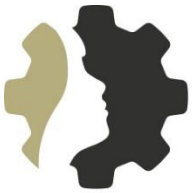

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Preparing for the Coming TIDE: Reflections on the Challenges and Opportunities Automation and AI will bring to the U.S. Workforce

Chapter 1: A Brief History of Technological Revolutions

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Today's rising TIDE of automation is sometimes called the "Fourth Industrial Revolution." As this term indicates, this is far from the first time that humans have experienced a disruptive technological revolution. Several times in the past, human societies in general—and the nature of work in particular—transformed in response to technological leaps.

Many of the tensions and challenges that workers and labor markets face today have been with us for centuries or even millennia. To understand how our society and government might react to rapidly advancing AI and robotics, it very much helps to understand how human societies changed in response to previous technological revolutions and how those revolutions got us to where we are today.

Agricultural Revolution (10,000 BC to 2,000 BC)

Around twelve thousand years ago, humans across world subsisted by gathering seeds and fruits from local flora, just as their human and pre-human ancestors had for millions of years. In the Fertile Crescent, however, small bands of humans were in the process of learning something extraordinary. Over the course of many generations, they figured out how to subsist not merely by hunting animals and being the passive beneficiaries of the abundant cereals, pulses, and flax that grew around them, but by actively raising the animals and cultivating the plants themselves. By 9,000 BC, these Neolithic hunter-gatherers had domesticated pigs, sheep, and eight plants—flax, emmer and einkorn wheat, barley, peas, lentils, chickpeas, and bitter vetch—that provided a stable food source for the humans who cultivated them.

This Agricultural Revolution marked the first radical transformation of how human beings supported themselves and interacted with other members of their community. During the Agricultural Revolution, humans began transitioning from being nomadic hunter-gatherers to settled farmers. The early stages of this transformation were powered by innovations in the production and use of stone tools, including farming-specific tools such as sickles and hoes. The rise of permanent settlements and the professionalization of farming led to further technological

innovations such as fencing, irrigation, ploughs, and granaries, which enabled the inhabitants of settlements to efficiently produce and store even more food.

Eventually, the resulting surplus of food allowed some inhabitants of those settlements to engage in work that went beyond subsistence farming. The resulting *division of labor* marked the earliest appearance of labor markets. Some farmers dropped their ploughs to become bakers, carpenters, metalworkers (leading to the discovery of bronze and, ultimately, iron smelting), and soldiers, and each put considerable time and energy in mastering their craft. Permanent governments formed to manage the increasingly complex societies that resulted.

The brevity of the above description—and the term "Agricultural *Revolution*" itself—is somewhat misleading. These developments did not occur over the course of a few months or years, as in the case of political revolutions, or even over the course of several decades, as with later technological revolutions. Instead, the effects of the Agricultural Revolution took several millennia to unfold before recognizable civil societies began to form. Agriculture first arose in Mesopotamia around 10,000 BC, but the earliest Sumerian city-states did not develop until approximately 5,000 years later and the earliest surviving written laws did not appear until nearly 3,000 years after that. In the interim, agriculture spread from Mesopotamia to North Africa, India, and eventually Europe. Cultures in East Asia, New Guinea, South America, Mesoamerica, and sub-Saharan Africa independently developed their own agricultural societies during these millennia.

As slow as the pace of these changes were, the end result was certainly revolutionary. The basic structure of human societies had permanently changed.

Another innovation—writing—emerged as these early civilizations sought to regulate the more complex societies they were forming. The earliest Mesopotamian writings are, perhaps unsurprisingly, tax records,[1] but the written word soon enabled the development of complex written legal codes. Many of these early written laws focused on regulating paid work and the labor market. Nearly half of Hammurabi's Code, the most extensive Mesopotamian legal code to survive to the present day, addresses contractual relationships, often by explicitly specifying the type and amount of compensation individual workers should receive for completing specific tasks. In this way, Hammurabi's Code fixed the rate of pay for tasks performed by physicians, builders, field workers, tailors, ferryboat drivers, potters, ropemakers, masons, and ox drivers, along with numerous other professionals and artisans.

Two features of Hammurabi's Code and other ancient legal codes are striking to those familiar with today's post-industrial workforce. First, the ancient workforce largely consisted of three groups—(1) workers; (2) subsistence farmers (who rarely merit mention in ancient legal codes); and (3) people who today would be termed independent contractors. While wage employment—that is, the payment of a fixed salary or wage to secure a worker's services for specified intervals of time—certainly existed in antiquity, it was not the dominant form of workforce participation as it is today. Indeed, some ancient writers viewed wage labor as akin to slavery. As Cicero wrote:

[1] A History of World Societies 39.

> Unbecoming to a gentleman, too, and vulgar are the means of livelihood of all hired workmen whom we pay for mere manual labour, not for artistic skill; for in their case the very wage they receive is a pledge of their slavery.[2]

Consequently, ancient legal codes generally mention wage workers only in passing, if at all.

Second, and relatedly, the laws regarding compensation tended to focus on the task performed, rather than the time spent by the worker or artisan completing that task. The Agricultural Revolution thus created labor markets that revolved around "work" rather than around "jobs."

Over time, more complex labor markets developed, although the overall shape of the labor market remained largely unchanged. Ancient Rome was the first civilization known to have government-sanctioned guilds—occupational associations with social and political standing formed to enhance the interests of their members. More guilds formed later in medieval Europe, consisting of artists, lawyers, judges, notaries, physicians, among so many others.

Despite these developments, farming remained by far the most common occupation in the world for the next 12,000 years, until the forces of commercialization and industrialization began to take hold. Indeed, even today, nearly two-thirds of the developing world's rural population—a total of approximately 2 billion people—continue to live and work on small, subsistence-level farms.[3] Put another way, for more than a quarter of the world's population, the Agricultural Revolution remains the most important technological and economic revolution in their daily lives.

Industrial Revolutions (1760 to 1840; 1870-1914)

The term *Industrial Revolution* refers to the era when innovations in manufacturing and mechanization reshaped the face of the workforce and of society as a whole. Historians often speak of two separate Industrial Revolutions. The first began in the mid-to-late eighteenth century in Britain and gradually spread to other European countries and the United States. The pace of industrialization briefly slowed in the mid-1800s but picked up again by 1870, particularly in the United States. This second wave of industrialization—variously referred to as the Second Industrial Revolution or the Technological Revolution—deepened and accelerated the trends of the earlier burst of industrial innovation, as the harnessing of electrical power hastened both urbanization and the transition from agriculture- to manufacturing-based economies.

Throughout both phases of industrialization, people invented machines to perform what were previously manual tasks. The First Industrial Revolution saw the introduction of the locomotive, steam engine, sewing machine, and factory system. Tasks could be completed faster, with less manual labor. Employees paid a fixed wage in cities slowly displaced

[2] 1 M. Tullius Cicero, *De Officiis* § 42 (Walter Miller trans., Harvard University Press, 1913). In keeping with the times, Cicero considered agriculture the best "of all the occupations by which gain is secured." *Id.*
[3] George Rapsomanikis, Food and Agriculture Organization of the United Nations, The economic lives of smallholder farmers 1 (2015).

subsistence farmers in the countryside as the dominant form of labor. The rise of machinery meant that large number of employees often worked in a single factory or warehouse, adding risks to the work place that did not previously exist.

This first wave of industrialization began in Great Britain in what was essentially a legal vacuum in terms of worker protections. The few pre-industrial labor and employment laws that existed primarily protected employers by keeping wages down, preventing the movement of laborers (the sheriff could arrest laborers who moved and bring them back), and preventing alliances of workers (*i.e.*, unionizing). For example, a labor shortage following the Black Death resulted in the English Parliament passing the Statute of Laborers in 1351, which set wages to 1346 levels, prohibited the movement of laborers, required all able bodied men and women to work (or be imprisoned), and inflicted treble damages on lords who paid wages higher than the legal wage.[4] Other statutes supported by middle-class guilds, such as the Statute of Artificers 1563, limited entry into skilled occupations and imposed stiff penalties on persons who engaged in a trade without first completing a lengthy mandatory apprenticeship. The result was labor markets that were closed and resistant to change.

It is hardly a surprise, then, that the rapid technological change of the Industrial Revolution met with fierce resistance from workers whose livelihoods were threatened by this early wave of automation. The most famous resistance came from the Luddites, a group of skilled textile workers who destroyed the machines in the textile factories that threatened to render their hard-earned skills obsolete. Today, "Luddite" is a byword for someone who reflexively opposes technological progress. But history demonstrates that the Luddites as a group had ample reason for concern: most Luddites ultimately saw their occupations (croppers, weavers, hosiers) become obsolete by the mid-19th century and they lacked the education and skills to move into new trades that would allow them to maintain their standard of living. This suggests that the anxieties of today's workers who are vulnerable to technological displacement are hardly misplaced.

The transformative changes that industrialization brought to the American economy, particularly after the American Civil War, soon began putting pressure on a legal system designed to manage a predominantly rural and agricultural society. These pressures intensified as the second wave of industrialization reached its zenith in the late 1800s. By the turn of the century, American workers unhappy with working conditions, long hours, and low wages sought extensive legal protections.

These pressures eventually forced the government to embark on unprecedented interventions into the labor market. On March 4, 1913, President William Howard Taft signed a bill creating what is today the Department of Labor ("DOL").[5] The purpose was "to foster, promote and develop the welfare of working people, to improve their working conditions, and to

[4] Yale Law School, Lillian Goldman Law Library, The Statute of Laborers; 1351, http://avalon.law.yale.edu/medieval/statlab.asp (last visited Feb. 25, 2018).
[5] Judson MacLaury, "A Brief History: The U.S. Department of Labor", https://www.dol.gov/general/aboutdol/history/dolhistoryoxford (last visited Jan. 26, 2018).

enhance their opportunities for profitable employment."[6] Workers' compensation laws came into being around the same time. Maryland was the first state to pass a worker's compensation law that provided financial assistance to an employee injured at work in 1902.[7] The federal government passed the Workmen's Compensation Act of 1916.[8] This statute only applied to federal employees, but dozens of states passed comprehensive workers' compensation laws during the first two decades of the century. By 1940, every state outside the Deep South had a workers' compensation system in place.

The Great Depression sparked another burst of labor laws that imposed new responsibilities on employers. The most significant of these laws was the Fair Labor Standards Act of 1938 ("FLSA"), which addressed the problems of low wages, long work hours, and child labor.[9] Efforts to regulate workplace health and safety came more slowly. While states slowly adopted workplace safety laws over the course of the twentieth century, the federal government did not step in to regulate workplace health and safety in a uniform way until the passage of the Occupational Safety and Health Act of 1970.

Perhaps the most visible effect of industrialization on employer/worker relationships was the rise of labor unions. While guilds for certain skilled tradesmen existed in pre-industrial Britain and the United States, these organizations did not represent unskilled workers. They also focused more on protectionism than workers' rights. In addition, it was unclear whether unions were legal in the United States, a legacy inherited from Britain, which had prohibited workers from conspiring to raise wages or obtain other benefits.

As industrialization marched forward, so did workers' concerns over dangerous and unsanitary work conditions, long hours, and low wages. Inevitably, workers began to seek representation.[10] In the United States, union protections first appeared in the railroad industry and slowly began to gain traction in other industries. Trade unions initially resisted representing general laborers, but their growing ranks soon made that resistance untenable. By the late 1800s, unions representing both skilled and unskilled workers began to form.[11] In 1935, the federal government passed the National Labor Relations Act ("NLRA") giving employees the right to join a labor union and obligating employers to bargain with the union. 29 U.S.C. §151-169. The NLRA also created the National Labor Relations Board and provided the framework for unfair labor practices.

By the start of World War II, American labor markets had reached a state where their dynamics would be familiar to a time-traveler from 2020. While the nature of work and the obligations of employers have continued to evolve over the past three-quarters of a century, the

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[6] *Id*.
[7] Robert Gordon, "Workmen's Compensation Act (1916)", http://www.worldhistory.biz/modern-history/80266-workmen-s-compensation-act-1916.html.
[8] "The Workmen's Compensation Act: Definition and Significance", https://study.com/academy/lesson/the-workingmens-compensation-act-definition-significance.html (last visited Feb. 24, 2018).
[9] *Id*.
[10] *Id*.
[11] *Id*.

landscape that employers face today remains primarily a product of the changes that industrialization spurred.

Digital Revolution (1980-2010)

The most recent technological revolution owes both its name and its progress not so much to the invention of new physical devices, but rather to a new way of thinking about the transmission and storage of information. "Digital" signals can used to represent or transmit data as a sequence of discrete and finite values. These stand in contrast with analog signals, which can take on an infinite number of values within the range of values in which it operates. A familiar example, for those old enough to remember, is the difference between digital and analog radios. A typical digital FM radio tuner can only be set to values between approximately 87.9 and 107.9 MHz in steps of 0.2 MHz; such a digital radio can thus be tuned to 88.5, 88.7, and 88.9 MHz, but they cannot be set to values like 88.6, 88.75, or 88.8825435 MHz. Old-fashioned analog radio tuners, by contrast, operate by turning a knob that could be used to set the tuner to any value between the minimum and maximum frequency of the radio (i.e., 87.9 and 107.9 MHz).

The ability of analog devices to represent information in a way that uses all possible values may seem to give them an inherent advantage over digital technologies, but this comes at the cost of precision and efficiency. Because analog devices must be capable of taking on an infinite number of values, there is no way for analog devices to compress the information that they can represent. Likewise, particularly in settings where a device is operated by imprecise humans, it can be difficult to select the exact desired value using an analog device—a fact familiar to anyone who struggled to turn an analog radio knob to the position that gets the best signal for a particular station.

Moreover, there are many applications where the ability to represent a continuous set of values is of little or no practical use. One reason digital radios eventually displaced analog radios, for example, stems from the fact that if FM radio stations transmit on frequencies that are close to each other, their signals would interfere. As a result, radio stations in the United States operate on a standardized set of frequencies. Because there are no radio stations that transmit at 88.6 or 88.8825435 MHz, there is no practical need for a FM radio that can be set to those values. An analog radio's ability to represent those additional values is entirely wasted. A digital radio does not need to store or represent any information other than the discrete values that radio stations actually operate on, making them more information-efficient than their analog predecessors.

The beginning of the Digital Revolution is often traced to the 1970s, when the first commercially viable microprocessors began to hit the marketplace. Over the following decades, the rise of Information Age technologies often followed a familiar pattern, with major technological innovations bubbling under the surface for several years before exploding into widespread public use. Intel released its revolutionary 4004 microprocessor in 1971, but it wasn't until the launch of the Apple II in 1977 and the IBM personal computer four years later that the era of the personal computer truly began in earnest. The rise of mobile telephones, the Internet, and social media followed a similar pattern, with each technology experiencing several years of niche use before a period of rapid adoption.

The advent of the Information Age has radically transformed many industries. The convenience and ease of access to information on the Internet led an increasing number of businesses and individuals in developed countries to obtain more of their news and information online. This led to a dramatic drop in demand for print media during the 2000s. Proud newspapers like the *Seattle Post-Intelligencer* stopped printing physical broadsheets, while others such as the *Rocky Mountain Press* closed down entirely. The rise of e-commerce dealt a similarly staggering blow to many companies in the retail industry. Across America, once-buzzing shopping malls became empty hulls covered by graffiti as companies closed stores and filed for bankruptcy. Borders, once one of America's largest book retailers with 36,000 employees as recently as 2006, was a victim of both trends and closed its doors permanently in 2011.

At the same time, however, there was a dramatic increase in demand for workers in a variety of once-marginal or nonexistent fields. Demand for computer programmers skyrocketed and companies began hiring large in-house IT staffs, while entirely new jobs emerged in fields such as web design and social media management. The increasing sophistication and falling cost of networking technology also decreased the need for workers to be in the same physical workplace, and the proportion of Americans who worked remotely more than tripled between 1980 and 2010. The newfound practicality of mobile work for many office-based jobs decreased friction in the labor market.

Unlike the Industrial Revolutions that preceded it, the decades since the dawn of the Digital Revolution have not been a period of widespread automation. This lack of correlation between digitization and automation owes itself in part to the fact that our ability to generate data has far exceeded our ability to make sense of it. As a result, the Digital Revolution changed the mode and medium through which work was performed more than it changed the fundamental nature of work itself. That, in turn, meant that the Digital Revolution did not generate a sea change in labor and employment law similar to the one that accompanied the Industrial Revolutions.

In a narrow sense, the Digital Revolution was complete by 2010, by which time 99% of the world's data storage capacity came in digital formats, a complete reversal of the state of affairs that had prevailed just 25 years earlier, when 99% of the world's information capacity was still in analog form. But in a broader sense, the revolution is very much ongoing, as we continue to look for ways to leverage the advances in computation and data science that are the hallmarks of the Information Age. The technologies that promise to do this—particularly artificial intelligence and robotics—will form the backbone of the next technological revolution.