Building Better Jobs in an Age of Intelligent Machines

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MIT Task Force on the Work of the Future

The MIT Task Force on the Work of the Future launched by MIT President Reif in 2018

1. How are emerging technologies changing the nature of human work and the skills required?

2. How we can design and leverage technological innovations for the benefit of everyone in society?

The Task Force comprised

~20 faculty members from across all five schools
~20 graduate students
~34 person Advisory Board and Research Advisory Board
The Work of the Future:
Building Better Jobs in an Age of Intelligent Machines

2020

Don’t Fear the Robots, and Other Lessons From a Study of the Digital Economy

A task force assembled by M.I.T. examined how technology has changed, and will change, the work force.
I. Economic Context
After a Century of Automation, Why Are There Still So Many Jobs?

Employment to Population Ratio of U.S. Adults, 1890 - 2015

The prospect of mass unemployment runs contrary to the evidence. Even as technological advances have made life longer, more comfortable, and more interesting, it has generally led to net job creation rather than net job destruction. How do we know this to be true? Figure 1 shows that the fraction of U.S. adults working in paid employment rose steeply throughout the 20th century.

If automation (or its predecessor, mechanization) tends to render human labor redundant, then paid employment would not have risen persistently over the most technologically innovative century in human history. Indeed, in the economic research on automation and employment, no rigorous evidence suggests that automation has caused aggregate employment to fall over a sustained time period.

Moreover, even as concern about technological unemployment has risen in recent years, the industrialized world has seen sustained rapid employment growth.

If automation "saves labor," why does it not reduce total employment? While this question lacks a definitive answer, it is certain that even as technological advances displace human labor from some tasks, they spur three other forces that generate new work. First, automation makes workers more productive in the tasks that are not automated: roofers wield pneumatic nail guns to hang shingles; doctors deploy portfolios of tests to make diagnoses; architects rapidly render designs; teachers deliver lessons through telepresence; filmmakers use computer graphics to simulate unworldly action sequences; and long-haul truck drivers upload their route parameters to cloud-based dispatching platforms to ensure that they never ride with an empty load. In each of these instances, automation of a subset of tasks augments the productivity of workers accomplishing larger objectives by vastly increasing their efficiency.

Source: Blau, Francine D, and Anne E Winkler. The Economics of Women, Men, and Work. 8th ed. New York: Oxford University Press, 2018, Table 5.1
Distribution of Jobs in 1940

- Farm & mining: 18%
- Health svcs: 0%
- Personal svcs: 8%
- Cleaning & protective svcs: 4%
- Construction: 6%
- Transportation: 6%
- Production: 27%
- Clerical & admin: 8%
- Sales: 8%
- Technicians: 1%
- Professionals: 7%
- Managers: 8%
Distribution of Jobs in 1940 and 2018

1940

- Farm & mining: 18%
- Health svcs: 1%
- Personal svcs: 3%
- Cleaning & protective svcs: 4%
- Construction: 5%
- Transportation: 6%
- Production: 7%
- Clerical & admin: 6%
- Sales: 8%
- Technicians: 4%
- Professionals: 7%
- Managers: 8%

1980

- Farm & mining: 5%
- Health svcs: 0%
- Personal svcs: 3%
- Cleaning & protective svcs: 8%
- Construction: 9%
- Transportation: 6%
- Production: 13%
- Clerical & admin: 8%
- Sales: 8%
- Technicians: 1%
- Professionals: 4%
- Managers: 22%
More Than $2/3^{rd}$s of 2018 Jobs Had Not Yet Been Invented in 1940

Autor, Salomons, and Seegmiller 2020
Examples of New Occupations Added to the U.S. Census Between 1920 and 2018

<table>
<thead>
<tr>
<th>YEAR</th>
<th>EXAMPLE TITLES ADDED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>Automatic welding machine operator</td>
</tr>
<tr>
<td>1950</td>
<td>Airplane designer</td>
</tr>
<tr>
<td>1960</td>
<td>Textile chemist</td>
</tr>
<tr>
<td>1970</td>
<td>Engineer computer application</td>
</tr>
<tr>
<td>1980</td>
<td>Controller, remotely piloted vehicle</td>
</tr>
<tr>
<td>1990</td>
<td>Certified medical technician</td>
</tr>
<tr>
<td>2000</td>
<td>Artificial intelligence specialist</td>
</tr>
<tr>
<td>2010</td>
<td>Wind turbine technician</td>
</tr>
<tr>
<td>2018</td>
<td>Pediatric vascular surgeon</td>
</tr>
</tbody>
</table>

Source: Autor, Salomons, and Seegmiller, 2020
The U.S. Has Gotten Much More Productive since 1975, but Most Workers Have Benefited Little

U.S. Productivity and Compensation Growth, 1948 – 2018

Today's concerns originate in what happened after 1980. As compared to the earlier period, earnings growth in the past 40 years has been slow, sporadic, and unequal. Between 1948 and 1978, U.S. total output per hour of work rose by 108%, as shown in Figure 4, an annual growth rate of 2.4%. During the same period, average compensation of production and non-supervisory workers (a stand-in for the median since median wages are not available for this period) rose in near lock-step, increasing by 95%. By contrast, in the subsequent four decades, between 1978 and 2016, aggregate productivity rose by a further 66% (an annual growth rate of 1.3%), while production and nonsupervisory compensation rose by a mere 10% and median compensation rose by 9%. This growing gulf between rising productivity and stagnating median wages is often referred to as "the great divergence."

Within this "great divergence" lurk further disparities of race and gender. In this period, white men and white women notched the bulk of the modest median wage growth (see Figure 5). Specifically, the median hourly wages of white men rose by 7% while those among Black and Hispanic men rose by only 1% and 3%, respectively. And among women, median hourly wages rose by 42% among white women, relative to only 25% and 26% among Black and Hispanic women, respectively.

Reported changes in "real" wage levels should be viewed as approximate; it is not possible to capture all changes in living standards across decades using a single cost of living index. Indeed, the true purchasing power of the median worker has likely risen faster than these numbers suggest, which also means that productivity likely rose faster than...
What Are the Causes?

1. **Technology**: Digitalization of work made highly-educated workers more productive, made less-educated workers easier to replace with machinery.

Changes in Employment in Low, Medium, & High Paying Occupations

Figure 6. Employment Growth Has Polarized Between High- and Low-Paid Occupations

CHANGES IN OCCUPATIONAL EMPLOYMENT SHARES AMONG WORKING/AGE ADULTS, 1980–2015

Figure is constructed using U.S. Census of Population data for 1980, 1990, and 2000, and pooled American Community (ACS) data for years 2014 through 2016, sourced from IPUMS (Ruggles et al., 2018). Sample includes working-age adults ages 16–64 excluding those in the military. Occupational classifications are harmonized across decades using the classification scheme developed by Dorn (2009).

Figure 7. Low-Skill Workers in the U.S. Receive Lower Pay Than in Other Industrialized Countries

PPP ADJUSTED GROSS HOURLY EARNINGS OF LOW-SKILL WORKERS IN THE U.S. AND OTHER OECD NATIONS

Source: https://stats.oecd.org/Index.aspx?QueryId=82334

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What Are the Causes?

1. **Technology**: Digitalization of work made highly-educated workers more productive, made less-educated workers easier to replace with machinery.

2. **Globalization**: Trade has been a huge positive for world welfare but has placed pressure on manufacturing jobs and manufacturing-intensive communities.

Manufacturing employment, as a percent of US population ages 18-64

CHINA TRADE SHOCK

US import penetration in manufacturing by China

1982 Chinese reforms accelerate
1995
2000
2005
2010

2001 China joins the WTO

2007 - 2009 The Great Recession
What Are the Causes?

1. **Technology**: Digitalization of work made highly-educated workers more productive, made less-educated workers easier to replace with machinery.

2. **Globalization**: Trade has been a huge positive for world welfare but has placed pressure on manufacturing jobs and manufacturing-intensive communities.

3. **Institutions**: Weakened labor unions, historically low minimum wage, and outdated employment regulations have harmed rank and file workers.
Less-Educated Workers in the U.S. Receive Lower Pay Than in Other Industrialized Countries

Purchasing Power-Adjusted Hourly Earnings of Low-Education Workers in 2015

<table>
<thead>
<tr>
<th>Country</th>
<th>Earnings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mexico</td>
<td>$3.68</td>
</tr>
<tr>
<td>Chile</td>
<td>$4.02</td>
</tr>
<tr>
<td>Hungary</td>
<td>$4.82</td>
</tr>
<tr>
<td>Slovak Republic</td>
<td>$6.28</td>
</tr>
<tr>
<td>Korea</td>
<td>$6.30</td>
</tr>
<tr>
<td>Greece</td>
<td>$6.49</td>
</tr>
<tr>
<td>Portugal</td>
<td>$6.49</td>
</tr>
<tr>
<td>United States</td>
<td>$6.90</td>
</tr>
<tr>
<td>Japan</td>
<td>$10.33</td>
</tr>
<tr>
<td>Ireland</td>
<td>$12.19</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>$12.59</td>
</tr>
<tr>
<td>Canada</td>
<td>$13.18</td>
</tr>
<tr>
<td>Austria</td>
<td>$14.01</td>
</tr>
<tr>
<td>Iceland</td>
<td>$15.38</td>
</tr>
<tr>
<td>Finland</td>
<td>$16.74</td>
</tr>
<tr>
<td>Australia</td>
<td>$17.39</td>
</tr>
<tr>
<td>Germany</td>
<td>$17.71</td>
</tr>
<tr>
<td>Norway</td>
<td>$18.18</td>
</tr>
<tr>
<td>Denmark</td>
<td>$20.97</td>
</tr>
<tr>
<td>Belgium</td>
<td>$24.28</td>
</tr>
<tr>
<td>United States</td>
<td>$25.33</td>
</tr>
</tbody>
</table>

Source: https://stats.oecd.org/Index.aspx?QueryId=82334

2020 Final Report
China’s admission to the World Trade Organization in 2001 spurred the loss of at least 1 million U.S. manufacturing jobs during the first decade of the 2000s, and that number is larger still if one includes the impacts outside of manufacturing. In the U.S., these job losses were highly concentrated in local labor markets, many in the South Atlantic and South Central regions of the U.S. In these trade-exposed labor markets, the China trade shock generated sustained adverse impacts on employment rates, household incomes, and other measures of population distress. It further contributed to political polarization that is currently playing out at all levels of U.S. politics.

Thus, although China's emergence as a global economic power was driven by domestic developments within China, the speed and magnitude of the China trade shock on U.S. labor markets was, unlike the impacts of digitalization, a direct outgrowth of U.S. policy. Similar pressures from digitalization and globalization affected most industrialized countries. What sets the United States apart? U.S.-specific institutional changes and policy choices failed to blunt—and in some cases magnified—the consequences of these pressures on the U.S. labor market:

1. First, the capacity of rank-and-file workers to bargain for wage growth to match productivity growth was hobbled by a steep, sustained fall in union representation. Between 1979 and 2017, the fraction of U.S. workers covered by collective bargaining agreements fell from 26% to 12%. And this fall was even steeper in the private sector: from 21% of workers in 1979 to 6% in 2019 (Figure 13).
High Inequality and Low Taxes Do Not Predict Faster Growth

Average GDP Growth Rate 1960 – 2011 vs. GDP per Capita in 1960

Figure 12. Countries That Were Wealthier in 1960 Grew Less Rapidly Over the Next Four Decades

Sources: Feenstra et al. (2015); Penn World Tables 9.1, Population (Gapminder, HYDE (2016) & UN (2019))
II. Technological Context

The Momentous Impacts of Technological Change are Unfolding Gradually
Autonomous Vehicles: Significant Uncertainty Related to AV technology

- **Waymo**
  - Self-driving taxi trials in Phoenix

- **Uber**
  - Trials restarted after accident

- **Honda, Volkswagen, Toyota**
  - Highway driving

- **Fiat-Chrysler Nissan-Renault**
  - Fully driverless

- **GM (Cruise)**
  - Commercial ride-hailing service

- **Tesla**
  - “Significantly better than humans”

- **Most OEMs**
  - Fully driverless
Shaken by hype, self-driving leaders adopt new strategy: Shutting up

OCTOBER 18, 2018

Three former executives at Google, Tesla and Uber who once raced to be the first to develop self-driving cars have adopted a new strategy: Slow down. And shut up.
AVs Estimated to Displace 1.3 – 2.3m U.S. Workers

- Biggest shocks at least 20 years out, size similar to recent China trade shock
- Regional disparities – esp. hard on South
- Potential increase in workers’ commuting range—OR increased congestion, collapse of public transit
Additive Manufacturing has Transformative Potential
The Momentous Impacts of Technological Change are Unfolding Gradually

1. Autonomous vehicles
2. Industrial robotics
3. Intelligent supply chains
4. Additive manufacturing
5. Artificial intelligence
The Momentous Impacts of Technological Change are Unfolding Gradually

1. The largest labor-market effects of technology we’re seeing still stem from maturing Information Technologies – Internet, mobile computing, E-commerce, electronic health records (EHR)

2. Artificial Intelligence and robotic applications take years (sometimes decades) to develop and deploy, especially into safety- and production-critical applications

3. We can see glimpses of the future today. It will take time to fully distribute. This time window offers opportunity
III. The Work of the Future
Institutional Innovation  
Must Complement Technological Innovation

1. Invest and innovate in skills and training

2. Ensure productivity gains translate into better quality jobs

3. Expand and shape innovation
The Work of the Future is Ours to Invent

1. There is a palpable fear of the future – a consequence of divergence between innovation and labor market opportunity

2. If we deploy new technologies into existing labor systems, we will get the same problematic results

3. We should reject false tradeoffs between economic growth and strong labor markets

4. The majority of today’s jobs had yet to be invented a century ago. The job of the present is to build the work of the future