

# THE MACROECONOMICS OF AI AND THE DIGITAL ECONOMY

How AI-related technologies will significantly reshape the macroeconomy?



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## ABSTRACT

AI-related technologies will profoundly transform the macroeconomy, including the content of work, the distribution of income between labor and capital, the inequalities of income and wealth across households, and the rate of growth of aggregate GDP and labor productivity. There is, as yet, no empirical multi-sector, general equilibrium model of the US or other major economy to assess the impacts of AI across sectors and over time. Given the scale of the macroeconomic disruptions that lie ahead, such empirical modeling is a major research priority. Future reports of the AI Task Force on the Macroeconomy will aim to quantify macroeconomic pathways for the US and developing countries in an AI-empowered world economy.

## THE MACROECONOMICS OF AI AND THE DIGITAL ECONOMY

The digital revolution – including AI, advanced computation, the Internet, 5G, mobile connectivity, low Earth-orbital satellites, robotics, and related technologies – is fundamentally transforming the world economy, and at an accelerating rate. While advances in Information and Communications Technologies (ICTs) have been transforming the macroeconomy for decades, recent breakthroughs in AI, robotics, quantum computation, and other areas, will dramatically increase the pace, scope, and depth of structural change. The macroeconomic implications of AI, robotics, and associated technologies will be enormous, but are still poorly studied and inadequately assessed. This paper will offer a brief qualitative overview of the macroeconomic changes that will result from AI. A detailed and accurate quantitative assessment is not yet possible, since neither academic researchers nor governments have as yet carried out the necessary technical modeling.

Most reports by business consultants anticipate enormous macroeconomic effects of AI. These reports, as discussed below, expect that a large proportion of current work activities will be replaced by AI systems in the coming two to three decades. McKinsey & Company (2023)<sup>1</sup> identifies four major areas where generative AI will deeply transform business: customer operations, marketing and sales, software engineering, and R&D. According to McKinsey's estimates, "Current generative AI and other technologies have the potential to automate work activities that absorb 60 to 70 percent of employees' time today." Such massive change is likely to depress the wages of many workers, cause widespread unemployment or early retirement, call for significant public investments in job retraining and income redistribution.

There are, at the same time, some skeptics, including the 2024 Nobel laureate Daron Acemoglu, who recently wrote:

Using existing estimates on exposure to AI and productivity improvements at the task level, these macroeconomic effects appear

nontrivial but modest—no more than a 0.66% increase in total factor productivity (TFP) over 10 years. The paper then argues that even these estimates could be exaggerated, because early evidence is from easy-to-learn tasks, whereas some of the future effects will come from hard-to-learn tasks, where there are many context-dependent factors affecting decision-making and no objective outcome measures from which to learn successful performance. Consequently, predicted TFP gains over the next 10 years are even more modest and are predicted to be less than 0.53%. (Acemoglu, 2024)<sup>2</sup> See also *The Economist* (2023)<sup>3</sup> for a view that the effects of AI will be largely benign or positive for workers, so not much to worry about.

I largely concur with the business view that AI-related technologies will profoundly transform the macroeconomy, including the content of work, the distribution of income between labor and capital, the inequalities of income and wealth across households, and the rate of growth of aggregate GDP and labor productivity. Moreover, while the changes ahead will create large winners – including significant parts of the workforce, the owners of financial capital, and the owners of intellectual property – the changes are also likely to immiserize large parts of society as well, at least on a pre-tax-and-transfer basis. Those who will be hard hit include lesser-skilled workers and households without financial wealth.

There are two main reasons that I hold this view. First, the ICTs have already profoundly transformed the economy, so it is highly plausible that recent advances, which are at least as significant as previous breakthroughs, will have enormous effects in the future. Second, we see that the latest advances in AI, notably in deep learning, are already profoundly transforming science, technology, and the economy. Consider that both the 2024 Nobel Prizes in chemistry and physics both went to AI pioneers. Consider that the richest people in the world, with trillions of dollars of net worth, are the owners of the new technologies.

{1} McKinsey & Company (2023), "The Economic Potential of Generative AI," June, <https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-economic-potential-of-generative-ai-the-next-productivity-frontier#business-value>

{2} Acemoglu, D. (2024). "The Simple Macroeconomics of AI," Massachusetts Institute of Technology April 5, 2024

{3} *The Economist* (2023). "Blue-Collar Bonanza: Why Conventional Wisdom on Inequality is Wrong," December 2023. <https://www.economist.com/mist.com/weeklyedition/2023-12-02>.

## MACROECONOMIC CONSEQUENCES OF GENERAL PURPOSE TECHNOLOGIES

General purpose technologies (GPTs) are fundamental technologies that transform every sector of the economy (Bresnahan and Trajtenberg, 1995)<sup>4</sup>. The Industrial Revolution was triggered by the steam engine, perhaps the most transformative GPT in modern history, though the take-up of steam power was gradual and the peak macroeconomic effects were in the second half of the 19th century (Craft, 2004)<sup>5</sup>. The steam engine and related technologies that followed (the notably the internal combustion engine, electric motor, and gas turbine) ultimately freed the economy from the “organic constraint” of energy of the pre-fossil-fuel age, that is, mainly the energy of animal traction and human labor. The steam engine fundamentally transformed life on a planetary scale by the end of the 19th century. The modern steam engine not only gave rise to modern factory production, an industrialized military, the railroad, the steamship, and a vast increase in global food production made possible by advances in transport and the mechanization of agriculture. In turn, these economic changes gave rise to fundamental changes in social life, including vast increases in global wealth, new forms of class conflict, soaring rates of urbanization, the emergence of mass literacy in parts of the world, unprecedented population growth, large-scale global migration, imperialism backed by the power of industrialized armies, and much more.

Economists generally identify five main GPTs since the start of the industrial revolution: (1) the modern Watt steam engine (introduced in the 1770s and gradually introduced across the economy in the following decades); (2) the age of electrification, beginning with telegraphy (introduced in the 1840s); (3) the internal combustion engine (introduced in the 1870s); (4) information and communications technologies (introduced in the 1930s); and (5) digital technologies and artificial intelligence (introduced in the 1970s).

These GPTs not only transformed business enterprises and the content of work, but also the size and organization of our cities; the scope of government; the distribution of work between primary (commodity), secondary (industrial), and tertiary (service) sectors; the economic returns to education; the distribution of income between

capital and labor; the household distribution of income and wealth; demographic patterns (fertility, mortality, life expectancy, population growth); and the allocation of time across work, commuting, household chores, schooling, leisure, retirement, shopping, and other activities.

Consider three fundamental macroeconomic changes due to GPTs. First, the mechanization of agriculture after 1850 led to a decisive decline in the proportion of employment in farming, falling from more than 60% of US employment in 1850 to under 20% in 1950 to less than 1% of US employment today. The mere 0.8% of US workers in agriculture today not only produce the basic foodstuffs for the remaining 99% of the US population, but also a significant surplus for export to the rest of the world! Second, as the share of employment in agriculture plummeted, households moved from rural villages and towns to urban areas. The rate of urbanization in the United States was a mere 15.4% in 1850, but soared to 64% in 1950. Today, with just 1% of the US employment in agriculture, the US urbanization rate has reached 80%. The trend to urbanization is of course worldwide, and will include around 70% of the world population by 2050.

Third, the shift from rural areas to urban areas contributed to the demographic shift from high to low fertility. In 1850, the total fertility rate (TFR) was around 5.8, meaning that as a statistical average, each woman would have 5.8 children during her lifetime. By 1950, the TFR had declined to 3.0. By 2020, the TFR stood at just 1.8, below the replacement rate of slightly above 2.0. Many societal and economic changes contributed to the decline in TFR, a pattern that is also characteristic of all countries in economic development, yet the shift from farm work to urban work was surely a fundamental cause. In pre-industrial societies, children were viewed as net economic assets, since they performed economically useful farm chores from a young age. Schooling was limited and adolescents joined the full-time workforce. With the shift of households to cities, children became costly. In the urban setting, they generally do not contribute to household income and instead impose a high cost on parents during the years of schooling. The technology-induced shift from rural to urban livelihoods therefore contributed to profound changes in demography as well as economy.

{4} Bresnahan, T. F., & Trajtenberg, M. (1995). General purpose technologies 'Engines of growth'? *Journal of Econometrics*, 65(1), 83-108

{5} Crafts, N. (2004). Steam as a general-purpose technology: A growth accounting perspective. *The Economic Journal*, 114(495), 338-351

## MACROECONOMIC PATTERNS OBSERVED DURING THE ICT REVOLUTION

The ICT revolution is 90 years old. It's beginning can plausibly be dated to 1936, with Alan Turing's introduction of the concept of the Turing Machine, an imagined device that uses algorithms to perform complex computations, and which laid the intellectual framework for the computer age to follow. The first robot (defined as an autonomous, programmable machine with moving parts) is dated to 1937. In 1945, John von Neumann designed first computer architecture for a stored-program computer, building on Turing's work. The von Neumann architecture was put to work in the first mainframe computers (ENIAC and UNIVAC) in the mid-1940s. In 1947, the discovery of the transistor at Bell Labs made possible the digital age. In 1948, Claude Shannon at MIT unveiled his information theory, which became a fundamental pillar of digital connectivity. In 1954, a key patent was filed for autonomous, programmable industrial robots. In 1959, the integrated circuit was first created, another fundamental building block in the design and construction of modern computers. With the arrival of integrated circuitry, Moore's Law commenced and has continued to this day, an approximate doubling of computer power every 18-24 months. The Internet was born in 1969 as ARPANET, connecting computers at UCLA and Stanford. In 1971, Intel introduced the first microprocessor, and the age of personal computers took off. The first mobile phone prototype was unveiled in 1973. In 1974, the TCP/IP protocol was rolled out. The World Wide Web was invented in 1991. Apple unveiled the iPhone in 2007, revolutionizing smartphone technology. Deep neural networks were implemented during the 2010s, leading to ChatGPT and publicly available large language models (LLMs) beginning in 2022.

These mutually reinforcing advances have given rise to a 21st century economy built on advanced computation, digital connectivity, and artificial intelligence. The ICT inventions first began to make a deep impact on the US

macroeconomy deeply in the 1960s. The most notable advances were seen in the automation of industrial tasks, producing a sharp rise in labor productivity in manufacturing and a sharp decline in manufacturing employment. The decline in manufacturing employment followed by roughly 75 years the decline in employment in agriculture, and for the same reason: the shift from human labor to machines. Sociologists by the 1960s were already speaking of a "post-industrial" society as jobs began to shift decisively the service sector. In fact, manufacturing value added did not decline; manufacturing employment did.

The macroeconomic implications of ICTs, including AI, Robotics, and other expert systems, have by now generated a substantial theoretical literature in academic economics. The main focus has been on the extent to which the ICTs are complements of labor, and hence raise the marginal productivity of labor and wages, or are substitutes of labor, and hence lower the marginal productivity of labor and wages. The general point has been the ICTs have generally been complements for skilled labor and substitutes for unskilled labor. This is partly because unskilled labor is mostly involved in repetitive actions that can be mechanized, while skilled labor is generally involved in cognitive activities that until recently could not be mechanized. The theoretical result is the reduction of earnings of low-skilled workers, the rise in earnings of high-skilled workers, and the greater share of capital income in national income, as machines replace (some workers). See for example, Acemoglu and Restrepo (2018)<sup>6</sup>, Acemoglu (2024)<sup>2</sup>, Benzell, Kotlikoff, LaGarda, and Sachs (2015)<sup>7</sup>, Berg, Buffie, and Zanna (2018)<sup>8</sup>, Frey, Benedikt, and Osborne (2017)<sup>9</sup>, Hémous and Olsen (2022)<sup>10</sup>, Korinek, Schindler, and Stiglitz (2021)<sup>11</sup>, and Sachs, Benzell, and Lagarda, G. (2018)<sup>12</sup>.

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[6] Acemoglu, D., and Restrepo, P. (2018). The Race between Man and Machine: Implications of Technology for Growth, Factor Shares, and Employment. *American Economic Review* 108(6): 1488-142.

[7] Benzell, S. G., Kotlikoff, L. J., LaGarda, G., & Sachs, J. D. (2015). Robots are us: Some economics of human replacement (NBER Working Paper No. 20941). National Bureau of Economic Research.

[8] Berg, A., Buffie, E., and Zanna L.-F. (2018). "Should We Fear the Robot Revolution? (The Correct Answer is Yes)," IMF Working Paper, May

[9] Frey, Carl Benedikt, and Michael A Osborne, 2017, "The future of employment: how susceptible are jobs to computerisation?" *Technological Forecasting and Social Change*, Vol. 114, pp. 254-280.

[10] Hémous, D., & Olsen, M. (2022). The Rise of the Machines: Automation, Horizontal Innovation, and Income Inequality. *American Economic Journal: Macroeconomics*, 14(1), 179-223.

## There have been five main empirical macroeconomic implications of the ICT revolution, occurring mainly during the sixty years from 1960 to 2020. These are:

1. A fall in the share of national income accruing to labor and a corresponding rise in the share of national accruing to capital (Figure 1). In 1970, the share of wage compensation in domestic income was 51.6 percent. In 2020, it had declined to 44.5 percent

(Karabarbounis and Neiman, 2014)<sup>13</sup>

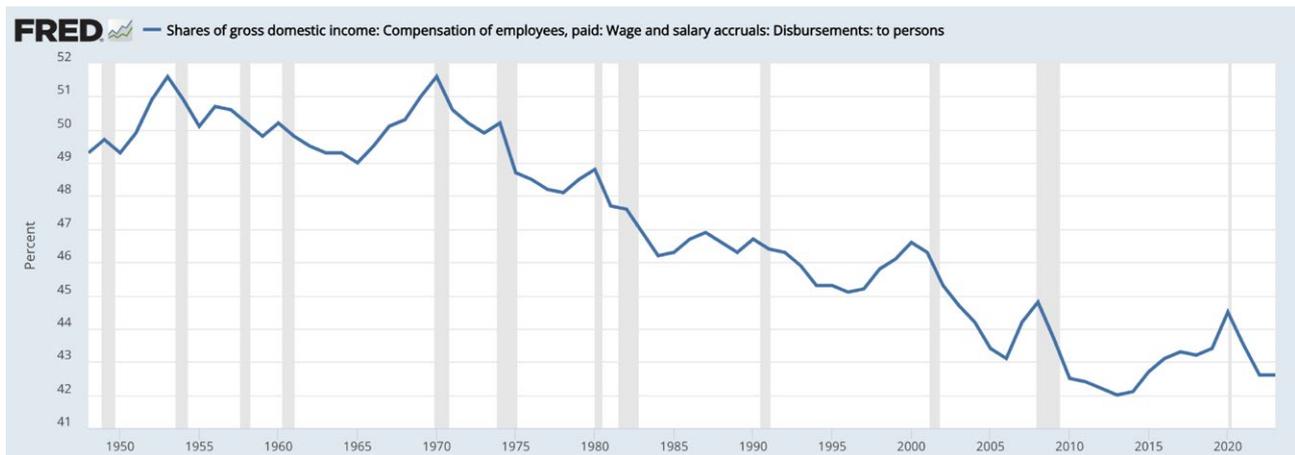


Figure 1. Share of Compensation of Employees in Gross Domestic Income, Federal Reserve of St. Louis

2. Decline in the relative wages of workers displaced by automation, notably workers with a high-school diploma or less, compared with rise in the real wage of college degree holders, 1979-2019 (Figure 2). According to Acemoglu and Restrepo (2022)<sup>14</sup>, “between 50% and 70% of changes in the U.S. wage structure over the last four decades are accounted for by relative wage declines of worker groups specialized in routine tasks in industries experiencing rapid automation.”

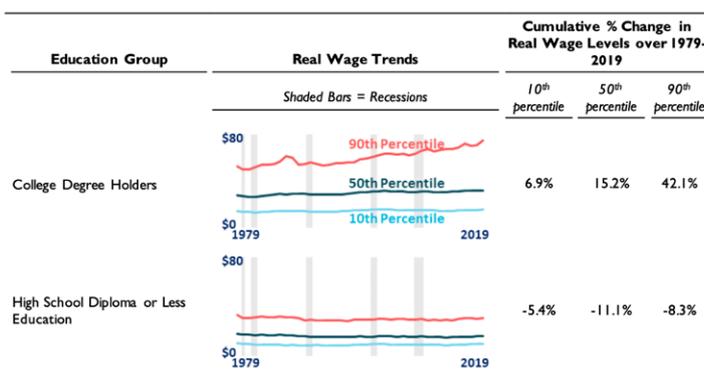


Figure 2. Wage Trends by Education Level (Pew Research)

<https://sgp.fas.org/crs/misc/R45090.pdf>

Sources: CRS estimates using Current Population Survey Outgoing Rotation Group data for 1979-2019. Recession data (in gray) are from the National Bureau of Economic Research, at <http://www.nber.org/cycles.html>.

Notes: Sample comprises nonfarm wage and salary workers who are 25-64 years old and provide sufficient information to compute an hourly wage. Periods of recession are shaded in gray. Dollar amounts are adjusted for inflation using the CPI-U.

[11] Korinek, A., M. Schindler, and J. E. Stiglitz. (2021). “Technological Progress, Artificial Intelligence, and Inclusive Growth.” IMF Working Paper. No. 2021/166. <https://www.imf.org/en/Publications/WP/Issues/2021/06/11/Technological-Progress-Artificial-Intelligence-and-Inclusive-Growth-460695>.

[12] Sachs, J.D., Benzell, S.G., Lagarda, G. (2018). A One-Sector Model of Robotic Immiserization. In: Pupillo, L., Noam, E., Waverman, L. (eds) Digitized Labor. Palgrave Macmillan, Cham. [https://doi.org/10.1007/978-3-319-78420-5\\_3](https://doi.org/10.1007/978-3-319-78420-5_3)

[13] Karabarbounis, Loukas, and Brent Neiman (2014). “The global decline of the labor share,” The Quarterly Journal of Economics, Vol. 129, No. 1, pp. 61-103.

[14] Acemoglu, D. and Restrepo, P. (2022). Tasks, automation, and the rise in US wage inequality. *Econometrica*, 90(5):1973-2016.

3. A rise of mega-wealth linked to the digital economy, with 10 of the 12 richest owner-entrepreneurs of the tech sector, with a combined net worth of \$1.8 trillion (Table 1).

Elon Musk	\$348	Technology
Jeff Bezos	\$219	Technology
Larry Ellison	\$206	Technology
Mark Zuckerberg	\$198	Technology
Bernard Arnault	\$163	Consumer
Bill Gates	\$162	Technology

Warren Buffett	\$150	Diversified
Larry Page	\$150	Technology
Steve Ballmer	\$145	Technology
Sergey Brin	\$141	Technology
Jensen Huang	\$124	Technology
Michael Dell	\$119	Technology

Table 1. Richest 10 People in the World

Source: Bloomberg, November 26, 2024, <https://www.bloomberg.com/billionaires/?sref=IiIN3Swk>

4. An overall reduction of working hours per adult population, reflecting the rise in time spent on non-work activities, including education, leisure (shorter workdays and work weeks), and retirement (Figure 3).

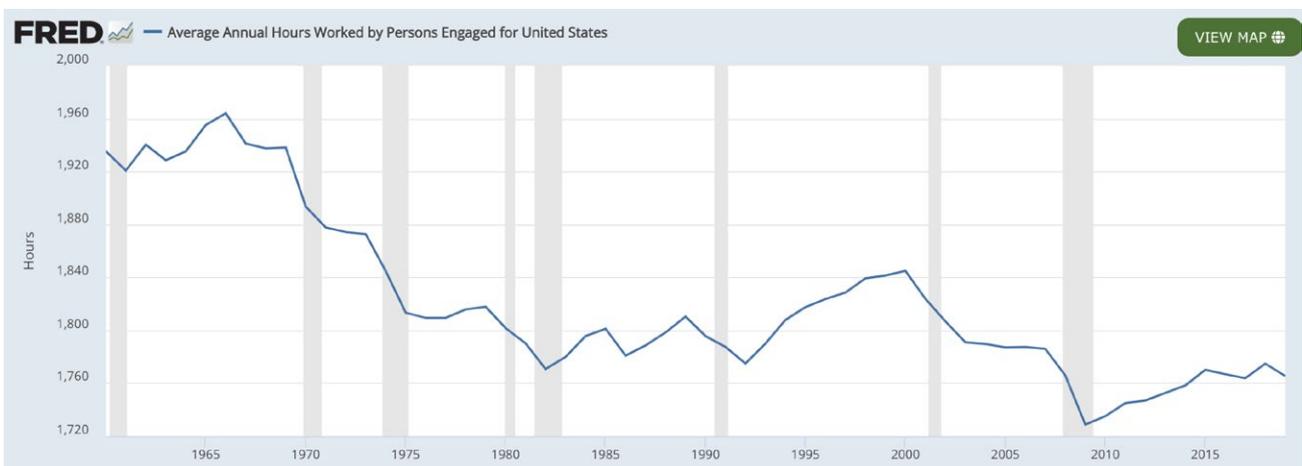


Figure 3. Average Annual Hours Worked by Persons Engaged

5. A rapid rise in labor productivity (output per worker) in manufacturing during the 1980 –2008, the period of rapid automation (Figure 4)

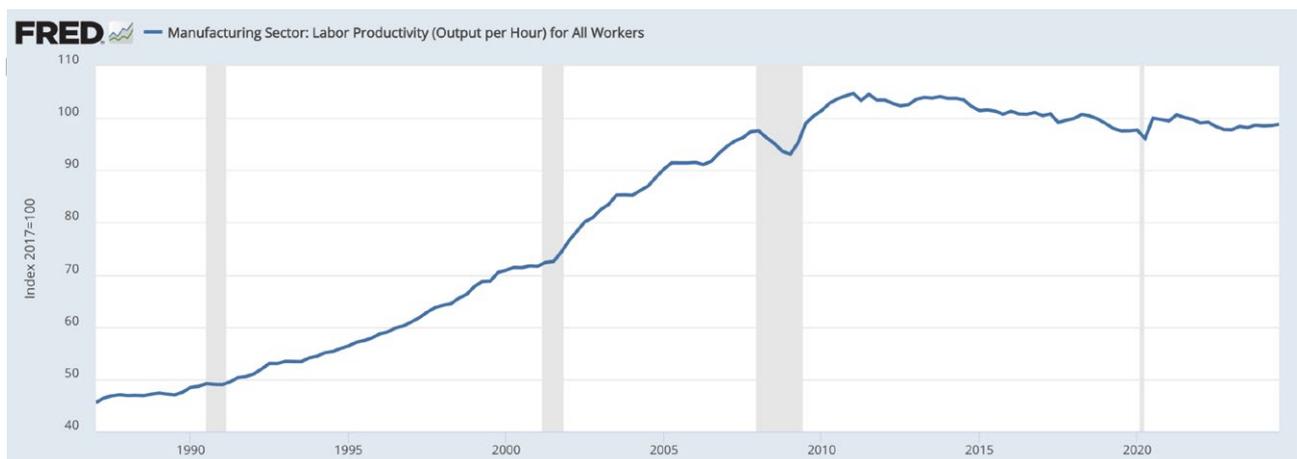


Figure 4. Labor Productivity in Manufacturing, 1987-2024

Each of these macroeconomic trends traces back to the ICTs of the 1960-2020. The ICT technologies – computation and connectivity harnessed to robotics and automation – had differential effects on the workforce. Repetitive jobs on the assembly line were replaced by robots and smart systems. The result was a large decline in manufacturing employment as machines replaced labor. This decline in manufacturing employment occurred across the high-income world, and was not restricted to the United States, nor was it related to whether countries had manufacturing trade surpluses or deficits. Workers with higher educational attainment, notably those with a university degree, were in occupations not highly vulnerable to replacement by machines. Their wages rose relative to workers with high-school degrees.

## HOW THE AI REVOLUTION WILL QUALITATIVELY ALTER THE MACROECONOMY

The coming AI and robotics revolutions will alter and intensify the macroeconomic trends of the past 60 years. Most importantly, the AI revolution will disrupt sectors far beyond manufacturing. Many jobs now requiring a university degree will be replaced by AI-empowered robots and machine-based systems. The reason is that AI will enable machine tasks beyond the repetitive tasks that were automated during the first ICT wave.

### Here are several of the likely qualitative macroeconomic consequences of the coming revolutions in AI and robotics:

1. The growth in real earnings of many high-skilled workers will be suppressed as AI systems substitute for a wide variety of currently high-skilled tasks (writing, editing, computer coding, customer interface, graphic design, financial analysis, medical diagnostics, legal drafting, and others).
2. The distribution of income will shift from both high-skilled and low-skilled workers to capital, that is, to the owners of robots, IP, cloud services, and other digital systems;

3. Real wages across the all categories of skills are likely to fall in absolute terms as robots increasingly substitute for workers across all skill categories;
4. Owners of all forms of capital, including financial equity, IP, and physical plant and equipment (including robots), will experience rising wealth and incomes, while households without capital assets will fall into relative and in many cases absolute poverty;
5. Mega-wealth will be hyper-concentrated among owners of digital systems. Currently, eight of the top ten wealthiest individuals in the world are in the tech sector.
6. There will be a rise in the typical number of lifetime job transitions (changes of career during the lifetime) as jobs continue to change in content and skill requirement.
7. Lifelong training and learning will therefore become commonplace. Higher education that is now predominantly on campus will shift to continuing adult higher education primarily conducted online.
8. Outlays on transport services, now roughly 15% of household outlays in the US, will decline as outlays shift from car ownership to lower-cost options, including public transport and shared vehicle services (autonomous taxis, car-hailing services, etc.);
9. An increasing array of digital services will become freely available, as is currently the case with an array of social media, geospatial map services, entertainment services, search engines, chatbots, online data processing, and others. Standard measures of real consumption, based only or mainly on market purchases of goods and services, will increasingly fail to measure the full value of consumption.
10. There will be major changes time allocation, intensifying the trends of the past century. In particular, there will be less time devoted to working, shopping, and commuting, and more time devoted to education, leisure, and online activities.

## QUANTIFICATION OF THE AI MACROECONOMIC IMPACTS

There is, as yet, no empirical model of the US or other major economy to assess the impacts of AI across sectors and over time. Such a quantification would aim to predict changes over time in employment, capital stock (tangible and intangible), earnings, capital income, returns to IP, occupational structure, time allocation (work, leisure, commuting, shopping, screen time, schooling, training, retirement, etc.), and frequency of job change, according to economic sector. The modeling would also predict trends in the household distribution of income and wealth. Macroeconomic modeling has not yet reached this level of sophistication or ambition. Given the scale of macroeconomic disruptions ahead, such empirical modeling is a major research priority.

To date, the few studies of AI and the macroeconomy mainly estimate the types and numbers of jobs likely to be impacted by AI, without considering the general equilibrium effects on the economy (that is, without considering how workers will change jobs and sectors as old patterns of work are altered by AI, and how overall output and capital incomes will be affected). Most such studies, carried out principally by consultant firms, predict that large swaths of current employment will be affected. Jobs especially at risk involve repetitive tasks such as data entry clerks, telemarketers, and customer service representatives.

Goldman Sachs (2023)<sup>15</sup> estimates that AI will boost worldwide GDP by 7% over the coming decade, while exposing 300 million full-time jobs to automation;

PwC (2018)<sup>16</sup> estimates that by the mid-2030s, up to 30% of jobs could be automated. McKinsey Global Institute (2023)<sup>1</sup> estimates that up to 70% of current job tasks (measured by total hours) will be subject to automation, and that roughly half of today's work activities will be automated by 2045.

The predicted magnitudes are enormous, pointing to massive disruptions of work in the next

twenty years. Yet the predictions are far from precise and are not precise regarding the general equilibrium effects on earnings, income distribution, sectoral allocation of employment, GDP growth, and other macroeconomic variables. That quantitative analysis is yet to be done, and will be a priority for the AI Macroeconomics Task Force, which aims to make a rigorous and detailed assessment of the macroeconomic effects of AI on the US economy.

## AI AND DEVELOPING ECONOMIES

The AI revolution will have profound implications for the economic development strategy and pathways of today's developing countries. In traditional development practice, economic development in the tradable sector of the economy proceeded up the technology ladder from labor-intensive manufacturing to capital-intensive manufacturing. Low-income developing countries without a dominant commodity export (oil, gas, gold, diamonds, copper, etc.) imported capital (both loans and foreign direct investment) to combine with low-cost, low-skilled labor, in order to generate export earnings that would be reinvested in infrastructure, human capital, and local adaptation of international technologies. Over time, wages would rise, and production would shift to more capital-intensive and skill-intensive sectors. A typical industrial progression in East Asia proceeded from basic assembly operations (toys, electronics, apparel), to textiles, petrochemicals, pulp and paper, and metallurgy, and eventually to machinery of increasing sophistication. In the East Asian context, this staged development process, which was pioneered by Japan, was dubbed "the flying geese" model by Japanese economists.

This pathway to development was already coming to an end roughly 20 years ago, as labor-intensive manufacturing in electronics, apparel, assembly operations, and other areas was increasingly automated. The labor-intensive jobs in manufacturing tended to diminish or disappear entirely, replaced increasingly by robotics and other automated production systems. This disappearance of labor-intensive manufacturing gave rise to the

{15} Goldman Sachs, "Generative AI could raise global GDP by 7 percent," 2023. <https://www.goldmansachs.com/intelligence/pages/generative-ai-could-raise-global-gdp-by-7-percent.html>

{16} PwC (2018). "Will robots really steal our jobs?" <https://www.pwc.com/it/it/ghosts/impact-of-automation.html>

concept of “premature deindustrialization” (Rodrik, 2016)<sup>17</sup>.

The emerging developing paradigms looked for alternative pathways to development of the traded goods sector. These included the promotion of online digital services (e.g., the business processing operations led Indian companies), skilled distance work by digital nomads (e.g., coders and programmers working far from HQ), low-wage data entry services for Big Tech, tourism, promotion of tax havens, all of which offered employment at a distance in service-sector activities, both unskilled and skilled. The new strategy requires a combination of physical infrastructure (high-speed connectivity, reliable electrification), skilled workers (trained for online activities), a manageable time zone (for overlap with HQ), and physical and digital security.

In practice, many developing countries are failing to generate sufficient remunerative employment in tradable goods or services to deploy the growing labor force. The result, typically, is significant outward migration, either as unskilled workers (in the EU, Gulf countries, US) or as skilled workers (brain drain) in the high-income countries. Part of the income stays with the migrant workers; a fraction returns as remittances to families that remain at home. Such widespread migration, in turn, has provoked significant social and political divisions especially within the host countries.

The AI revolution will powerfully affect the future pathways of economic development. Laborintensive manufacturing is likely essentially to disappear. The mechanization of agriculture and mining will similarly accelerate, leading to higher production in these important tradable sectors (important for the balance of payments and national income) but with adverse consequences on job creation and the distribution of income.

AI will have several powerful positive effects. Healthcare and education will plummet in cost, as online services replace far-more-expensive in-person services. The opportunity for a surge in

human capital is real. The advent of ubiquitous online education can greatly expand the access to quality education. The big challenge for educators lies in learning to use the new AI-powered tools and enhanced digital connectivity effectively, in conjunction with in-person education, to deliver quality education. AI will also support instruction in local languages, another potentially significant contribution to learning.

Online work will also greatly expand the range of occupations and jobs that can be promoted. A significant proportion of work in the future will be online, and will not be dependent on physical proximity. The work, in short, will depend on skills, not location. This could facilitate tens of millions of decent jobs in developing countries being carried out online, without the need for migration or the massive inflow of capital for buildings and machinery.

The rapid skilling of tens or hundreds of millions of young people in today’s developing countries will also accelerate voluntary migration as well, perhaps in lifestyles and career paths in which skilled young people routinely live and work in several different countries during their adult years.

There is a profound potential downside, however. Today’s capital scarce low-income developing countries may find themselves trapped in poverty unless they can gain early access to physical infrastructure (electrification, fiber), education, and a modicum of financial wealth. AI will drive down labor earnings not only for low-skilled but also for many high-skilled jobs. Today’s low-income countries with rapidly expanding populations could soon find themselves bereft of any foothold in the high-income world economy, lacking skills, infrastructure, or employment prospects for their young population.

The next edition of the Macroeconomic Task Force Report will aim to identify appropriate development strategies for low-income countries (LICs) and lower-middle-income countries (LMICs) in an AI-empowered world economy.

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[17] Rodrik, Dani. (2016). “Premature Deindustrialization,” *Journal of Economic Growth* 21:1–33 DOI 10.1007/s10887-015-9122-3

## THE MACROECONOMICS OF THE TRANSITION TO AGI

According to some technologists, we are rapidly approaching Artificial General Intelligence (AGI), which in economic terms signifies an economy in which all human tasks can be performed at least as well by AI-empowered machines such as humanoid robots. The possibility of AGI suggests both a utopian age – in which robots do the drudge work and humanity enjoys soaring living standards and leisure – or a dystopian wage – in which robots do the work and most humans are reduced to penury and serfdom, scraping out an existence with market wages driven down to the (low) cost of robots with whom they compete.

Early studies of robot-human substitution, such as Sachs, Benzell, and Lagarda (2018)<sup>12</sup>, showed that both the utopian and dystopian scenarios are theoretically possible. In an overlapping generations (OLG) framework, in which workers save for their future retirement, the advent of AGI would tend to drive down wages precipitously, and thereby also drive down the saving out of wage income. The result could be a downward spiral of wellbeing, in which the current old generation would reap a windfall from their ownership of the more productive capital stock, but in which young workers and future generations of workers would see their living standards plunge. This dystopian scenario could be turned into a utopian scenario, however, if the old generation gives part of its windfall to the young generation either through within-household bequests, or by paying taxes that are then redistributed to the young workers. In that event, the old capital owners benefit from the breakthrough to AGI, while the young workers share in the bounty (either through the receipt of bequests or transfers from government) and thereby also save more for the future. As long as a system of bequests and government taxes and transfers benefits each young generation, then AGI delivers utopia rather than dystopia.

A recent sophisticated study by Korinek and Suh (2024)<sup>18</sup> provides a far fuller and more

sophisticated account of the utopian-dystopian divide. They show generally that dystopia becomes more likely – that is, a collapse of wages – if automation proceeds rapidly relative to capital accumulation (as occurs in the OLG framework). Utopia (rising wages and living standards as a result of the transition to AGI) is more likely if the emergence of AGI is gradual relative to the rate of capital accumulation, and if there are some residual tasks in which robots never displace humans

Another dimension that will shape the utopian-dystopian outcome is demography. If the total workforce is declining because of fertility rates below replacement rates (as is occurring throughout the developed economies), then wages are more likely to be sustained on the transition to AGI. At the same time, a declining population may induce labor-saving automation, as in Acemoglu and Restrepo (2021)<sup>19</sup>.

## AI AND MACROECONOMIC POLICY

The profound disruptions in the economy that lie ahead raise fundamental issues of public policy. There are at least five major macroeconomic issues. First, should governments encourage or discourage AI-induced automation, for example by taxing or banning robots in certain economic spheres? Second, should governments attempt to promote AI technologies that are complements to workers (that is, bolster the marginal productivity of workers), rather than substitutes for workers? Third, how should the educational curriculum be changed to maximize the benefits of AI for society? Fourth, how should governments engage in intertemporal fiscal policies, e.g., by taxing old wealth owners in order to make transfers to young workers, in order to ensure that all generations benefit from the transition to AGI? Fifth, should robots be taxed in view of the rising share of income that will accrue to robots, and if so, is the taxation to raise revenues for redistribution or is it to induce firms to hire fewer robots and more workers?

{18} Korinek, Anton and Donghyun Suh (2024). "Scenarios for the Transition to AGI," Technical Report, National Bureau of Economic Research.

{19} Acemoglu, D. and Restrepo, P. (2021). "Demography and Automation," Review of Economic Studies.

These are topics for future exploration. At this stage, we note that Autor (2024)<sup>20</sup> holds the optimistic view that with the right kind of training, AI will empower expertise and decisionmaking among a broader part of society, thereby becoming a complement rather than substitute of work effort: “For workers with foundational training and experience, AI can help to leverage expertise so they can do higher-value work. AI will certainly also automate existing work, rendering certain existing areas of expertise irrelevant. It will further instantiate new human capabilities, new goods and services that create demand for expertise we have yet to foresee.”

In addition to education and R&D policies, fiscal policies will surely play a crucial role in determining whether society heads towards the utopian or dystopian outcome. Several papers, including Thuemmel, U. (2023)<sup>21</sup> are examining the role of taxation of robots both to raise revenues for redistribution to workers whose wages decline, or to fund Universal Basic Incomes, as well as to change market incentives on the margin for the adoption of labor-saving technologies versus workers. Intertemporal fiscal policies will also shape the “race” between capital accumulation and innovation described by Korinek and Suh as vital for whether workers’ living standards rise or plummet on the transition to AGI.

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{20} Autor, David (2024). “Applying AI to Rebuild Middle Class Jobs,” Technical Report, National Bureau of Economic Research.

{21} Thuemmel, U. (2023). “Optimal Taxation of Robots,” of the European Economic Association, Volume 21, Issue 3, Pages 1154–1190.

## AI AND MACROECONOMIC MODELING

There are, as already emphasized, no macroeconomic models that incorporate AI and other digitals at a detailed sector level, and that are therefore designed to offer a quantitative assessment of the macroeconomic implications of the AI revolution. Most macroeconomic models are short term, designed to address issues of macroeconomic stabilization over the business cycle. Many fewer macroeconomic models are designed to assess and predict longterm economic developments at the sector level. Typical models use a very simple aggregate production function to estimate the trend of aggregate GDP over the time horizon of 25 – 50 years, but without any detailed integration of technological changes into the modeling framework.

The AI (and more general digital) revolution calls for a new kind of macroeconomic modeling, that would include most or all the following 10 modeling attributes:

1. A multi-sector model to track and predict developments across major sectors (at least SIC-1)
2. A detailed delineation of major digital technologies, including AI, robotic, and others, to be included in the technology specification of each sector;
3. A detailed delineation of job tasks, identify those in which AI systems can substitute or complement labor;
4. A specification of which job tasks can be carried out online and which must be on site;
5. A detailed distinction between materialized goods (e.g., books) versus dematerialized goods (e.g., e-books), and on-site services (e.g., retail outlets, movie theaters) versus online services (e.g., online shopping, movie streaming);
6. A delineation of free online goods and services (e.g., mapping services, social media, etc.) and subscription online goods and services;
7. An identification of wholly new forms of digital goods and services that are not currently in the national accounts;
8. A detailed specification of time allocation at the household level (work, commuting, shopping, leisure, personal care, etc.);
9. A specification of the changing educational and training mix in an AI-based economy, including online life-long learning;
10. A time horizon of at least 20 years (one generation) and ideally up to 40 years.

A principle aim of the AI Macroeconomic Task Force is to assemble the building blocks of AI macroeconomic model, using the US and a selected developing country for the basic template.

{20} Autor, David (2024). "Applying AI to Rebuild Middle Class Jobs," Technical Report, National Bureau of Economic Research.

{21} Thuemmel, U. (2023). "Optimal Taxation of Robots," of the European Economic Association, Volume 21, Issue 3, Pages 1154–1190.

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