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

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

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Digital Platforms in the cloud are fundamental features of the present phase of the digital revolution and are entangled with computation intensive automation.¹ This abundance of computing power enabling the generation and analysis of data on a scale never before imagined 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 computation-intensive automation (CIAutomation) – debated variously now as AI, machine learning, and intelligence augmentation – is deployed. CIAutomation can serve to augment intelligence, human intelligence codified into software, making for skilled workforces, as well as serving to displace work and cut the intelligence out of tasks. In our view, the labor and labor market issues in the next years will be powerfully interwoven with the questions of the deployment of platforms and CIAutomation, both the technologies themselves and the rules shaping them. *Second*, we argued in the earlier piece 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

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Governance by platform. Digital platforms are regulatory structures, and thus, systems of governance. The platform's operation set the rules and parameters of action for participants, systems of governance. The question is not only how to express public interests in the operation of platforms, but also a matter of which "public" is to be 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 just adapt to the emergence of the digital economy and society. We must recognize that our policy choices form part of the technological trajectories themselves.³

Recalling the Basics:

This phase of the digital era rests on the extraordinary abundance of data computation, storage, and transmission. Cloud computing facilitating digital platforms, data and analytics, and CIAutomation are all enabled by the availability of massive inexpensive processing, storage and telecommunications bandwidth. "As we observed elsewhere, the early days of computing were characterized by scarcity, which in turn constrained software capabilities."⁴ Gradually but inexorably, the exponential increase in computing capacities, 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 Lifting constraints has opened a new digital era of platforms, big data, and CIAutomation.⁶

Consider platforms. Digital Platforms, which we will define in a moment, are, to be cursory, 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 ICT-enabled services transformation is most clearly seen in finance with online trading and ATMs, and with media, a run of offerings from Napster through now Netflix and the array of offerings, such as YouTube.¹⁰ The services transformation was in part accelerated 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 competed principally on price. The terms of competition could be transformed when the sale of a product faced with 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, inside the operations of particular institutions or firms.

Platforms, while they may operate within particular organizations, are digital structures with the capacity for 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 would be “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, the label of platforms refers to multi-sided digital frameworks that shape, intermediate, the terms on which participants – often but not always buyers and sellers – interact with one another.¹²

Platforms are, in that sense, algorithm-enabled “cyberplaces” where constituents can act, interact, or transact. Those transactions are, shall we say, diverse, whether categorized by market or social function or by technical character. Each category opens equally diverse issues and questions. There are consumer good platforms from eBay through Amazon and Alibaba that link buyers to sellers, raising legal questions of liabilities. There are service platforms such as Uber or Upwork that change who can buy and sell people-delivered services, raising labor market issues as well as forcing rethinking of traditional regulation. Taxis cannot discriminate, but can Uber drivers? Hotels must obey land use rules, and not discriminate, but must Airbnb providers do so?¹³ And, if, for example, discrimination is possible, then who should enforce anti-discrimination – the private parties contracting, the platform owner, or the state? Who could inspect the algorithms, who should have access to the private databases for what purpose? From a different vantage, that of industrial production, the Internet of Things, a vague category of objects linked through cyber connections, opens questions of industrial standards and data. Who sets the industrial standards on production platforms, standards which will powerfully affect competition amongst industrial equipment producers, and who will own or have access to what kinds of data? The corporate market competition amongst the likes of Cisco, G.E., Google, Komatsu, and Siemens often turns on the answers to such questions.

But let us not run ahead. Why, first of all, do we say that Platforms are digital structures that run in the cloud? Simply, cloud computing architecture provides the power for a broad array 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 abstraction of computing functions. “Abstraction” and “virtualization” become code words of the new computing; with sufficient resources, abundance, many “virtual” machines can run in a single collection of servers; and diverse computing infrastructures may be accommodated. Providing these “computing clouds” favors scale. Scale favors players, with the largest data processing needs raising issues about the possibilities for local competitors and the national control of data. Indeed, cloud architectures first emerged as companies like

Amazon, Google, Microsoft, and Salesforce.com sought to provide for their own computer needs and then sold computing capacities and services, in varied packages.

For 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. Start-up costs are reduced; costs of expansion of 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 that which can be afforded by an individuals’ credit card – depending on what one wants to do. That makes access to inexpensive elastic computing resources and scaling easier for startups, and makes experimentation within larger companies easier, since a central CIO (Chief Information Officer) need no longer be a choke point for access to computing resources. Put differently, one might say cloud reduces the importance of the cost of computing out in the calculations of the cost of the equation for starting a firm or experimenting with a new application. Organized effectively, “cloud” can speed the development of applications; 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 the sort of world that we will 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 Apple.²¹ And indeed they had unleashed a new world. There were, even earlier, skeptics. Kurt Vonnegut’s first novel, *Player Piano*,²² setting aside that the computing machines in his novel used electronic tubes not integrated circuits, reads like the dystopian literature in academic and popular

press today.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? Some part of an answer begins with three questions: 1) What happens to productivity; 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 loses, who captures whatever gains there are.

The Productivity Debate:

Clearly since the mid 19th century basic standards of living have been transformed and productivity of the advanced economies has risen remarkably.²⁴ A core debate is whether that historic run will continue. How profoundly ICT is now transforming our lives as we experience them, is open to debate. Robert Gordon argues that the basic changes in transport, 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 Let us set aside that debate and focus on whether slowed productivity reflects disappointing limits of ICT technologies.

Productivity matters since at its core, however formally defined and measured, the notion represents the increased ability to generate from a given endowment of productive resources goods and services valued in the market.²⁶ We are richer not just because of savings and investment, though that is essential, but because of the 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 sustained productivity increase in the past decades.²⁷ Let us set aside the observation that much of the value of ICT, from search through social media, is provided free, in exchange for being subject to advertising, and consequently the benefit may not be effectively measured.²⁸ Let us accept, for this essay, Gordon's finding that the drop-off in the pace of productivity

increase since 1972 is evident. His conclusion that after 2007 labor productivity will grow at no more than 1.3 percent per annum is sobering, as this will be significantly slower than that 2.0 percent growth from 1891 to 2007. The core question is not whether there has been a slowing, but why, and what ICT has to do with that.

Before turning to the direct question of ICT's impact on productivity, we must at least note that there are an array of alternate explanations of the productivity slowdown that are unrelated to technology as such. Those alternate explanations would 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 a real life story of the reorganization of communities and work. Thus, the post-WW II structural transformation of countries from France through Japan involved 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 post war years lagged German rates, not because different technologies were being deployed, but in part because the French were not closing many inefficient plants to avoid the political, not strictly electoral, consequences of closures.³¹ The deployment of technology is as crucial to productivity as the technology itself. We return to that reality in a moment.

Transformative technologies, those that touch 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 roles of steam, of railroads, of 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 contention has two components: the first is the proposition that ICT has had only limited scope in the economy, one might say, limited to our entertainment and a bit of convenience in finance; second, that the technology wave has passed so the story is done and has been shown to be limited. Both assertions are mistaken.

First, ICT is, in fact, recasting a significant portion of the economy. It is not, of course, just the technology that is driving change or the popular applications, but the radical innovation in production organization, product, and business models. The early phases of the ICT revolution certainly touched principally services that at the core are about 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, as instances, were converted into digital formats they could be shared electronically, innovative approaches such as Napster gave rise to disputes about property and eventually to iTunes, Spotify, YouTube, and an array of digital businesses.³⁵

Importantly, in this early Internet phase of the digital revolution ICT-enabled services, as mentioned above, began to be increasingly extended to “everything” and the underlying business models often changed character. The examples abound, some well known, others less discussed: airplane engines, and indeed 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 embedding smart sensor in building management services are able to increase comfort while decreasing heating/cooling costs.

The platform phase is simply the latest step in this unfolding story of the deployment of ICT technologies throughout the economy. At the core of the economic and social tsunami generated by transformative technologies, technologies such as electricity, which ultimately touch most 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 it is 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, multi-sided platforms provide new ways that buyers and sellers that could not previously reach each other, that

could not previously form a market, can interact. Importantly, in our view, the buzz about (choose your favorite commercially branded label) The Internet of Things, Internet of Everything, Industrial Internet amounts to new ways that sensor-enabled objects will be controlled and interact through platforms. The platforms themselves facilitate the aggregation and analysis of data with the intent to control systems and actions.³⁶ Simply, we are entering a world that will be characterized by a data analysis-based economy and society where 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 system and data analytics are breathtaking. In the prosaic world of industry, Cisco GE, IBM, and Siemens, in both their publicity and business strategies, highlight industrial applications from energy management through pipelines through 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 for industrial verticals like Manufacturing, Aviation, Transportation, 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 (2016) describes the Democratic National Committee’s VoteBuilder platform.³⁹ These instances are hardly the 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 middle-sized companies.⁴⁰ The question the initial study “Industrie 4.0” posed for the now ongoing debate in Germany and elsewhere is how to craft cyber tools in a platform era to support and sustain skill-based competitive advantage. Research on both manufacturing and supply chains indicate that basic production is primed for

reformulation through platforms and other ICT innovations.⁴¹ For us, the recent merger/association of the Tech Shops with Flextronics is an instance of the maker movement possibly combining with mainstream manufacturing in a way that could alter how we look at small start-ups 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 OECD work, is that the productivity frontier has been pushed, but the best practices are not being implemented broadly in the economy. The problem, if that argument holds upon review, then becomes one of deployment and diffusion, of business practice and structural policy, not of the inherent possibilities of the technologies.⁴³ The OECD studies argue that the leading 10% of global firms have significant and steady productivity increases in the 21st century while the laggard 90% are trailing 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 3 1/2 per cent in the manufacturing sector over the 2000s, compared to an average growth in labour productivity of just 1/2 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 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 the gap really is 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 on study.⁴⁷ Some suggest, for example, that part of the story is that the leading 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 might well keep high productivity activity in core firms and locate low productivity in the supplier companies. Overall, the whole system 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. There is, in fact, an endless library that 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 sets the productivity outcomes.⁴⁹ So, an evident issue is what sets deployment trajectories and pace of deployment. A second 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 both production reorganization, 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.

There are significant political and policy implications of the seeming reality of the technology frontier advancing amongst leaders with significantly slow diffusion to, or effective deployment by, the rest. Technology deployment and diffusion is, we hasten to underscore, often a matter of radical changes in how people earn their livings and live their lives. It is almost never a simple or conflict free process. Rapid growth in the “fast-growth countries” such as Germany, Japan, and France after WW II involved fundamental structural change as people and resources moved from the countryside to cities, from agriculture to industry, and bombed factories were replaced by newer ones.⁵¹ In the slow-growth countries, existing industries had to be reorganized, and entrenched organized interests often resisted. The politics of 21st century growth will involve very deep dislocations in already rich well-organized societies; and that will be very difficult politically.⁵² Capturing the possibilities of the technology is more a political problem than a

narrowly economic constraint. That suggests 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 frontiers 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 technical possibilities that are created, they are enormous, but on the capacity to deploy and diffuse those possibilities.

Jobs in the 21st Century Digital Economy:

Let us turn to the concrete question of jobs and work from abstraction of 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, there are several different discussions about the digital influence on jobs and work:

1) The current focus: Current focus has been on the labor market including the ways work is organized and compensated. Much of this initial discussion about the influence of Platforms, and ICT, more generally, focuses on matching; whether it be 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 improve. A related concern has been the way 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 into gig and contract relations.⁵⁴ Of course, there is an argument about how much has really changed. Are there more such relationships, or just more such relationships that are visible now that they are online, rather than signaling a real increase in temporary

work? Some suggest that gig work and contract work is merely a formalization of what already existed.

The literature on the transference 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 instances of Uber and Airbnb.⁵⁵ This is natural as these two directly threaten two traditional industries, transport and lodging. However, the scope of platform impact is far greater and extends broadly. If we extend the scope of consideration to YouTube, which includes videos of all sorts ranging from pure entertainment through self-help and self-diagnosis, as only three examples to Amazon self-published books and app stores, what we term “digital consignment,” the broader dimensions of this informalization become apparent.⁵⁶

2) The underlying fundamentals: In any discussion of jobs, the fundamental underneath the labor markets, or entangled with the labor markets, is the production system. Hence, a deeper question is how production itself will be reorganized as ICT sweeps through.⁵⁷ Even here there is an array of questions. One issue, of course, is what will be made where. Production has been both decomposed while being shuffled about geographically and then redeployed, reconstituted, in new forms.⁵⁸ 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.⁵⁹ 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 varied 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 controlled by major corporations? Will at least, in part, the maker movement vision of small entrepreneurial local firms and “makers” facilitated by new technologies such as 3D printing and locally available become significant economically?⁶⁰

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 shown that there is an organizational and locational divide between product conception through to prototype and volume production, with significant implications for the mix of skills and the possibilities of value creation and capture.⁶¹ 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.⁶²

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.⁶³ The Flex Invention Lab permits production and process revision but the industrial standards mean the process is ready to be moved to volume.⁶⁴ The initial per unit cost can be 2X-10X 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.⁶⁵ 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 there will not be a single dominant 21st century production system, but rather that a variety of ways for organizing production will emerge as manufacturing is reconstituted and the chains of value creation reconfigured. Mirroring what might become a plethora of

production organization models, there is likely to be a wide variety of different types of compensated employment.

3) CIAutomation: What all emerging models of 21st 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 indeed generate a dystopia of unemployment, unskilled workers, and greater inequality.⁶⁶ The primary focus presently has been on the fear of the destruction and devaluation of work and skills.⁶⁷ Importantly, there is an alternate view, that human intelligence and capacities can be augmented by computation, what is called “intelligence augmentation (IA)”. What will be the balance 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.⁶⁸ 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,⁶⁹ increasingly for all firms sustained innovation is required. To date the innovation dynamic itself has not been “automated” and remains the domain of human inventiveness and initiative.⁷⁰ Indeed, it is also true that at scale even commodity production such as occurs in a Google or Amazon data center is not easily copied and becomes a site for sustained innovation. The core of innovation 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 upper 10% of highly trained individuals, those lucky enough to be anointed as YouTube “stars” or have their app go viral, and start a new firm that is acquired by an existing firm? The question of where work will come from remains for the rest of the population, those with more modest training and education that

are not blessed by inherited status, not born with innate and recognized intelligence, or just not lucky? Will the ICT technology 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, there is substantial evidence 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.⁷¹ If so, then computing power will augment the human-centered innovation process, not displace people centered innovation. Of course, this begs the question of whether broad swaths of work 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 skilled labor shortages it uses intelligence augmentation to permit lowskill-level equipment operators to be able to work effectively in situations previously reserved for only highly experienced operators.⁷² 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 machine 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.⁷³ Moving the technology frontier outward opens sets of new possibilities, often each set of possibilities 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 one but also maintain the materials strength or integrity, one must consider whether to reduce the amount of iron and steel, to strengthen a lighter weight materials such as aluminum, or to invent entirely new materials based on nano-fabrication.⁷⁴ If you want to reduce engine emissions one 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 that were hybrids. A hybrid offers opportunities to improve technologies such as batteries and electric engine systems for automobiles while staying within the extant carbon energy system infrastructure, and preparing for a transition.⁷⁵

The implication for us, stated simply, is that if we invest in technologies, business models, and companies with 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 create inadvertently the dystopian outcome, a road toward digital displacement. We will make the prophecy of ICT displacing work self-fulfilling. By contrast, if we make a concerted effort to discover how to use ICT to augment intelligence, upgrade jobs throughout the spectrum of work, then perhaps we can harness digital resources to build a broadly better future. The difficulty is that it is likely easier to identify the specific problems in which CIAutomation that displaces jobs can be a good investment than to understand the character of the ways Intelligence Augmentation can be effective. The responsible choice is public investment to develop and elaborate a predominantly Intelligence Augmentation future. Any other alternative policy risks unnecessarily generating the digital dystopia of CIAutomation, including AI and deep learning, simply displacing work.

That leads to a very basic question. Are workers an asset to be promoted and developed? In that case a primary challenge is imagining and investing in tools that make all sorts of workers more productive and effective, 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 that profitable strategy can be a good jobs strategy of investment in workers and organizational strategies to engage worker possibilities and capabilities.⁷⁶ 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.⁷⁷ 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 overdraw 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 products. Rivals can by now easily reproduce functional equivalents, yet enticing users to adopt them is difficult, as Google has found with its Documents offering.

Our view has been that the 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 arise quickly. First, does sustained innovation require human imagination and implementation *throughout* a firm’s organization or only at the high-end design and strategy level? There is more than one choice. 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 variant 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 twist a phrase from the political debate, can develop and apply technology strategies. It is much harder to develop organization strategies engaged with the workforce throughout. Second, does 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? 21st Century production will be reshaped through digital tools and powerfully by CIAutomation, sensors, and data analytics in particular.⁷⁸ For a discussion of work, we must ask, what trajectory will CIAutomation, which underpins industrial reorganization and the design of work and labor markets, take? Will we redesign work to take advantage of human cognition and creativity? Will robots and computation intensive tools more generally simply displace workers? Or, can Intelligence Augmentation, which likely requires considerable re-imagination and re-organization of production, be a viable option? Our view is that the outcomes lie in our choices and visions, how we deploy and use technology; the outcomes are not inherent in the technology itself. 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 by 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, and 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 CIA /human collaborations, and then encourage their deployment and development.

There is an important matter concerning skills that must be noted immediately. User interfaces are critical matters. Few staff displaying skills in a “Window’s office environment would be effective in a traditional Unix operating system. The skills and knowledge required in Intelligence Augmentation production system remains 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, early 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 on one substitution approach hid the system transformation that changed industrial competition. Toyota engaged the work force in improving the production process itself; drawing on worker knowledge and insight. Knowledge transfer, as instances like a Danish machinery firm, Unimerco, demonstrate, requires human engagement to permit insight steeped in tacit understanding.⁷⁹

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

There is a third more abstract approach. The evident challenge is to create dialogue for those who examine mind brain and human behavior and those developing CIA and Robotics. There are basic questions. What is the difference between digitally generated behavior that imitates intelligence and the structures of mind and brain 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 dynamics. Of course it is a single woven 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?

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.⁸⁰ The policy, and then political question is, at its core for us, 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.⁸¹

First, public or private governance? Critically, the rise of the platform economy directly raises the question of private governance and public responsibility. We must manage the conflicts in this platform era between public and private governance. Digital platforms are regulatory structures. The platform's operation set the rules and parameters of action for participants, whether it is Uber/Lyft, Google, Facebook, Airbnb, or others. The governance rules are, as Larry Lessig argued years ago, an outcome of the code itself.⁸² Sometimes a firm will introduce 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 successful, then address resistance from government authorities – or force changes in the public 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, to be employees, independent contractors, or entrepreneurs or something else entirely? Should Airbnb landlords be subject to the land-use regulations and disability-access rules that apply to hotels?

Some observers focus on the struggle, not on the public versus private tension, but on the battle for market control amongst platforms such as Google and Facebook as the issue. Certainly there is a struggle amongst platforms, each with its own private rules and regulations, for market and social position. But there is also a deep conflict *between* platform-based private rule-making inscribed in code and public rule-making in its many forms. 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 separated debates be integrated in policy discussion. 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

the Snowden incident, but what Google or Facebook, Apple, or Amazon know about us, and what they can do with the troves of data they generate. Are Uber, Google, or Fed Ex, 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 break-up of AT&T through “net neutrality” is clearly about industry structure, competition, and power. Obviously, IP 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, 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 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 rule making in the Platform Economy. Addressing the tension between public and private governance in the Platform economy quickly becomes a question of which public, which government. Whose competition or privacy rules apply? These are issues both internationally and within Federal systems. Uber in San Francisco has different social and economic meaning than in France or Finland and, in fact, San Francisco and Austin, Texas. Google, as Microsoft once did, provokes different reactions regarding competition and anti-trust 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 TPP and its debates about Intellectual Property, about institutions such as WIPO (World Intellectual Property Organization) which itself generated treaty agreements that resulted in United States in the DMCA (Digital Millennium Copyright Act), or about the reconciliation of national laws.⁸³ 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.⁸⁴ There are no straightforward answers, just complex questions.

Politics, of course, translates these debates into social and economic policy. Resolving the politics of structural change in the Platform Economy will be vital to the pace and distribution of economic growth.⁸⁵ Indeed, politics will be an important shaping force for the organization and politics in the Platform Economy. There will certainly be the ongoing struggles that come with economic change as existing sectors decline or transform giving rise to new, as new firms displace old ones, 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. Hopefully, this paper helps point the way and provide framing for an ongoing discussion.

Notes

¹ The term “Computation Intensive Automation”, CIAutomation, includes, but is not limited to Artificial Intelligence and Machine learning. The intent in 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 what data is collected, who has access and control, and how it is 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, CA: Stanford Business Books, 2006).

² Martin Kenney and John Zysman, “The Rise of the Platform Economy,” *Issues in Science and Technology* (Spring 2016).

³ 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* for how policy choices have affected the development of the mobile internet industry in China.

⁴ John Zysman, Jonathan Murray, 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 that there is an 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., for Moore's Law, Peter Bright, "Moore's law really is dead this time" *Ars Technica* (February 10, 2016); for magnetic storage, see Ruper 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 whether there was a phase change or this gradually emerged and now the implications and opportunities have become salient and contemporary is perhaps unanswerable.

⁷ John Zysman, "The 4th Service Transformation: The Algorithmic Revolution" Prepared for 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 manuscript.

¹¹ See: John Zysman, Stuart Feldman, Kenji Kushida, Jonathan Murray, 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 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

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

¹⁵ Though we hasten to 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. Page 65.

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

¹⁸ Though we hasten to add that 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).

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* no. 20485 (2014). Andrew McAfee Erik Brynjolfsson, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (WW Norton & Company, 2014).

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

²⁵ William Nordhaus provides a remarkably concise analysis of the book in the New York Review of Books: William D. Nordhaus, "Why Growth Will Fall" *The New York Review of Books* (August 18, 2016).

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." Paul Krugman, *The Age of Diminishing Expectations* (MIT Press, 1994).

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

²⁸ Hal Varian amongst 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. Op Cit. Nordhaus.

²⁹ William Lazonick, "Profits without Prosperity," *Harvard Business Review* (September 2014).

³⁰ John Zysman. *Governments, Markets, and Growth* (University of California Press, 1983).

Barry Eichengreen, *The European Economy Since 1945* (Princeton University Press, 2007).

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

³² Carlota Perez, *Technological Revolutions and Financial Capital* (Edward Elgar Publishing: 2003). Joseph A. Schumpeter, *The Theory of Economic Development: An inquiry into profits, capital, credit, interest, and the business cycle* (Transaction publishers, 1934).

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

³⁴ Stuart Feldman John Zysman, Kenji Kushida, Jonathan Murray, 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 University Press, 2013).

³⁵ It is worth considering whether this remarkably greater access to information will have impacts similar to the arrival of inexpensive printing. For the impact, see, for example, Lucien Febvre, 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). Let us note, 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, 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 Paris 2015. *Data-Driven Innovation: Big Data for Growth and Well Being* This significant study makes a point that is not always widely understood See page 41 in particular.

³⁸ To to be added

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

⁴⁰ "Industrie 4.0" Securing the future of German manufacturing industry: Final report of the Industrie 4.0 Working Group April 2013, Recommendations for implementing the strategic initiative INDUSTRIE 4.0 Authors: Professor Dr. Henning Kagermann- National Academy of Science and Engineering; Professor Dr. Wolfgang Wahlster -German Research Center for Artificial Intelligence; Dr. Johannes Helbig; Deutsche Post. 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?" Prepared for OECD discussions in March 2016. On Manufacturing see for example: John Zysman, Dan Breznitz, Martin Kenney, Paul Wright, "21st Century Manufacturing" Prepared for UNIDO, (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 Op Cit. Page 9.

⁴⁵ Op Cit. page 12.

⁴⁶ One early reader of our text asked whether the 10% has a monopoly/oligopoly position and thus are 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 where platforms are of vital importance, the winner-take-all types of outcomes ensure that it is impossible for the other 90 percent or even 99 percent to ever overtake the winning 10 percent! For example, very, very few firms in the Apple Computer ecosystem can match its profit margins or “productivity.”

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

⁴⁸ Martin Kenney elaborates speculating that the elite firms are firing their “low-productivity” workers, say janitors, secretaries etc. and rehiring them at sub contractor 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), pp.1-120 (2005).

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

⁵² See for example John Zysman, *Governments Markets and Growth: Financial Systems and The Politics of Industrial Change* (University of California Press, 1983). And, Barry Eichengreen, *The European Economy Since 1945* (Princeton University Press, 2007).

⁵³ In an earlier essay we touched on a number of these questions. See Martin Kenney, and John Zysman. “The Rise of the Platform Economy” *Issues in Science and Technology* (Spring 2016). 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.

⁵⁴ On 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). For temporary or contract work, 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.” In Future of Work Symposium, US Department of Labor (2015).

⁵⁵ See, for example, Alex Rosenblat, Luke Stark, “Algorithmic Labor and Information Asymmetries: A Case Study of Uber’s Drivers” *International Journal of Communication*, 10: 3758–3784 (2016). Also, 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 Kenney and Zysman. 2015. Op cit.

⁵⁷ This section draws extensively on work we have done under the rubric “Escape from the Commodity Trap”. For this essay, in particular, we are drawing on: John Zysman, “Escape from the Commodity Trap: Will the Production Transformation Sustain Productivity, Growth and Jobs” Prepared for the European Commission (2014) ISBN 978-92-79-34561-6 // doi:10.2777/48430.

⁵⁸ Ibid. page 13 Zysman, considering the decomposition of production, the locational dispersion, and the resulting commodification, has argued that:

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.

⁵⁹ 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).

⁶⁰ There is an array of literature on this. See for example: Suzanne Berger, *Making in America: MIT Task Force on Production in the Innovation Economy* (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.

⁶¹ 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):263-278 (2011). 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):140-144 (2009).

⁶² Of course, this assumes that a nation such as China with a huge internal market does not become the site for these advanced activities.

⁶³ 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.

⁶⁴ Conversation with Steven Heintz, General Manager, Flex and head of the San Francisco based Flex Invention Lab.

⁶⁵ 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, Timo Seppälä, “The Changing Geography and Ownership of Value Creation: Evidence from Mobile Telecommunications.” *Industry & Innovation* (2016) Under revision.

⁶⁶ Brynjolfsson and McAfee 2014, op.cit.

⁶⁷ 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).

⁶⁸ Kenney and Zysman, Op Cit. page 63

⁶⁹ Niels Christian Nielsen, John Zysman, Jonathan Murray, “Productivity Sinkhole or Commoditization; Services Transformation and Professionalization: The algorithmic revolution and empower human value creation” *Danish Technology Institute Copenhagen* (2013). ISBN 978-87-92359-10-0.

⁷⁰ To be added.

⁷¹ To be added.

⁷² Hisashi Asada, “Partnership-driven Business Growth in Komatsu: Autonomous Trucking and Smart Construction.” Presentation. 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 op. cit. suggested would occur.

⁷³ To be added,

⁷⁴ To be added.

⁷⁵ 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. James Womack, Daniel T. Jones, *The Machine That Changed the World*, (Free Press New York, 1990) is the most famous instance of a broad literature on the topic.

⁷⁶ Zeynip Ton, *The Good Jobs Strategy: How the smartest companies invest in employees to lower costs and boost profits* (Houghton Mifflin Harcourt, 2014).

⁷⁷ Op.Cit. Autor.

⁷⁸ For an overview of 21st century manufacturing, please see Paul Kenneth Wright, *21st Century Manufacturing* Pearson (2001).

⁷⁹ Niels Christian Nielsen and Maj Nielsen “Spoken about Knowledge Why it Takes Much More than Knowledge Management to Manage knowledge” in Op Cit. John Zysman, Abraham Newman, *How Revolutionary was The Digital Revolution* (Stanford University Press, 2006).

- ⁸⁰ Orly Lobel, "The Law of the Platform Economy," in *How Revolutionary Was the Digital Revolution: National Responses, Market Transitions, and Global Technology* ed. John Zysman and Abraham Newman (Palo Alto: Stanford University Press, 2006).

⁸¹ Consider that array of discussions and extensive literatures about, amongst other things:

- Privacy,
- Security,
- Competition and anti-trust,
- Intellectual property including Digital Rights Management,
- Fair use of course falls across the competition and Free Speech domains.
- Consumer protection which 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

⁸² Larry Lessig. *Code and Other Laws of Cyber Space* (Basic Books, 1999).

⁸³ The reconciliation of national law is evident in the privacy negotiations between the US 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.

⁸⁴ More generally, consider whether treaties are the appropriate means of dealing 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 (Digital Millennium Copyright Act), 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 IMF 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 selecting for discussion private interests. The process of access to trade negotiations favors some interests, while other interests are excluded from discussion.

⁸⁵ 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.