



The Internet and Jobs

Opportunities and ambiguous trends

Lorenzo Pupillo, Eli Noam and Leonard Waverman

Summary

Virtually all of the empirical literature on the impact of the internet on jobs indicates that the internet has indeed created many new jobs, but that a large number of jobs may also have been destroyed or downgraded in the process, at least in the short run. Furthermore, studies suggest that routinisation, job market polarisation and new labour market inequalities have emerged in recent years. Thus, while the diffusion of the internet is generating opportunities, the phenomenon also comes with ambiguous trends that by themselves will not generate a more resilient and inclusive labour market. These changes cannot be treated as business-as-usual developments by governments and the private sector. Failing to mitigate short-term job losses risks triggering pushbacks and restrictive policy responses that threaten to slow down the ICT (information, communication and technology) revolution.

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1. Introduction

The progress of technology in recent decades has been extraordinary. The great opportunities have been well recognised, but technology has also generated new divisions between winners and losers. In particular, information and communications technology (ICT) has been an engine of growth and transformation of economy and society but has impacted job flows and wage inequality. The result has been fear and uncertainty, and backlash. The purpose of our book is therefore to produce facts, analysis and evidence on the relationship between the diffusion of internet and its impact on employment. The book also aims to fill a gap between academic research in this field, the cost and benefits of ICT diffusion and more general and accessible materials.

We took as our point of departure the structural transformation the world of work is currently undergoing. According to the OECD, three major forces are profoundly changing the world of work: demographic change, globalisation and technology, especially the digital revolution.¹ Among the demographic factors, the aging population is capturing the attention of policy-makers in the OECD countries for its impact on the affordability of health care and pension systems. These changes may suggest the need to create incentives for older workers to remain active in the labour market for a longer period of time. But such incentives may anger younger workers who feel that older workers are taking their jobs.

In the area of globalisation, the fragmentation of production processes and jobs along a global value chain is changing the occupational structure of jobs and their tasks. These powerful changes are often mistaken for the third force at work – the digitisation process. Increasing computer power coupled with the growing penetration of the internet, Big Data, the Internet of Things (IoT) and Artificial Intelligence (AI) are profoundly changing the nature of work: by whom, where and how it will be performed.²

But what are the actual impacts of digitisation on labour? The current debate offers a variety of positions ranging from the pessimistic view of unprecedented job destruction, high rates of unemployment and massive increases in inequality to the optimistic idea that employment will adapt to the new technologies and that complementarities between humans and machines will generate new jobs and opportunities.

¹ See Stefano Scarpetta (2016), “What future for work?”, *OECD Observer*, No. 305 Q1.

² Ibid.

The most pessimistic study on the impact of digital technologies on future work is by Carl Benedikt Frey and Michael Osborn (2013). They evaluate the effect of what they call “computerization” on different occupations. They find that 47% of the total US employment can be classified in the “high-risk” category for becoming automated and therefore likely to disappear. A similar calculation for the UK finds a figure of one-third of jobs at high risk by automation over the next decades. However, their work has been criticised by a paper from the Organization for Economic Cooperation and Development (OECD) (Arntz, Gregory & Zierahn, 2016) claiming that occupation-based approaches tend to overestimate the impact of job automation, since occupations categorised as “high risk” may contain many tasks that are difficult to automate. Therefore, following the task-based approach instead of the broader occupational analysis, the OECD researchers’ findings reduce the pool of jobs at high risk across the OECD countries to on average only 9%.

A much more optimistic approach is suggested by the McKinsey Global Institute’s report (2011), which concludes on the basis of its global SME survey that the internet has created 2.6 jobs for every one job destroyed.³ Enrico Moretti (2012) follows the path of digital technologies as powerful catalysts for job creation, and observes that high-tech jobs trigger a multiplier effect, increasing employment and salaries in non-high-tech sectors: one high-tech job creates five complementary non-high-tech jobs, both in skilled occupations (lawyers, teachers) and in unskilled ones (waiters, carpenters).

Beyond the issue of the net impact on employment, which our book deals with in several chapters, there are also fundamental questions related to the structural changes in the workplace that affect the nature of work itself. One of the most discussed issues is job and wage polarisation. As discussed in chapter 3, a study by Autor, Katz and Kearney (2006) shows that the US labour market has become increasingly polarised both in terms of occupations and wage distribution between high-skilled, conceptual, non-routine jobs and low-skilled, manual, but non-routine jobs at the opposite end of the jobs/income spectrum. The jobs most at risk from IT, however, are the routine, middle-skilled jobs, set in the middle of the jobs or wage distribution. This process is explained by the hypothesis that computers substitute for workers in carrying simple cognitive and manual activities (“routine” tasks), while computers complement workers in carrying out problem-solving and complex communication activities (“non-routine” tasks). Goos, Manning and Salomons (2009) show these findings for Europe. The jobs and wages polarisation has determined what has been called the great “hollowing out” of the middle class: higher paying jobs requiring high skills and creativity have proliferated; demand for low skills, manual jobs not replaceable by computers has also increased; but middle skills, middle-class jobs like bookkeeping, clerical work and routine manufacturing jobs, have been substituted by computers and the internet. These processes combined with some of the effects of globalisation also have strong socio-economic implications, which have contributed

³ Matthieu Pelissie du Rausas, [James Manyika](#), [Eric Hazan](#), [Jacques Bughin](#), [Michael Chui](#) and Rémi Said (2011), “Internet matters: The Net’s sweeping impact on growth, jobs and prosperity”, McKinsey Global Institute.

to recent seminal political outcomes such as the Brexit vote in the UK, Trump's election in the US and the rise of populism in Europe.

This labour market process of substitution of computers for workers to execute routine jobs, called routinisation and often associated with labour market polarisation, seems to signal the deeper and more structural effects of how digitalisation will affect our lives. According to Brynjolfsson & McAfee (2011 and 2014), the technological progress is "at an inflection point – the early stages of a shift as profound as that brought on by the Industrial Revolution".⁴ This transformation brings a bounty of innovation related to the exponential, digital and combinational nature of the new digital technologies. While we have experienced so far only the transformation of the way in which we communicate, most of the gains from the digital transformation are still ahead of us. However, with the bounty brought by these technologies also comes the tendency to replace human capital in skilled tasks once considered safe from automation.

But is this not a scenario we have already witnessed over the past two centuries? Technological innovations have always disrupted the job market, but after a period of labour turmoil, previous technological revolutions have brought more jobs and prosperity. The question now is: *Is it different this time and if so, why is that the case?* This question resides at the centre of Nigel M. de S. Cameron's 2017 book "*Will robots take your job?*". Two dimensions may make it reasonable to think that this wave of technological disruption could in fact be different: *time and scale*.

We are in the midst of a transition to a digital economy, and there is widespread consensus that the transformation brought by the digital technologies in the economy and society today is proceeding *at much faster speed* than those generated by previous waves of technologies.⁵ Although this digital transformation started in the middle of the last century, the pace of change has accelerated as digital infrastructure is further deployed and powerful devices like smart phones connect people everywhere at any time.⁶ Tom Standage, digital editor for *The Economist*, interviewed for a Pew Research on the future of jobs stated:

Previous technological revolutions happened much more slowly, so people had longer to retrain, and [also] moved people from one kind of unskilled work to another. Robots and AI threaten to make even some kinds of skilled work obsolete (e. g., legal clerks). This will displace people into service roles, and the income gap between skilled workers whose jobs cannot be automated and everyone else will widen. This is a recipe for instability.⁷

⁴ Erik Brynjolfsson and Andre McAfee, (2014), *The Second Machine Age*, New York, NY: W.W. Norton & Company, p. 251.

⁵ See James Manyika (2017), "Technology, jobs and the future of work", McKinsey Global Institute, May.

⁶ Note that the world-wide-web began in 1996, and the I-Phone debuted on 29 June 2007!

⁷ Aaron Smith and Janna Anderson (2014), "AI, Robotics and the Future of Jobs", Pew Research Center, August, p. 11.

The McKinsey Global Institute states that AI is contributing to a transformation of society “happening ten times faster and at 300 times the scale, or roughly 3,000 times the impact” of the Industrial Revolution.⁸ The speed of this technological change is linked to the exponential trends in technology development and its evolution may be faster than our reaction capacity. According to some observers, the acceleration of computer hardware over decades, fuelled by Moore’s Law, has allowed us to “remain on the steep part of the S-curve for far longer than has been possible in other spheres of technology”.⁹ All this means that it is difficult to predict what will happen and that the changes in the future will likely be massive.

The breadth of change is major and the impact of technological change is more pervasive than past changes that were linked to the diffusion of other technologies. Their impact is much more widespread than in the past. All sectors of the economy are involved. The example of self-driving vehicles is a case in point. Not only will many driving jobs disappear (truck, bus and taxi drivers), but with fewer vehicles purchased there will be an impact on car manufacturing, the petroleum industry, farming (ethanol) and the auto insurance industry. Greater safety will also have an impact on the health care industry. Furthermore, these effects will not be geographically limited as was the case in the closing of factories in steel towns or mines in coal-mining villages.¹⁰

A helpful contribution to the discussion of the impact of automation on jobs comes from David Autor (2014) who draws our attention to the possible complementarity between people and machines. He starts from recalling the work of the Hungarian scientist and philosopher Michael Polanyi who in 1966 observed: “We can know more than we can tell...The skill of a driver cannot be replaced by a thorough schooling in the theory of a motorcar; the knowledge I have of my own body differs altogether from the knowledge of its physiology.”¹¹ This statement, also known as the Polanyi’s paradox, emphasises the difference between tacit knowledge and explicit knowledge and characterises the interplay between humans and computers. The computers are quite good in replicating explicit, codifiable procedures such as multiplication. However, tasks that require flexibility, judgment and common sense, skills that we understand only tacitly, are poorly performed by computers. In other words, humans have comparative advantages when flexibility, problem-solving skills and creativity are required. Autor observes that the extent to which a machine can substitute for human labour has been overstated while the strong complementarities between computers and human labour that, increase productivity and demand for skilled labour, have been ignored. A task that cannot be computerised does not mean that computerisation has no effect on that task. On the contrary, tasks that cannot be computerised are generally complemented by the technology. Think about the role played by mechanisation in construction. Using cranes, excavators and pneumatic nail guns, the amount of physical work that a worker can accomplish in an eight-hour work day

⁸ *The Economist* (2016), “The return of the machinery question”, 25 June.

⁹ Martin Ford (2015), *Rise of the Robots*, New York, NY: Basic Books, p. 69

¹⁰ See De S. Cameron (2017), *op. cit.*, p. 69.

¹¹ David Autor (2014), “Polanyi’s Paradox and the Shape of Employment Growth”, NBER Working Paper No. 20485, National Bureau of Economic Research, Cambridge, MA. This paragraph draws from this paper.

increased tremendously. Of course, automation has substituted for human labour in construction but has not devalued the work of construction workers. Indeed, no matter how much capital equipment is available, a construction site without construction workers would be useless. Construction workers perform ad-hoc tasks such as control, guidance and flexibility in managing everyday situations. Therefore, automation has complemented construction workers. Yet, technology is going further and deeper.

The idea of the complementarity between humans and machines, such as through highly capable robots, needs to be considered dynamically, taking into account how good machines are becoming in substituting for workers in functions that require flexibility, once considered a unique characteristic of the human being. The recent victory of ALPHAGO, the artificial intelligence system built by Google–DeepMind, over the human champion Lee Se-dol in the strategy game of Go, shows the power of the combination of deep learning systems with reinforcement learning techniques. This combination is making viable a new approach in gaming. Instead of trying to incorporate smart strategies in the computer, this new approach allows the computerised system to build and learn winning strategies almost by itself.¹² For how long thus will the Polanyi’s paradox hold? According to a recent book by McAfee & Brynjolsson (2017), “computers still don’t really understand the human condition [...]and digital technologies do a poor job of satisfying most of our social drives. So, work that taps into these drives will likely continue to be done by people for some time to come. Such work includes tasks that require empathy, leadership, teamwork, and coaching.”¹³

Against this challenging background, our book attempts to contribute to the debate on the impact of the internet on jobs and to complement the existing literature. It is first necessary to clarify that the chapters presented in the book deal primarily with the impact that computers and networks are having on jobs, (the “third industrial revolution”) rather than on robots, artificial Intelligence, the Internet of Things or Big Data. The nature of broadband or internet as a general-purpose technology makes it difficult to disentangle the specific contribution of application technologies. The empirical papers presented in the book focus on the fundamental building blocks rather than more specific refinements and applications of these technologies, while the more theoretical chapters discuss these issues in broader terms.

The first chapter in our book confirms the economists’ view that the displacement of jobs due to the diffusion of computers and networks is a short-term issue and that employment will not be reduced in the long run. The chapter shows that ICT investments have no effects on labour demand in the long run. More precisely, it claims that the substitution effect and the scale effect compensate each other completely and that the short-run disruption effects on the job market tend to disappear in about 20 years in most OECD countries.

¹² Andrew McAfee and Erik Brynjolsson (2016), “Where Computers Defeat Humans, and Where They Can’t”, *New York Times*, 16 March.

¹³ Andrew McAfee and Erik Brynjolfsson (2017), *Harnessing Our Digital Future – Machine, Platform, Crowd*, New York, NY: W.W. Norton & Company.

The book also provides new quantitative evidence of the impact of the internet on jobs. On the issue of routinisation, focusing on this process in Europe, the book shows clearly that individuals in routine jobs, *ceteris paribus*, display a higher probability to become unemployed, challenging the idea of recent decades that only unskilled workers represent the vulnerable segment in the labour market. All the empirical papers indicate that the internet has a positive impact on the creation of jobs, but it is not clear if the jobs created outnumber the ones destroyed. In the media and entertainment business, for instance, the internet has significantly changed the labour market for talent. It has added new jobs for performers, but these new jobs tend to be at the lower end of the pay spectrum. Overall, it is unclear whether the incremental gains in lower-paying jobs are meaningful enough to outweigh the increased competition that characterises the life of professional performers today.

Looking at the impact of internet connectivity on employment, the book shows that broadband contributes to the creation of jobs in certain industries and geographies. However, broadband is also a key factor in capital-labour substitution in sectors such as tourism or in rural areas where, contrary to what happens in metropolitan areas, job losses driven by productivity enhancements cannot be compensated by innovation-led new business models.

We also present an ad-hoc approach to the estimation of the balance between gains and losses of employment in the digital economy. It uses a bottom-up accounting of both job destruction and job creation. While the effects vary significantly by location and sector, the overall outcome is a small but constant growth in most places where investments in digital economy are robust.

Besides offering an assessment of the quantitative impact of the internet on jobs, chapters in the book also discuss the distributional effects of digital technologies on income inequality and insecurity, and the impact on the middle class in western countries. The first concern raised is linked to the unequal distribution of job losses. The loss is mostly concentrated in low-pay industries, and job mobility from the lower to middle class is slowing. There is also a generational inequality created by the internet: older people become obsolete faster than before. Is this a global phenomenon? The book discusses the case of Canada and suggests that wage and jobs polarisation are not as present as they are in the US. Is this related to the fact that Canada lags the US in many types of ICT infrastructures, application adoption and usage? It is too early to tell. As is the case for other technological revolutions, it takes time for change to fully manifest its effects.

We also point out in the book the potential contribution to the economy that may come from the structural change in US infrastructure from a rigid hardware-based architecture to a software-based infrastructure, which is flexible and fluid in topology and capable of scaling clients and resources on demand.

All contributions in the book point to the need to govern the changes in the labour market induced by the internet through new approaches and solutions. These changes in the labour market should not be managed on a “business as usual” basis since there is nothing routine about structural unemployment. The speed and the scale of changes induced by the digital

revolution require new education and labour market adjustment policies that facilitate structural and social adjustment without slowing innovation.

There is a strong need for a massive improvement of ICT skills of the population at large. Such skills are needed, not just in the ICT sectors or in closely related finance/insurance, professional services and real estate. A lack of ICT skills threatens the growth and well-being of the economy more generally. Chapters in the book show how the private sector is responding to these challenges by retraining its labour force. Also, the private sector is providing support for general improvement in secondary and high school education and post-secondary science, technology, engineering and math (STEM) career skills. One chapter suggests that this process should be encouraged by government through a “knowledge tax credit” by allowing qualified expenditures on R&D and workforce training to offset taxes. The author of that chapter also urges governments to ensure that education is more closely linked to occupational needs, such as in nano- and micro-technology, rapid prototyping, logistics and bio-manufacturing.

Furthermore, special attention should be devoted to help workers who lose their jobs, through retraining and subsidies, without reducing the incentive for workers to return to the workforce. A chapter in the book discusses the role that fiscal policy can play in making robotic innovation a win-win development for everyone. More generally, policies must avoid a ‘crowding out’ of private investment when subsidising the diffusion of innovation, such as broadband networks.

Yet another role for online platforms is that of job matching and transforming informal work into formal employment, especially for emerging economies.

2. Key messages from our book, chapter by chapter

The chapters of the book are grouped thematically into three parts: 1) The Impact of Technological Change on Jobs; 2) Internet Economic Fundamentals and their Impact on the Economy and Distribution; and 3) Policies to Facilitate Structural and Social Adjustments without Slowing Innovation. In the following sections, we highlight the main ideas contained in the book’s chapters.

2.1 The impact of technological change on jobs

In chapter 2, entitled, “ICT Investments and Labor Demand in OECD Countries”, Vincenzo Spiezia, Senior Economist at the OECD, provides new estimates of the effect of ICT investments on labour demand in 19 OECD countries over the period from the early 1990s to 2012. He measures ICT technical progress as the decline in the user cost of ICT capital and estimates the effects of such a decline on the demand for labour. The findings suggest that ICT investments have no effects on labour demand in the long run. A permanent decrease in the user cost of ICT capital reduces labour demand per unit of output but it increases output by the same proportion. In other words, the substitution effect and the scale effect compensate each other completely. In the short run, however, due to sluggish adjustments in production inputs, a one-off permanent decrease in ICT user cost results in a temporary increase in labour demand followed by a temporary decrease. Spiezia’s estimates suggest that these temporary effects

tend to disappear in about 20 years in most OECD countries. While the negative employment effects of ICTs are estimated to eventually fade away, their medium-term persistence justifies policy measures such as investment incentives, labour market activation policies and temporary income support.

In the third chapter of Part I, Jeffrey Sachs of Columbia University and Seth Benzell and Guillermo LaGarda, of Boston University, approach the issue of whether robots raise or lower economic well-being. In their chapter entitled “A One-Sector Model of Robotic Immiserization”, they claim, on the one hand, that robots raise output and bring more goods and services within consumers’ reach. On the other hand, they eliminate jobs, shift investments away from machines that complement labour, reduce wages and harm workers who cannot compete. The net effect of these offsetting forces is unclear. In a one-sector model, the authors investigate a possible mechanism by which innovation in automation may reduce welfare. They show in this setting how fiscal policy can make robotic innovation a win-win for all generations. Indeed, policies that redistribute income across generations can ensure that a rise in robotic productivity benefits all generations.

In the fourth chapter, entitled “Routinization and the Labor Market: Evidence from European Countries”, a group of Italian economists – Federico Biagi, University of Padova, Paolo Naticchioni, Roma TRE University, Giuseppe Ragusa, LUISS University, Claudia Vittori, University of Rome La Sapienza – provide new evidence on the ongoing routinisation processes in Europe. In particular, they claim that routinisation processes do not depend on the type of variable considered; groups of countries characterised by very different institutions, cultures and labour market conditions share similar routinisation trends; routinisation levels are different across groups, suggesting that groups of countries can be placed at different stages in the technological/routinisation process; routinisation seems to represent a driver, among others, of unemployment inflows and finally individuals in routine jobs, *ceteris paribus*, have a higher probability of becoming unemployed. This evidence challenges the view of earlier decades that only unskilled workers represent the weak segment in the labour market. This evidence applies also to routine workers, who are not necessarily unskilled. If confirmed, this issue would represent an important new dimension in policy debates in the coming years, to think about some new targeting dimensions of the active and passive labour market policies, with two main objectives. On the one hand, such policies may ease the reallocation of routine workers towards other types of jobs, and on the other hand, they may provide some sort of additional institutional insurance for workers exposed to higher unemployment risks.

The fifth chapter, “Labor Markets in the Digital Economy: Modeling employment from the bottom-up” by Jonathan Liebenau from the London School of Economics, claims that the effects upon labour markets of changes in the digital economy are poorly understood because analyses have not focused on the appropriate level of jobs within specified sectors. Liebenau, instead, uses a bottom-up accounting of both job destruction and job creation that provides a more accurate assessment of the effects of investment in the digital economy. While the effect differs significantly from sector to sector and place to place, overall he observes modest but steady growth in most places where investments in the digital economy are robust. This is an

important finding both for the general understanding of the effects of the digital economy and for our ability to be specific about the impacts of investments of certain kinds on the local economies. It provides a clearer idea of labour market skills requirements and this helps monitor education and training policies, if only to evaluate the refrain coming from employers and amplified by researchers, who perennially claim that the labour market is desperately in need of hundreds of thousands of newly-skilled workers.

In particular, the studies show some surprising results. Trade data and industry structure evidence indicate that the UK economy is more capable of meeting the expectations of digital economy requirements in areas such as smart metering and intelligent transport systems infrastructure than might have been expected. Their reliance on imports may be less than sometimes assumed, and fewer of the jobs generated by such spending will be created abroad. Another surprise finding is the strong effect that policies regarding restricting the export of data and on energy pricing have on the ability of cloud services to generate domestic employment. Especially given that cloud service provision is highly portable, the ability to avoid exporting all new employment opportunities rests on the local economy's ability to achieve growth in those sectors that benefit from the new digital services, as well as to attract the providers of those services who rely upon data centres and skilled staff.

In chapter 6, "The Impact of the Broadband Internet on Employment," Raul Katz from Columbia University states that the topic of the impact of the broadband internet on employment has been present in the public policy arena on a regular basis in recent years. Unfortunately, such an important debate has been approached with little formalisation of the research of impact and understanding of the evidence. Before even tackling the prescriptive side of the policy debate, researchers appear to be aligned in one of two camps: either that the internet contributes to the creation of jobs; or, that the internet is the source of job destruction. Unfortunately, in many cases, research is being conducted hypothetically (e.g. what kind of jobs are susceptible to elimination as a result of digitisation?) without looking at the empirical evidence. The chapter summarises the results of investigations conducted by this author and other researchers on the impact of broadband on employment. This chapter argues that, based on the evidence, the response to the question of impact of broadband on employment is: it all depends. The chapter shows that broadband contributes to the creation of jobs in certain industries and geographical areas, while also being a key factor in capital-labour substitution (i.e. job losses) under certain conditions. This kind of differentiated answer does not satisfy pundits or ideologues. In the final analysis, however, if policy-makers are oriented towards making good decisions, they need to have a solid, unbiased understanding of the evidence.

In the final chapter of Part I, "The Impact of the Internet on Employment and Income in the US Media and Entertainment Business," David Viviano, chief economist at the SAG-AFTRA Labor Union of actors and other performers, emphasises that the internet has undoubtedly changed the labour market for talent in the media and entertainment business. The internet's impact on the sector is still evolving, but some insights can already be drawn. The internet has added new jobs for performers; however, the vast majority of these new jobs tend to be at the lower end of the pay spectrum. The internet has also created new ways to distribute and monetise

library video content. While these new revenue streams are becoming more significant in the aggregate, they have yet to become a significant source of income for individual performers. Furthermore, the internet has disrupted this labour market by driving up competition and increasing year-to-year income variability. At this point it is unclear whether the incremental gains in lower-paying jobs and new but smaller 'residuals' payments to actors are high enough to outweigh the increased competition, wage compression and income variability that professional performers face in the internet age.

2.2 Internet economic fundamentals and their impact on the economy and distribution

The first chapter in Part II (chapter 8), by Eli Noam from Columbia University – “Inequality and the Digital Economy” – assesses the distributional effects of the Digital Economy. Noam opens with the observation that policymakers in developed countries have believed and hoped for many years that the Internet, and more generally the digital economy, would replace and enhance industrial jobs. Yet after several decades of digital evolution, one can observe that the internet has displaced many blue-collar jobs in manufacturing as well as pink-collar jobs in retailing and among clerical staff. It has also created new jobs, but those who get the new jobs are not the same people who have lost them. Furthermore, what is striking is not the loss per se but the fact that the losses have not been distributed equally. A majority of the jobs were in low-paying industries and the traditional job mobility from lower to middle class is becoming more difficult. There is also a generational inequality accelerated by the internet: the rapid transformation in knowledge and technology makes the experience less valuable and quickly renders the old out-of-date. It is necessary to realise that the impact of internet-induced economic displacements in developed economies will not go away. It will get worse in the short term. This creates a challenge to managers and policy-makers in the digital sector. Otherwise, a backlash will create forces that will restrict innovation. It is therefore important for academics, public-policy analysts, NGOs, companies and governments to think creatively about new approaches to these issues, and to balance the public interest, technological innovation and financial investment in the emerging environment.

In chapter 9, “Job Losses and the Middle Class: Canada and the USA, and the Possible Role of ICT,” Len Waverman, of the DeGroot School of Business, McMaster University uses comparisons between Canada and the United States to examine whether recent job losses in the middle class is a general phenomenon, or more uniquely an American experience. The role of ICT in such “polarisation” is examined and the Canadian productivity and ICT experience relative to the US are discussed. While data indicate that wage and job polarisation have not occurred in Canada as of 2013, Professor Waverman claims that “it’s too early to tell”. The explosion of social media, viral networks and applications spawned in 2007 by the iPhone are now only a few years old! Most advances have been directed at the consumer market. Even there, new advances such as self-driving cars and virtual reality are not market ready. We have not yet begun to tap the enormous potential. It is important to remember that other general purpose inventions were slow to come to fruition and uneven in timing and impact. Productivity

will improve as the ICT revolution continues to expand beyond consumer-driven social media. Yet, the US data show that ICT, at least in the short to medium term, has been a source of growing income disparity because of the displacement of “routine” jobs. The level of skill required to move from routine-based jobs to non-routine or cognitive occupations is high. These are very different transitions from the past. Rich countries – the West – have done little to enable such job/occupational shifts. And for those who cannot at their life cycle stage make such adjustments, we have not created the necessary social safety nets.

In the final chapter of Part II, “Internet Innovations –Software Is Eating the World: Software Defined Ecosystems and the Related Innovations result in a Programmable Enterprise”, Robert Cohen, senior economist at the Economic Strategy Institute, claims that a structural change in US infrastructure from a rigid, inflexible, hardware-based architecture (“The Old IP”) to the “New IP” – a software-based infrastructure that is flexible, fluid in topology and architecture, and capable of scaling clients and resources on demand – is underway. This makes it possible for US firms that are early adopters to expand the optimisation of their current operations. Cohen estimates that these firms are likely to add \$3 trillion to the US economy over the next 10 years and about 8 million new jobs. His essay describes the software-based innovations that are changing the internet and creating new economic opportunities. These innovations have been well-documented as individual technology advances. Here, the author links them together to argue that as the internet evolves to a new stage, it is providing a series of changes that, operating in concert, create new environments for businesses and consumers.

2.3 Policies to facilitate structural and social adjustments without slowing innovation

Chapter 11, which opens Part III of this book, is entitled “ICT Innovation, Productivity, and Labor Market Adjustment Policy,” by Robert D. Atkinson, of the Information Technology and Innovation Foundation. He states that there is increased interest in the question of how to facilitate labour market adjustments from technological innovation. Some of this interest appears to be a result of efforts to try to respond to the recent increase in populism from both the right and the left, fuelled, as some believe, by labour market insecurities. Some is due to the weak global labour market performance in the wake of the Great Recession, where tens of millions of jobs were destroyed, and job creation has been tepid. And some is due to the belief that technological change, particularly in the information and communications technology sector is fuelling (or about to fuel) rapid productivity growth and accompanying job loss. Regardless of the reasons, improving worker adjustment policies in the United States is long overdue. The alternatives – doing relatively little– risks not only increasing opposition to ICT-driven technological change but reducing the efficiency of the labour market. He concludes that the major risk to the global economy over the next decade is not too much disruption, but too little. In other words, the risk is that productivity will grow too slowly. As such it is critical that labour market policies, including adjustment policies, support, not hinder ICT-led creative disruption. One way to do that is to make improvements in workforce training and labour market adjustment policies.

Chapter 12, “Ensuring the Education and Skills Needed for ICT Employment and Economic Growth” by Richard Clarke from AT&T, offers a view from the private sector on the issue of mitigation and adjustment policies. Clark points out that over the last 40 years, ICTs have been the most important source of economic growth and sectoral change in the output and labour markets in America. Indeed, it is hard for anyone under the age of 50 to imagine a time when manual processes were the exclusive way of conducting a financial transaction or making an airline reservation. But with these changes in technology have come great changes in the educational requisites for workers. STEM knowledge and advanced education are now the key to productive employment and a middle-class lifestyle. While traditional educational systems have faced difficulties in effectively providing widespread STEM education, ICT organisations themselves may offer a partial remedy. By harnessing the ability of ICTs to convey such education via online MOOCs or nanodegrees, it may be possible to ensure that the economic revolution that ICTs have wrought will continue into the 21st century.

An additional view from the private sector comes in the chapter 13 by Andrea Iapichino, Amelia De Rosa and Paola Liberace, all from Telecom Italia (TIM) and entitled “Smart organizations, new skills and smart working to manage companies’ digital transformation”. The authors discuss the implications of digital transformation for organisations and the future of work. They first describe the drivers of digital transformation, both social and technological, and focusing on the profile of the new “smart organization” and its required skills. They then present TIM’s way to enact the transition from knowledge to skills, through its TIM Academy initiative and Knowledge Management process, and towards a new way of working through its Smart Working project. The digital transformation can be a great opportunity for the Company if this process is managed throughout the range of peoples’ skills and engagement.

A contribution from the developing world is chapter 14 “Investigating the potential for micro-work and online freelancing in Sri Lanka”, by Helani Galpaya, Suthaharan Perampalam, Laleema Senanayake, of LIRNEasia. Sri Lanka is a lower middle-income country that has benefited significantly from the increase in business process management (BPM) work from developed countries. Many global BPM operations have set up business in Sri Lanka and provide a range of services to overseas clients. While there is much room for improvement in computer literacy and internet access (in 2015, 26.8% of the population was computer literate and over 25% of households had a computer), there is wide enough diffusion of computers to make participation in microwork a viable option for many, beyond the educated elite. Therefore, using focus groups and a sample survey, the paper asks whether it is possible that the digital dividend could be spread more inclusively through the participation on microwork platforms. And if so, how do we encourage this? The authors show that whether people engage in full-time or part-time work, online work presents a way to increase their income, sometimes significantly. There is a sufficient number of people in the country with the right type of skills exist, but it has to be “pitched” in the right way. Awareness has to be increased, including a recognition of the pitfalls (e.g. not getting paid for work done), and the solutions to these pitfalls. Policy-makers need to facilitate a legitimate payment mechanism, which is an oft-cited

problem. This chapter concludes that online free-lancing and microwork presents a growth opportunity for Sri Lanka.

The final contribution of the book (chapter 15), entitled “Do Municipal Broadband Networks Stimulate or Crowd Out Private Investment? An Empirical Analysis of Employment Effects,” by Hal Singer, senior economist at Economics Incorporated, addresses the role of public funding for broadband networks at the municipal level. Economists have studied the employment and spillover effects from broadband investment generally, as well as the employment effects from municipal-owned broadband networks. In contrast to the well-documented link between broadband deployment and jobs, the literature finds scant evidence that muni-networks are associated with private-sector employment gains. Economic theory offers a possible explanation for this result—namely, private firms do not wish to compete against government-owned enterprises, which do not take profits into consideration when setting prices. Accordingly, any incremental investments by local firms wishing to exploit the muni-network could be offset by forgone investments by privately owned internet service providers (ISPs). NTIA data of US broadband deployment by both privately and muni-networks in December 2010 tends to corroborate this “crowding-out hypothesis.” US counties that enjoyed privately owned broadband deployment in 2010 realised faster-than-average private-sector employment growth from 2010 through 2013, whereas US counties that relied on government provision of high-speed networks in 2010 experienced no similar lift in private-sector employment growth. This chapter concludes by spelling out various policy implications of these findings.

3. Conclusion

Our book brings new evidence of the impact of the internet on jobs. All of the empirical contributions indicate that the internet has a positive impact on the creation of jobs, but it is not clear if more jobs are created than are destroyed. Furthermore, routinisation, job market polarisation and new labour market inequalities show that, while the diffusion of the internet is generating opportunities for many, it is also accompanied by ambiguous trends that by themselves will not generate a more resilient and inclusive labour market.

The book points to the need to manage these changes in the labour market not as “business as usual”, since there is nothing routine about structural unemployment, nor the rapid speed at which changes are occurring. Failing to mitigate “short-term” job losses risks a policy response to reduce both the speed and the extent of the ICT revolution. 20 years is not the short run for those affected... It is a generation! Technological innovation has always had disruptive effects on the job market. To ignore the “short run” is to risk bringing back a modern version of the Luddites, with profoundly negative consequences.

Some chapters in the book refer to the new efforts required in retraining the labour force and in STEM career skills acquisition and improvement. But one area of particular interest that needs further research is the analysis and design of the new set of skills that allow working alongside the smart new machines. This means researching how to better understand the

complementarity between man and machine and how to develop the skills that allow men and women to do “what computers are not good at”.¹⁴ Moving from STEM (science, technology, engineering and mathematics) to STEAM (adding arts to the mix) would be a right step in this direction. Furthermore, soft skills such as leadership, team-building and creativity will become increasingly important and are less likely to be automated.

Thus, the future of work could be seen not in its replacement or displacement by technology but in the complementarity between humans and machines. Smarter machines and smarter people can complement each other to create a mass of customised products and services: the world of new artisans.¹⁵ In the era of the Paradox of Progress, it is up to us to work in a way that allows the promise to prevail. This book is a small effort in this direction.

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¹⁵ See Rework America (2015), *America’s Moment*, New York, NY: W.W. Norton & Company, p. 131.

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