group. Observed heterogenous effects show promise for AI pair programmers to help people transition into software development careers.

Writing

Algorithmic Writing Assistance on Jobseekers' Resumes Increases Hires

Emma van Inwegen
MIT

Zanele Munyikwa
MIT

John J. Horton
MIT & NBER

March 7, 2023

Abstract

There is a strong association between the quality of the writing in a resume for new labor market entrants and whether those entrants are ultimately hired. We show that this relationship is, at least partially, causal: a field experiment in an online labor market was conducted with nearly half a million jobseekers in which a treated group received algorithmic writing assistance. Treated jobseekers experienced an 8% increase in the probability of getting hired. Contrary to concerns that the assistance is taking away a valuable signal, we find no evidence that employers were less satisfied. We present a model in which better writing is not a signal of ability but helps employers ascertain ability, which rationalizes our findings.

Call Centers

Generative AI at Work

Erik Brynjolfsson, Danielle Li & Lindsey R. Raymond

WORKING PAPER 31161 **DOI** 10.3386/w31161 **ISSUE DATE** April 2023

We study the staggered introduction of a generative AI-based conversational assistant using data
from 5,179 customer support agents. Access to the tool increases productivity, as measured by
issues resolved p
skilled workers, a
suggestive evide
workers and help
assistance impro
improves employ

Goodbye, humans: Call centers 'could save $80b' switching to AI

You'll just have to learn to code instead – oh wait, computers can do that, too

Katyanna Quach Thu 1 Sep 2022 // 08:03 UTC

B | Center on Regulation and Markets at BROOKINGS

POLICY BRIEF | JUNE 2023

THE TURING TRANSFORMATION:

ARTIFICIAL INTELLIGENCE, INTELLIGENCE AUGMENTATION, AND SKILL PREMIUMS

AJAY AGRAWAL, JOSHUA GANS, AND AVI GOLDFARB

Almon Brown Strowager, an American undertaker from the 19th century, allegedly angry that a local switch operator (and wife of a competing undertaker) was redirecting his customer calls to her husband, sought to take all switch operators to their employment graves. He conceived of and, with family members, invented the Strowager switch that auto-

including a Bar exam, the SAT, and various AP-level courses. AI pioneer and Turing Award winner Geoff Hinton remarked in 2016 that time was up for radiologists and that no one should continue training in that field. Whether that will hold true or not, it is hardly surprising that recent developments in AI have reinforced the widespread view that the intent of AI research is to re-

"One worker's automation is another's augmentation. Automation of rare high value skills can mean augmentation for everyone else. Similarly, augmentation that complements the lucky humans with rare high value skills can mean increased inequality and a hollowing out of the middle class."

Working Paper 24-013

Navigating the Jagged Technological Frontier: Field Experimental Evidence of the Effects of AI on Knowledge Worker Productivity and Quality

Fabrizio Dell'Acqua
Edward McFowland III
Ethan Mollick
Hila Lifshitz-Assaf
Katherine C. Kellogg
Saran Rajendran
Lisa Krayer
François Candelon
Karim R. Lakhani

Harvard Business School

Figure 2: **Performance Distribution - Inside the Frontier**

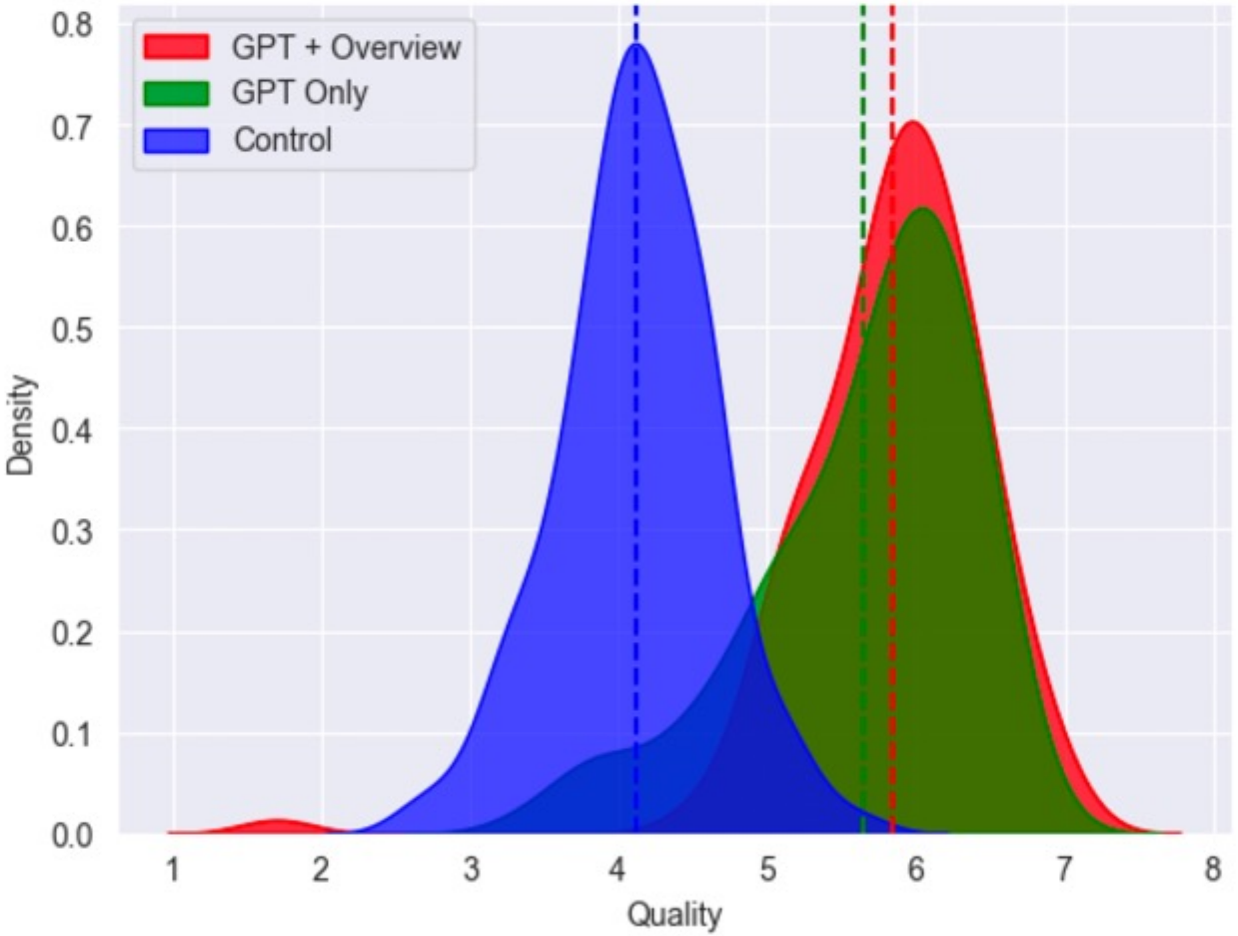
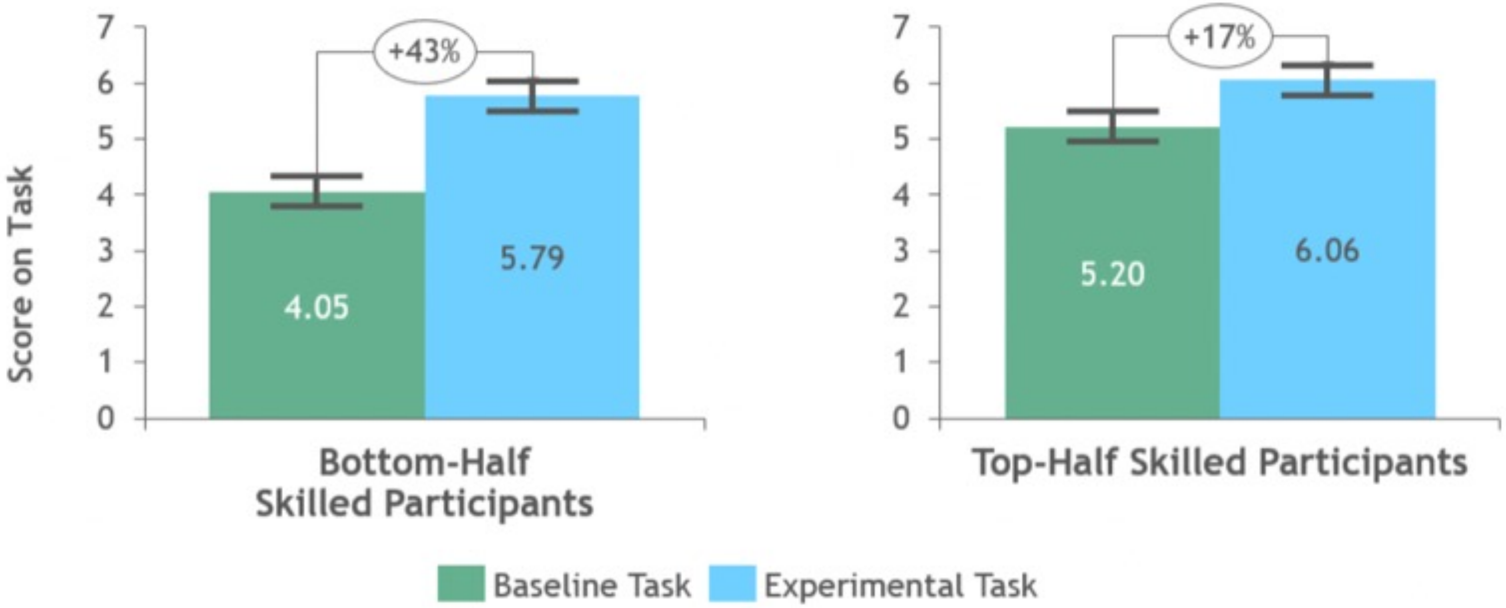


Figure 5: **Bottom-Half Skills and Top-Half Skills - Inside the Frontier**



- The first 50 years of computing contain many technologies that appear to be intelligence augmenting, creating new capabilities and new products and services.

- The last 10 years have seen a rise in artificial intelligence applications, whose inventors directly aspire to automate tasks currently performed by humans.

- The apparently augmenting technologies appear to have increased inequality.

- But one person’s automation is another’s augmentation.

- Perhaps the automating technologies will decrease inequality, depending on whose work gets automated and whose gets augmented.

Harms of AI

Daron Acemoglu

WORKING PAPER 29247 **DOI** 10.3386/w29247 **ISSUE DATE** September 2021

This essay discusses several potential economic, political and social costs of the current path of AI technologies. I argue that if AI continues to be deployed along its current trajectory and remains unregulated, it may produce various social, economic and political harms. These include: damaging competition, consumer privacy and consumer choice; excessively automating work, fueling inequality, inefficiently pushing down wages, and failing to improve worker productivity; and damaging political discourse, democracy's most fundamental lifeblood. Although there is no conclusive evidence suggesting that these costs are imminent or

"damaging competition, consumer privacy and consumer choice; excessively automating work, fueling inequality, inefficiently pushing down wages, and failing to improve worker productivity; and damaging political discourse, democracy's most fundamental lifeblood."

future of life INSTITUTE

Pause Giant AI Experiments: An Open Letter

We call on all AI labs to immediately pause for at least 6 months the training of AI systems more powerful than GPT-4.

View this open letter online.

Published	PDF created	Signatures
March 22, 2023	May 5, 2023	27565

AI systems with human-competitive intelligence can pose profound risks to society and humanity, as shown by extensive research[1] and acknowledged by top AI labs.[2] As stated in the widely-endorsed Asilomar AI Principles, *Advanced AI could represent a profound change in the history of life on Earth, and should be planned for and managed with commensurate care and resources.* Unfortunately, this level of planning and management is not happening, even though recent months have seen AI labs locked in an out-of-control race to develop and deploy ever more powerful digital minds that no one – not even their creators – can understand, predict, or reliably control.

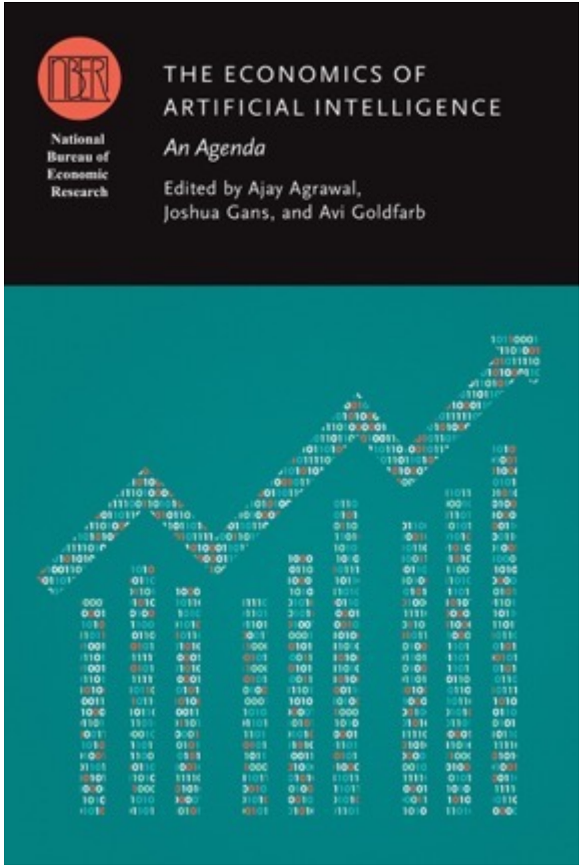
“Should we risk loss of control of our civilization?” Should we develop nonhuman minds that might eventually outnumber, outsmart, obsolete and replace us?”

“Should we let machines flood our information channels with propaganda and untruth?”

“Should we automate away all the jobs, including the fulfilling ones?”

Open questions

- Will AI lead to a large improvement in productivity?
- If it does, which forces dominate with respect to inequality?
- What does equilibrium look like when fake images, sounds, and videos are easy to create?
- How soon, and under what circumstances, should we be concerned about market power?


National
Bureau of
Economic
Research
THE ECONOMICS OF
ARTIFICIAL INTELLIGENCE
An Agenda
Edited by Ajay Agrawal,
Joshua Gans, and Avi Goldfarb

Policy options and challenges

- The social safety net: With the familiar tradeoffs.

- Bill Gates called for taxation of robots.
  - Standard argument: less investment, slower productivity growth
  - Stiglitz and Korinek (2019): A combination of finely balanced IP rights and capital taxation can limit distortions and enable distribution.

- Universal basic income
  - Goolsbee (2019), Furman (2019), Furman and Seamans (2019), and others are quite critical of this idea.

- The challenge of finding meaning in leisure.
  - Francois (2019), Stevenson (2019)

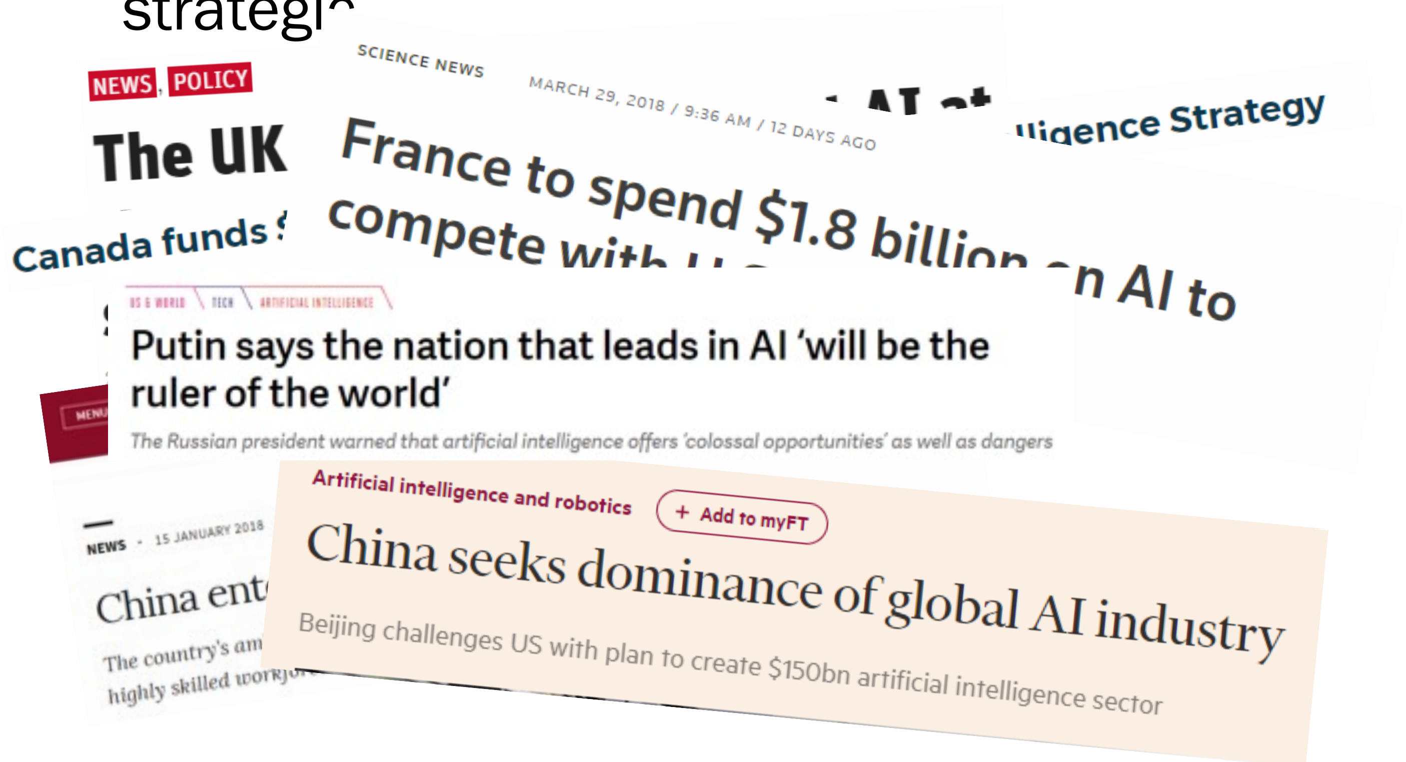
- Political economy
  - Arrow's impossibility theorem (Francois 2019)
  - Inequality, mass displacement, and threats to democracy (Trajtenberg 2019).

Other AI policy topics

- Privacy (already covered)
- Bias (already covered)
- Trade
- Liability
- Collusion

Trade

- Many countries view A.I. investments as strategic



A.I. and trade policy

- Only worth these investments if there are large anticipated rents from leading in A.I.
- Trade agreements currently include provisions for environmental and labor standards to avoid a race-to-the-bottom.
- Could include A.I. industry subsidy provisions, including rules on access to government data.
- On privacy, the E.U. might want U.S. and China to have stricter privacy results so that E.U. companies can succeed despite the E.U.'s stricter take on the right to privacy.

Goldfarb and Trefler (2018)

Impact of AI: Translation and Trade

- On eBay, the introduction of an upgraded machine translation system increased exports by 10.9%

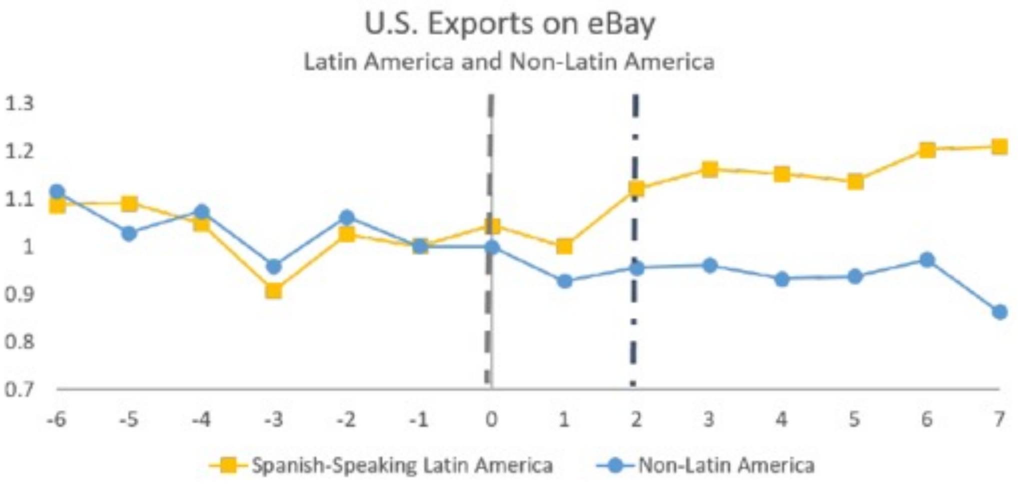
$$log(Y_{clt}) = \beta Num\_Words_{clt} \times Post_t + \gamma XR_{ct} + \eta_c + Num\_Words_g + \xi_t + \epsilon_{clt}. \quad (1)$$

The regression is performed at the country–title length–time period level. Y_{clt} is the exports to country c of title length l in period t; Num_Words_{clt} is the title length; $Post_t$ is the dummy for the introduction of eMT; XR_{ct} is the average daily bilateral exchange rate at t; η_c are importing country fixed effects; Num_Words_g are title length fixed effects; and ξ_t are time fixed effects.

Table 1: Overall Policy Effect

Panel A. Overall Effect	(1)	(2)	(3)	(4)
	All Data		+/- 6 Weeks	
	Main Spec	Add'l Controls	Main Spec	Add'l Controls
No. Words*Post	0.0106	0.014	0.0079	0.0123
	(0.0014)	(0.0025)	(0.0021)	(0.0043)
Obs	3024	3024	2592	2592

(a)



(b)

Table 3: Other Robustness Analyses

	(1)	(2)	(3)	(4)
Panel A. Listings without Modification (+/- 4 Weeks)				
	Main Spec	Add'l Controls		
No. Words*Post	0.0149	0.0218		
	(0.0037)	(0.0068)		
Obs	1728	1728		
Panel B. By No. Photos				
	0-8 Photos		1-4 Photos	
	Main Spec	Add'l Controls	Main Spec	Add'l Controls
No. Words*Post	0.0126	0.0153	0.0128	0.0149
	(0.0017)	(0.0016)	(0.0031)	(0.003)
No. Words*Post*No. Photos	-0.0006	-0.0004	-0.0004	-0.0003
	(0.0002)	(0.0002)	(0.0001)	(0.0001)
Obs	27216	27216	12096	12096
Panel C. Buyer Experience X Product Type				
	Homogeneous Product		Differentiated Product	
	Main Spec	Add'l Controls	Main Spec	Add'l Controls
No. Words*Post	0.0102	0.0113	0.0179	0.0193
	(0.0021)	(0.0021)	(0.0024)	(0.0029)
No. Words*Post*Experienced	-0.0061	-0.0065	-0.0095	-0.0064
	(0.003)	(0.003)	(0.0033)	(0.0031)
Obs	6048	6048	6048	6048

Notes: We control for variables according to equation (1). In Panel B, we additionally control for the dummy for number of pictures, its interaction with "No. Words", and its interaction with "Post". In Panel C, we additionally control for the standalone dummy variable "Experienced", its interaction with "No. Words", and its interaction with "Post". Standard errors clustered at the country level.

Liability

- The purpose of the tort system is to deter people and companies from injuring others, and to compensate injured parties.

- Tort risk can increase or decrease innovation, depending on whether the risk is driven by new or existing products.

- Need clear liability rules. Those rules need to be strict enough for consumers to trust the technology (and for the technology to be safe!) but not so strict that companies bear too much risk.

Galasso and Luo (2018)

Collusion

Artificial Intelligence, Algorithmic Pricing, and Collusion

Emilio Calvano

Giacomo Calzolari

Vincenzo Denicolò

Sergio Pastorello

AMERICAN ECONOMIC REVIEW
VOL. 110, NO. 10, OCTOBER 2020
(pp. 3267-97)

Abstract

Increasingly, algorithms are supplanting human decision-makers in pricing goods and services. To analyze the possible consequences, we study experimentally the behavior of algorithms powered by Artificial Intelligence (Q-learning) in a workhorse oligopoly model of repeated price competition. We find that the algorithms consistently learn to charge supracompetitive prices, without communicating with one another. The high prices are sustained by collusive strategies with a finite phase of punishment followed by a gradual return to cooperation. This finding is robust to asymmetries in cost or demand, changes in the number of players, and various forms of uncertainty.

Collusion

Algorithmic Pricing and Competition: Empirical Evidence from the German Retail Gasoline Market*

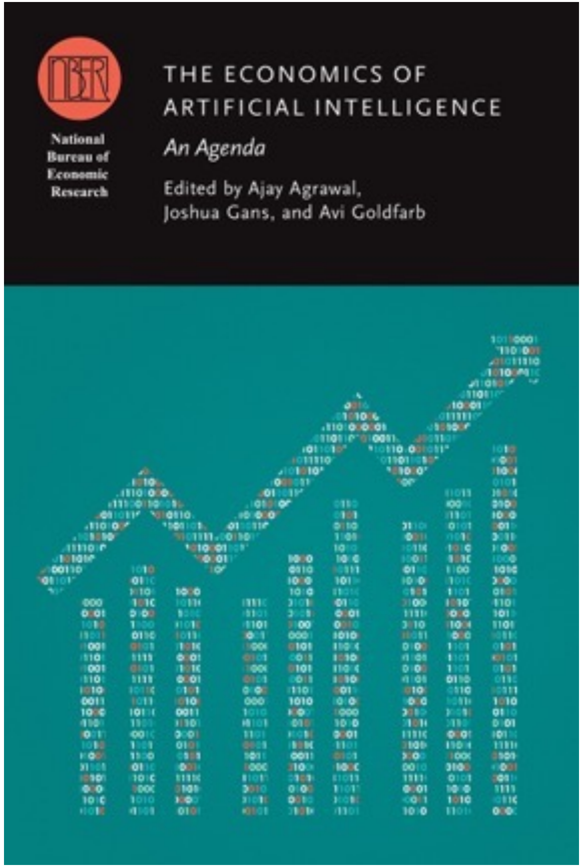
Stephanie Assad[a], Robert Clark[b], Daniel Ershov[c], Lei Xu[d]

June 7, 2023

Abstract

We provide the first empirical analysis of the relationship between algorithmic pricing (AP) and competition by studying the impact of adoption in Germany's retail gasoline market, where software became widely available in 2017. Because adoption dates are unknown, we identify adopting stations by testing for structural breaks in AP markers, finding most breaks to be around the time of widespread AP introduction. Because station adoption is endogenous, we instrument using headquarter adoption. Adoption increases margins, but only for non-monopoly stations. In duopoly and triopoly markets, margins increase only if all stations adopt, suggesting AP has a significant effect on competition.

Journal of Political Economy
Just Accepted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Edited by Ajay Agrawal,
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AEA: Continuing Education - Algorithmic Exclusion

Catherine Tucker

Outline

Algorithmic Exclusion?

Sparse Data

Fragmented Data

What are the effects?

Conclusions

Agenda

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Algorithmic Exclusion

When Algorithms err because data is missing due to differences in privilege

- Sparsity
- Fragmentation

In equation form (this may be lunchtime but this is MIT):

$$Y = X\beta + \epsilon$$

Agenda

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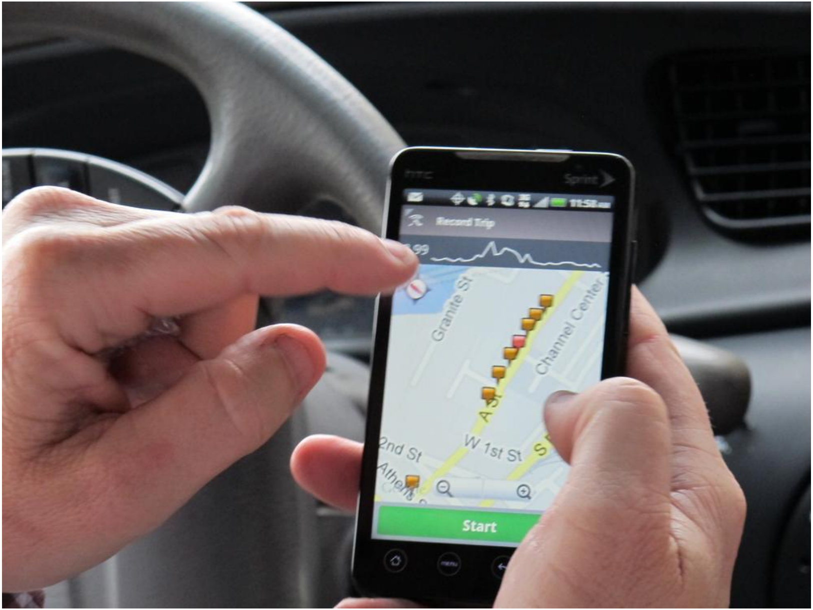
Sparse Data


Sprint
Record Trip
Granite St
Channel Center
2nd St
W 1st St
Start

More general point that a broad digital footprint is a matter of privilege

- Computer Work
- Mobile Data
- Internet of Things

The idea of data deserts is neglected

Agenda

Algorithmic Exclusion?

Sparse Data

Fragmented Data

What are the effects?

Conclusions

Fragmented Data

- Algorithmic data is not usually from single source
- Datasets have to be matched a
- How do you match? Cell phones..Email addresses...Names

Agenda

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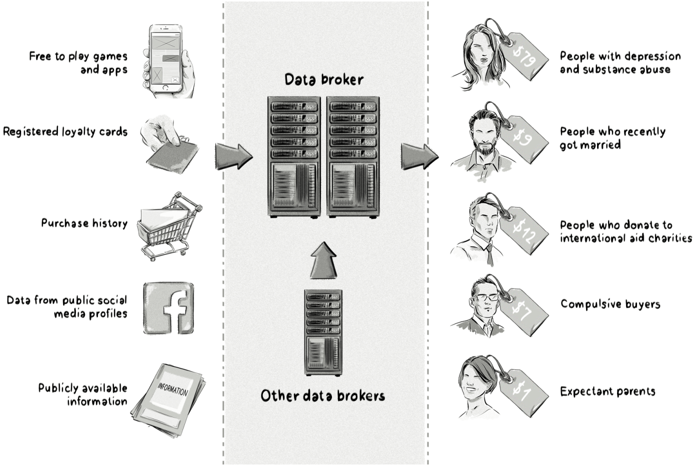
Based on Algorithms of Data Brokers



What Kind of Predictions are bought by data broker clients (Lotme)

- Age (76%)
- Gender (61%)
- Income (50%)
- Education (40%)
- Children (32%)

But how do Data Brokers Know Age and Gender?

Simple prediction task

- Data on Browsing behavior
- May tell us whether someone is a female (if I browse sanitary products)
- May tell us age (if I browse retirement homes)

We asked how good data brokers are at this

What we did

- We identified cookies from ‘pureprofile’ panel survey.
- We asked data brokers to tell whether they were male or (25-34)

Results

Data Broker	Number of Cookies	Gender Accuracy
A	1396	27.5
B	408	25.7
C	1777	35.2
D	495	56.4
E	527	48.8
F	480	47.9
G	562	46.8
H	1016	33.2
I	2336	33.6
J	14342	42.4
K	346	30.6
L	547	51.9
M	456	49.1
N	5099	62.7

We went out and got new data on the people who were profiled

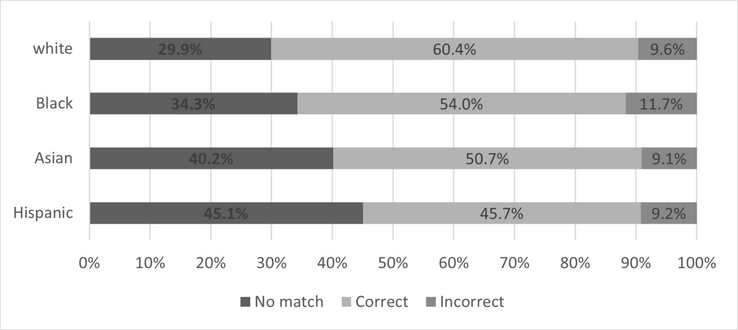
- We wanted to know if this was related to income inequality

Results

- Richer, more educated, home-owning people are more likely to be profiled accurately
- In particular, they are more likely to have accurate demographic information

With new coauthors we found some interesting results for race using public records data in North Carolina

And Race..


white
29.9%
60.4%
9.6%
Black
34.3%
54.0%
11.7%
Asian
40.2%
50.7%
9.1%
Hispanic
45.1%
45.7%
9.2%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
No match
Correct
Incorrect

But should we care if people are poorly profiled by algorithms as they have missing data?

Summary

- Data is often sparse
- Data is often fragmented
- This leads to algorithmic exclusion where algorithms work poorly
- Interaction with inequality appears important outside of advertising

Agenda

Algorithmic Exclusion?

Sparse Data

Fragmented Data

What are the effects?

Conclusions

Outline

Algorithmic Exclusion?

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Fragmented Data

What are the effects?

Conclusions

Punchline

- Perhaps for low-income people AI not making predictions is a bigger concern
- Algorithmic transparency or auditing doesn't address this
- Instead we need to also think about data deserts in the way we think about food deserts in a world of algorithms

Thank you!

cetucker@mit.edu

AI and Innovation

AI as a GPT for innovation

4

The Impact of Artificial Intelligence on Innovation
An Exploratory Analysis

Iain M. Cockburn, Rebecca Henderson, and Scott Stern

4.1 Introduction

Rapid advances in the field of artificial intelligence have profound implications for the economy as well as society at large. These innovations have the potential to directly influence both the production and the characteristics of a wide range of products and services, with important implications for productivity, employment, and competition. But, as important as these effects are likely to be, artificial intelligence also has the potential to change the innovation process itself, with consequences that may be equally profound, and which may, over time, come to dominate the direct effect.

Consider the case of Atomwise, a start-up firm that is developing novel technology for identifying potential drug candidates (and insecticides) by

A.I. as a General Purpose Technology for Innovation

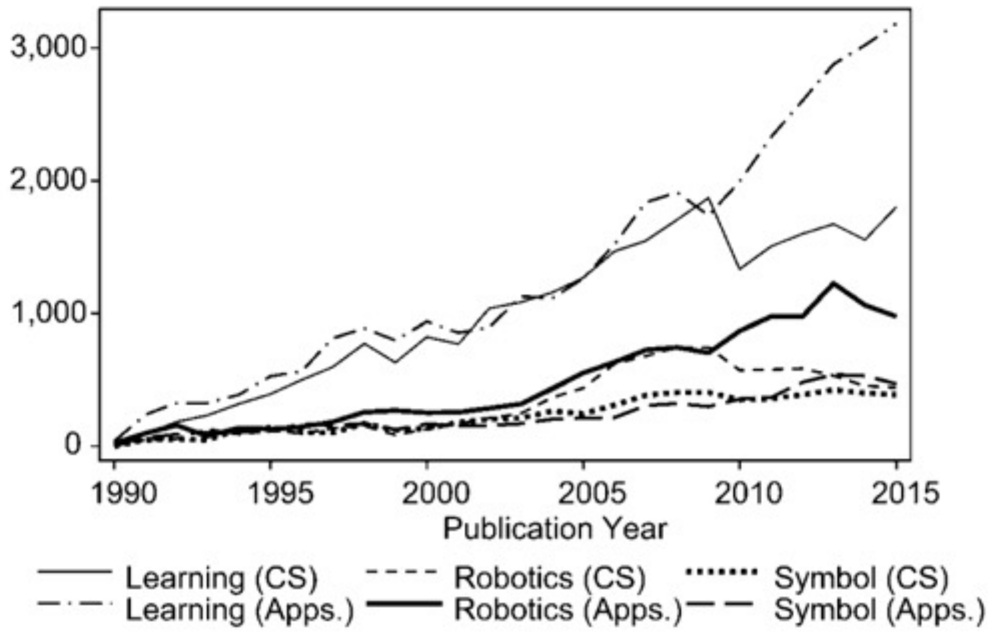

Fig. 4.4 Publications in computer science versus application journals by AI field

Could lead to exponential growth in ideas and reverse the trend that scientific ideas are getting harder to find.

Aghion, Jones, and Jones (2018)
Agrawal, McHale, and Oettl (2018)
Cockburn, Henderson, and Stern (2018)

An invention of a method of inventing

- Griliches (1957) highlighted that some new research tools are inventions that constitute a new way of creating new products.

- Hybrid corn represented a widely applicable method for breeding may new varieties. Previously, a primary focus of agricultural innovation was increased specialization of natural varieties through self-fertilization.

- The discovery of double-cross hybridization "was the invention of a method of inventing", generating a large impact on agricultural productivity.

Cockburn, Henderson, and Stern (2018)

A.I. as an invention of a method of inventing

- “One of the important insights to be gained from thinking about IMIs, therefore, is that the economic impact of some types of research tools is not limited to their ability to reduce the costs of specific innovation activities—perhaps even more consequentially they enable a new approach to innovation itself, by altering the “playbook” for innovation in the domains where the new tool is applied.”

- A.I. is already widely used in research and innovation across many fields.

Atomwise

nature > review articles > article

Review | Published: 02 August 2023

Scientific discovery in the age of artificial intelligence

Hanchen Wang, Tianfan Fu, Yuanqi Du, Wenhao Gao, Kexin Huang, Ziming Liu, Payal Chandak, Shengchao Liu, Peter Van Katwyk, Andreea Deac, Anima Anandkumar, Karianne Bergen, Carla P. Gomes, Shirley Ho, Pushmeet Kohli, Joan Lasenby, Jure Leskovec, Tie-Yan Liu, Arjun Manrai, Debora Marks, Bharath Ramsundar, Le Song, Jimeng Sun, Jian Tang, Petar Veličković, Max Welling, Linfeng Zhang, Connor W. Coley, Yoshua Bengio & Marinka Zitnik — Show fewer authors

Nature **620**, 47–60 (2023) | Cite this article

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We build self-driving labs—that combine material science with the power of artificial intelligence, robotics, and advanced computing—to rapidly design and test new materials and molecules.

nature

NEWS | 30 November 2020

'It will change everything': DeepMind's AI makes gigantic leap in solving protein structures

Google's deep-learning program for determining the 3D shapes of proteins stands to transform biology, say scientists.

Ewen Callaway

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From Predictive Algorithms to Automatic Generation of Anomalies

52 Pages • Posted: 12 May 2023

Sendhil Mullainathan
University of Chicago; National Bureau of Economic Research (NBER)

Ashesh Rambachan
Massachusetts Institute of Technology (MIT)

Date Written: May 9, 2023

Abstract

We ask how machine learning can change a crucial step of the scientific process in economics: the advancement of theories through the discovery of "anomalies." Canonical examples of anomalies include the Allais Paradox and the Kahneman-Tversky choice experiments, which are concrete examples of menus of lotteries that highlighted flaws in expected utility theory and spurred the development of new theories for decision-making under uncertainty. We develop an econometric framework for anomaly generation and develop two algorithmic procedures to generate anomalies (if they exist) when provided a formal theory and data that the theory seeks to explain.

Our algorithmic procedures are general since anomalies play an important role across a wide variety of fields in economics. As an illustration, we apply our procedures to generate anomalies for expected utility theory

"Scientific discovery in economics iterates between theory development and anomaly generation."

"anomaly generation is an empirical activity at its core."

"We rely on the creativity and intuition of researchers for all of these steps in generating anomalies"

"machine learning algorithms can process far more domain-specific data than any one person."

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4443738

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From Predictive Algorithms to Automatic Generation of Anomalies

52 Pages • Posted: 12 May 2023

Sendhil Mullainathan
University of Chicago; National Bureau of Economic Research (NBER)

Ashesh Rambachan
Massachusetts Institute of Technology (MIT)

Date Written: May 9, 2023

"Our main contribution is to develop algorithmic procedures that take as inputs *any* formal theory and data from a scientific domain that it seeks to explain, applies a supervised learning algorithm to that data, and then automatically generates anomalies, if they exist."

"Scientific discovery in economics iterates between theory development and anomaly generation."

"anomaly generation is an empirical activity at its core."

"We rely on the creativity and intuition of researchers for all of these steps in generating anomalies"

"machine learning algorithms can process far more domain-specific data than any one person."

https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4443738

Nagaraj (2018), Nagaraj & Stern (2020)

- Emphasizes the importance of “information infrastructure”: Better maps unlocked enormous wealth.

- Landsat, a NASA satellite mapping program, led to substantial new gold deposit discoveries.

- Helped junior firms relative to established miners.

Example: Information infrastructure and ML to advice scientific discovery

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Research › Working Papers › Machine Learning as a Tool for...

Machine Learning as a Tool for Hypothesis Generation

Jens Ludwig & Sendhil Mullainathan

WORKING PAPER 31017 **DOI** 10.3386/w31017 **ISSUE DATE** March 2023

https://www.nber.org/papers/w31017

While hypothesis testing is a highly formalized activity, hypothesis generation remains largely informal. We propose a systematic procedure to generate novel hypotheses about human behavior, which uses the capacity of machine learning algorithms to notice patterns people might not. We illustrate the procedure with a concrete application: judge decisions about who to jail. We begin with a striking fact: The defendant's face alone matters greatly for the judge's jailing decision. In fact, an algorithm given only the pixels in the defendant's mugshot accounts for up to half of the predictable variation. We develop a procedure that allows human subjects to interact with this black-box algorithm to produce hypotheses about what in the face influences judge decisions. The procedure generates hypotheses that are both interpretable and novel: They are not explained by demographics (e.g. race) or existing psychology research; nor are they already known (even if tacitly) to people or even experts. Though these results are specific, our procedure is general. It provides a way to produce novel, interpretable hypotheses from any high-dimensional dataset (e.g. cell phones, satellites, online behavior, news headlines, corporate filings, and high-frequency time

1 Introduction

Science is curiously asymmetric. New ideas are meticulously tested using data, statistics and formal models. Yet those ideas originate in a notably less meticulous process involving intuition, inspiration and creativity. The asymmetry between how ideas are generated versus tested is noteworthy because idea generation is also, at its core, an empirical activity.

“human cognition is no longer the only way to notice patterns in the world. Machine learning algorithms can also notice patterns, including patterns people might not notice themselves.”

“data on human behavior is exploding”

“these changes can be leveraged to expand how we generate hypotheses.”

“We begin with a striking fact. When we build a deep learning model of the judge—one that predicts whether the judge will detain a given defendant—a single factor emerges as having large explanatory power: the defendant’s face. A predictor that uses only the pixels in the defendant’s mugshot explains from one-quarter to nearly one-half of the predictable variation in detention.”

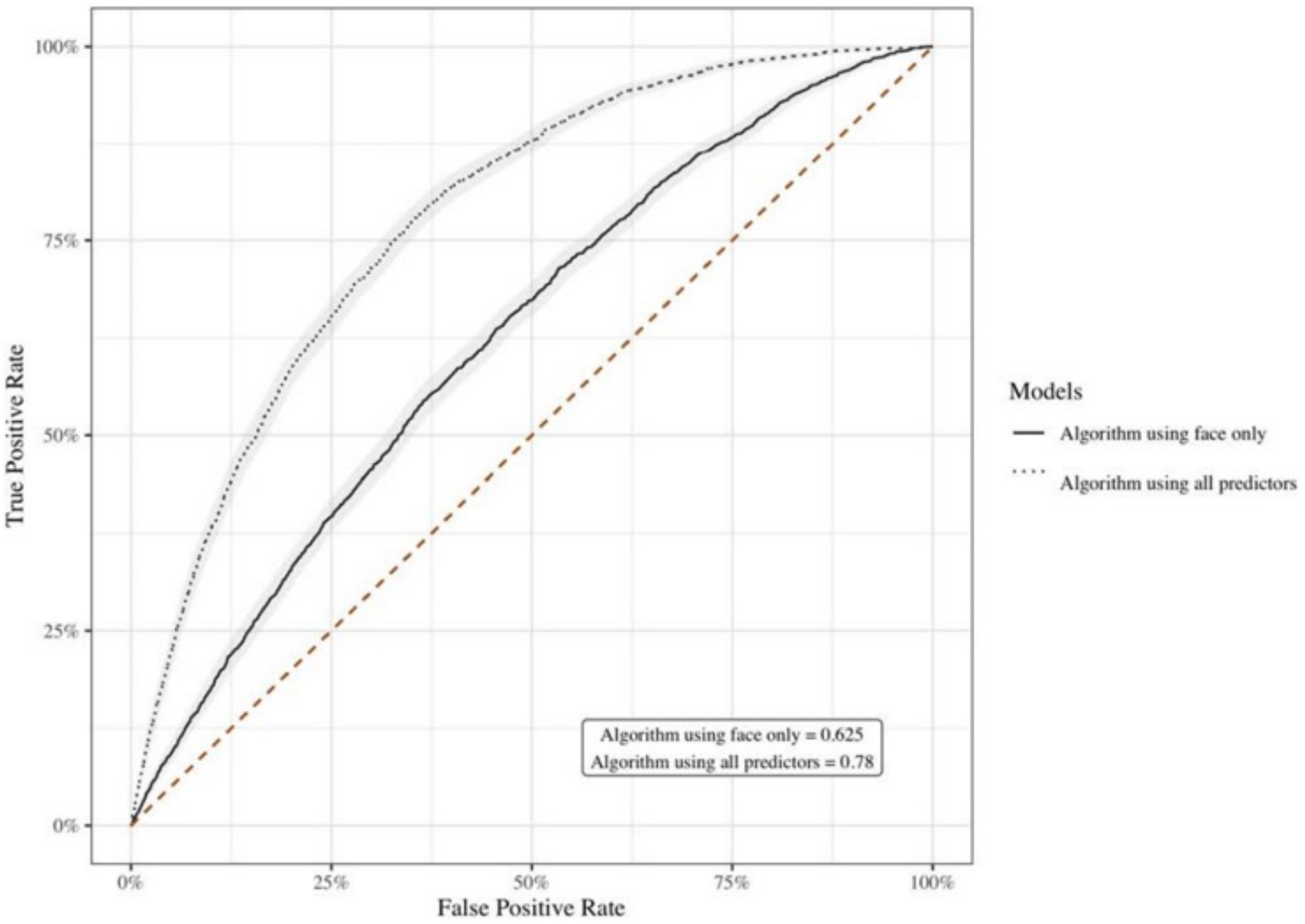
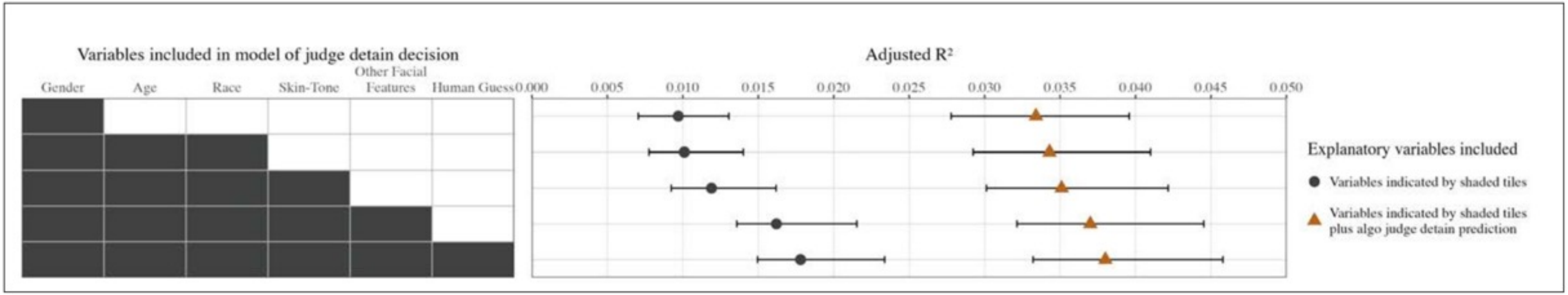


Figure A.X: Accuracy of algorithmic models of judge decisions

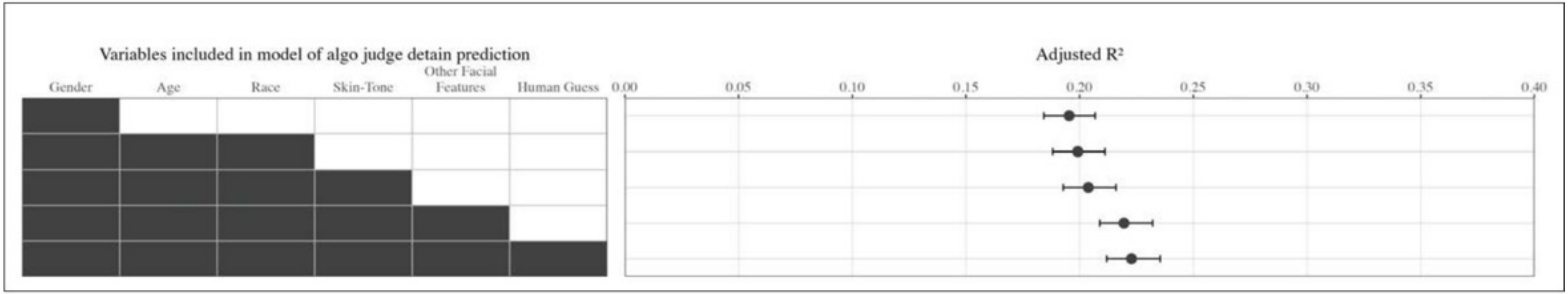
“When we control for age, gender, race, skin color, and even the facial features suggested by previous psychology research (dominance, trustworthiness, attractiveness and competence), none of these factors (individually or jointly) meaningfully diminishes the algorithm’s predictive power (see Panel A of Figure I).



Panel A: Correlates of judge detention decision, with and without mugshot algorithm prediction

“When we control for age, gender, race, skin color, and even the facial features suggested by previous psychology research (dominance, trustworthiness, attractiveness and competence), none of these factors (individually or jointly) meaningfully diminishes the algorithm’s predictive power (see Panel A of Figure I).

known features explain 22.3% of the variation in predicted detention (see Panel B of Figure I). The key point is that the algorithm has discovered a great deal more as well.”



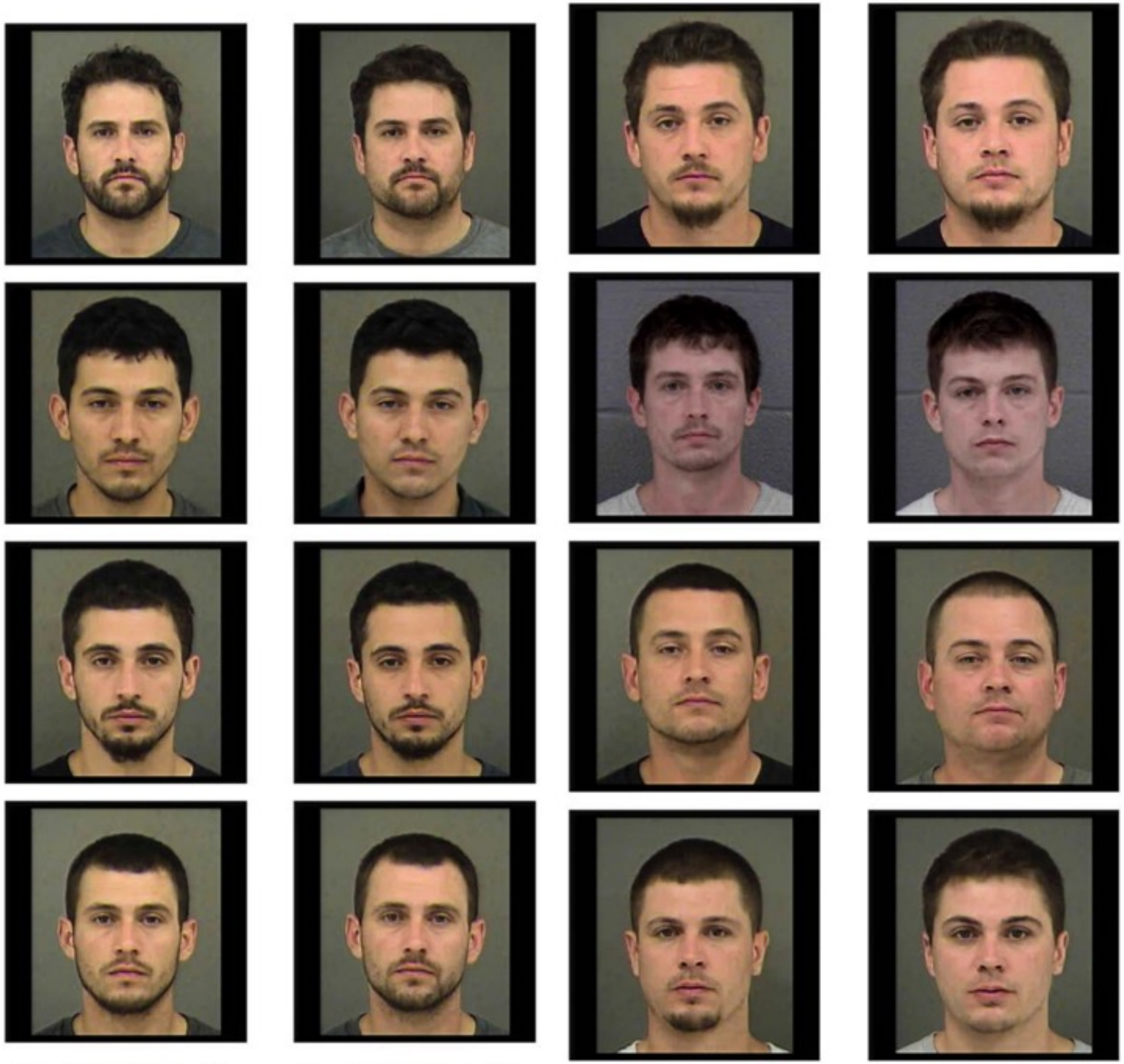
Panel B: Correlates of algorithm prediction of judge detention decision

“What, then, are the novel facial features the algorithm has discovered? If we are unable to answer that question, we will have simply replaced one black box (the judge’s mind) with another (an algorithmic model of the judge’s mind). We propose a solution whereby the algorithm can communicate what it “sees.”

our procedure begins with a mugshot and “morphs” it to create a mugshot that maximally increases (or decreases) the algorithm’s predicted detention probability.

The algorithm discovers, and people name that discovery…. The first can be called “well-groomed”

…the second can be called “heavy-faced””



Higher Predicted Detention Risk   Lower Predicted Detention Risk   Higher Predicted Detention Risk   Lower Predicted Detention Risk

Summary of their process

50

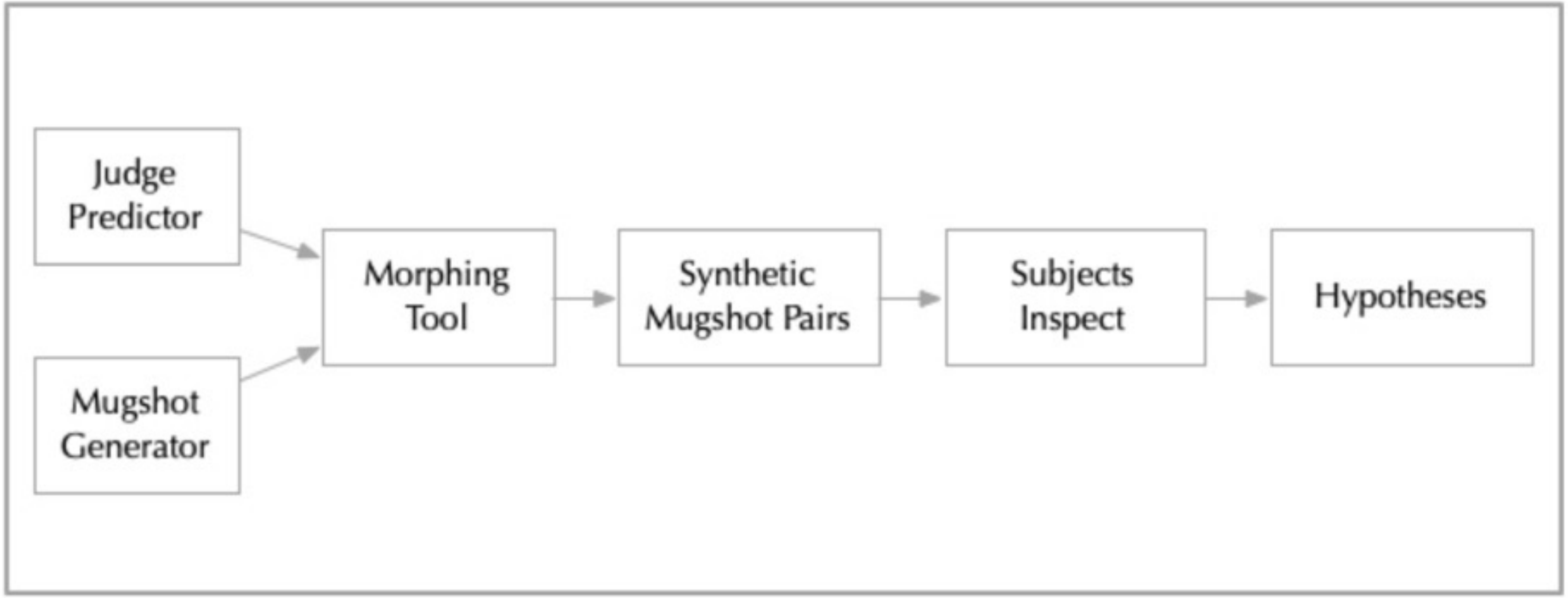


Figure IV: Hypothesis generation pipeline

Notes: The above diagram illustrates all the algorithmic components in our procedure by presenting a full pipeline for algorithmic interpretation.

4

The Impact of Artificial Intelligence on Innovation
An Exploratory Analysis

Iain M. Cockburn, Rebecca Henderson, and Scott Stern

4.1 Introduction

Rapid advances in the field of artificial intelligence have profound implications for the economy as well as society at large. These innovations have the potential to directly influence both the production and the characteristics of a wide range of products and services, with important implications for productivity, employment, and competition. But, as important as these effects are likely to be, artificial intelligence also has the potential to change the innovation process itself, with consequences that may be equally profound, and which may, over time, come to dominate the direct effect.

Consider the case of Atomwise, a start-up firm that is developing novel technology for identifying potential drug candidates (and insecticides) by

American Economic Journal: Macroeconomics 2021, 13(1): 299–332
https://doi.org/10.1257/mac.20170105

Are We Approaching an Economic Singularity? Information Technology and the Future of Economic Growth†

By William D. Nordhaus*

III. Rapid Technological Change through Superintelligent Innovation

A first possible source of extremely rising economic growth comes from rapid improvements in technology generated by superintelligent agents.

9

Artificial Intelligence and Economic Growth

Philippe Aghion, Benjamin F. Jones, and Charles I. Jones

9.3 Artificial Intelligence in the Idea Production Function

An even stronger version of this acceleration occurs if the automation applies to the idea production function instead of (or in addition to) the goods production function. In fact, one can show that there is a mathematical singularity: a Type II event where incomes essentially become infinite in a finite amount of time.

Artificial Intelligence and Governments:

the Good, the Bad, and the Ugly

Martin Beraja (MIT)

AEA Continuing Education, January 2023

AI and Governments: the Good, the Bad, and the Ugly

- AI is a **multi-faceted** technology, with different features and uses
- Has brought opportunities and challenges, raising questions about **the role of gov'ts**

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     "*Data-intensive innovation and the state: Evidence from AI firms in China*" (with Yang and Yuchtman)

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3. **The Ugly:** AI is a surveillance technology. Gov't misuse for repression and social control?
   "*AI-tocracy*" (with Kao, Yang and Yuchtman)
   "*Exporting the surveillance state via trade in AI*" (with Kao, Yang and Yuchtman)

Outline

1. **The Good:** Access to Government Data as Innovation Policy
2. The Bad: Inefficient Automation
3. The Ugly: AI-tocracy

The Good: Access to Government Data as Innovation Policy

- Much focus on how data collected by **private** firms shapes AI innovation
  (Agrawal et al., 2019; Jones and Tonetti, 2020)
- Yet, throughout history, **states** have also collected massive quantities of data
- The state has a large role in many areas
  - Public security, health care, education, basic science...

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Can access to **government data** stimulate **commercial** AI innovation?

A common way in which firms **access** to gov't data is by **providing services** to the state

Think about facial recognition AI sector in China...

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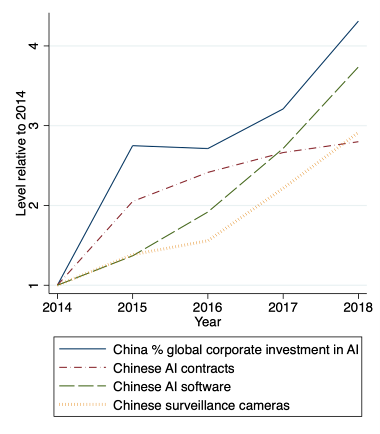
AI and the State in China



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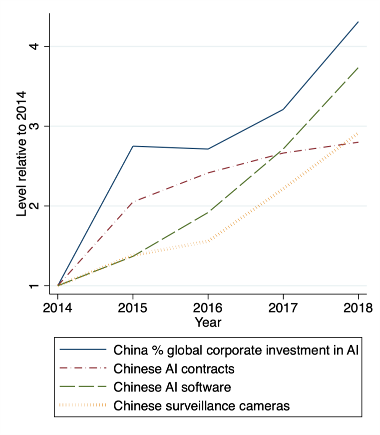
Think about facial recognition AI sector in China...

- Algo's trained on video of faces from many angles
- Government units collect this data through their surveillance apparatus, and contract AI firms
- Firms gaining access to this data use it to train algorithms and provide gov't services
- If gov't data or algorithms are **sharable** across uses, they can be used to develop commercial AI (e.g., a facial recognition platform for retail stores)

AI and the State in China



Data 1: linking AI firms to govt. contracts

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   - 7,837 firms
   - Two sources: Tianyancha (People's Bank of China) and PitchBook (Morningstar)

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3. Link government **buyers** to AI **suppliers**
   - 10,677 AI contracts issued by public security arms of government (e.g., local police department)

财政部唯一指定政府采购信息网络发布媒体 国家级政府采购专业网站　服务热线：400-810-1996

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中国政府采购网　首页 » 地方标讯 » 中标公告

道路交通安全综合管理平台维护升级项目中标（成交）公告

2016年12月30日 16:26 来源：中国政府采购网 【打印】【显示公告概要】

1、项目名称:道路交通安全综合管理平台维护升级项目
2、项目编号: GZGC-2016-38
3、项目序列号: S5200000000007081001
4、项目联系人: 王维娟
5、项目联系人电话: 0851-85226523
6、项目用途、简要技术要求及合同履行日期: 嵌入式"人脸识别"系统软件开发
7、采购方式: 公开招标
8、采购日期 2016-12-07
9、公告媒体 贵州省政府采购网
10、评审时间: 2016-12-29
11、评审地点: 贵州省公共资源交易中心
12、评审委员会成员名单:
熊验翔、李旭、彭歆北、戚玉峰、黄荣伟
13、定标日期 2016-12-29
14、中标（成交）信息:

序号	中标供应商	中标供应商地址	主要中标内容	中标金额(元)
1	上海依图网络科技有限公司	上海市闵行区吴中路1189号，德必易园830-846室	嵌入式"人脸识别"系统软件开发	639000.00

15、PPP项目:否
16、采购人名称: 贵州省公安厅交通管理局
联系地址:贵阳市龙洞堡园林路116号
项目联系人:宋先生
联系电话:0851-85226880
17、采购代理机构全称:贵州贵财招标有限责任公司
联系地址:贵州省贵阳市观山湖区金阳北路233号贵州产业投资（集团）有限责任公司大楼413室
项目联系人:王维娟
联系电话:0851-85226523
18、采购文件上传（PDF格式）:
附件:
gzgc-2016-38(12月2日修改版).pdf
19、书面推荐供应商参加采购活动的采购人和评审专家推荐意见（如有）:
无

贵州贵财招标有限责任公司

Data 2: AI firms' software production

Registered with Min. of Industry and Information Technology

Categorize by intended customers (with RNN model using tensorflow):

1. **Commercial:** e.g., *visual recognition system for smart retail*;
2. **Government:** e.g., *smart city — real time monitoring system on main traffic routes*;
3. General: e.g., *a synchronization method for multi-view cameras based on FPGA chips*.

Data 3: measuring access to government data

Within AI public security contracts: variation in the data collection capacity of the public security agency's local surveillance network

1. Identify non-AI contracts: police department purchases of street cameras
2. Measure quantity of advanced cameras in a prefecture at a given time
3. Categorize public security contracts as coming from "high" or "low" camera capacity prefectures

Public security contracts "data-richness" & Commercial AI innovation

Regional variation in contracts

Empirical strategy

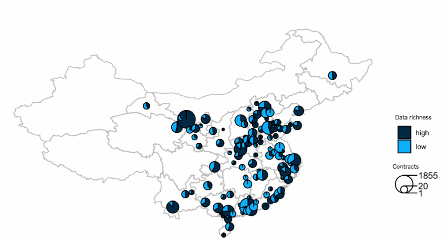
- **Triple diff:** software releases before and after firm receives 1st data-rich contract (relative to data-scarce)

$$y_{it} = \sum_T \beta_{1T} T_{it} Data_i + \sum_T \beta_{2T} T_{it} + \alpha_t + \gamma_i + \sum_T \beta_{3T} T_{it} X_i + \epsilon_{it}$$

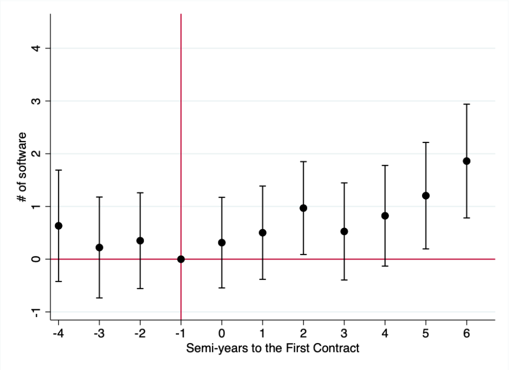
  - T_{it}: 1 if T semi-years before/since firm i's 1st contract
  - $Data_i$: 1 if firm i receives "data rich" contract
  - X_i pre-contract controls: age, size, and software prod

Public security contracts "data-richness" & Commercial AI innovation

Regional variation in contracts



Cumulative commercial software releases



Magnitude: 2 new products over 3 years

Outline

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3. **The Ugly:** AI-tocracy

The Ugly: AI-tocracy

- As a technology of **prediction**, gov'ts may use AI for repression and social control (Zuboff, 2019; Tirole, 2021; Acemoglu, 2021)
- Facial recognition AI, in particular, is a technology of **surveillance** (and dual-use)

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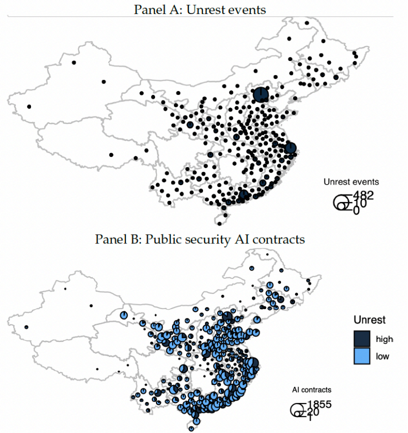
  Evidence from China?

Unrest and gov't procurement of AI



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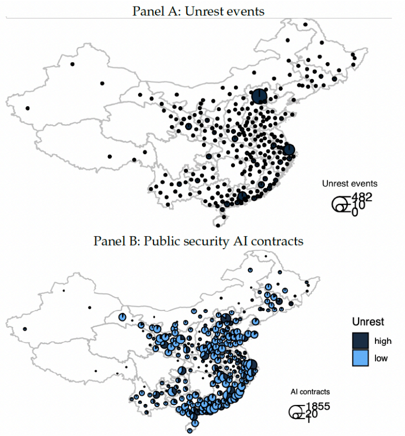
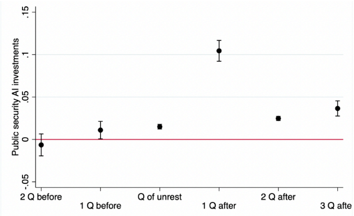
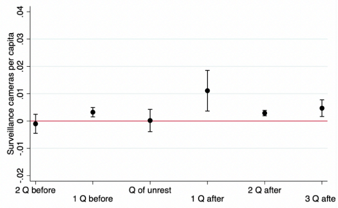
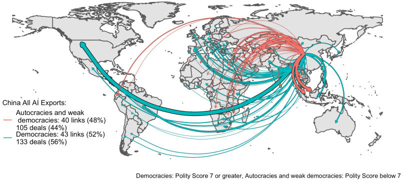


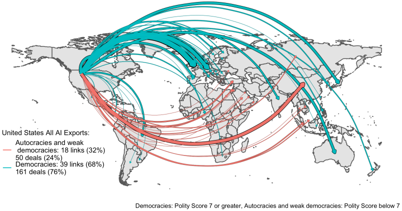
Unrest ⟶ Gov’t buys AI and cameras





Exports of AI: China v. US





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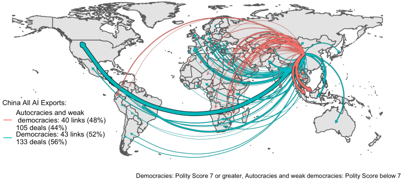
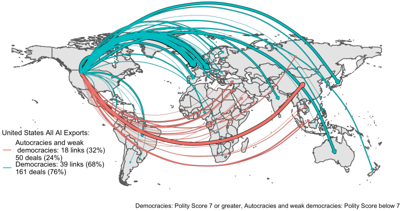
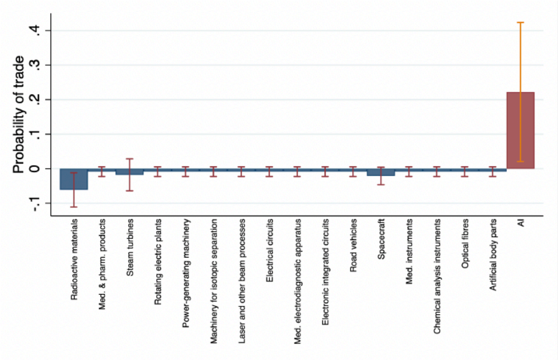




Autocracies and weak democracies are more likely to import AI from China



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- Past automation (robots) has **displaced workers** and **lowered their earnings**

  Acemoglu and Restrepo, 2020, 2022; Humlum, 2021

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- Two economic arguments for slowing down automation based on:

  1. Equity considerations (Guerreiro et al, 2022; Costinot and Werning, 2022)
  2. Efficiency considerations (Beraja and Zorzi, 2023)

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Are these arguments as strong for AI (e.g., LLMs) as they were for robots?

Firms

Continuous time $t \geq 0$

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Occupations

Continuous time $t \geq 0$

Occupations

$h = A$ (degree $\alpha \geq 0$) or $h = N$

FIRMS

Continuous time $t \geq 0$

Occupations

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$$y^A = F\left(\mu^A, \alpha\right) \quad , \quad y^N = F^\star\left(\mu^N\right) \equiv F\left(\mu^N, 0\right)$$

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Final good producer

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Automation

$\partial_A G^\star\left(\mu^A, \mu^N; \alpha\right) \downarrow$ in α (labor-displacing)

$G^\star\left(\mu^A, \mu^N; \alpha\right)$ concave in α (costly)

Continuous time $t \geq 0$

Occupations

$h = A$ (degree $\alpha \geq 0$) or $h = N$

$$y^A = \mu^A + \alpha \quad , \quad y^N = \mu^N$$

Final good producer

$$G^\star\left(\mu^A, \mu^N; \alpha\right) \equiv$$

$$\left[\left(\alpha + \mu^A\right)^{\frac{\nu-1}{\nu}} + \left(\mu^N\right)^{\frac{\nu-1}{\nu}}\right]^{\frac{\nu}{\nu-1}} - \mathcal{C}\left(\alpha\right)$$

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Profit maximization

$$\max_{\alpha \geq 0} \int_0^{+\infty} Q_t \Pi_t\left(\alpha\right) dt$$

$$\Pi_t\left(\alpha\right) \equiv \max_{\mu^A, \mu^N \geq 0} G^\star\left(\mu^A, \mu^N; \alpha\right) - \mu^A w_t^A - \mu^N w_t^N$$

Workers

Preferences

$$U_0 = \int \exp(-\rho t) \frac{c_t^{1-\sigma}}{1-\sigma} dt$$

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$$\left(\mu_t^A, \mu_t^N\right) \begin{cases} = 1/2 & \text{in } t = 0 \\ \text{Reallocation} & \text{afterwards} \end{cases}$$

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Budget constraint

$$da_t^h = \left[\mathcal{Y}_t^{h,\star} + r_t a_t^h - c_t^h\right] dt$$

Preferences

$$U_0 = \int \exp\left(-\rho t\right) \frac{c_t^{1-\sigma}}{1-\sigma} dt$$

Budget constraint

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$$\left(\mu_t^A, \mu_t^N\right) \begin{cases} = 1/2 & \text{in } t = 0 \\ \text{Reallocation} & \text{afterwards} \end{cases}$$

Two frictions

1. Reallocation (neoclassical)

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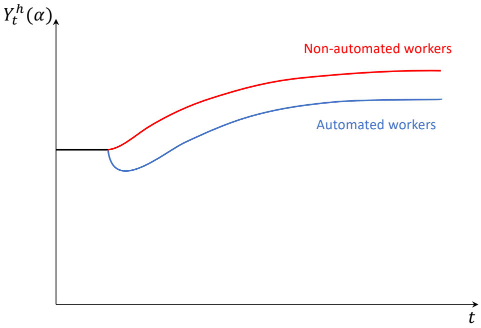
$$a_t^h \geq \underline{a} \quad \text{for some} \quad \underline{a} \leq 0$$

Workers' Incomes



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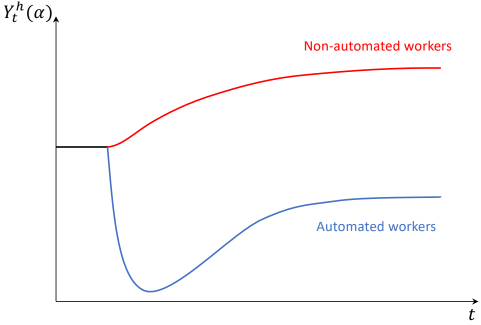

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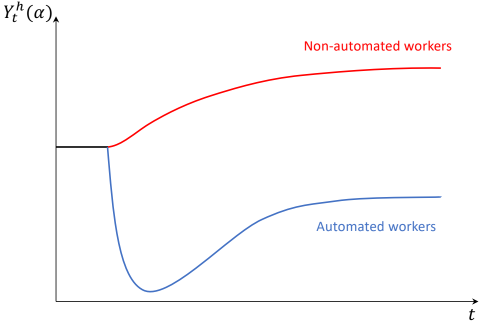

Ricardian workers (ample savings, borrow easily)

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- Non-auto. better-off; Auto. worse-off

Equity and Efficiency Rationales for Taxing Automation

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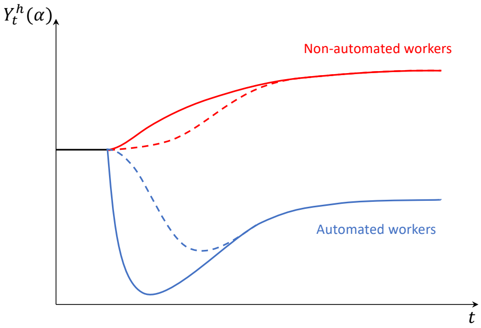

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  Permanent income redistribution

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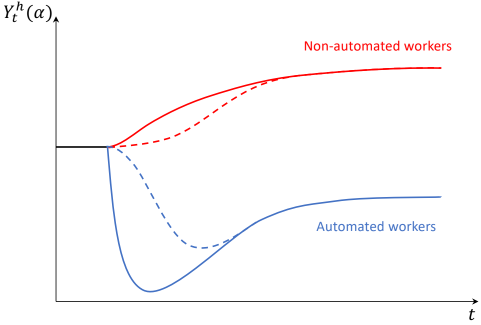

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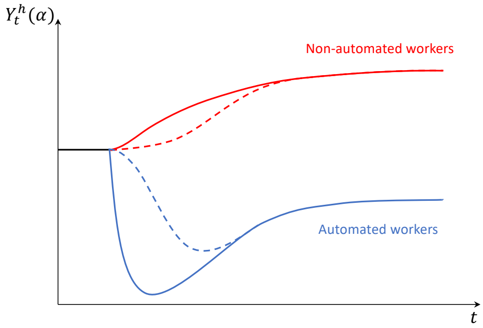

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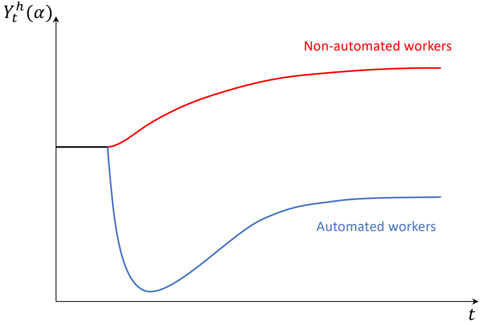
- In practice, workers may be financially vulnerable...

Workers' Incomes



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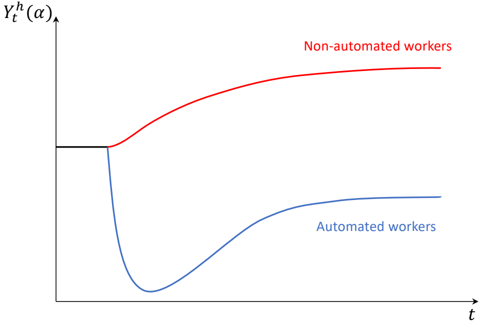

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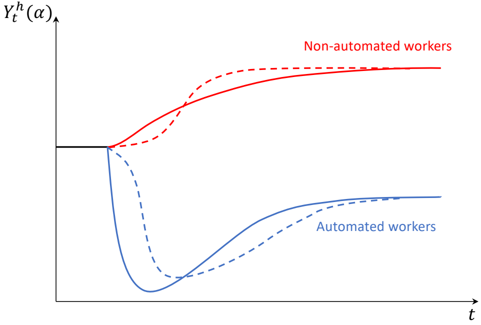

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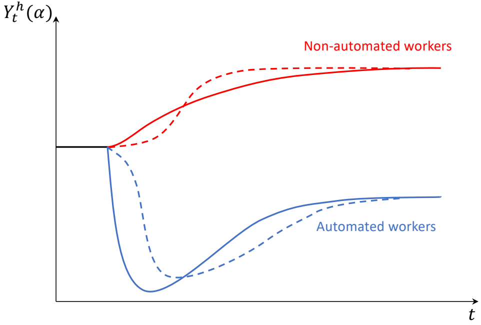

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- No **Efficiency** v. **Equity** trade-off

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- **Adds**: gradual autom. + idiosync. risk (Huggett-Aiyagari) + gross flows (McFadden)

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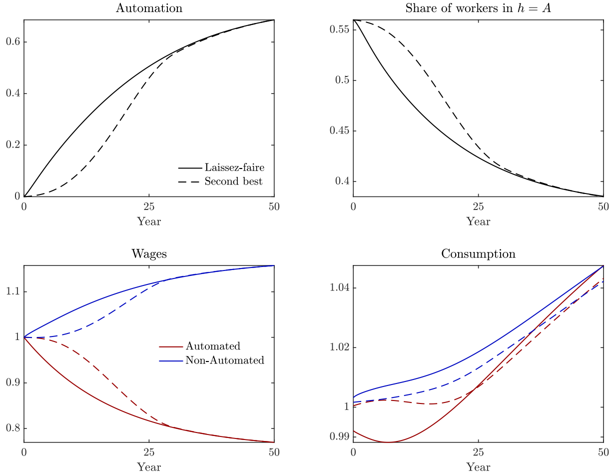

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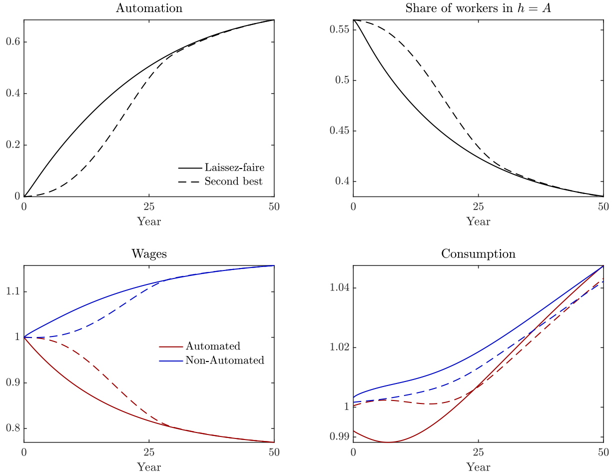

Half-life of automation

16 years at LF v. 22 years at SB

Welfare gains

0.8% for A workers and 0.2% overall

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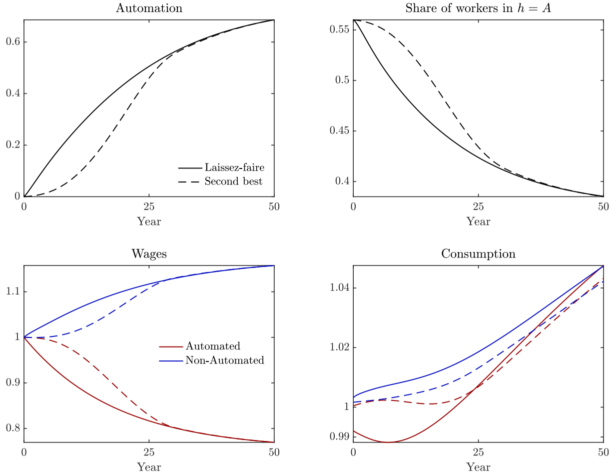

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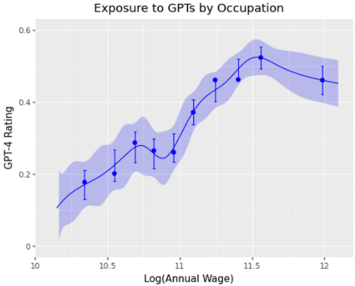
Wage supplements: In PDV, second best *as if* giving \$19,116 to *A*, and taking \$4,615 from *N*

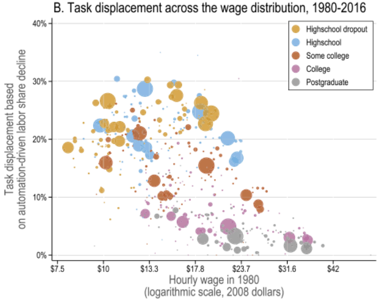
Robots$\neq$ AI (generative, LLMs)

ROBOTS≠ AI (GENERATIVE, LLMS)

- Equity rationale seems much **weaker for AI** than it was for robots
  - Robots automate routine, low-to-middle-wage jobs (car manuf)
  - AI (likely) automates cognitive, middle-to high-wage jobs (lawyers, journos, soft devs)



Eloundou et al (2023)



Acemoglu and Restrepo (2022)

ROBOTS ≠ AI (GENERATIVE, LLMS)

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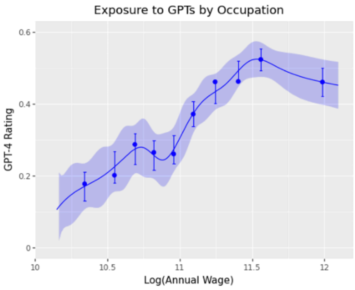

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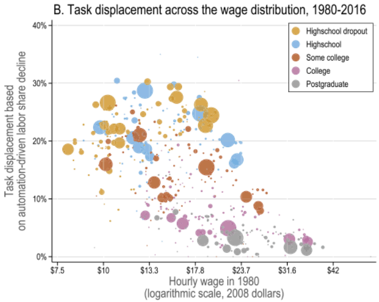

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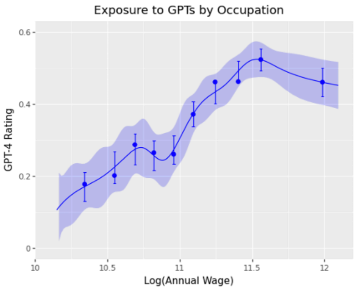
- Weaker rationale for **slowing down AI** due to job automation. AI **alignment** concerns?



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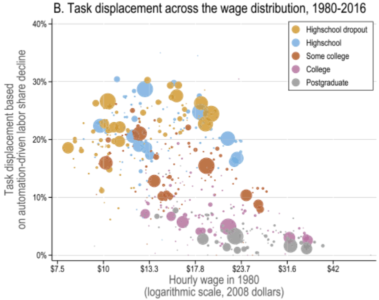

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Final thoughts

- AI is a new technology with many different features and uses
- Touches on issues across fields: macro (growth, innovation, labor), pol. econ, IO

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- Touches on issues across fields: macro (growth, innovation, labor), pol. econ, IO
- We have a responsibility to study the benefits, risks, and policy implications of AI
  - Otherwise, we leave the task to...
- We have only started to scratch the surface. More questions as AI is widely adopted.