

# Consumer Protection for General Purpose Technologies

Avi Goldfarb  
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Based on work with Yuval Lidany

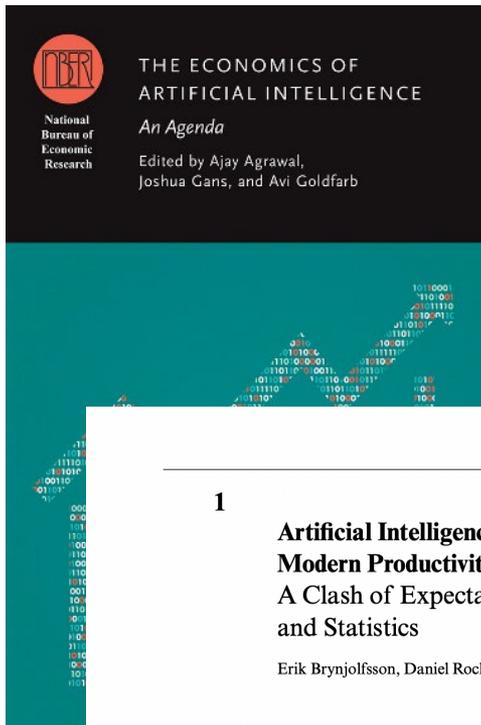
Disclosure: [www.avigoldfarb.com/disclosure](http://www.avigoldfarb.com/disclosure)

# Key points

- Artificial intelligence is likely to be the next general purpose technology.
- General purpose technologies generate an innovation feedback loop between producing and applications industries.
- Early regulatory and enforcement decisions for GPTs have an outsized impact on the rate and direction of innovation.
- Beyond “impact”, we don’t have deep research knowledge on the follow-on effects of policy and enforcement on innovation cycles between producing and application industries.

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

Erik Brynjolfsson, Daniel Rock, and Chad Syverson

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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).<sup>1</sup>

## I. AI as a GPT

### 1. Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics

Erik Brynjolfsson, Daniel Rock, and Chad Syverson

*Comment:* Rebecca Henderson

### 2. The Technological Elements of Artificial Intelligence

Matt Taddy

### 3. Prediction, Judgment, and Complexity: A Theory of Decision-Making and Artificial Intelligence

Ajay Agrawal, Joshua Gans, and Avi Goldfarb

*Comment:* Andrea Prat

### 4. The Impact of Artificial Intelligence on Innovation: An Exploratory Analysis

Iain M. Cockburn, Rebecca Henderson, and Scott Stern

*Comment:* Matthew Mitchell

### 5. Finding Needles in Haystacks: Artificial Intelligence and Recombinant Growth

Ajay Agrawal, John McHale, and Alexander Oettl

### 6. Artificial Intelligence as the Next GPT: A Political-Economy Perspective

Manuel Trajtenberg



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# Research Policy

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

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### ABSTRACT

Many emerging technologies have aspects of General Purpose Technologies (GPTs) and hold potential for large-scale economic impact. Thus, it is important for policy makers to understand the characteristics of these technologies, especially GPTs. We describe an approach that uses data from online job postings to estimate the relative likelihood of different emerging technologies, and find that a science technologies is relatively likely to be a general purpose technology. We describe an approach that uses data from online job postings to estimate the relative likelihood of different emerging technologies, and find that a science technologies is relatively likely to be a general purpose technology.



POLICY FORUM | ARTIFICIAL INTELLIGENCE

## GPTs are GPTs: Labor market impact potential of LLMs

Research is needed to estimate how jobs may be affected

[TYNA ELOUNDOU](#), [SAM MANNING](#), [PAMELA MISHKIN](#), AND [DANIEL ROCK](#) [Authors Info & Affiliations](#)

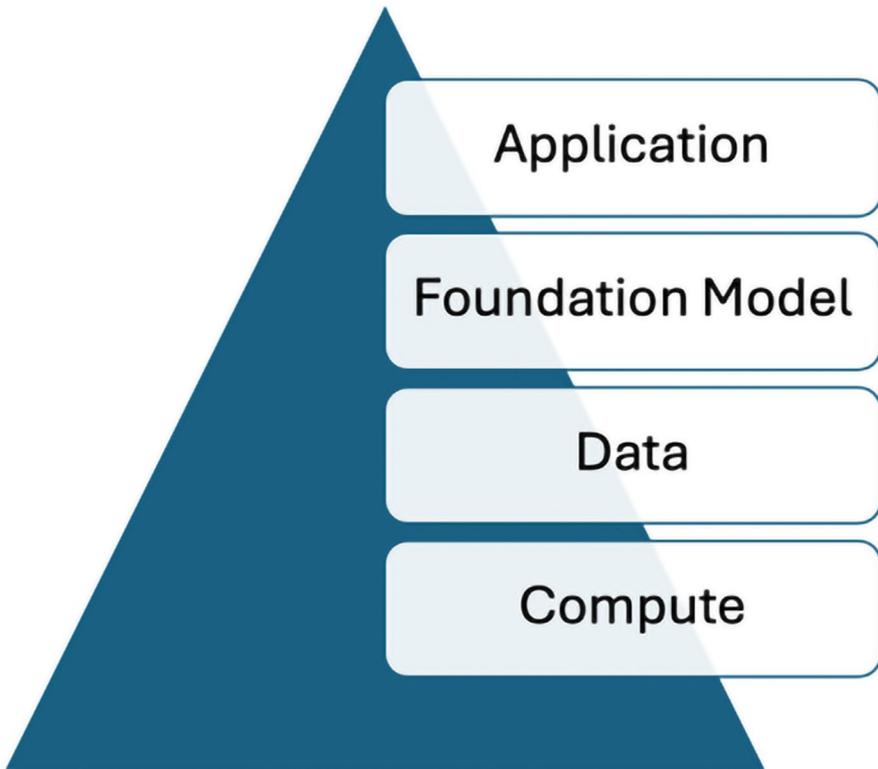
## IS GENERATIVE AI A GENERAL-PURPOSE TECHNOLOGY? IMPLICATIONS FOR PRODUCTIVITY AND POLICY

OECD ARTIFICIAL INTELLIGENCE PAPERS

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# What is Artificial Intelligence?





## Old Moats for New Models: Openness, Control, and Competition in Generative Artificial Intelligence

Pierre Azoulay, Joshua Krieger, and Abhishek Nagaraj

# *Technological Change in the Machine Tool Industry, 1840-1910*

## I

TECHNOLOGICAL change has come to absorb an increasing share of the attention of the economist in recent years. Several attempts have been made to assess the quantitative importance of technological change, as opposed to increases in factor supplies, in accounting for the secular rise in per capita incomes in the United States. It appears, in all these studies, that technological changes (shifts in the production function) have been far more important than has the mere growth in the supplies of capital and labor inputs, as conventionally measured (movement along an existing production function).<sup>1</sup> In a sense, this should be cause for deep concern, since the comparative neglect of the process of technological change (with the major exceptions until very recent years, of the works of Marx, Schumpeter, and Usher) suggests a serious malallocation of our intellectual resources. If the studies of such people as Abramovitz and Solow are even approximately correct with respect to orders of magnitude, then the contribution of technological change to rising per capita incomes absolutely dwarfs the contribution from a rising but qualitatively unchanging stock of capital. It would appear that we have indeed been playing Hamlet without the Prince.

Even the recent quantitative studies referred to in the previous

end of the period under consideration, by the demands of bicycle and automobile manufacturers.<sup>11</sup>

Thus the machine tool industry itself was generated as the result of the specific production requirements of a sequence of industries which adopted techniques of machine production throughout the period. In each case, the introduction of a new process or a new product required an adaptation and adjustment in the capital goods industries to new technical requirements and specifications which did not initially exist. There took place, as it were, a period of technical gestation at the intermediate stages of production, during which time the appropriate accommodations were made to the specific technical needs of the new process or product. As the demand for particular kinds of machines became sufficiently great, reflecting the fact that the same machines came to be employed in a progressively increasing number of industries, the production of that machine itself came to constitute a specialized operation on the part of individual establishments.<sup>12</sup>

The machine tool industry, then, originated out of a response

<sup>11</sup> Joseph W. Roe. "Machine Tools in America." *Journal of the Franklin Institute*

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



Avi Goldfarb<sup>a,b</sup>, Bledi Taska<sup>c</sup>, Florenta Teodoridis<sup>d,\*</sup>

	ML	BI	Big Data	Data Mining	Data Science	NLP	Cloud	Telecom	GIS	Quantum	Robotics	Nanotech	IoT	CRISPR	VR	3D	Polymer	Block-chain	Web2.0	SOA	RFID
ML	100	9.8	32.5	12.8	44.8	14.1	19.2	1.9	0.6	0.6	6.3	0.0	5.7	0.1	1.5	0.3	0.0	2.2	0.0	0.7	0.1
BI	4.4	100	10.7	5.9	9.0	0.6	10.3	2.0	0.5	0.1	0.7	0.0	0.9	0.0	0.1	0.0	0.0	0.3	0.0	0.7	0.0
Big Data	19.1	14.0	100	6.5	21.3	3.8	27.6	2.8	0.5	0.2	0.9	0.0	3.2	0.0	0.2	0.0	0.0	0.7	0.1	1.0	0.2
Data Mining	20.7	21.1	17.8	100	26.6	6.2	7.0	2.2	1.1	0.3	1.1	0.0	1.1	0.1	0.2	0.0	0.0	0.4	0.1	0.2	0.1
Data	36.2	16.1	29.3	13.3	100	7.6	13.5	1.9	1.0	0.2	1.5	0.0	2.7	0.1	0.3	0.1	0.0	0.7	0.0	0.3	0.2
NLP	54.3	5.4	25.1	14.7	36.3	100	14.2	3.9	0.4	0.5	4.4	0.0	3.1	0.0	0.4	0.0	0.0	2.1	0.1	0.5	0.0
Cloud	4.9	5.9	12.1	1.1	4.3	1.0	100	4.2	0.3	0.2	0.6	0.0	2.7	0.0	0.1	0.0	0.0	0.6	0.1	1.2	0.0
Telecom	0.7	1.6	1.8	0.5	0.9	0.4	6.1	100	0.7	0.1	0.4	0.0	1.3	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.2
GIS	2.0	3.5	2.5	2.2	3.8	0.3	3.9	6.2	100	0.0	0.6	0.0	0.5	0.0	0.1	0.1	0.0	0.0	0.0	0.6	0.2
Quantum	14.9	4.3	8.0	4.3	5.6	2.9	22.4	3.0	0.2	100	4.3	0.1	74.3	0.1	0.5	0.0	0.0	13.2	0.0	0.6	0.0
Robotics	9.1	2.1	2.1	1.0	2.8	1.7	3.4	1.5	0.3	0.3	100	0.1	1.8	0.1	1.1	1.9	0.0	1.0	0.0	0.1	0.2
Nanotech	5.6	0.9	2.0	0.2	3.3	0.2	1.2	6.1	0.3	0.5	9.3	100	3.6	1.1	0.7	3.2	1.9	0.0	0.2	0.0	0.0
IoT	13.7	4.9	13.3	1.7	8.1	1.9	24.9	8.4	0.4	7.6	2.9	0.1	100	0.0	1.1	0.3	0.0	6.2	0.0	0.8	0.7
CRISPR	2.0	0.2	0.7	2.3	2.5	0.1	0.5	0.1	0.0	0.2	3.0	0.3	0.0	100	0.2	0.1	0.0	0.2	0.0	0.0	0.0
VR	16.6	1.7	3.2	1.1	3.9	1.3	4.7	2.0	0.4	0.2	8.8	0.1	5.2	0.1	100	2.7	0.0	2.4	0.1	0.2	0.1
3Dprint	3.4	0.4	0.5	0.3	1.0	0.0	0.9	0.8	0.3	0.0	16.3	0.3	1.7	0.0	2.9	100	0.4	0.2	0.0	0.0	0.3
Polymer	0.5	0.2	0.0	0.7	0.4	0.0	0.1	0.2	0.0	0.0	0.7	1.3	0.0	0.0	0.2	2.9	100	0.0	0.0	0.0	0.1
Blockchain	21.4	5.5	11.2	2.3	8.0	5.1	23.1	2.6	0.1	5.4	6.8	0.0	24.5	0.0	2.0	0.2	0.0	100	0.0	0.8	0.3
Web2.0	1.4	4.0	8.1	2.0	0.8	0.8	21.1	6.5	0.4	0.0	0.3	0.1	0.2	0.0	0.3	0.1	0.0	0.1	100	2.0	0.0
SOA	3.9	9.1	9.4	0.7	1.8	0.8	26.3	2.1	1.1	0.1	0.3	0.0	1.8	0.0	0.1	0.0	0.0	0.4	0.3	100	0.0
RFID	0.6	1.0	4.1	0.4	3.5	0.1	2.3	6.0	0.7	0.0	2.1	0.0	3.9	0.0	0.1	0.3	0.0	0.3	0.0	0.0	100

# Key points

- Artificial intelligence is likely to be the next general purpose technology.
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## General purpose technologies

### ‘Engines of growth’?

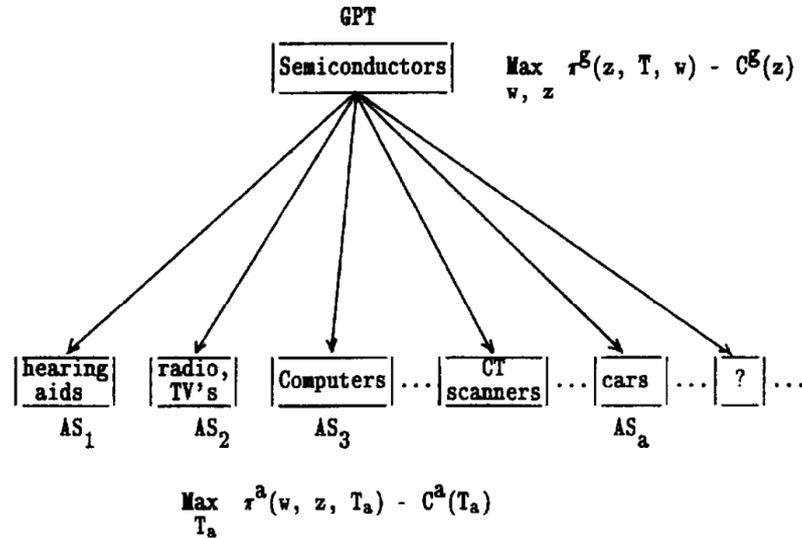
Timothy F. Bresnahan<sup>\*,a,c</sup>, M. Trajtenberg<sup>b,c</sup>

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<sup>c</sup>*NBER*

- Examples: The steam engine, electrification, semiconductors, etc.
- Intersection of micro (economics of innovation) and macro (economics of growth)
- The long run impact on productivity and society is large.

**Notation:**

- GPT: General Purpose Technology
- AS<sub>a</sub>: Application Sector a
- z: "Quality" of the GPT
- w: Market price of the GPT
- c: Marginal cost of GPT
- T<sub>a</sub>: Technological level (or "performance") of AS<sub>a</sub> (T: vector of T<sub>a</sub>'s)
- $\tau^G, \tau^a$ : Gross rents of the ith sector, i: GPT, AS<sub>a</sub>
- $C^i$ : R&D costs of the ith sector, i: GPT, AS<sub>a</sub>

Fig. 1. The framework of analysis.

# General Purpose Technology: Definition

1. Widespread use
2. Potential for innovation
3. Innovation in application industries

The outsized impact on productivity is through the innovation in application industries, or “co-invention”, which generates an innovation feedback loop.

# Similarities and Differences in the Adoption of General Purpose Technologies

Ajay K. Agrawal, Joshua S. Gans & Avi Goldfarb

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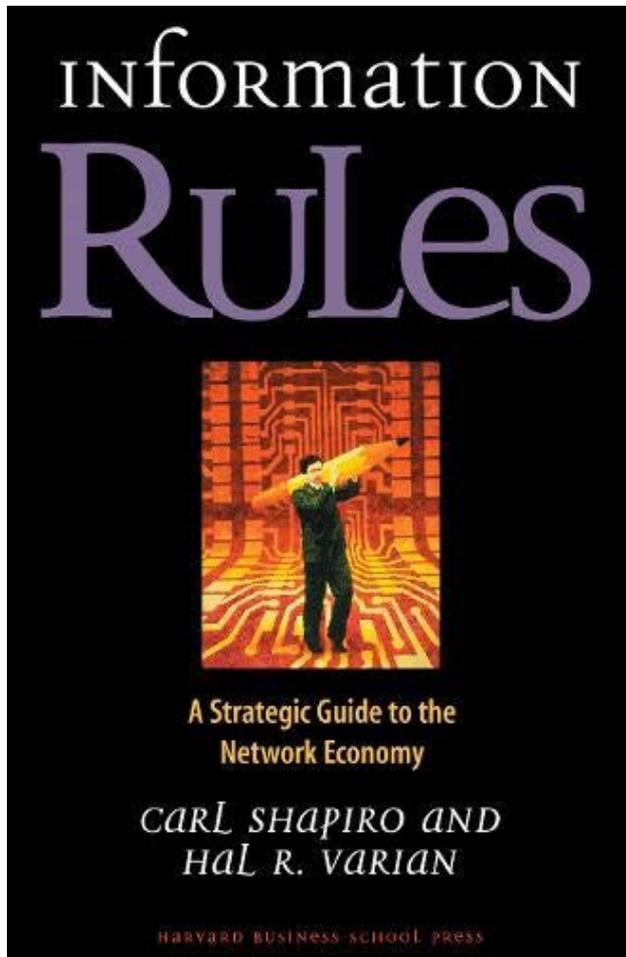
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Economic models provide little insight into when the next big idea and its associated productivity dividend will come along. Once a general purpose technology (GPT) is identified, the economist's toolkit does provide an understanding when firms will adopt a new technology and for what purpose. The focus of the literature has been on commonalities across each type of GPT. This focus is natural, given that the goal of the literature has been to identify generalizable insights across technologies. Broadly, this literature emphasizes heterogeneity in co-invention costs across firms. Each GPT, however, provides a distinct benefit. Steam provided a new power source. The internet facilitated communication. The differences between GPTs are important for understanding adoption patterns. Using the examples of the internet and artificial intelligence, we discuss how both co-invention costs and distinct benefits determine the adoption of technology. For both technologies, we demonstrate that discussions of the impact of a GPT on productivity and growth need to emphasize the benefits as well as the costs. The goal of this paper is therefore to link the literature on co-invention costs with an understanding of the distinct benefits of each GPT.



## Digital Economics<sup>†</sup>

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:

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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 McEllean 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.

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

# Regulating GPTs

- The stakes are higher.
- Not only because of the potential productivity impact.
- Decisions affect the rate and direction of downstream innovation, and the co-invention feedback loop.

# Key points

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# Early online verification

- The internet made it feasible for millions of users to connect.
- Not designed for large scale commerce.
- No trust or verification systems built into TCP/IP



*"On the Internet, nobody knows you're a dog."*



### Overall profile makeup

94 positives. 91 are from unique users and count toward the final rating.

4 neutrals. 0 are from users no longer registered.

1 negatives. 1 are from unique users and count toward the final rating.

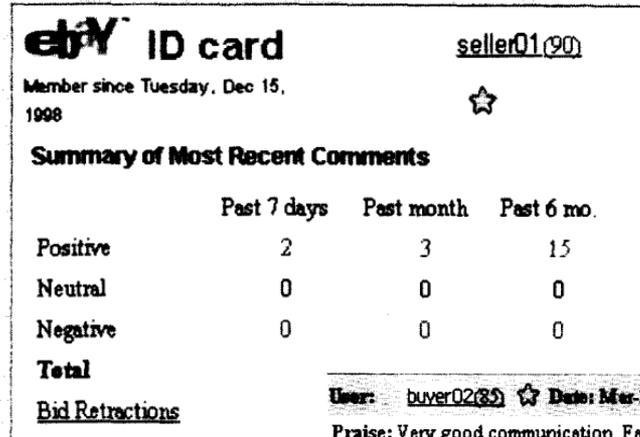


Fig. 3. Feedback Profile of ti

Fig. 4. Some of the Individual Comments about the Seller.

Note that the seller's response to the one negative feedback alleges that it was retaliatory in nature rather than a real indicator of the seller's performance.

## EVIDENCE OF THE EFFECT OF TRUST BUILDING TECHNOLOGY IN ELECTRONIC MARKETS: PRICE PREMIUMS AND BUYER BEHAVIOR<sup>1</sup>

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as to whether online feedback mechanisms induce trust and lead to higher auction prices. This study examines the extent to which trust can be induced by proper feedback mechanisms in electronic markets, and how some risk factors play a role in trust formation. Drawing from economic, sociological, and marketing theories and using data from both an online experiment and an online auction market, we demonstrate that appropriate feedback mechanisms can induce calculus-based credibility trust without repeated interactions between two transacting parties. Trust can mitigate information asymmetry by reducing transaction-specific risks, therefore generating price premiums for reputable sellers. In addition, the research also examines the role that trust plays in mitigating the risks inherent in transactions that

## TRUST AMONG STRANGERS IN INTERNET TRANSACTIONS: EMPIRICAL ANALYSIS OF eBAY'S REPUTATION SYSTEM

Paul Resnick and Richard Zeckhauser

### ABSTRACT

*One of the earliest and best known Internet reputation systems is run by eBay, which gathers comments from buyers and sellers about each other after each transaction. Examination of a large data set from 1999 reveals several interesting features. First, despite incentives to free ride, feedback was provided more than half the time. Second, well beyond reasonable expectation, it was almost always positive. Third, reputation profiles were predictive of future performance, though eBay's net feedback statistic is far from the best predictor available. Fourth, there was a high correlation between buyer and seller feedback, suggesting that the players reciprocate and retaliate.*

# The Digitization of Word of Mouth: Promise and Challenges of Online Feedback Mechanisms

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Online feedback mechanisms harness the bidirectional communication capabilities of the Internet to engineer large-scale, word-of-mouth networks. Best known so far as a technology for building trust and fostering cooperation in online marketplaces, such as eBay, these mechanisms are poised to have a much wider impact on organizations. Their growing popularity has potentially important implications for a wide range of management activities such as brand building, customer acquisition and retention, product development, and quality assurance. This paper surveys our progress in understanding the new possibilities and challenges that these mechanisms represent. It discusses some important dimensions in which Internet-based feedback mechanisms differ from traditional word-of-mouth networks and surveys the most important issues related to their design, evaluation, and use. It provides an overview of relevant work in game theory and economics on the topic of reputation. It discusses how this body of work is being extended and combined with insights from computer science, management science, sociology, and psychology to take into consideration the special properties of online environments. Finally, it identifies opportunities that this new

## Online Reputation Mechanisms and the Decreasing Value of Chain Affiliation

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SAGE

Brett Hollenbeck

### Abstract

This article investigates the value of business format franchising and how it is changing in response to a large increase in consumer information provided by online reputation mechanisms. Theory has suggested that much of the value of chain affiliation to firms comes from the ability of chain partners to use the same name, imagery, logo, and marketing to create a common brand reputation and signal specific qualities in settings with asymmetric information between buyers and sellers. As more information becomes available, consumers should rely less on branding for quality signals, and firms' ability to extend reputations across heterogeneous outlets should decrease. To examine this empirically, the author combines a large panel of hotel revenues with millions of online reviews from multiple platforms. Chain-affiliated hotels earn substantially higher revenues than equivalent independent hotels, but this premium has declined by over 50% from 2000 to 2015. This can be largely attributed to an increase in online reputation mechanisms, and this effect is largest for low-quality and small-market firms. Measures of the information content of online reviews show that as information has increased, independent hotel revenue has grown substantially more than chain hotel revenue. This result should be viewed as descriptive, with attempts to come to near causality including the use of machine learning to derive latent dimensions of firm quality from the text of online reviews. Finally, the correlation between firm revenue and chain-wide reputation is decreasing, whereas the correlation with individual hotel reputation is increasing.

### Keywords

Branding, online reviews, online platforms, franchising, machine learning

Online supplement: <https://doi.org/10.1177/0022243718802844>

## Reviews, Reputation, and Revenue: The Case of Yelp.com

Michael Luca<sup>†</sup>

### Abstract

Do online consumer reviews affect restaurant demand? I investigate this question using a novel dataset combining reviews from the website Yelp.com and restaurant data from the Washington State Department of Revenue. Because Yelp prominently displays a restaurant's rounded average rating, I can identify the *causal* impact of Yelp ratings on demand with a regression discontinuity framework that exploits Yelp's rounding thresholds. I present three findings about



A Report From the  
Federal Trade Commission Staff  
December 1999

*The FTC's First Five Years*

*Protecting  
Consumers  
Online*

*[www.ftc.gov](http://www.ftc.gov)*

## **Enforcement decisions are central to this history**

“In September 1994, the Federal Trade Commission brought its first law enforcement action against a fraudulent online operator. In September 1999, it brought its 100th case to stop an Internet scam.”

“The FTC has targeted its online law enforcement efforts at fraud and deception.”



# An alternative path

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## Public Relations Firm to Settle FTC Charges that It Advertised Clients' Gaming Apps Through Misleading Online Endorsements

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August 26, 2010



**Tags:** [Consumer Protection](#) | [Bureau of Consumer Protection](#)

A public relations agency hired by video game developers will settle Federal Trade Commission charges that it engaged in deceptive advertising by having employees

Enforcement of ratings happened later, after online verification systems were well-developed.

# **ONLINE PRIVACY**

# Privacy regulation choices also affected the rate and direction of innovation



SELF-REGULATION  
AND PRIVACY ONLINE:

A REPORT TO CONGRESS

FEDERAL TRADE COMMISSION  
JULY 1999

- “...the core principles of privacy protection common to the government reports, guidelines, and model codes that have emerged since 1973: (1) Notice/ Awareness; (2) Choice/Consent; (3) Access/Participation; (4) Integrity/Security; and (5) Enforcement/Redress.”
- COPPA to protect children
- Self-regulation and enforcement of contracts for everyone else, based on the above principles.

# Different regulators took different paths

ECONOMIC RESEARCH ON PRIVACY REGULATION:  
LESSONS FROM THE GDPR AND BEYOND

Garrett Johnson

Working Paper 30705  
<http://www.nber.org/papers/w30705>

NATIONAL BUREAU OF ECONOMIC RESEARCH  
1050 Massachusetts Avenue  
Cambridge, MA 02138  
December 2022

[Home](#) > [Marketing Science](#) > [Vol. 40, No. 4](#) >

## The Short-Run Effects of the General Data Protection Regulation on Technology Venture Investment

Jian Jia , Ginger Zhe Jin , Liad Wagman 

Published Online: 1 Mar 2021 | <https://doi.org/10.1287/mksc.2020.1271>

### Abstract

The General Data Protection Regulation (GDPR) was enacted in the European Union in April 2016 and went into effect in May 2018. We study its impact on investment in new and emerging technology firms. Our findings indicate negative post-GDPR effects after its 2018 rollout on European ventures relative to their counterparts in the United States and the rest of the world, and considerably lesser effects after its 2016 enactment and before implementation. The negative effects manifest in the number of and amounts raised in financing deals, and are particularly pronounced for newer, data-related, and business-to-consumer ventures.

# THE



# ECONOMY

## TOOLS AND APPLICATIONS

**ISAAC BAILEY  
LAURA VELDKAMP**

4

## Privacy and Innovation

Avi Goldfarb, *Rotman School of Management, University of Toronto*

Catherine Tucker, *MIT Sloan School of Management and NBER*

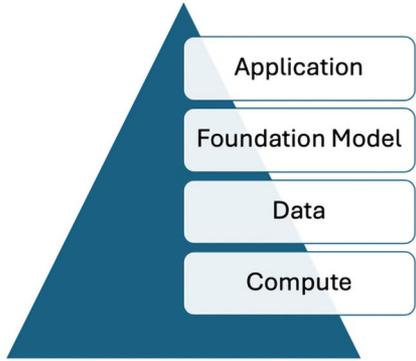
### Executive Summary

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.



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

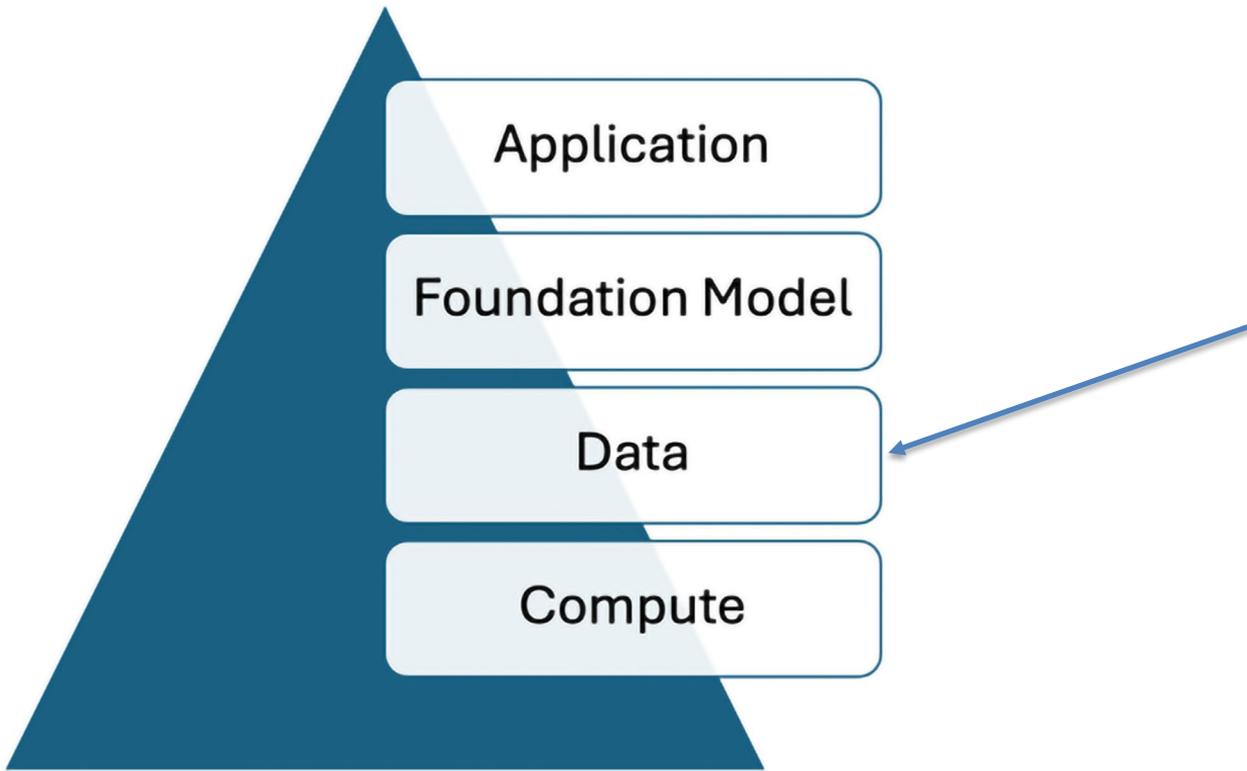
Avi Goldfarb<sup>a,b</sup>, Bledi Taska<sup>c</sup>, Florenta Teodoridis<sup>d,\*</sup>



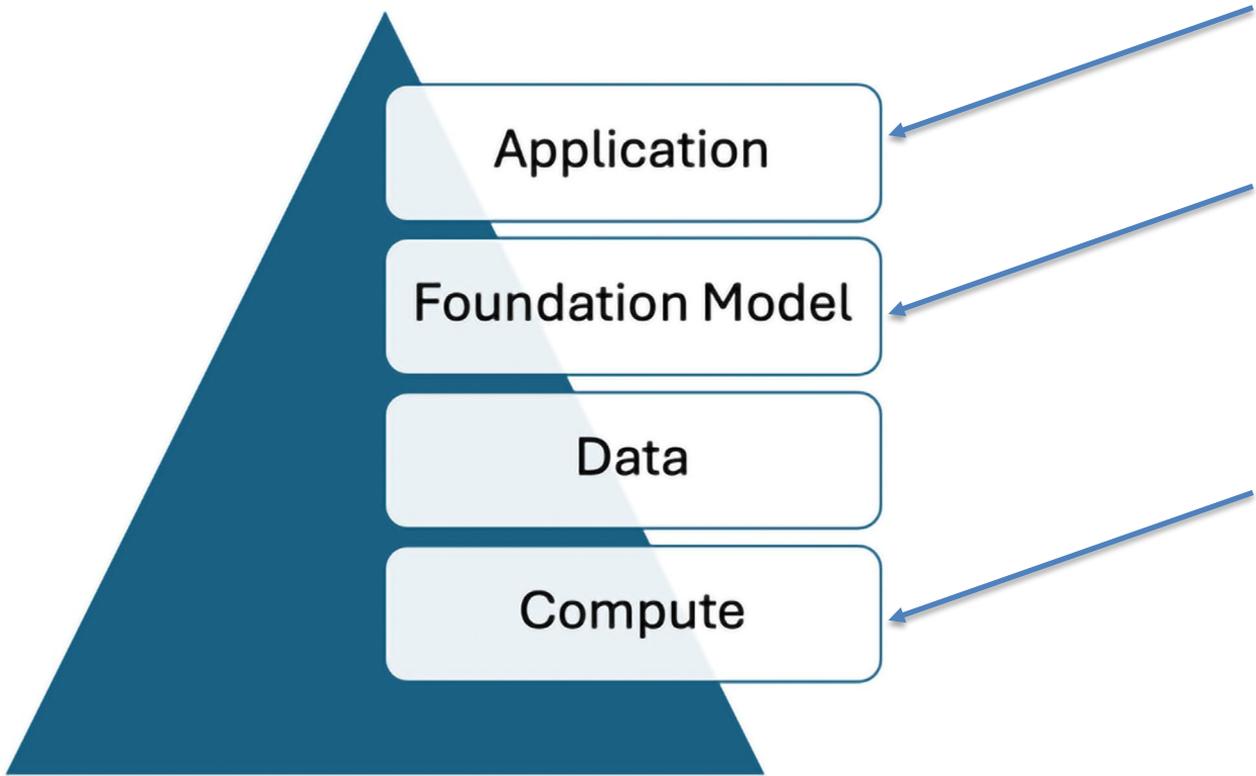
Old Moats for New Models: Openness, Control, and Competition in Generative Artificial Intelligence

Pierre Azoulay, Joshua Krieger, and Abhishek Nagaraj

	ML	BI	Big Data	Data Mining	Data Science	NLP	Cloud	Telecom	GIS	Quantum	Robotics	Nanotech	IoT	CRISPR	VR	3D Print	Polymer	Blockchain	Web2.0	SOA	RFID
ML	100	9.8	32.5	12.8	44.8	14.1	19.2	1.9	0.6	0.6	6.3	0.0	5.7	0.1	1.5	0.3	0.0	2.2	0.0	0.7	0.1
BI	4.4	100	10.7	5.9	9.0	0.6	10.3	2.0	0.5	0.1	0.7	0.0	0.9	0.0	0.1	0.0	0.0	0.3	0.0	0.7	0.0
Big Data	19.1	14.0	100	6.5	21.3	3.8	27.6	2.8	0.5	0.2	0.9	0.0	3.2	0.0	0.2	0.0	0.0	0.7	0.1	1.0	0.2
Data Mining	20.7	21.1	17.8	100	26.6	6.2	7.0	2.2	1.1	0.3	1.1	0.0	1.1	0.1	0.2	0.0	0.0	0.4	0.1	0.2	0.1
Data	36.2	16.1	29.3	13.3	100	7.6	13.5	1.9	1.0	0.2	1.5	0.0	2.7	0.1	0.3	0.1	0.0	0.7	0.0	0.3	0.2
NLP	54.3	5.4	25.1	14.7	36.3	100	14.2	3.9	0.4	0.5	4.4	0.0	3.1	0.0	0.4	0.0	0.0	2.1	0.1	0.5	0.0
Cloud	4.9	5.9	12.1	1.1	4.3	1.0	100	4.2	0.3	0.2	0.6	0.0	2.7	0.0	0.1	0.0	0.0	0.6	0.1	1.2	0.0
Telecom	0.7	1.6	1.8	0.5	0.9	0.4	6.1	100	0.7	0.1	0.4	0.0	1.3	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.2
GIS	2.0	3.5	2.5	2.2	3.8	0.3	3.9	6.2	100	0.0	0.6	0.0	0.5	0.0	0.1	0.1	0.0	0.0	0.0	0.6	0.2
Quantum	14.9	4.3	8.0	4.3	5.6	2.9	22.4	3.0	0.2	100	4.3	0.1	74.3	0.1	0.5	0.0	0.0	13.2	0.0	0.6	0.0
Robotics	9.1	2.1	2.1	1.0	2.8	1.7	3.4	1.5	0.3	0.3	100	0.1	1.8	0.1	1.1	1.9	0.0	1.0	0.0	0.1	0.2
Nanotech	5.6	0.9	2.0	0.2	3.3	0.2	1.2	6.1	0.3	0.5	9.3	100	3.6	1.1	0.7	3.2	1.9	0.0	0.2	0.0	0.0
IoT	13.7	4.9	13.3	1.7	8.1	1.9	24.9	8.4	0.4	7.6	2.9	0.1	100	0.0	1.1	0.3	0.0	6.2	0.0	0.8	0.7
CRISPR	2.0	0.2	0.7	2.3	2.5	0.1	0.5	0.1	0.0	0.2	3.0	0.3	0.0	100	0.2	0.1	0.0	0.2	0.0	0.0	0.0
VR	16.6	1.7	3.2	1.1	3.9	1.3	4.7	2.0	0.4	0.2	8.8	0.1	5.2	0.1	100	2.7	0.0	2.4	0.1	0.2	0.1
3Dprint	3.4	0.4	0.5	0.3	1.0	0.0	0.9	0.8	0.3	0.0	16.3	0.3	1.7	0.0	2.9	100	0.4	0.2	0.0	0.0	0.3
Polymer	0.5	0.2	0.0	0.7	0.4	0.0	0.1	0.2	0.0	0.0	0.7	1.3	0.0	0.0	0.2	2.9	100	0.0	0.0	0.0	0.1
Blockchain	21.4	5.5	11.2	2.3	8.0	5.1	23.1	2.6	0.1	5.4	6.8	0.0	24.5	0.0	2.0	0.2	0.0	100	0.0	0.8	0.3
Web2.0	1.4	4.0	8.1	2.0	0.8	0.8	21.1	6.5	0.4	0.0	0.3	0.1	0.2	0.0	0.3	0.1	0.0	0.1	100	2.0	0.0
SOA	3.9	9.1	9.4	0.7	1.8	0.8	26.3	2.1	1.1	0.1	0.3	0.0	1.8	0.0	0.1	0.0	0.0	0.4	0.3	100	0.0
RFID	0.6	1.0	4.1	0.4	3.5	0.1	2.3	6.0	0.7	0.0	2.1	0.0	3.9	0.0	0.1	0.3	0.0	0.3	0.0	0.0	100



**Old Moats for New Models: Openness, Control, and Competition in Generative Artificial Intelligence**



**Old Moats for New Models: Openness, Control, and Competition in Generative Artificial Intelligence**

# Key points

- Artificial intelligence is likely to be the next general purpose technology.
- General purpose technologies generate an innovation feedback loop between producing and applications industries.
- Early regulatory and enforcement decisions for GPTs have an outsized impact on the rate and direction of innovation.
- **Beyond “impact”, we don’t have deep research knowledge on the follow-on effects of policy and enforcement on innovation cycles between producing and application industries.**

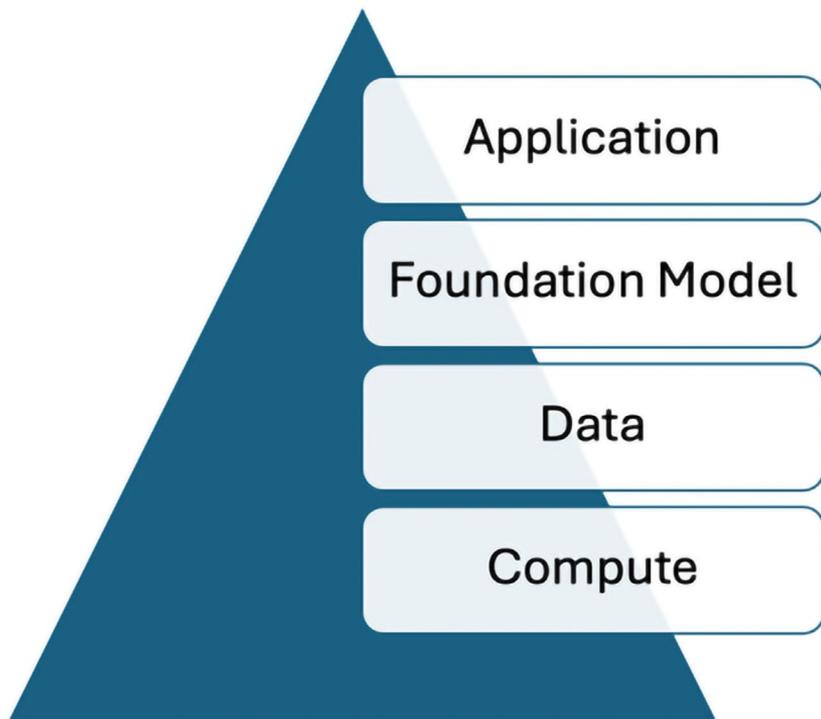
# Technology policy

- Challenging for many established reasons
  - Technological and demand uncertainty
  - Need for experimentation
  - Etc.

# Technology policy

- Challenging for many established reasons
  - Technological and demand uncertainty
  - Need for experimentation
  - Etc.
- We don't have resolution to the uncertainty with AI, but economists have a rich literature on these challenges
  - Summarized, e.g., in Bryan and Teodoridis (Brookings 2024)

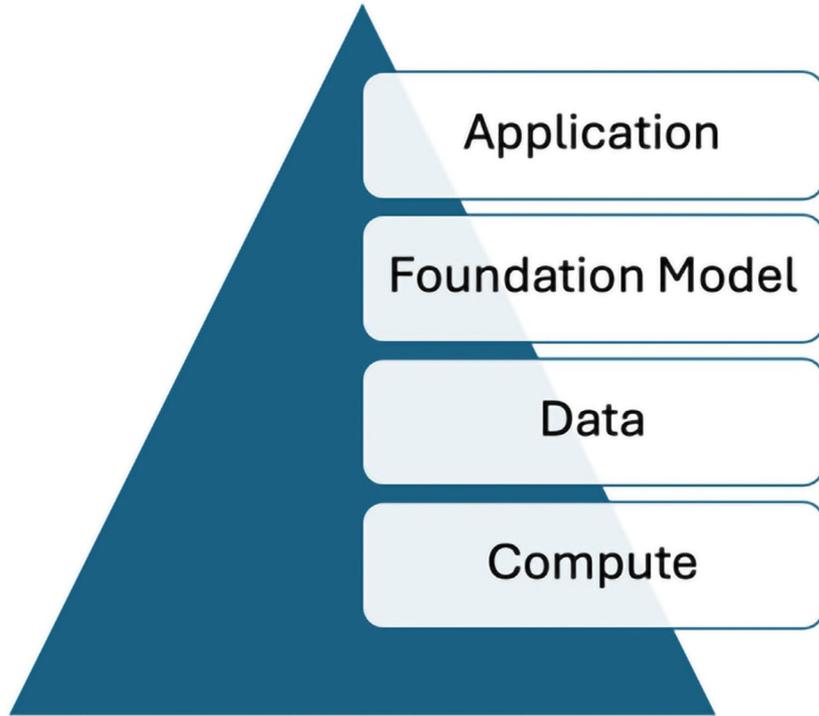
# GPT Policy: A nascent literature



- As with the task-based labor models, we know policy and enforcement will “impact” the rate and direction of innovation in AI.
- But we don’t know the direction of the impact.
- The tradeoffs may be different than those when the focus is on short-term consumer benefits and consumer harm.

Old Moats for New Models: Openness, Control, and Competition in Generative Artificial Intelligence

# GPT Policy: A nascent literature



- How does antitrust enforcement on compute affect innovation in the foundation model and application layers?
- How do restrictions on data flows affect foundation models and the types of compute?
- What types of restrictions on foundational model outputs affect the feasible set of applications?
- Etc.

Old Moats for New Models: Openness, Control, and Competition in Generative Artificial Intelligence

# Key points

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