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The impact of AI on employment: a historical account of its evolution

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The impact of AI on employment: a historical account of its evolution

By: Martha Garcia-Murillo and Ian MacInnes

Abstract

Artificial Intelligence (AI) is likely to have a significant impact on work. Examples from the past demonstrate that it has created jobs but also displaced workers. The primary question this study aims to answer is what have been the effects that previous revolutionary computing technologies have had and how have institutional values shaped the way workers were affected. The paper involves a historical analysis of the experiences that society in the United States has had with technological innovation. The research relies on academic, government, and trade publications of earlier periods in the development of computer technology. In this effort, we examine the literature on institutional economics to help us understand the way society has transitioned and the forces that have shaped the outcomes. Institutional economics has two main branches that explain change: the ceremonial and the instrumental. The ceremonial values perspective focuses on the customs and conventions that prevail in a community. The instrumental perspective focuses on a society's processes of inquiry, acquisition of knowledge, and use of scientific inquiry to solve problems

Our analysis suggests that in all of these periods initial implementations suffered from installation problems, system bugs, and troubleshooting frustrations that generated employment; however, as the technology improves, it is likely to enhance productivity, but displace, workers. Up to this point, the U.S. government has not been able to respond adequately to the challenge. We attribute this to the ceremonial values that public officials and society entertain about personal responsibility and small government.

Keywords:
Artificial intelligence (AI), Technological displacement, Economic transition, Ceremonial values, Instrumental values, Public policy

1. Introduction

In the 1940 and early 1950s, newspapers wrote about humans' becoming "moronic button-pushers, lever-pullers {Forester, 1981 #124}, and dial-watchers', at the service of an "aristocracy of super-minds" (Proudfoot, 2018); at the other extreme, we have statements that claim that "AI will give humans a 'blissful' and 'truly meaningful' future." (Proudfoot, 2018). The truth, however, is somewhere in between.

Slow and exciting transitions challenge our ability to react to the negative effects that come with change. In this paper, we focus on the impact that artificial intelligence can have on labor markets during the transition period by looking back at other points in time, when computers were revolutionizing the economy and transforming work. The subtle manner in which technological transformations affect work pose a double jeopardy; they challenge our inability to react in time to ameliorate the effects of change and then themselves give rise to negative effects. During the Industrial Revolution, machines overcame the limitations of the human muscle; today, artificial intelligence is overcoming the limitations of human cognition (Berry & Elliott, 2016). The greater capabilities of AI will continue to penetrate our digital economies and will make it difficult, if not impossible, to stop any progress on our path towards greater reliance on technology

AI is showing promising results for education by offering a more personalized learning (Aleven, Roll, McLaren, & Koedinger, 2016; Baker, 2016; Barros & Verdejo, 2016) infrastructure to optimize the location of electric car stations (Asamer, Reinthaler, Ruthmair, Straub, & Puchinger, 2016; Di Lecce & Amato, 2011) law to determine ownership at a time when work is not only more collaborative but also computer-generated (Davies, 2011) and even in an area where we didn't think that computers could do well, the creative industries (Birtchnell & Elliott, 2018). The greater capabilities of these systems will continue to reduce the need for human toil by either enhancing performance or altogether eliminating the human component. It is therefore not surprising that most people consider technological advances beneficial. We ourselves are optimistic about this progress, as it has resulted in better working conditions and has eliminated many dangerous and menial jobs. It has shortened working hours, while also expanding the variety and amount of new products and services [U.S. Department of Health, 1966 #138] {Berman, 2018 #1174}. However, AI also poses challenges for labor because the intention of such efforts is to develop programs that exhibit intelligence "using processes like those used by humans in the same task" (Simon, 1995, p. 96), and thus, we need to determine how to successfully transition workers when they are displaced from their jobs.

lllustrating the negative effects of technological transformation, a 2015 story in *The Atlantic* magazine (Thompson, 2015) described how the closing of the Campbell Works mill in 1977 resulted in the loss of 50,000 jobs and $1.3 billion in manufacturing wages. This, however, was not the worst calamity; the town also experienced increases in

depression, spousal abuse, and suicide. According to (Thompson, 2015) , the caseload of the area's mental health tripled within a decade.

Both agricultural technology and new opportunities in industry moved people into the manufacturing sector and then globalization and automation moved others into the service sector. Today, 80 percent of the U.S. population works in services (BLS, 2017), and AI has advanced to a point where it has started to replace jobs in those areas as well (Frey & Osborne, 2017).

This paper is a historical recollection of the experiences that U.S. society has had with technological innovation. In this effort, we take advantage of the literature on institutional economics to help us understand the way society has transitioned and the forces that have shaped the outcomes. We also look at the computing literature to track the early history of technological development. AI today is the result of a long evolutionary path that has brought with it greater and more powerful capabilities. We are optimistic about the benefits that AI can bring to the economy and the well-being of labor, but we are cautious about how society is to make the transition, as we have not done well with transitions in the past. Many specific people and towns have suffered, even when in the long term society at large benefited.

2. An institutional change framework

The narrative presented here to explain the transition towards an economy that relies more on AI uses the lens of institutional economics, particularly its contributions that explain change. The focus of this paper is historical, describing moments in history when computers and automation changed society as it transitioned from a less to a more technology-driven economy, as AI is doing now.

Institutional economics has two main branches that explain change: the ceremonial and the instrumental. The ceremonial, which is associated with the work of Thorstein Veblen, Clarence Ayres, and J. Fagg Foster (Bush, 1983), is also known as the VAF branch (or VAFB branch after Bush's contribution) (Elsner, 2012). The ceremonial values perspective focuses on the customs and conventions that prevail in a community. It values hierarchies and makes comparisons regarding people and their worth within the community (Bush, 1983). Ceremonial values refer to tradition, authority, and myths that are beyond the scrutiny of scientific inquiry (Elsner, 2012).

The instrumental perspective focuses on a society's processes of inquiry, acquisition of knowledge, and use of scientific inquiry to solve problems (Bush, 1983). These processes are subject to logic and efficiency, and, in the presence of new technological knowledge, the expectation is that behaviors will be scrutinized and adapted (Elsner, 2012).

When external factors affect prevailing institutions, the outcome will depend on how strong/weak the ceremonial values of society are with respect to its instrumental values.

A challenge to any analysis of institutional economics is that societies are composed of heterogeneous groups of players, each of which behaves according to its own rules. The private sector plays by the rules of market-driven institutions, the scientific community is mainly instrumental, while civil society and government have both ceremonial as well as instrumental values. The strength of one type over the other will determine the outcome. The presence of these values generates significant uncertainty for those negatively affected.

In a market context, companies are playing, and in fact are required, to play a prisoner's dilemma-type game. In other words, if a competitor decides to introduce AI to make its operations more efficient, faster, cheaper, and better, one is pushed to do the same to remain viable in the market. The scientific community has a similar instrumental set of values, although in their case, the reward is not money but prestige. Government and society have both instrumental values, which are most visible in the strong belief that they both entertain about the value of education, and ceremonial values, which can be seen in their espousal of individualism, self-reliance, limited government, and abhorrence of welfare programs.

The following sections present evidence of the ways these two forces affected workers during earlier technological transitions.

3. Origins – The instrumental values of the scientific community

We should not think of artificial intelligence as a field that emerged independently from its past. The search to replace/simulate human actions with machines has a long history that predates the invention of computers. Curiosity, imagination, economics, and science have been the drivers behind the quest for the development of a machine that can behave like a human. The earliest manifestations of this desire were best described in a 1950s *Scientific American* article by Walter (1950), where he states, “There is an intense modern interest in machines that imitate life” (p. 42).

The scientific community operates under strong instrumental values that derive not only from the desire to enhance knowledge, but also from a subtle spirit of competition to bring to the market of ideas the newest scientific advances.

It has been more than three-quarters of a century since Alan Turing designed, in 1945, the automatic computing engine (ACE). A smaller machine, known as the *pilot model ACE*, at that time the fastest computer in the world, ran its first program in 1950 with a clock speed of 1 megahertz (Copeland & Proudfoot, 2000). The successor to the pilot ACE was the De Ferranti Mark I, which was, in 1951, the first commercially available computer (Copeland & Proudfoot, 2000). Turing was a pioneer in the field of artificial intelligence. He often talked about machines’ being able to (1) learn from experience

and (2) solve problems by searching through multiple possibilities (Copeland & Proudfoot, 2000). Initial attempts to replace humans were directed at the players of board games. Christopher Strachey, then the schoolmaster at Harrow School in the United Kingdom, wrote a program to play checkers. Soon after, in 1951, a Ferranti Ltd. engineer, Dietrich Prinz, wrote the first chess program (Copeland & Proudfoot, 2000).

From the beginnings of AI, in the early 1950s, scientists formulated different approaches its development. One branch exploited the natural world as models for machines. An example of this effort was the Testudo, an animal-emulating machine with a smooth shell, a protruding neck, and a single eye that scanned the surroundings for a light stimulus. This system, with only six components, was able to generate a new movement pattern every tenth of a second, which prompted those working under this model to argue that all the permutations generated by such a simple system illustrated “the certainty, randomness, free will or independence so strikingly absent in most well-designed machines” (Walter, 1950, p. 44).

Another branch of AI development had a more utilitarian objective: to design a system able to perform a specific task. These efforts began in the late 1940s with experiments led by (Wiener, 1948) to develop systems that could emulate specific human activities, in their case firing a weapon. For this to be feasible, developers needed to design a fire control system, which led them to write software based on feedback. In this effort, the pattern to be followed was compared to the machine’s executed pattern. The difference between them was relayed back into the system to move the machine closer to the

desired outcome. These experiments were also conducted in conjunction with experts in medicine, such as the Mexican physician and physiologist Arturo Rosenblueth. The branch became to be known as cybernetics. In Wiener's (1948) own words:

> After much consideration, we have come to the conclusion that all existing terminology has too heavy a bias to one side or another to serve the future development of the field as well as it should; and as happens so often to scientists, we have been forced to coin at least one artificial neo-Greek expression to fill the gap. We have decided to call the entire field of control and communication theory, whether in the machine or in the animal, by the name *Cybernetics*, which we from the Greek κυβερνητική; or steersman. (p. 19)

Originally, AI did not evolve to replace humans at work, but simply to emulate human behavior. The non-utilitarian approach originated with Turing who, in 1950, proposed a test to determine if a system was convincingly human-like. The "Turing test" entailed the ability of a computer to convince a participant located in a different room that he or she was talking to a human rather than a machine (Nilsson, 2005). However, there were also calls for the field to develop AI with more utilitarian objectives in mind.

A more utilitarian approach was proposed fifty years later by (Nilsson, 2005), who suggested an "employment test" to determine the capabilities of AI to perform ordinary

human jobs. Progress in AI, he stated, can be measured by the proportion of jobs that can be acceptably done by machines.

It is not certain that we may someday be able to replace most human jobs with AI, and there are people who argue that this is not desirable. From an economic perspective, dissenters argue that it will be too costly and that there are many human workers that can perform the work, and from a societal perspective, they argue, people need the work to earn a living and feel fulfilled

Early developments in computers illustrate the instrumental values that prevail in the pursuit of knowledge. Contributions from one scientist are further advanced by others who try different approaches or expand what is known into different domains or cases. There is within communities of scholars a desire to tackle the world's problems to find solutions, but there is also great value in the discovery of new knowledge, regardless of its practical applications. The value system that prevails in universities also involves a certain level of competition in the form of a tenure system that rewards the continual publication of scientific advancements, as well as a competitive funding process that awards grants based on scientific merit.

4. The instrumental values of the private sector and the quest for greater efficiencies

AI research, normally done in academic settings and in industrial computing labs, evolved along different paths. However, these paths began to cross forty years ago. In the 1980s and 1990s, AI research changed to concentrate on amplifying the intelligence of human beings rather than on imitating humans (Proudfoot & Copeland, 2012). This change has been called *weak or narrow AI*. The practical application of narrow AI led to the development of systems for diverse uses, such as in search-and-rescue efforts after a disaster (Blitch, 1996), in the automated identification of diseases such as TB (Shabut et al., 2018), and in the semi-automated supervision of building operations like HVAC work (Kreider, Xing An, Anderson, & Dow, 1992), among others. Because AI-to-replace-work is a relatively recent pursuit compared to the evolution of computers within the private sector, we find it necessary to examine the impact that the evolution of computers had on work when they were introduced into companies, in order to give us a sense of the impact that artificial intelligence can have on the labor market today.

Automation was originally used to describe “the linking together of machine tools into a continuous production line by mechanical devices to load, unload and transfer between machines or between stations in a single machine” (Ashburn, 1962, p. 21) p. 21. This process was known as “Detroit automation” because it was used in the automobile industry, specifically at Ford, which introduced it in 1946. The rest of the manufacturing

sector, however, was moving in the same direction. The General Electric plant in Schenectady, NY introduced conveyor belts to produce electric motors on three automated lines (Ashburn, 1962). In the manufacture of radio and television, the sector moved quickly to printed circuit boards, which were assembled via automation. In lumber yards, boards were segregated by length, width, and thickness by a kind of conveyorized automation. Cigarette manufacturers used automation to make and package their products. The introduction of automatic machines at the Timken Roller Bearing company increased the production of bearings per man fourfold, compared to its previous manufacturing method (Ashburn, 1962).

There were many advantages to the use of computers in manufacturing, in the making of cars, for example. Simply changing the tape or other control input enable a machine to produce many different items in small quantities. The introduction of mechanization to automobile production not only reduced costs, but also allowed management to control the pace of production (Levin & Rumberger, 1983, p. 12). However, the main reason for automation was to reduce labor costs and increase production (Ashburn, 1962). This was necessary from a company perspective, because at the time, the United Automobile Workers (UAW) had secured high wages that reduced profits.

4.1 Transitions and traditions

Ironically, when computing systems were introduced, one of their promises was that they would reduce employee work-time and increase efficiency; however, companies found that the new and complex systems consumed great amounts of labor, particularly

when they failed to work. Computers were subject to many systems problems, as was evident, at the time, in the many lawsuits that companies filed against computer manufacturers. These problems were known as “bugs,” and the process of debugging an automated production line could take weeks, or even months. Employees, thus, had more work than ever. Management spent time on countless phone calls with computer manufacturers to solve problems, and clerical workers spent time re-entering lost data and comparing output against manual records to check for errors, and performing computing functions when the systems were down (Gesmer, 2001).

Even in those early days, change came quickly. In just thirty years, computers underwent multiple generations of development (Butler, 1981). In the early 1950s, they used vacuum tubes and required paper punch cards, with programming done in binary code. In the late 1950s, transistors replaced vacuum tubes, and programming languages like FORTRAN replaced machine language. In the 1970s, third-generation machines formed the data processing infrastructure (Mandell, 1982). An illustration of the speed at which computing was changing is the price reduction predicted by the chip maker Texas Instruments, which announced in 1978 that they expected that the price of “their new 64K dynamic RAM would fall from $55 at introduction, to $38 by the end of 1979, $18 in 1980, $8 in 1983 and $4 in 1985” (Forester, 1981, p. xiv).

At this pace of development, institutions had to evolve fast to accommodate market changes, and the labor force had to undergo a tremendous transformation of their skills. One of the first changes that had to be made, which accommodated both instrumental

and ceremonial values, were changes to the educational system. When computers first entered the private sector, schools were moving from an analog platform, namely paper and pencils, to a digital platform that was foreign to managers.

While the situation was challenging for corporations, labor was enjoying the opportunity to acquire new skills. The installation of the first corporate computers required high skills that were not yet available anywhere in the country. It was a partnership between IBM and Columbia University in 1946 that led to the offering of the first classes in computing. Harvard University in the U.S. and Cambridge University in the UK both installed computer laboratories that led to the granting of the first computer degrees in 1947 and 1953, respectively.

Initial educational gains were gradually lost. James Bright (1958) found that increasing automation after the introduction of mainframes led to an increase in skill levels followed by a sharp decrease, as the degree of mechanization increased. He stated,

> … [T]here was more evidence that automation has reduced the skill requirements of the operating work force, and occasionally of the entire factory force including the maintenance organization ... automated machinery tends to require less operator skill after certain levels of mechanization are achieved. It seems that the average worker will master different jobs more quickly and easily in the use of highly automatic machinery. Many so-called key skill jobs, currently requiring long experience and training, will be reduced to easily learned,

machine-tending jobs (Bright, 1958, pp. 86-87),(as quoted in Levin (Levin & Rumberger, 1983) p.8.

The gradual introduction of machines into manufacturing had a devastating effect on cities like Detroit. At its peak in the 1950s, Dodge Maine employed 35,000 workers in 4.1 million square feet of floor space. In 1979, fewer than 5,000 workers remained (Thomas, 1997). From an industry perspective, the instrumental values of institutional change contributed to the sector's need for automation. Domestic competition and, later, competition from abroad, specifically from smaller and more fuel-efficient cars from Japan, threatened the industry, causing it to restructure and move to less costly locations.

The institutions that prevail in the private sector, from an institutional economics perspective, are entirely instrumental in their thinking; in other words, there is a rational justification for the behavior of manufacturers that is consistent with what is expected of the private sector. Instrumental values manifest in "problem-solving activities upon which the life processes of the community depend" (Bush, 1983, p. 37). "Change … is the consequence of dynamic pressures exerted on the institutional structure by innovations in the arts and sciences" (Bush, 1983, p. 38).

In Detroit, the government's response, as well as that of the population, reflected a completely different set of values that hindered the city's transition towards a more automated future. At a societal level, its institutions exhibited more ceremonial values

related to people's inability to accept greater racial integration and tolerance. The city suffered from years of racial inequality and injustice. There were strong racial divisions between blacks and whites, who refused to work side-by-side (Darden, 2010). In the factories, union members were overwhelmingly white males enjoying greater security than their black and female counterparts, who were rarely unionized and who received low wages and few, if any, benefits (Boyle, 2001). The migration of blacks to the city in the 1940s, seeking jobs in the automobile factories, caused middle-class whites to move to the suburbs, and resulted in the city's urban decline. These ceremonial beliefs made it politically difficult to intervene to improve the situation of negatively affected and otherwise disadvantaged groups.

Response from the government also suffered from ceremonial institutional responses to technological change. In the early 1970s, the city was suffering from poverty, deterioration of its infrastructure, and a stagnant tax base (Thomas, 1997). The introduction of automation and computers in the previous decades exacerbated the civil unrest of the 1960s. On July 22, 1967, the city of Detroit exploded when an enraged crowd responded to a police raid, which resulted in the death of 43 people, 33 of them black. Civil disturbances and continued decline required government action. The response from the Johnson administration was to support the development of six or seven "model cities," but the ceremonial function of government led to the expansion of the number of cities to 150, which would get support from Congress, without their allocating additional funds from the budget. With limited resources, government interventions were less comprehensive and focused primarily on physical infrastructure.

Meanwhile, efforts to address the social suffering were under attack. The Aid to Families with dependent children, for example, lost funding (Thomas, 1997). Citizens complained that the brick-and-mortar focus ignored the true needs of the residents. After 1967, and the ineffective response from the government, the murder rate grew, the drug trade flourished, the quality of the public schools dropped, and the city continued to suffer from urban riots (Thomas, 1997).

A similar situation occurred when automation was introduced into the production of coal. Of course, we cannot attribute the plight of Appalachia solely to technology. It was, in fact, a long process that included not only technology, but also management decisions, legislation, and unions. In 1947, for example, the Taft Hartley Act restricted the activities of labor unions, such as their ability to strike if it endangered the nation's safety (Drake, 2001). (Other factors contribute today to the decline of labor in the mining sector.) As accidents continued to prevail in the 1950s, an agreement was made between the United Mine Workers of America and the Bituminous Coal Operators Association, which aimed to improve miners' working conditions. It established higher wages, certain health benefits, and a welfare fund in exchange for allowing the introduction of technology into the mines. The result was amazing efficiency, but fewer and fewer miners were being employed. Whereas over half a million men went under the Appalachian Mountains to mine coal during World War II, by 1960 less than 150,000 were needed. According to (Drake, 2001), "[T]his agreement set the stage for the human tragedies of the coal fields during the 1950s and 60s brought on by massive technological unemployment" p. 202. More than 50% of miners had lost their job by the mid-1950s.

Unemployed miners found themselves cut off from healthcare, as well as the welfare fund that had been negotiated by the Union. “[T]here was no one in those years to help those caught in this human tragedy” (Drake, 2001, p. 202). For decades, Appalachia has remained depressed, and by any statistical standard it is still among the poorest areas of the country (Drake, 2001).

The instrumental nature of the private sector, coupled with the ceremonial values of society and the mixed values of government, plunged many of the communities affected not only by automation, but also by other external forces, into endemic cycles of poverty, continued urban decay, and crime.

The next section explores the effects of the introduction of smaller and more powerful computers into other sectors of the economy.

5. Labor transitions in the era of the personal computer

The 1980s saw the introduction of personal computers (PCs). This was a period of transition, when greater computer resources became available to the population both at home and at work. Automation then was defined as “the performance by a machine of a work task previously done by a human worker. The key point is that the machine has eliminated the work entirely from the process rather than simply extending the capability of the worker” (Hunt & Hunt, 1986, p. 14).

Because the use of personal computers primarily affected office workers, concerns focused on impact that PCs could have on that sector of the labor force. Hunt and Hunt (1986) defined office automation as the elimination of clerical work tasks through the utilization of capital equipment. Examples of office automation were the replacement of telephone operators by automatic switching and of stenographers by office dictation equipment. Computers were used to determine the appropriate price for an insurance policy, work which had previously been done by raters, and sorting devices eliminated the need for mail clerks (Hunt & Hunt, 1986). However, office automation also expanded human capabilities by providing workers with tools that enabled them to perform more complex tasks.

In the 1980s, the introduction of personal computers by companies produced disappointments reminiscent of those of the earlier mainframe period. There was a “bewildering array of incompatible hardware and software on the market” (Hunt & Hunt, 1986, p. 23) which hindered change. Local area networks that handled communication among workstations, and electronic mail, were limited by the small number of text lines that were allowable, and graphics were not supported. (Forester, 1992) stated that “mass unemployment has not occurred as a result of computerization chiefly because the introduction of computers into the workplace has been slower and messier than expected for a variety financial, and managerial reasons” p. 2. In fact, an increase in employment happened during this period, just as it had with the introduction of mainframes, in both cases due to the frequent failures of these new and complex systems.

As in the mainframe period, there is also evidence of deskilling. Analyses of office industries show that in a variety of areas, automation reduced the need for skills. In the printing industry, for example, skills such as typesetting, press operating, and photoengraving, which required complex craft skills, were easily done by machines (Zimbalist, 1979) as cited in Levin, 1983.

In addition, statistics begin to reveal how PCs and other economic factors were affecting labor. There is evidence that employment was negatively affected, in terms of both the number of full-time jobs, but at this time, wages as well.

Once again, the instrumental values of the private sector pushed companies to introduce equipment that they believed would confer a competitive advantage. “Machinery offers to management the opportunity to do by wholly mechanized means that which it had previously attempted to do by organization and disciplinary means. The fact that many machines may be paced and controlled according to centralized decisions, and that these controls may thus be in the hands of management, removed from the site of production to the office—these technical possibilities are of just as great interest to management as the fact that the machine multiplies the productivity of Labor” (Braverman, 1974), as cited in (Levin & Rumberger, 1983) p. 12. One of the fundamental characteristics of computers is their ability to take over small tasks in increasing numbers.

A report from the Bureau of Labor Statistics predicted that employment would increase by 22 million or 23% between 1978 and 1990. As one may have expected, the growth in high technology jobs placed the industry among the five fastest-growing occupations. These included jobs for data processors, machine mechanics, computer systems analysts, and computer operators. In the 1980s, these fields were expected to increase by over 100%, more than four times the employment growth rate for all other occupations, amounting to approximately 200,000 new jobs (Rosenthal, 1980).

However, even though high technology professions at the time were estimated to grow faster than any other profession, the actual number of jobs was much higher for low-skilled workers like janitors, nurses' aides, sales clerks, cashiers, and waiters. These occupations were expected to create over 600,000 new jobs. Specifically, Levin and Rumberger (1983) stated, "150,000 new jobs for computer programmers are expected to emerge during this 12-year period, a level of growth vastly outpaced by the 800,000 new jobs expected for fast food workers and kitchen helpers" p. 10. In addition, of the twenty high-growth jobs, only three or four would have required more than a high school diploma, and only two, a college degree (teaching and nursing). The Bureau of Labor Statistics also reported that typist, word processor, stenographer, and statistical clerk were declining occupations (Silvestri & Lukasiewicz, 1989). The economy also experienced an increase in involuntary part-time employment, from 17% in 1969 to 21% in 1979 and 29% in 1993. (Partridge, 2003) conducted research on clerical employment in the early 1980s, which coincided with the market introduction of microprocessors. The rationale for the study was that clerical jobs, at the time, were considered among

the most numerous entry opportunities for young workers, disadvantaged workers, and those just entering the labor market.

Income inequality was becoming another problem. In 1999, the Bureau of Labor Statistics estimated that there would be greater opportunities in higher-paying occupations for people with education and other forms of training, while these growing fields would be closed to those with low educational attainment (Silvestri & Lukasiewicz, 1989).

Personal computers have gradually eroded employment. The impact this time, however, may not be as localized as it was with the automation of manufacturing, which affected specific cities. The impact this time will be more generalized, diffuse, and potentially difficult to identify for public policy purposes. This time, the impact has had another negative effect on workers: a wage compression that has kept incomes stagnant or falling. From 1979 to 1990, earnings for low-skill workers declined in real terms (Feenstra & Hanson, 1999). This is not to say that technology is the sole culprit; economies are complex systems. Among other factors is the increasing number of women entering the labor force. In the late 1940s, only 32% of women worked, compared to close to 60% in 1990 (Blaustein, Cohen, Haber, & Upjohn Inst. for Employment Research, 1993). In the early 1980s, the country also suffered a recession, during which unemployment increased to 9.5%, the highest of the entire post-World War II era (Blaustein et al., 1993). There was also significant growth in trade, which led to additional competition and pressures to reduce costs (Tilly, 1991).

The improvement of the labor force through education is an instrumental value of American society. It is clear that new technologies eliminate the need for the skills associated with older technologies and require the learning of new skills. Since the advent of computers, work has been done through a symbolic, as opposed to a physical, interface, one that is conceived to be more complex. It requires people to have the technical skills to conceptualize and manage more abstract processes and to analyze, interpret, and make decisions based on collected data (National Research Council, 1999).

In the United States, The WorkTrend™ 1985 to 1996 Survey reported on workers' mixed feelings about their new reality. Seventy-one percent agreed or strongly agreed that their jobs made good use of their skills and abilities. However, there was a substantial negative trend regarding the extrinsic aspects of work, specifically pay benefits and job security, for all occupational groupings, which dropped from 72% who rated their benefits as good or very good in 1985 to 64% in 1996 (National Research Council, 1999).

By the 1990s, it was already acknowledged that wages were depressed, with inequality increasing significantly (Blackburn, Bloom, & Freeman, 1990). A report from the National Research Council (1999) attributed this to the greater diffusion of computers in the workplace and to skill differentials, as reflected in wages. By the early 1990s, income inequality between college and high school graduates had widened. This was

the result of a greater demand for workers with higher education (Blackburn et al., 1990). Even within occupations, the National Research Council (1999) found increasing wage differentials, between 42% and 79%, which were not associated with educational attainment. The report suggests that “workers may be entering the occupation who perform new skills or tasks not previously integral to the occupation. Second, the nature of the skills or tasks required of workers in the occupation may be changing, with those who can ably perform the newly required skills and tasks earning labor market rewards, and vice versa. Third, there could simply be growing dispersion in the types of workers (differentiated by skills and tasks) in many occupations.” p. 68

Within the context of an institutional analysis, we cannot isolate the impact of technology on work from other factors that affect the way different constituencies organize. The private sector will continue to operate under an instrumental set of values. When PCs were entering the market, the U.S. was also experiencing greater competition from abroad, which contributed to downward pressure on wages, while it increased uncertainty and job instability for workers (National Research Council, 1999).

The actions of government reflect the ceremonial values that prevail in American society, two of which are self-reliance and the desire for small government. In the 1970s, the government created a program that automatically extended benefits for an additional 13 weeks during economic downturns, for people normally entitled to 26 weeks of coverage under unemployment insurance (Hansen, Byers, & Thal, 1990). However at a time when PCs were becoming more pervasive and the economy was

experiencing high levels of unemployment due to the 1981-1982 recession, the Reagan administration decided to cut back the benefits of people who were experiencing economic hardship (Hansen et al., 1990). The government saved a calculated 3.7 billion dollars in fiscal year 1983 due to the reduction of extended benefits to unemployed workers. However, structural economic changes, as well as the 1981-82 recession, did not improve unemployment figures, forcing Congress to pass the Tax Equity and Fiscal Responsibility Act of 1982, which reinstated some unemployment insurance benefits through the Federal Supplemental Compensation Program (FSC), although they were less generous than those that had been cut.

The desire for small government continued through several administrations, including Democratic ones, such as Clinton’s, whose policy was most famously captured in his phrase “the era of big government is over.” He proceeded to enact the Personal Responsibility and Work Opportunity Act of 1996, which aptly exemplifies one of America's core values. This piece of legislation implemented mandatory work requirements and time limits for the recipients of benefits (Haskins, 2007). From the perspective of these authors, such a ceremonial approach to the economy over time has undermined the welfare system through increasing requirements and reductions of benefits, resulting in inequality, stagnant wages, and a greater reliance on credit, and has forced people to work multiple jobs to maintain a basic standard of living.

6. Artificial intelligence and work

Now, on the frontiers of AI, when computers are increasingly able to do what humans do, and better, we may have arrived at a victory for both entities: “man mechanized and machine humanized” (Muri, 2007, p. 4) p. 4 .

AI is on the leading edge of computing evolution. Society today is already benefiting from what is known as *weak AI*. This includes applications such as Apple’s Siri and Google’s Photo Search (Niewiadomski & Anderson, 2016). Compared to these narrow applications, strong AI, also known as *general AI*, offers the possibility of machines’ behaving as if they were intelligent, while also exceeding human capacities. They are expected eventually to exhibit the full range of human cognitive abilities (Niewiadomski & Anderson, 2016). The 2016 Davos World Economic Forum named this technological change the Fourth Industrial Revolution.

AI today, unlike other periods in the evolution of computers, benefits from resources that were not previously available. In the past, computers were connected through slow, narrowband networks, while today bandwidth is large. This gives robots access to cloud platforms that allow them to search and retrieve a vast amount of knowledge residing in networked machines, from which they can learn. This is what James Kuffner called *cloud robotics* (Kuffner, 2010). Similarly, deep learning algorithms allow robots to learn

and generalize associations, taking advantage of large datasets that serve as training platforms for the generation of new knowledge (Pratt, 2015).

AI has benefited from the gradual development of computing, which has continued to evolve. Computer performance has maintained its course of development as forecast by Moore in 1965, today reaching nanometer-size components. Modern mainframe supercomputers can execute trillions of calculations per second (AP, 2013), compared to the 17,000 they were capable of in the 1950s (IBM, NA). Manufacturing machines have also evolved from primitive, massive behemoths to numerically controlled systems that include 3D production, enabling the execution of complex designs at much-reduced costs. The primitive computer communication networks of the past have been replaced with ubiquitous wireless devices that transfer data at much faster speeds and that learn from each other.

According to (Kuffner, 2010), cloud robotics is possible because of connected high-powered computers handling vast amounts of data which individual robots can search, instead of relying on their own data storage, and this accelerates the learning process. High-speed communication not only allows access to data on other machines, but also enables agents to use the processing power of cloud devices. Interconnected robots can take advantage of simulations to generate solutions for scenarios by remembering only those that work. The much more powerful computer processing capabilities of robots today can empower machines to learn from photos and recorded videos of human activity. This can be done much more easily because of the millions of records

that people have posted on social media. As of 2013, users had uploaded one trillion photos, and as of July of 2015, 400 new videos were being uploaded to YouTube every minute (Statista, NA).

With all the promises of AI, there are far more problems yet to be solved, which AI developers should be able to tackle successfully. It is possible that many AI applications will bring with them the same types of installation problems, system bugs, and troubleshooting frustrations that have plagued previous generations of computing. We are thus not so concerned about the short-term effects of the technology on labor as much as about the transitional pain that many people will suffer as these technologies begin to impinge on their work.

One of the major challenges for policymakers and society at large is the fact that, even at times of rapid technological development, organizational change happens at a relatively slower pace. At such times, there is often great enthusiasm about the benefits that technology can bring to society. For instance, one could project that AI will bring tremendous benefits to society in the form of engaging educational experiences that take advantage of learners' unique styles and medicine that can diagnose with greater accuracy all types of illness and then design tailored treatments. However, we have seen that we are slow to respond, time and time again, as we see how the promises of technology, at least initially, are overblown, while in reality they are fraught with problems. Thus, we lower our guard and try to continue with our lives as if nothing is happening.

It wasn't until recently that the introduction of a technology had an immediate impact. Uber and Airbnb negatively affected the taxi and accommodations industries to such a large extent that some cities were forced to either ban, suspend, or implement regulations to alleviate the problems that it was having in these markets.

AI will result in job losses, but there are also forces that generate new jobs. Over time, the aggregate level of employment may not decline and may even grow; however, long-term and aggregate statistics often fail to recognize the painful dislocation and the long-term unemployment of workers who lose their work to automation. The lack of jobs and the financial hardship that it brings to workers can have severe consequences for them and their families. Tangible effects are the deterioration of physical and mental health, which can lead to isolation for fear of criticism and shame. Announcements of plant closings with mass layoffs due to the introduction of new technology can generate great anxiety and resistance.

The challenges to, and effects on, American society can be even greater due to the ceremonial values associated with the notion that welfare creates a social class dependent on public support. This belief from some government representatives and leaders has continued to erode the safety net for people who find themselves unemployed or unable to earn enough income, so that they have to depend on programs such as the Supplemental Nutritional Assistance Program (SNAP).

The American values associated with self-reliance inform government policies that try to reduce the number of recipients of social services. Presidential administrations from Clinton to Trump have moved toward making welfare recipients to work for their benefits. While at the time of this writing there has not been any legislation to reduce benefits or the number of beneficiaries, nor to impose additional requirements, the Trump administration was able to allow states to obtain waivers to impose work requirements on Medicaid recipients (Thrush, 2018).

As in the transitions during the mainframe and PC eras, we risk yet again putting a large segment of the population at risk of being unable to transition successfully to the Fourth Industrial Revolution, the AI Revolution.

7. Implications and recommendations

Given that negative consequences are often forgotten, society undermines the impact of new technologies by stating the oft-quoted “creative destruction argument” that new technologies create at least as many jobs as they eliminate, that the catastrophic forecasts of the past have never come to fruition and that we are just crying wolf yet again. Can we say that this time is different? No, we do not espouse the catastrophic forecasts that others have made and are, in fact, also optimistic about what artificial intelligence will offer. However, the evidence from previous technological (r)evolutions does suggest that transitions can negatively affect thousands of people because we are often distracted by the marvelous new inventions.

It is true that microchips have not suddenly put millions of people out of work, in part because computers in the workplace have been implemented more slowly than expected, as organizations today, as in the past, will continue to face challenges in adapting to new market realities. Regardless, these technologies will continue to erode employment, and competition from AI will put pressure on wages.

The introduction of more sophisticated computing technologies has increased productivity, reduced hazards, improved workers' conditions and society's quality of life, and expanded the range of goods and services that we have at our disposal. It has also generated an explosion of new knowledge available for both education and research. These technologies, however, have had negative effects on certain communities who were unable to transition successfully. From a Schumpeterian perspective, creation happens, but not for the same people who see their lives destroyed as a result of technological advance and of inadequate institutional responses to innovation, along with other socioeconomic factors that might contribute.

The fact that institutions change so slowly, the fact that social conventions, cultural expectations, and government ideologies are often resistant to, and at times unaware of, changing realities, makes us vulnerable to the boiling frog effect, which although proven wrong (Gibbons, 2002) in the case of actual frogs, is still a powerful metaphor that captures our inability to adapt to slowly advancing change. It is particularly apt when change involves hyperbolic growth curves, the implications of which may not be

recognized until after it is too late to mitigate their negative effects. If AI finally reaches a point of inflection where the impact will be suddenly felt, this will cause immediate displacement to many workers and even if it doesn't substantially raise the overall unemployment rate, the impact on salaries from the many people facing competition from AI alternatives could be devastating.

A challenge to any proposed action is that the solution can be slow to be designed, accepted, and eventually implemented. The most common recommendation is for education/training, which coincides with our instrumental values. Education, however, takes time, often years, and those who are displaced do not always have the resources to temporarily replace wages with expensive training. In the 1700s, the workers in Leeds who were being replaced by machines were told to begin to learn another business, to which they responded, " Who will maintain our families, whilst we undertake the arduous task; and when we have learned it, how do we know we shall be any better for all our pains; for by the time we have served our second apprenticeship, another machine may arise, which may take away that business also" (Cloth merchants, 1791). This is truer today, when technology is changing much faster. Levin and Rumberger (1983) suggested that we devote resources to general education requirements that will create good citizens and productive workers. Everyone, they suggest, should have strong analytic, expressive, communicative, and computational skills, as well as an extensive knowledge of political, economic, social, and cultural institutions, because we cannot predict with certainty the types of jobs that will be available for people as they progress in their education. It is best to provide students

with a strong general education and the ability to adapt to a changing work environment. Adaptation requires sufficient knowledge of culture, language, society, and technology, and the ability to apply that information, as well as to acquire new knowledge. The young population should also be prepared with general academic and vocational training over specific training that can be learned on the job. People will not be able to acquire “a set of skills at the beginning of their careers that will be useful for their entire work lives (Levin & Rumberger, 1983, pp. 12, 17).

Any type of state support for those negatively affected, however, directly violates the ceremonial values of society that continue to put the individual ahead of the community and personal responsibility ahead of community responsibility for the welfare of our neighbors, and that put stock in merit but forget about luck. The American Dream includes “a good life for my family” and “financial security” (Ford, 2012), but then our governance institutions fail to alleviate instability and uncertainty through strong and stable health insurance or public support for when adversity strikes.

We do not currently advocate an overhaul of the country’s welfare system, as this will come with tremendous difficulties arising from the polarized political system, the difficulty that society has in changing its cultural values, and the optimism towards technology that will make any conversation about support for those affected difficult for many to hear. We do, nonetheless, believe that small-scale experimentation at the city and state levels can offer valuable experience and data from which larger initiatives can be developed.

Some smaller cities, for example, are now experimenting with a universal basic income, an idea proposed by Thomas Paine in the 1700s (Paine, 1995) and then almost implemented during the Nixon administration in 1969 (Martin, 2016). Today, the only state in the U.S. that has a guaranteed income is Alaska, where, since 1982, every resident has received a dividend from the Alaska Permanent Fund (APF), which draws its revenues from the oil companies operating in the state (Berman, 2018).

Greater health protections need to be put in place, because when workers lose their jobs, they often lose their health insurance. An AI's taking a worker's job away would also take away that person's affordable health coverage. While most private sector businesses operate under an instrumental value system, the health care segment operates under a more ceremonial set of values that prevents price transparency on the part of providers. Changes to make health care universal and more affordable, for example, will be difficult, but this is an area where experimentation at a lower geographical level could be productive.

8. Conclusions

We have yet to determine what effects AI will have on society. Any predictions are likely to be more speculation than fact. Thus, we find that providing a historical recounting of past revolutionary technologies and societal transitions can provide some insight into to what we are likely to encounter as AI becomes more widespread.

History, however, does not help to alert society or government of the painful transitions that occur when significant technological revolutions happen. The well-known Luddite fallacy represents the disdain that optimists exhibit when concerns about the negative effects of technology on employment are being voiced. This hinders potential efforts to design solutions for the negative effects that technological transitions have on people.

We find that both the academic community and the private sector work under an instrumental value system, while society and government work under a more ceremonial institutional framework. Such a disparity in values, we believe, would pose a challenge to any call for action to prepare for the likely negative effects that AI will have on work. Under these circumstances, we recommend considering, first, education and training, as this path of action is consonant with all of the institutional values that prevail in society. There is widespread agreement on the value of enhancing knowledge to prepare people for a more digital-dependent, robot-enhanced world.

Other solutions will be more difficult to implement, given the stronger values espoused in society and government. Because of this, we suggest experimenting at a more local level. Local experiments can generate data and knowledge about promising initiatives and can help with identifying factors that might facilitate or impair their success. We are, however, racing against the clock as the coming inflection point for AI will likely have brutal consequences and the problem is that we don’t know when that will be.

Nonetheless, AI will bring positive changes to society in similar ways that other computing technologies have in the past. The transition is likely to follow the same patterns as well. As AI is not entirely ready for deployment, the transition is likely to start with the pains of implementation, as its initial applications experience failures. This, along with enthusiasm for the technology, will create jobs and a demand for training and education. Over time, as AI improves, it will then enhance, but also replace, work. We will begin to see a greater need for certain professions, but also the decline of others.

In the fight between instrumental and ceremonial values, instrumental values will continue to evolve and propel AI forward. Society, on the other hand, will evolve slowly, and our ability to enjoy the wonders of AI while minimizing the negative effects will depend on our ability to recognize its effects on work and then experiment with ways to alleviate negative effects that come with a high human cost.

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