ETLA ELINKEINOELÄMÄN TUTKIMUSLAITOS
THE RESEARCH INSTITUTE OF THE FINNISH ECONOMY

ETLA Raportit
ETLA Reports

17 October 2016

No 61

The Next Phase in the Digital Revolution

Platforms, Abundant Computing, Growth and Employment

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Suggested citation: Zysman, John & Kenney, Martin (17.10.2016).
"The Next Phase in the Digital Revolution: Platforms, Abundant Computing, Growth and Employment".
ETLA Reports No 61. https://pub.etla.fi/ETLA-Raportit-Reports-61.pdf

This project is supported by the Kauffman Foundation and the BRIE-ETLA Research Collaboration.
This report is a (mildly) revised version of an earlier BRIE Working Paper 2016-3.

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ISSN-L 2323-2447
ISSN 2323-2447 (print)
ISSN 2323-2455 (pdf)

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The Next Phase in the Digital Revolution: Platforms, Abundant Computing, Growth and Employment

Abstract

This report argues that computer-intensive automation (CIAutomation) is likely to change the nature of work and manufacturing value creation in the emerging Platform Economy. The industrial and service changes based on low-cost computation, as they become more generalized, may reverse Robert Gordon's observations about the slowing growth in productivity. However, the increased adoption of CIAutomation also poses profound dilemmas for society that revolve around whether this automation will be used to solely to replace workers or can be integrated into production of goods and services in ways that augment human capacities and intelligence. Finally, we speculate upon the role of the state in in governing and shaping the emergence of the Platform Economy.

Key words: Platforms, automation, gig economy, governance, public policy

JEL: D780, L860, O330

Digivallankumouksen seuraava aalto: yleistyvät alustat, lisääntyvä laskentateho sekä vaikutukset työhön ja kasvuun

Tiivistelmä

Laskentaintensiivinen automaatio (*computer-intensive automation; CIAutomation*) muuttaa digitaalisessa alustaloudessa tehtävän ihmistyön luonnetta ja teollista arvonluontia. Yksikköhinnaltaan yhä halvemman laskentakapasiteetin sovellukset sekä teollisuudessa että palveluissa saattavat lopulta osoittaa vääräksi mm. Robert Gordonin esittämän näkemyksen tulevien vuosien ja vuosikymmenien hitaasta tuottavuuskehityksestä. Yleistyvä automaatio nostaa yhteisön ja politiikan agendalle kiperiä kysymyksiä: onko teknisen ratkaisujen kehittämisessä ja soveltamisessa painopiste ihmistyön korvaamisessa vai täydentämisessä? Lopuksi keskustelemme kansallisvaltion roolista alustatalouskehityksen suuntaamisessa ja hallitsemisessa.

Asiasanat: Digitaaliset alustat, automaatio, keikkatalous, hyvä hallintotapa, yhteiskuntapolitiikka

JEL: D780, L860, O330

1 Societal Challenges in the Platform Economy

Digital platforms in the cloud are fundamental features of the present phase of the digital revolution and are entangled with computation-intensive automation (CIAutomation).[1] This abundance of computing power enables the generation and analysis of data on a scale never before imagined and permits the reorganization/transformation of both services and manufacturing. This essay expands two central issues that we raised in "The Rise of the Platform Economy."[2]

First, we asked whether the digital revolution would provide real and rising incomes with reasonable levels of equality—whether a utopian or dystopian future would be realized. Here we argue that the productivity possibilities of the digital era are just coming into view. Their consequences will be a matter of choice in policy and corporate strategy. Moreover, we emphasize here that much will depend on how CIAutomation—variously called artificial intelligence (AI), machine learning, and intelligence augmentation—is deployed. CIAutomation can augment human intelligence codified into software, making for skilled workforces, as well as displacing work and cutting the intelligence out of tasks. In our view, the labor and labor market issues in the next few years will be powerfully interwoven with the questions of the deployment of platforms and CIAutomation—the technologies themselves and the rules shaping them.

Second, we argued in the earlier article that, as communities, we can choose the kind of society we create in the digital era and that the digital technology will not itself dictate the answer. Here we emphasize the tension in a platform era between public governance and private governance by platform. Digital platforms are regulatory structures and thus systems of governance. The platform's operations set the rules and parameters of action for participants and systems of governance. The question is not only how to express public interests in the operation of platforms but also which "public" is represented. Sensible policy requires that we envision a future and design policy to achieve our visions, rather than allow a set of marginal choices in otherwise siloed policy debates determine the outcome. Policy must not merely adapt to the emergence of the digital economy and society. We must recognize that our policy choices will help direct the technological trajectories.[3]

2 Recalling the Basics

This phase of the digital era rests on the extraordinary abundance of data computation, storage, and transmission. Cloud computing, which facilitates digital platforms, data and analytics, and CIAutomation, is enabled by the availability of massive inexpensive processing, storage, and telecommunications bandwidth. As we observed elsewhere, "the early days of

[1] The term "computation-intensive automation," or CIAutomation, includes, but is not limited to artificial intelligence and machine learning. The goal of creating a new neutral phrase is to avoid all the built-in biases of existing language. Likewise, the issue of data is not the "size of the cache" but which data are collected, who has access and control, and how they are analyzed. See also the introduction and conclusion of John Zysman and Abraham Newman, *How Revolutionary Was the Digital Revolution? National Responses, Market Transitions, and Global Technology* (Stanford: Stanford Business Books, 2006).

[2] Martin Kenney and John Zysman, "The Rise of the Platform Economy," *Issues in Science and Technology* (Spring 2016): 61-69.

[3] On how policy choices have affected the development of the mobile internet industry in China, see Kai Jia and Martin Kenney, "Mobile Internet Platform Business Models in China: Vertical, Horizontal, or Business Group–Like Structures?" submitted to *California Management Review*.

computing were characterized by scarcity, which in turn constrained software capabilities."[4] Gradually but inexorably, the exponential increase in computing capacity, noted in popular discourse, by continuous reference to Moore's law and the consequences of doubling processing power every two years and data storage on a roughly similar trajectory, has changed the game.[5] The lifting of constraints has opened a new digital era of platforms, big data, and CI-Automation.[6]

Consider platforms. Digital platforms, which we define below, are, in short, digital algorithms and software structures that run in the cloud and operate on data. The story begins, one might say, with the digital transformation of services. The application of rule-based information technology tools to service activities was the start of the algorithmic revolution.[7] As Zysman argued elsewhere:

> Service activities themselves are changed when they can be converted into formalizable, codifiable, computable processes, processes often with clearly defined rules for their execution. In search of fresh imagery for a complex process, [let us] call this the algorithmic service transformation, facilitated by IT tools.[8]

The services transformation has powerful implications for the broader economy. "Services were once seen as a sinkhole of the economy, immune to significant technological or organizationally driven productivity increases. Now the IT enabled reorganization of services, and business processes more generally, has become a source of dynamism in the economy."[9]

The services transformation enabled by information and communications technology (ICT) is most clearly seen in finance with online trading and automated teller machines (ATMs) as well as media, as seen in offerings from Napster to Netflix and YouTube.[10] The services trans-

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4 John Zysman, Jonathan Murray, and Kenji Kushida, "Clouducopia: Into the Era of Abundance," CLSA Blue Book (January 2013) We wrote then, "In the early days of the computing industry, hardware resources were extremely scarce. Processors had limited computational capacity. The limited size of computer program memory and disk storage put severe constraints on the size and complexity of computer applications. The earliest network connections could only transmit data slowly and at very high cost.
The cost and limited capacity of these foundational components of computing infrastructure —computation, memory, storage and network bandwidth—placed severe limits on the complexity of the software operating systems and applications which ran on top. Optimizing for these limitations meant that software was always written—or targeted—for the specific underlying hardware on which it would run. IBM produced highly optimized operating systems dedicated to specific mainframe hardware memory and storage architectures. DEC did the same for its mini-computers, and even later-generation companies such as Sun Microsystems followed the same model to extract every last ounce of performance from their workstation and service products."

5 We do recognize the ongoing debate over whether two of the fundamental drivers, Moore's Law and the incessant improvement in magnetic storage, may be coming to an end (e.g., on Moore's Law, see Peter Bright, "Moore's Law Really Is Dead This Time," *Ars Technica* (February 10, 2016); on magnetic storage, see Rupert Goodwins, "The Future of Storage: 2015 and Beyond," ZDNet (January 1, 2015), http://www.zdnet.com/article/the-future-of-storage-2015-and-beyond/.

6 Whether there was a point or a phase change or this emerged gradually and now the implications and opportunities have become salient and contemporary is perhaps unanswerable.

7 John Zysman, "The 4th Service Transformation: The Algorithmic Revolution," Services Issue: CACM, *Communications of the ACM* 49:7 (2006).

8 Ibid.

> Certainly business processes from finance and accounting through to customer support and CRM are altered when they can be treated as matters of information and data management. Routine and manual functions are automated, and fundamental reorganization of activities is enabled. Likewise, sensors and sensor based networks change many personal services. For example, with sensors and communications, some services such as the monitoring aspects of the home care for the ill, the convalescent, or the elderly can be transformed fundamentally from highly personal activities requiring a continuous presence to a distance activity with sensor data signaling a need for attention.

9 Ibid.

10 For a discussion of YouTube, see Bryce Anable and Martin Kenney, "Gamers, Pranksters, Gurus, and Beyond: Understanding the Dynamics of the YouTube" (2016) Unpublished working paper available from the author on request.

formation was accelerated in part by what we have called the industrial commodity trap: the emergence of diverse competitors throughout the world producing relatively similar products, components, and modules who compete principally on price. The terms of competition could be transformed when the sale of a product facing intense price competition could become the sale of a distinctive value-creating service. When port management services could integrate the sale of a crane—or soil and plant management services complement the sale of sensor-enabled farm equipment—services became entangled with everything.[11] At that time, these algorithmic processes driving services were, principally, within the operations of particular institutions or firms.

Although platforms may operate within particular organizations, they are digital structures with the capacity for a more powerful reach, linking groups of users and potential service or product providers. Hence the algorithmic revolution was necessary for and undergirds the emergence of the platform economy.

If platforms are digital algorithms running in the cloud, what do we mean by "platforms"? A computer science definition is that platforms provide a set of shared techniques, technologies, and interfaces to a broad set of users who can build what they want on a stable substrate. But as conventionally used now, platforms refer to multisided digital frameworks that shape or intermediate the terms on which participants—often, but not always, buyers and sellers—interact with one another.[12]

In that sense, platforms are algorithm-enabled "cyberplaces" where constituents can act, interact, or transact. Those transactions are diverse, whether categorized by market or social function or by technical character. Each category introduces equally diverse issues and questions. Consumer good platforms, from eBay to Amazon and Alibaba, link buyers to sellers, raising legal questions of liability. Service platforms, such as Uber or Upwork, change who can buy and sell people-delivered services, raising labor market issues as well as forcing a rethinking of traditional regulation. Taxis cannot discriminate, but can Uber drivers? Hotels must obey land use rules and not discriminate, but must Airbnb hosts do so?[13] And, if, for example, discrimination is forbidden, then who should enforce antidiscrimination: the private parties using the service, the platform owner, or the state? Who could inspect the algorithms, and who should have access to the private databases for what purpose? From a different vantage point, that of industrial production, the Internet of Things—a vague category of objects linked through cyber connections—poses questions about industrial standards and data. Who sets the industrial standards on production platforms will powerfully affect competition among industrial equipment producers, and who will own or have access to what kinds of data? The corporate market competition among, for example, Cisco, GE, Google, Komatsu, and Siemens often turns on the answers to such questions.

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11 See John Zysman, Stuart Feldman, Kenji Kushida, Jonathan Murray, and Niels Christian Nielsen, "Services with Everything: The ICT-Enabled Digital Transformation of Services," in *The Third Globalization? Can Wealthy Nations Stay Rich in the Twenty-First Century?* ed. Dan Breznitz and John Zysman (Oxford: Oxford University Press, 2013).

12 There is a large and growing literature on this topic. One might start with Annabelle Gawer and Michael A. Cusumano, *Platform Leadership: How Intel, Microsoft, and Cisco Drive Industry Innovation* (Boston: Harvard Business School Press, 2002). A more recent and significant statement is Geoffrey Parker, Marshall W. Van Alstyne, and Sangeet Paul Choudary, *Platform Revolution: How Networked Markets Are Transforming the Economy—and How to Make Them Work for You* (New York: W.W. Norton & Company, 2016). For a theoretical conceptualization of platforms as private market regulators, see Kevin J. Boudreau and Andrei Hagiu, "Platform Rules: Multi-Sided Platforms as Regulators," *SSRN Electronic Journal,* doi:10.2139/ssrn.1269966

13 For a discussion, see Debra Cassens Weiss, "Does Airbnb Have a Legal Responsibility to End Bias by Its Hosts?" *ABA Journal,* http://www.abajournal.com/news/article/does_airbnb_have_a_legal_responsibility_to_end_bias_by_its_hosts/.

But let us not get ahead of ourselves. First, why do we say that platforms are digital structures that run in the cloud? Simply, cloud computing architecture provides the power for a broad range of interactions.[14] Cloud computing is about how computing is done, not about where computing takes place.[15] The abundance of computing power facilitates virtualization and the abstraction of computing functions. "Abstraction" and "virtualization" have become code words of the new computing; with sufficient resources, many "virtual" machines can run in a single collection of servers, and diverse computing infrastructures can be accommodated. Providing these "computing clouds" favors requires scale. Scale favors players, and the largest data-processing needs raise issues about the possibilities for local competitors and the national control of data. Indeed, cloud architectures first emerged as companies such as Amazon, Google, Microsoft, and Salesforce.com sought to provide for their own computer needs and then sold computing capacity and services, in varied packages.

In this essay, the consequences for the user, not the "how" of cloud computing for the providers, is important. "Cloud computing delivers computing services—data storage, computation and networking—to users at the time, to the location and in the quantity they wish to consume, with costs based only on the resources used. "[16] Powerful computing resources can more easily be assembled, orchestrated, and deployed as needed. And since computing can be moved from a capital expense to an operating expense, the ability to create, experiment with, and launch platforms is radically improved. Startup costs are reduced, and the cost of expanding computing resources can be managed on an "as-needed" basis.[17] More formally stated, cloud computing expands the availability of computing while lowering the cost of access to computing resources, sometimes to a level that can be afforded by an individual—depending on what one wants to do. This provides access to inexpensive easily scalable computing resources for existing firms and startups alike and allows experimentation within larger companies easier, since a central chief information officer (CIO) no longer need be a chokepoint for access to computing resources. Put differently, one might say that the cloud reduces the significance of the cost of computing in calculations of the cost of starting a firm or experimenting with a new application. Organized effectively, the "cloud" can speed the development of applications because elements can be developed, assembled, and deployed more rapidly. Value in computing moves up the value chain from provision of the basic infrastructure to the creation and deployment of applications.[18]

The key question is: what sort of world will we build with platforms, data, and CIAutomation?[19] How, we must ask, will value be created and who will capture that value? The pioneers of the digital age thought they were creating a utopia of possibility and opportunity.[20] These pioneers included Bob Noyce at Intel, Bill Gates at Microsoft, and, of course, Steve Jobs at Ap-

[14] See, for example, Jonathan Murray, Kenji E. Kushida, and John Zysman, "The Gathering Storm: Analyzing the Cloud Computing Ecosystem and Implications for Public Policy," *Communications and Strategies* 85 (2012): 63-85. Although it is "easy" to construct a platform actually having it become successful is quite difficult.

[15] We recognize that the world's most powerful cloud computing firms and most dramatic users of cloud computing are concentrated on the West Coast of the United States with Silicon Valley being the epicenter with powerful outposts in Seattle, i.e., Amazon and Microsoft and China.

[16] Ibid., 65.

[17] For example, computing-intensive firms such as Airbnb, Netflix, Snapchat, and Uber, from their inception have used Amazon Web Services or other such firms to provide their computing needs.

[18] Cloud service provision has proven to be Amazon's most profitable market segment.

[19] Again, we use this term to avoid the semantically loaded terms of artificial intelligence and machine learning.

[20] Walter Isaacson, *The Innovators: How a Group of Hackers, Geniuses, and Geeks Created the Digital Revolution* (New York: Simon and Schuster, 2014).

ple.[21] And indeed they unleashed a new world. Early on, however, skeptics emerged. Kurt Vonnegut's first novel, *Player Piano,*[22] reads like the dystopian literature in academic and popular press today, if one puts aside that in his novel the computing machines used electronic tubes and not integrated circuits.[23] Indeed, the original cover had the line: America in the Coming Age of Electronics. In the world he feared, work was a privilege, and, except for a privileged few who ran the system, jobs for the masses consisted of Works Progress Administration–like infrastructure repair and the military.

Which future will we have: dystopia or utopia? Noyce and Jobs or Kurt Vonnegut? The answer begins with three questions: (1) What happens to productivity, and at what pace is value, particularly value realizable in the market, generated in the digital era?; (2) What sort of jobs are created, for whom, and how are labor markets organized?; (3) Who wins and who loses; who captures whatever gains are realized?

3 The Productivity Debate

Since the mid-nineteenth century, basic standards of living have clearly been transformed and productivity in the advanced economies has risen remarkably.[24] A core debate is whether that historic pattern will continue. How profoundly ICT is now transforming our life as we experience it is open to debate. Robert Gordon argues that the basic changes in transportation, housing, medicine, and the like that took place from 1870 to 1970 were profound shifts but that the ICT-driven changes in our lives are superficial.[25] Here we set aside that debate and focus on whether slowing productivity reflects the disappointing limits of ICT.

Productivity matters because, at its core, however formally defined and measured, the notion represents the increased ability to generate goods and services valued in the market, from a given endowment of productive resources.[26] We are richer not just because of savings and investment, though they are essential, but because of sustained innovation in what we do and how we do it: what is produced and how it is produced. Gordon, most notoriously, and others have argued that ICT, despite the hype, has not resulted in a sustained increase in productivity in the past few decades.[27] Let us put aside the observation that much of the value of ICT, from search to social media, is provided free, in exchange for being subject to advertising, and consequently the benefit may not be effectively measured.[28] In this essay, we accept Gordon's

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21 The classic reference here is Michael Swaine Paul Freiberg, *Fire in the Valley* (New York: McGraw Hill, 2000).

22 Kurt Vonnegut, *Player Piano* (New York: Delta, 1992).

23 See for example, David H. Autor, "Polanyi's Paradox and the Shape of Employment Growth," National Bureau of Economic Research Working Paper no. 20485 (2014); Andrew McAfee and Erik Brynjolfsson, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (New York: W.W. Norton, 2014).

24 Robert J. Gordon, *The Rise and Fall of American Growth: The US Standard of Living since the Civil War* (Princeton: Princeton University Press, 2016).

25 William D. Nordhaus provides a remarkably concise analysis of the book in "Why Growth Will Fall," *New York Review of Books* (August 18, 2016) http://www.nybooks.com/articles/2016/08/18/why-economic-growth-will-fall/.

26 The classic comment is, of course, Paul Krugman's: "Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker" (*The Age of Diminishing Expectations* [Cambridge: MIT Press, 1994] p. 11.

27 Robert J. Gordon, "The Demise of US Economic Growth: Restatement, Rebuttal, and Reflections," National Bureau of Economic Research Working Paper no. w19895 (2014).

28 Hal Varian, among others, has argued this. The difficulty is that this has always been the case; and indeed the understatement in earlier years may even have been greater (Nordhaus, "Why Growth Will Fall").

finding that the drop-off in the pace of productivity increases since 1972 is evident. His conclusion that, after 2007, labor productivity grew at no more than 1.3 percent per annum is sobering, as this is significantly slower than the 2.0 percent growth from 1891 to 2007. The core question is not whether labor productivity has slowed but why, and what role ICT has played in this process.

Before turning to the direct question of ICT's impact on productivity, we must at least note that many alternate explanations of the productivity slowdown are unrelated to technology. These alternate explanations include the impact of the 2007-8 financial collapse on productivity as well as the prior diversion of financial resources from productive investment to speculation.[29] Moreover, productivity is not simply a technical matter but, rather, involves the reorganization of communities and work. Thus, the post–World War II structural transformation of countries from France to Japan comprised political strategies to move the losers out of the way or compensate them while supporting investment by winners to deploy new production in agriculture and industry.[30] Indeed, French productivity in steel in the postwar years lagged German rates, not because different technologies were being implemented but in part because the French were not closing many inefficient plants to avoid the political consequences of closures.[31] The deployment of technology is as crucial to productivity as the technology itself. We return to that reality below.

Transformative technologies, which affect a broad swath of activities as they are introduced in an economy, are said by authors from Schumpeter to Carlota Perez to drive rapid growth and productivity.[32] The historic role of steam, railroads, and electricity are evidence of these characteristic and powerful general-purpose technologies.[33] The core argument made by Gordon and others is that ICT, beginning with the semiconductor revolution, has not had the impact of earlier transformative technologies. That view has two components: first, that ICT has had only limited scope in the economy, in entertainment, and in making finance more convenient; second, that the technology wave has passed, so the story is done. Both assertions are mistaken.

First, ICT is, in fact, recasting a significant portion of the economy. It is not, of course, just technology that is driving change or popular applications but radical innovation in production organization, products, and business models. The early phases of the ICT revolution certainly affected principally services that, fundamentally, concern information, communications, finance, media, and insurance.[34] ATMs in finance merely replaced workers in an existing business model, and while high-frequency trading on Wall Street radically changed competition in the sector, the basic business model remained the same. As media, books, and music, for instance, were converted into digital formats, they could be shared electronically, as innovative

29 William Lazonick, "Profits without Prosperity," *Harvard Business Review* 2014, 92(9): 46-55.

30 John Zysman, *Governments, Markets, and Growth* (Berkeley: University of California Press, 1983); Barry Eichengreen, *The European Economy since 1945* (Princeton: Princeton University Press, 2007).

31 Zysman develops this point of view in *Governments, Markets, and Growth* and in *Political Strategies for Industrial Order* (Berkeley: University of California Press, 1977).

32 Carlota Perez, *Technological Revolutions and Financial Capital* (Cheltenham, UK: Edward Elgar, 2003); Joseph A. Schumpeter, *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle* (New Brunswick, NJ: Transaction, 1934).

33 On GPTs, see, for example, Elhanan Helpman, *General Purpose Technologies and Economic Growth* (Cambridge: MIT Press, 1998).

34 Zysman et al., "Services with Everything."

approaches such as Napster gave rise to disputes about property and eventually to iTunes, Spotify, YouTube, and a host of digital businesses.[35]

Importantly, in this early internet phase of the digital revolution, ICT-enabled services, as mentioned above, increasingly began to be extended to "everything," and the underlying business models often changed character. Examples abound, some well known, others less so: airplane engines, and even truck tires, can be sold as services with charges related to usage. The sensor-based, real-time monitoring that creates efficiency in engine maintenance and tire replacement is often best captured and utilized by an outside party; ICT systems that embed smart sensors in building management services are able to increase comfort while decreasing heating/cooling costs.

The platform phase is simply the latest chapter in this unfolding story of the deployment of ICT throughout the economy. At the center of the economic and social tsunami generated by transformative technologies, technologies such as electricity, which ultimately affect almost everything in a society, are not only the new products but also the new needs created by the new technology. All that may not show up as productivity increases. However, whether they involve radio and television or Google Scholar, that process, and the entrepreneurial creation of new firms, these creations and deployments add to wealth, to new capabilities, and new possibilities.

For now, let us focus on platforms. Certainly, multisided platforms provide new ways for buyers and sellers that could not previously reach each other and that could not previously form a market, to interact. Importantly, in our view, the buzz about (choose your favorite commercially branded label) the Internet of Things, the Internet of Everything, and the Industrial Internet amounts to new ways in which sensor-enabled objects will be controlled and interact through platforms. The platforms facilitate the aggregation and analysis of data in order to control systems and actions.[36] Simply, we are entering a world that will be characterized by a data analysis–based economy and society, in which observation and interpretation of our behavior and the optimization of our physical systems will be based upon computation.[37]

The sheer breadth and dimensions of the impacts of platforms, sensor-based systems, and data analytics are breathtaking. In the prosaic world of industry, Cisco, GE, IBM, and Siemens, in both their publicity and their business strategies, highlight industrial applications from energy management to pipelines to aircraft management. For example, one GE executive on a LinkedIn page commented upon GE strategies to integrate ICT and data to provide "solutions that enable improved asset management, predictive maintenance and new business models based on IoT [Internet of Things] for industrial verticals like Manufacturing, Aviation, Transporta-

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35 It is worth considering whether this remarkably greater access to information will have impacts similar to those of the arrival of inexpensive printing. On the impact, see, for example, Lucien Febvre and Henri-Jean Martin, *The Coming of the Book: The Impact Of Printing 1450-1800* (London: Verso, 1976).

36 For a discussion of the history of "data," see Daniel Rosenberg, "Data before the Fact," in *"Raw Data" Is an Oxymoron*, ed. Lisa Gitelman (Cambridge: MIT Press, 2013): 15-40. Though we will not focus on the entire matter of data analytics, consider the notion of "big data" for a moment. This is not just a matter of collection data about your commercial transactions or shipping to identify consumer patterns and evolving B2B supply arrangements. It could and does include collecting data about tire performance, engine performance, and bridge structure integrity, among so many other things. This data can be mined to better optimize performance of these physical objects. The term "data" itself refers to collections of observations that must be organized and structured and thus converted into information, and the information interpreted and understood to be transformed into actionable knowledge.

37 OECD, *Data-Driven Innovation: Big Data for Growth and Well Being* (Paris, 2015). This significant study makes a point that is not always widely understood See in particular p. 41.

tion, Power Generation, Healthcare, Energy and Oil & Gas."[38] These illustrations are drawn from industry, but similar platforms are being built in politics, as Daniel Kreiss describes with regard to the Democratic National Committee's VoteBuilder platform.[39] These examples are hardly marginal. They are much more than the superficial reorientation of a narrow economic segment that Gordon highlights. They are, rather, indications of the transformation of an economy.

Indeed, the deeply provocative German discussion of "Industrie 4.0" envisions how data capture and analytics will reform and reorganize manufacturing and supply chains. German competitive advantage in manufacturing rests with skilled labor and highly sophisticated specialized small and medium-size companies.[40] The question the initial study "Industrie 4.0" posed for the now ongoing debate in Germany and elsewhere is how to craft cybertools in a platform era to support and sustain skill-based competitive advantage. Research on both manufacturing and supply chains indicates that basic production is primed for reformulation through platforms and other ICT innovations.[41] For us, the recent merger/association of Tech Shops with Flextronics is an example of the maker movement possibly combining with mainstream manufacturing in a way that could alter how we look at small startups in traditional sectors.[42] The important point is that we are in the midst of a transformation, not at the end.

This is all very well, the skeptics such as Gordon would say, but where is the concrete evidence that this round of innovation will reignite the rapid productivity growth of the period that ended in the 1970s? One response, suggested in recent work by the Organization for Economic Cooperation and Development (OECD), is that the productivity frontier has been pushed outward, but the best practices are not being implemented broadly in the economy. The problem, if that argument holds, then becomes one of deployment and diffusion, of business practice and structural policy, not of the inherent potential of the technologies.[43] The OECD studies argue that the top 10% of global firms have significant and steady productivity increases in the twenty-first century while the remaining 90% trail far behind.

> Productivity growth at the global frontier has remained relatively robust in the 21st century, despite the slowdown in average productivity growth. For example, labour productivity at the global frontier increased at an average annual rate of 3½ per cent in the manufacturing sector over the 2000s, compared to an average growth in labour productivity of just ½ per cent for non- frontier firms, and this gap is even more pronounced in the services sector.[44]
>
> *The Future of Productivity* illustrates that the main source of the productivity slowdown is not so much a slowing of innovation by the most globally advanced firms, but rather a slowing of the pace at which

[38] https://www.linkedin.com/in/ptyagi01

[39] D. Kreiss, *Prototype Politics: Technology-Intensive Campaigning and the Data of Democracy* (Oxford: Oxford University Press, 2016).

[40] H. Kagermann, W. Wahlster, and J. Helbig. "Industrie 4.0: Securing the Future of German Manufacturing Industry: Final Report of the Industrie 4.0 Working Group April 2013, Note first that Henning Kagermann was previously CEO of SAP. In a fundamental way, this is a classic German corporatist approach to policy. Note also that the working subtitle is "Platform Industrie 4.0," underlining our point that platforms are the phase in the powerful transformation of the economy driven by ICT.

[41] On supply chains, see, for example, Koen de Backere et al., "Where to Locate Innovative Activities in Global Value Chains: Does Co-Location Matter?" (paper presented for internal OECD discussions, March 2016). On manufacturing, see, for example, John Zysman, Dan Breznitz, Martin Kenney, and Paul Wright, "21st Century Manufacturing" published by UNIDO (United Nations Industrial Development Organization) Vienna 2013

[42] TechShop online announcement, June 23, 2016, http://www.techshop.ws/press_releases.html?&action=detail&press_release_id=99/.

[43] Organization for Economic Cooperation and Development, "The Future of Productivity," 2015.

[44] Ibid., 9.

> innovations spread throughout the economy: a breakdown of the diffusion machine. Indeed, a striking fact to emerge is that the productivity growth of the globally most productive firms remained robust in the 21st century but the gap between those high productivity firms and the rest has risen.[45]

A debate then emerges about the very character of the gap between the frontier and the rest: How big is the gap and what causes it?[46] Does the gap, for example, exist because of slow diffusion of leading technology and organizational/business principles or as a result of winner-take-all tendencies in the digital economy? The winner-take-all tendencies are reflected in the most recent OECD follow-up study.[47] Some suggest, for example, that part of the story is that the top 10% seem to be at the productivity frontier because they have dominant market positions unavailable to the other 90%. Along a different line, outsourcing of business services, such as janitorial or even secretarial and bookkeeping services, might well keep high-productivity activity in core firms and locate low productivity in the supplier companies. The system as a whole might not be any more productive.[48] All that said, and setting aside debates or skepticism about these results, the matter of how technology is deployed is central to the argument on the character of deployment and, in fact, to productivity growth. An endless literature shows that similar technologies, sometimes with identical machinery in different factories, have different consequences in terms of output; similar input but different output means that deployment determines the productivity outcomes.[49] So, an evident question is: what determines deployment trajectories and the pace of deployment?

Another stream of literature emphasizes that productivity has moved in jumps, as new paradigms of organization and innovative technologies combined to permit new plateaus.[50] Each jump to a new plateau implies production reorganization and new forms of work and work organization. Hence the question is not just whether new technology is present, but also how it is deployed and, as importantly, who figures out how to deploy it effectively.

The seeming reality of the technology frontier advancing among leaders with significantly slow diffusion to, or effective deployment by, the rest has significant political and policy implications. Technology deployment and diffusion is, we hasten to underscore, often a matter of radical changes in how people earn a living and live their life. It is almost never a simple or conflict-free process. Rapid growth in countries such as Germany, Japan, and France after World War II involved fundamental structural change as people and resources moved from the countryside to cities, from agriculture to industry, and bombed factories were replaced

45 Ibid., 12.

46 One early reader of our text asked whether the 10% has a monopoly/oligopoly position and thus is simply taxing the rest—in which case, the advice to the other 90% would be to get a similar position, which, whatever else one may say, cannot possibly generalize to an economy as a whole. In fact, in many of the sectors in which platforms are of vital importance, the winner-take-all types of outcomes ensure that it is impossible for the other 90% or even 99% to ever overtake the winning 10%! For example, very few firms in the Apple Computer ecosystem can match its profit margins or "productivity."

47 Dan Andrews, Chiara Criscuolo, and Peter N. Gal, "The Global Productivity Slowdown, Technology Divergence, and Public Policy: A Firm Level Perspective," OECD Background Paper, Global Forum on Productivity, July 2016

48 Martin Kenney elaborates, speculating that the elite firms are firing their "low-productivity" workers, say janitors, secretaries, etc., and rehiring them at subcontractor firms. This keeps their "high-productivity" workers, for example, software programmers. Some firms would become more productive, BUT the system would be no more productive. Moreover, asking the new firm with the low-productivity workers to be as productive as the high-productivity firm would be like asking an elephant to fly.

49 Of course, in capitalism the less-productive firms must adjust by improving productivity by innovating, cutting labor costs, matching the productivity of the leading firms, protecting their market, finding new activities, or getting government subsidies. In other words, the working of capitalism will ultimately punish less-productive firms.

50 Rachmandran Jaikumar, "From Filing and Fitting to Flexible Manufacturing: A Study in the Evolution of Process Control," *Foundations and Trends in Technology, Information and Operations Management*, 1(1) (2005): 1-120.

by newer ones.[51] In slow-growth countries, existing industries had to be reorganized, and entrenched organized interests often resisted. The politics of twenty-first-century growth will involve deep dislocations in already rich, well-organized societies, and that will be very difficult politically.[52] Capturing the potential of the technology is more a political problem than a narrowly economic constraint. That suggests a call to political action, rather than a descent into economic pessimism.

In sum, we are in the midst of the digital ICT revolution. The effects emanate from a small set of information-based sectors or leaders at the frontier of effective deployment, and these will diffuse through all services and industry. We can decide in 2116 whether the period from 1970 to 2070 brought as profound a change in our ways of life and standard of living as did the years 1870 to 1970. It is clear that the impact on productivity will depend not just on the enormous technical potential created but on the capacity to deploy and diffuse that potential.

4 Jobs and Labor Markets in the Twenty-First-Century Digital Economy

Let us turn to the concrete question of jobs and work, abstracted from productivity.[53] Who will work? What will they do? How might they be compensated? How will labor markets be organized? The "jobs" question is as hard to sort through as the question of productivity. In fact, several different discussions are going on about the digital influence on jobs and work:

1. The current focus: At present, the focus has been on the labor market, including the ways in which work is organized and compensated. Much of this initial discussion about the influence of platforms, and ICT, more generally, focuses on matching—whether matching jobs and employers or clients and contractors or, most abstractly, creators and consumers. The implication is that if only more individuals could participate in the market, or if only good matches could be made more easily, growth would accelerate and well-being would increase. A related concern has been the way in which digitization has transformed employment relations between employer/worker (capital/labor). The concern here is that it risks facilitating a redefinition of the core of the economy from employment relations to gig and contract relations.[54] Of course, one could argue about how much has really changed. Are there more such relationships or are more such relationships merely visible now that they are online, rather than sig-

[51] On Japan, see, for example, Martin Kenney and Richard Florida, *Beyond Mass Production* (Oxford: Oxford University Press, 1993).

[52] See, for example, Zysman, *Governments Markets and Growth;* and Eichengreen, *The European Economy since 1945*.

[53] In an earlier essay we touched on a number of these questions. See Kenney and Zysman, "The Rise of the Platform Economy." We wrote:

> The character of some existing work—how much or how little, we cannot know—will be reframed but not eliminated by digital technology. Uber, Airbnb, TaskRabbit, Handy, and other platform firms are transforming industries by connecting "producers" with customers in new ways. In some cases, this is displacing or threatening existing, often regulated, service providers, such as taxis and hotels. In other cases, it is formalizing previously less organized or locally organized work. Still other platforms, such as app stores and YouTube, are creating entirely new value-creating activities that are formalizing into what can be seen as precarious careers, such as a YouTube producer or smartphone app developer. Finally, existing organizations are creating new digital and social media marketing departments and jobs. The question in these cases is what system of control and value capture will be in place. Our sense is not necessarily that there will be less work, but that for a growing number of jobs, the relationship with an employer will be more tenuous than ever. These changes are not likely to result in the workerless society. One possibility is a society in which the preponderance of the work and value creation is more dispersed than ever before, even as the platform owners centralize the transactions and capture their value. P. 63

[54] On the gig economy, see, for example, Gerald Friedman, "Workers without Employers: Shadow Corporations and the Rise of the Gig Economy," *Review of Keynesian Economics* 2 (2014): 171-188. On temporary or contract work, see Annette Bernhardt, Rosemary Batt, Susan Houseman, and Eileen Appelbaum, "Domestic Outsourcing in the US: A Research Agenda to Assess Trends and Effects on Job Quality" (paper presented at the Future of Work Symposium, US Department of Labor, 2015).

naling a real increase in temporary work? Some suggest that gig and contract work is just a formalization of what already existed.

The literature on the transfer of work to digital platforms and its accompanying transformation of once-stable employment to more precarious work is diverse and expanding rapidly, though much of it focuses on the examples of Uber and Airbnb.[55] This is natural, as these two directly threaten two traditional industries, transportation and lodging. However, the scope of platforms' impact is far greater than these two cases and extends broadly. Indeed, it remains to be seen whether these platforms emerge as the dominant model. Interestingly, "virtual co-operative" of taxi drivers has emerged in Paris aimed at disintermediating the taxi companies as well as responding to Uber. It operates for now on What's Ap.[56] Moreover, if we extend the scope of consideration to YouTube— which includes videos of all sorts, from pure entertainment to self-help and self-diagnosis—and to Amazon's self-published books and app stores, what we term "digital consignment," the broader dimensions of this informalization become apparent.[57]

2. The underlying fundamentals: In any discussion of jobs, the fundamental basis of labor markets, or entangled with labor markets, is the production system. Hence, a deeper question is: how production itself will be reorganized as ICT sweeps through?[58] Even here a multitude of questions arises. One issue, of course, is what will be made where. Production has been decomposed while being shuffled about geographically and then redeployed, reconstituted, in new forms.[59] The geographic redeployment of decomposed production changed the landscape. With redeployment, manufacturing turned away from a sectoral focus, in which clusters of production were built around a few firms in a particular segment of industry. It moved to distributed cross-national production networks.[60] But location is not the only question.

What will happen now to the geographic organization of production? Will we see another geographic reconfiguration? Some things are evident. CIAutomation in its many forms will lead to the substitution of capital for a wide variety of activities and the reorganization of much work. But will we have an era of capital-intensive highly centralized automated factories con-

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55 See, for example, Alex Rosenblat and Luke Stark, "Algorithmic Labor and Information Asymmetries: A Case Study of Uber's Drivers," *International Journal of Communication*, 10 (2016): 3758–3784. For a longer historical perspective on Uber based on the experience of San Francisco, see Veena Dubal, "Wage Slave or Entrepreneur? Contesting the Dualism of Legal Worker Identities" (paper presented at the SASE 28th Annual Meeting, Berkeley, CA, 2016).

56 This is based on direct observation and discussions with taxi drivers in Paris.

57 Kenney and Zysman, "The Rise of the Platform Economy."

58 This section draws extensively on work we have done under the rubric "Escape from the Commodity Trap." For this essay, in particular, we draw on John Zysman, "Escape from the Commodity Trap: Will the Production Transformation Sustain Productivity, Growth and Jobs" (paper presented at the European Commission, 2014), doi:10.2777/48430

59 Ibid., 13. Zysman, considering the decomposition of production, the locational dispersion, and the resulting commodification, has argued:

> Communications technology and container shipping together facilitated the decomposition and the geographic redeployment of production. One consequence was that skills and knowhow were transferred to competitors often dissolving clusters of capacity in the advanced countries as related clusters are built elsewhere. That in turn generated numerous points of competition throughout supply networks. Each production element (a component, a subsystem, a module, or service bundle) suddenly becomes a potential product, a point of competition with possible new competitors. Drawing on the widespread availability of conventional technology, an array of firms from diverse countries entered the markets. Price-based competition throughout markets for standard goods and services resulted and put pressure on wages and profit margins alike. If everyone can produce a good or service, the resulting intense competition leads to commodification. Commodification is competition based principally on price. There are always places where cost can be driven down by, for example, lower cost labor or subsidy of investment. The "commodity trap" with intensified price based competition on most conventional goods was set.

60 See, for example, Dan Breznitz, *Innovation and the State: Political Choice and Strategies for Growth in Israel, Taiwan and Ireland* (New Haven: Yale University Press, 2007); or Martin Kenney (ed.), *Locating Global Advantage: Industry Dynamics in the International Economy* (Stanford: Stanford University Press, 2004).

trolled by major corporations? Will the maker movement vision of small entrepreneurial local firms and "makers" facilitated by new technologies such as three-dimensional (3D) printing become, at least in part, significant economically?[61]

The reorganization of production is now beginning to suggest significant new possibilities, with implications for the organization and location, the sequence of activities, and the needed mix of worker skills. As noted, a number of scholars have pointed to an organizational and locational divide between product conception and prototype and volume production, with significant implications for the combination of skills and the possibilities of value creation and capture.[62] Consequently, while prototype experimentation may take place in an advanced country from a mix of available materials, moving to volume orders for products that are not yet tested in the market or with production processes not validated in the field is not only expensive, but rigid, limiting adaptation.[63]

The Flex Invention Lab in high-cost San Francisco suggests a new route. Here, very low volume is undertaken with fully industrialized production, both industrial equipment and supply-change arrangements.[64] The Flex Invention Lab permits production and process revision, but the industrial standards mean the process is ready to be scaled up.[65] The initial cost per unit can be between 2 to 10 times the anticipated cost of production at volume. But in small batches the price differential with fully constituted volume manufacturing is unimportant. As these manufacturing processes for particular products become more standardized, Flex and its clients can consider moving the production system to a middle-volume production location, often still in an advanced country. Then as demand—hopefully—spikes, the production system may again be transferred, this time to a very high-volume location. The flexible arrangements for low-volume but entirely automated production, with the possibility of revision, requires a mix of skilled workers with not only software and hardware skills but product integration experience.[66] Flex's announcement of growing ties to the Tech Shops that are rooted in the maker movement suggests that, rather than centralized factories or decentralized individual customization, entirely new approaches to production organization, and with it new strategies for entrepreneurship and new requirements for skill, may emerge. Importantly, it is possible that in the twenty-first century no single dominant production system will be dominant; rather, a variety of ways for organizing production will emerge as manufacturing is re-

61 There is a wide range of literature on this. See, for example, Suzanne Berger, *Making in America: MIT Task Force on Production in the Innovation Economy* (Cambridge: MIT Press, 2013). More recently, see Anna Waldman Brown, "Exploring a Maker-Industrial Revolution: Could the Future of Production Be Localized?" BRIE working paper, September 2016, forthcoming.

62 See, for example, the chapters in Martin Kenney with Richard Florida (eds.), *Locating Global Advantage: Industry Dynamics in the International Economy* (Stanford: Stanford University Press, 2004). For specific case studies, see Jyrki Ali-Yrkkö, Petri Rouvinen, Timo Seppälä, and Pekka Ylä-Anttila, "Who Captures Value in Global Supply Chains? Case Nokia N95 Smartphone," *Journal of Industry, Competition and Trade*, 11(3) (2011): 263-278; and Greg Linden, Kenneth L. Kraemer, and Jason Dedrick, "Who Captures Value in a Global Innovation Network? The Case of Apple's iPod," *Communications of the ACM*, 52(3) (2009): 140-144.

63 Of course, this assumes that a country such as China, with a huge internal market, does not become the site for these advanced activities.

64 Industrialized production suggests that even in the low-volume assembly, the same equipment, the same components and suppliers that would be used in volume production are used.

65 Conversation with Steven Heintz, General Manager, Flex and head of the San Francisco based Flex Invention Lab at Flex Labs in July 2016.

66 The whole process is suggestive of procedures reported to us by which Nokia, before selling its mobile phone division to Microsoft, would stabilize the production system for a new product in its home base in Finland before transferring the entire establish line closer to its several markets. This was reported at the time by senior Nokia executives. Some research suggests a slightly different version; that high-end phone development stayed in Finland and increasingly design for lower end phones was moved to China. For the process by which the design of lower-end Nokia feature phones moved to China, see Jyrki Ali-Yrkkö, Marcus M. Larsen, and Timo Seppälä, "The Changing Geography and Ownership of Value Creation: Evidence from Mobile Telecommunications." *Industry & Innovation* (2016), in revision.

constituted and the chains of value creation are reconfigured. Mirroring what might become a plethora of production organization models, a wide variety of different types of compensated employment is likely to emerge.

3. CIAutomation: What all emerging models of twenty-first-century production will have in common is the increasing importance of CIAutomation and data analytics, labeled variously as machine learning and artificial intelligence. Hence, what, we ask, will be the impact of CIAutomation on the tasks and work that people do? Will there be jobs at all? What sort of work will people do? The answers suggested by a vast bulk of the current academic and popular literature are that the current digital revolution will generate a dystopia of unemployment, unskilled workers, and greater inequality.[67] The primary focus at present has been on fear of the destruction and devaluation of work and skills.[68] Importantly, an alternate view is possible: that human intelligence and capacities can be augmented by computation, in what is called "intelligence augmentation" (IA). Where will the balance be found in this round of technological innovation, the balance between ICT-driven destruction and creation?

Focusing on the jobs that will be displaced or transformed by CIAutomation hides the opportunities that will be revealed, the innovative possibilities that will be unleashed. [69] While we have argued that anything that can be automated and reduced to an algorithmic process is vulnerable to being copied and to being commodified,[70] sustained innovation is increasingly required for all firms. To date, the innovation dynamic itself has not been "automated" and remains the domain of human inventiveness and initiative.[71] Indeed, it is also true that at scale even commodity production such as occurs at a Google or Amazon data center is not easily copied and Google and Amazon remain sites for sustained innovation. The core of innovation, in this view, is human value creation. Whether it is product designers for 3D printers in the maker movement or YouTube posters, new sorts of work, new types of tasks, and new forms of employment will be created. Is this new world going to be one with work and reward for the top 10% of highly trained individuals, those lucky enough to be anointed as YouTube "stars" or those who have their app go viral and start a new firm that is acquired by an existing firm? For the rest of the population, those with more modest training and education who are not blessed with inherited status, not born with innate and recognized intelligence, or just not lucky, the question of where in this digital era high value added work will come from remains. Will the ICT driving the transformation of work contribute to greater inequality in a society that has winner-take-all-like dynamics or, more properly, a steep power law of returns?

For now, substantial evidence indicates that intelligence augmentation—the complementary relationship between powerful computation and distinctly human capacities—can be even more effective than solutions that are exclusively computation based.[72] If so, then computing power will augment the human-centered innovation process, not displace people–centered in-

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67 Brynjolfsson and McAfee, *The Second Machine Age*.

68 There is a long history of this type of theorizing in the social science literature, see, for example, Harry Braverman, *Labor and Monopoly Capital* (New York: Monthly Review, 1972).

69 Kenney and Zysman, "The Rise of the Platform Economy," 63.

70 Niels Christian Nielsen, John Zysman, and Jonathan Murray, "Productivity Sinkhole or Commoditization; Services Transformation and Professionalization: The Algorithmic Revolution and Empower Human Value Creation," Danish Technology Institute Copenhagen (2013).

71 Zysman, "The 4th Service Transformation: The Algorithmic Revolution Prepared for Services Issue", BRIE Working Paper 171, 2006.

72 Ahuja, "Man and Machine: Questions of Risk, Trust and Accountability in Today's AI Technology", Computers and Society, http://arxiv.org/abs/1307.7127 (2013).

novation. Of course, this begs the question of whether broad types of work performed by people would, in any case, be replaced by CIAutomation. Will standard routine tasks, arguably the bulk of current work, be displaced? Or, perhaps, can even routine work be augmented? Komatsu, the Japanese capital equipment company, reports that, faced with shortages of skilled labor, it uses intelligence augmentation to permit low-skilled equipment operators to be able to work effectively in situations previously reserved for highly experienced operators.[73] In any case, we must ask ourselves whether ever more powerful computation tools will ultimately automate the innovation process itself, perhaps leaving a few places for people, and generate the much publicized, if improbable, Skynet nightmare of ever more intelligent machines steadily improving themselves.

This brings us to a core conclusion rooted in the history of technology. We know that an emerging technology presents several different trajectories.[74] Moving the technology frontier outward opens sets of new possibilities, and each set of possibilities often has distinct implications for value creation and capture. The new frontier, though, does not dictate the structures and organizational forms through which the technology is deployed. If one needs to reduce the weight of a car or engine but also maintain the materials strength or integrity, one must consider whether to reduce the amount of iron and steel, to strengthen lighter-weight materials such as aluminum, or to invent entirely new materials based on nano-fabrication.[75] If you want to reduce engine emissions, you can try to electrify the entire vehicle fleet and then decarbonize the resulting increase in electricity production with renewable energy and thus move to an entirely new energy system. Alternately, one can introduce a transition technology, as the Japanese automakers did with the Prius and Insight, which were hybrids. A hybrid offers opportunities for improving technologies, such as batteries and electric engine systems for automobiles, while staying within the extant carbon energy system infrastructure, and preparing for a transition.[76]

The implication for us, stated simply, is that if we invest in technologies, business models, and companies in the belief that CIAutomation will inevitably displace work, if we seek in investment after investment to find new ways of substituting capital for labor, then we may inadvertently create the dystopian outcome, a road to digital displacement. We will make the prophecy of ICT as displacing work self-fulfilling. By contrast, if we make a concerted effort to discover how to use ICT to augment intelligence and upgrade jobs across the spectrum of work, then perhaps we can harness digital resources to build a broadly better future. The difficulty is that it is easier to identify the specific ways in which CIAutomation displaces jobs than to demonstrate how intelligence augmentation can be effective in the deep reorganization often required to generate new ways of creating value and augmenting human capacities. The responsible choice is public investment to develop a future predominantly featuring intelligence augmentation. Any other policy risks unnecessarily generating the digital dystopia of CIAutomation, including AI and deep learning, in which work is simply displaced.

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[73] Hisashi Asada, "Partnership-Driven Business Growth in Komatsu: Autonomous Trucking and Smart Construction" (paper presented at the International Partnerships for Advanced Intelligent Systems at Stanford University, Stanford, October 22, 2015). Of course, it might also be added that now those skills that were in short supply will now no longer be needed at all! This, of course, resembles the deskilling that Braverman (*Labor and Monopoly Capital*) suggested would occur.

[74] Antonelli, "Handbook on the Economic Complexity of Technological Change", Edward Elgar Publishing (2011).

[75] http://www.telegraph.co.uk/expat/expatnews/7242574/The-car-in-front-will-be-carbon-fibre.html

[76] As a final example, American automakers discovered to their sorrow that if you invest in classic mass manufacturing, you will never be able to develop or even notice the possibilities of lean production that Japanese producers generated that gave Toyota its global leadership position. The most famous example of a broad literature on the topic is James Womack and Daniel T. Jones, *The Machine That Changed the World* (New York: Free Press, 1990).

That leads to a very basic question. Are workers an asset to be supported and developed? In that case, a primary challenge is imagining and investing in tools that make all sorts of workers more productive and effective, that is, an intelligence augmentation strategy. Or are workers simply a cost to be contained, an inconvenience perhaps to be eliminated? Zeynep Ton has shown that, even in the commodity retail business, a profitable strategy can be a good jobs strategy consisting of investment in workers and organizational strategies to tap worker potential and capability.[77] The overall digital investment objective for policy, and indeed for firms to be competitive, must be a good jobs strategy for a digital era.

Let us indulge, since we consider this so important, and restate the argument we are building. CIAutomation with algorithm-based digital tools is diffusing rapidly throughout the economy, both in services and manufacturing. Those tasks that can be stated as a sequence of computable steps will, as Autor and others argue, be touched by the spread of digital tools.[78] However, there is a dilemma, an algorithmic dilemma. The dilemma is that anything that much of what can be routinized as an algorithm can be copied, and that which can be copied – service offering, software product, manufacturing process – can be commoditized, often stripping out "rents" and high margins. Thus, continuing innovation, embedding the routine in the unique knowledge or process, is essential. We do not want to overstate the point. Consider, again, the example of Facebook or Google: a competitor could theoretically copy every single one of its features and still not turn Facebook or Google into a commodity and remove its profit potential. The same is true of Microsoft Office components. Rivals can by now easily reproduce functional equivalents, yet enticing users to adopt them is difficult, as Google has found with its Documents.

Our view has been that a high-road adaptation to the algorithmic revolution must effectively integrate human beings and their ingenuity—that sustained innovation requires human imagination and implementation. Many questions quickly arise. First, does sustained innovation require human imagination and implementation *throughout* a firm's organization or only at the high-end design and strategy level? More than one choice can be made. Recall that American mass manufacturing hinged on the notion of embedding strategy and development at an organizational core and then routinizing production activity. Japanese lean production strategies and the variants that have followed rest on engaging the workforce in continuous improvement. It is so much easier for smart technologists to envision that they alone, to echo the political rhetoric, can develop and apply technology strategies. It is much harder to develop organizational strategies engaged with the workforce throughout. Second, do intensive computation and machine learning automate continuous innovation? Or is machine learning just another routine that requires innovation?

4. Is there a strategy for intelligence augmentation? In the twenty-first century, production will be reshaped through digital tools, in particular by CIAutomation, sensors, and data analytics.[79] For a discussion of work, we must ask, what trajectory will be taken by CIAutomation, which underpins industrial reorganization and the design of work and labor markets? Will we redesign work to take advantage of human cognition and creativity? Will robots and compu-

[77] Zeynip Ton, *The Good Jobs Strategy: How the Smartest Companies Invest in Employees to Lower Costs and Boost Profits* (New York: Houghton Mifflin Harcourt, 2014).

[78] Autor, "Polanyi's Paradox and the Shape of Employment Growth."

[79] For an overview of twenty-first century manufacturing, see Paul Kenneth Wright, *21st Century Manufacturing* (Upper Saddleback River, NJ: Prentice Hall, 2001).

tation-intensive tools more generally simply displace workers? Or can intelligence augmentation, which likely requires considerable reimagination and reorganization of production, be a viable option? Our view is that the outcomes lie in our choices and visions of how we deploy and use technology; the outcomes are not inherent in the technology. The balance is yet to be determined.

To establish an intelligence augmentation technology trajectory, one objective must be to establish how intelligence augmentation, harnessing computer-human complementarities, can create advantage in ways that we value and will pay for in the marketplace. Let us speculate about three approaches to discovering and creating the possibilities for intelligence augmentation that can be supported in the market and developed using private as well as public investment? Each is an implicit research project.

First, let us start with what is already before us, with the concrete and immediate. We should establish a compendium of instances in which CIAutomation is being used to augment capacities, in particular, instances in which traditional production is or can be then undertaken more effectively by traditional production workers. That can be done by looking across sectors and across countries. From that compendium, we must try to infer the kinds of applications and deployments best suited to CIAutomation/human collaborations and then encourage their deployment and development.

One important matter concerning skills must be noted immediately. User interfaces are critical. Few staff who have skills in a Windows environment would be equally effective using a traditional Unix operating system. The skills and knowledge required in an intelligence augmentation production system remain an open question and will be discovered sector by sector, production phase by production phase. Indeed, the required mix of skills will depend on how the ICT tools are deployed and on the user interfaces that are developed. GM, we noted, in the early years viewed robots as directly replacing workers on the assembly line. For dangerous and dirty tasks, such as painting automobile bodies, that has been a good idea, but the one-for-one substitution approach hid the system transformation that changed industrial competition. Toyota engaged the workforce in improving the production process itself, by drawing on worker knowledge and insight. Knowledge transfer, as examples such as the Danish machinery firm Unimerco demonstrate, requires human engagement to permit insight based on tacit understanding.[80]

Second, funders—corporations, foundations, and governments—should create competitions and prizes for the deployment of intelligence augmentation.

A third, more abstract approach also exists. The evident challenge is to create dialogue for those who examine the brain and human behavior and those developing CIAutomation and robotics. Some basic questions arise. What is the difference between digitally generated behavior that imitates intelligence and the structures of the mind that facilitate our behavior? Can we, from this distinction, envision applications that favor human-computer alliances?

In sum, to understand the impact of ICT on work tasks and jobs, we must look at the reorganization of production and the transformation of work itself, as well as labor market dynam-

[80] Niels Christian Nielsen and Maj Nielsen, "Spoken about Knowledge Why It Takes Much More Than Knowledge Management to Manage Knowledge," in Zysman and Newman, *How Revolutionary Was the Digital Revolution*.

ics. Of course, it all weaves a single fabric in the end. If intelligence augmentation require new skills or an integration of work in new ways, who invests in worker skills and work redesign in a gig economy?

5 Governing the Digital Economy: Policy and Politics for the Platform Economy

The sweeping changes brought about by digital technologies more generally force debates about the institutions and rules of the economy and society.[81] The policy, and then political question is, at its core, what sort of world will we create in the digital era? The policy agenda is long and diverse, so perhaps a few comments organizing the discussion may be useful.[82]

First, public or private governance? Critically, the rise of the platform economy directly raises the question of private governance and public responsibility. In this platform era, we must manage the conflicts between public and private governance. Digital platforms are regulatory structures. The operation of the platform—whether Uber/Lyft, Google, Facebook, Airbnb, or others—sets the rules and parameters of action for participants. The governance rules, as Larry Lessig argued years ago, are an outcome of the code itself.[83] Sometimes, a firm introduces a platform whose operation directly challenges, or even violates, existing rules. If accepted by consumers, as is the case with Uber and Airbnb, it can result in a direct challenge to the state's regulatory authority. Advice often given in Silicon Valley is: "Don't ask permission, ask forgiveness." Investors and others encourage entrepreneurs considering a new business model to introduce it and, if it is successful, then address resistance from government authorities—or force changes in the law. When the platform rules occupy an unregulated space or a space in which existing regulations are unclear and difficult to apply, then new platform businesses often force us to consider new regulations or, at a minimum, new regulatory interpretations. Do we consider drivers for Uber employees, independent contractors, entrepreneurs, or something else entirely? Should Airbnb hosts be subject to the land-use regulations, public accommodations laws, and disability-access rules that apply to hotels?

Of course, in the discussion of public versus private governance, the question becomes a matter of which "public". Which political entity defines the rules or engages the struggle with the "private" platform, and how are differences among "publics" resolved?

Some observers focus on the struggle not on the public versus private tension but on the battle for market control among platforms such as Google and Facebook as the issue. Certainly

81 Orly Lobel, (2015, September 30). The law of the platform. Retrieved from https://www.law.umich.edu/centersandprograms/lawandeconomics/workshops/Documents/Paper%206.%20Lobel.%20The%20Law%20of%20the%20Platform.pdf.

82 Consider the discussions and extensive literatures about, among other things:
- Privacy,
- Security,
- Competition and antitrust,
- Intellectual property including digital rights management,
- Fair use of course falls across the competition and free speech domains.
- Consumer protection that changes character in an era of intertwined hardware/software offerings,
- Network regulation popularized in this round by "network neutrality,"
- Labor market rules including who is an employee, and
- Social welfare.

83 Larry Lessig. *Code and Other Laws of Cyber Space* (New York: Basic Books, 1999).

a struggle is under way among platforms, each with its own private rules and regulations, for market and social position. But a deep conflict *between* platform-based private rulemaking inscribed in code and public rulemaking in its many forms has also emerged. Should there be a public response, or should the market make these decisions?

Second, siloed debates. Managing the conflicts between public and private platforms requires that siloed and separate debates be integrated in policy discussions. In practice, questions about big data, privacy, and security are intimately tied together. It is not just what the government knows about us, a debate forced by Edward Snowden, but what Google, Facebook, Apple, or Amazon know about us and what they can do with the troves of data they generate. Are Uber, Google, or FedEx, for example, able to trade data about traffic flows with public authorities in exchange for favorable regulation? Or consider how competition law touching Uber spills into labor law affecting the character of the labor market. Or note that network regulation, from the breakup of AT&T to "net neutrality," is clearly about industry structure, competition, and power. Obviously, internet protocol rules also shape competition. A first task, then, is to find the key levers and pose the questions that move us from the siloed and narrow debates to the broader questions about the kind of society and economy we are developing.

Thus we note that the policy debates can be grouped into three basic domains with several sets of questions:

- Protection: the rules protecting workers, communities, and clients;
- Social policy, including social insurance that affects what risks workers can take in becoming entrepreneurs;
- Marketplace policy, about how we compete and who gains and who loses in the competition.

Third, global governance in the era of the platform economy. Finally, there is the question of global governance: the interplay between domestic and international rulemaking in the platform economy. Addressing the tension between public and private governance in the platform economy quickly becomes a question, as noted, of which public and which government. Whose competition or privacy rules apply? These issues arise both internationally and within federal systems. Uber has different social and economic meaning in San Francisco than in France or Finland or, in fact, Austin, Texas. Google, as Microsoft once did, provokes different reactions regarding competition and antitrust policy in the United States and Europe. Certainly, we must ask how, by what mechanisms, and in what venues, national differences in interests and objectives need to be addressed. We ask whether those discussions should be about treaties such as the Trans-Pacific Partnership (TPP) and its debates about intellectual property, about institutions such as the World Intellectual Property Organization (WIPO), which itself generated treaty agreements that in United States resulted in the Digital Millennial Copyright Act (DMCA), or about the reconciliation of national laws.[84] Increasingly, both nationally and internationally, we expect struggles will be about the collection, processing, and use of "data." Indeed the privacy debates about personal data may be further exacerbated by the commercial

[84] The reconciliation of national law is evident in the privacy negotiations between the United States and Europe over safe harbor. Today the issues focus on competition policy (Abraham Newman, *Protectors of Privacy: Regulating Personal Data in the Global Economy* [Ithaca: Cornell University Press, 2008]). European privacy rules, it is evident, have forced bilateral and multinational consideration of how firms will handle personal data across borders, setting choices for their broader operations, though it is possible that there is more here than meets the eye.

value of the data generated in the Internet of Things. One difficulty is that, in an era of rapidly moving technology that is constantly recasting industry competition, treaty agreements can be rigid and difficult to reform.[85] We have no straightforward answers, just complex questions.

Politics, of course, translates these debates into social and economic policy. Addressing the politics of structural change in the platform economy will be vital for the pace and distribution of economic growth.[86] Indeed, politics will be an important force in shaping the organization and polities in the platform economy. Ongoing struggles will come with economic change, as existing sectors decline or transform, as new firms displace old ones and as existing workforces are pushed aside, to be succeeded by new forms of work and new skills. As important will be the struggle over governance between the public efforts to establish the rules and the governance that is embedded in the "algorithms" and "code" of the platform. We hope that this paper will help point the way and frame an ongoing discussion.

[85] More generally, consider whether treaties are the appropriate way to deal globally with digital platform issues and digital technology issues more generally. The radical evolution of digital technology, infrastructure, goods, and services requires constant reformulation of policy. Recall, as simple example, that once we regulated broadcast—TV and radio—over the air and communications over the wires. Now, of course, what was once considered broadcast comes into our homes over wires even as much of our communication is migrating to wireless. Certainly the Clinton-era telecom reforms aimed at resetting these regulatory arrangements. How awkward it would have been if an international treaty had required a set of other countries to agree to our domestic reform. In the immediate debate note that the DMCA, which was intended to protect Hollywood, has implications for the broader digital economy and indeed for goods with embedded software. Some firms are suing with reference to DMCA to force customers of equipment, such as tractors, to return to the manufacturer for repair, citing risk of violation of copyrighted software in control systems. Would, as Brad de Long has asked, the International Monetary Fund have worked if its accommodation to changing financial power and structure required constant treaty renegotiation? Another problem is that the process of policy-making is significantly different for treaties and domestic law. Treaties are negotiated in secret, with the negotiators often discussing private interests. The process of access to trade negotiations favors some interests, while other interests are excluded from discussion.

[86] Gordon's vision is ultimately rooted in his understanding of the politics of change in advanced economies and less anchored in the story of the technologies themselves.

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ISSN-L 2323-2447, ISSN 2323-2447, ISSN 2323-2455 (Pdf)