HARNESSING THE POTENTIAL OF AI TO REVOLUTIONIZE PRODUCTIVITY: UNVEILING OPPORTUNITIES AND TACKLING CHALLENGES

Leon Bian
Fellow of WAPS

Abstract:

From the late 1990s through the early 2000s, productivity saw substantial gains, but growth slowed significantly in the mid-2000s across the United States and other advanced economies. This trend persisted until the early 2020s, when Artificial Intelligence (AI) emerged as a game-changing force, reshaping productivity across various industries. AI plays a multifaceted role in augmenting productivity, with its potential to automate tasks, optimize processes, and foster innovation. While AI significantly enhances efficiency and reduces costs, its deployment also raises considerable challenges and ethical considerations, highlighting the need for responsible integration. Detailed analysis and empirical data provide insights into how AI redefines productivity paradigms, the opportunities it presents, and the hurdles to overcome. The study aims to offer a balanced view of AI's societal role, underscoring its transformative impact on productivity growth while reiterating the importance of responsible and sustainable workforce integration.

1. Introduction

Productivity refers to the effectiveness of converting resources such as labor, capital, and materials into goods and services. It is measured by the ratio of outputs produced to the inputs used in production, which is often expressed as units of output per unit of input (for example, goods produced per hour of labor). Productivity growth measurement is an important indicator of economic health and efficiency in resource utilization. It also helps policymakers and businesses make informed decisions regarding investments, labor markets, and technological advancements. Understanding productivity trends is crucial for driving economic growth and achieving desired outcomes.

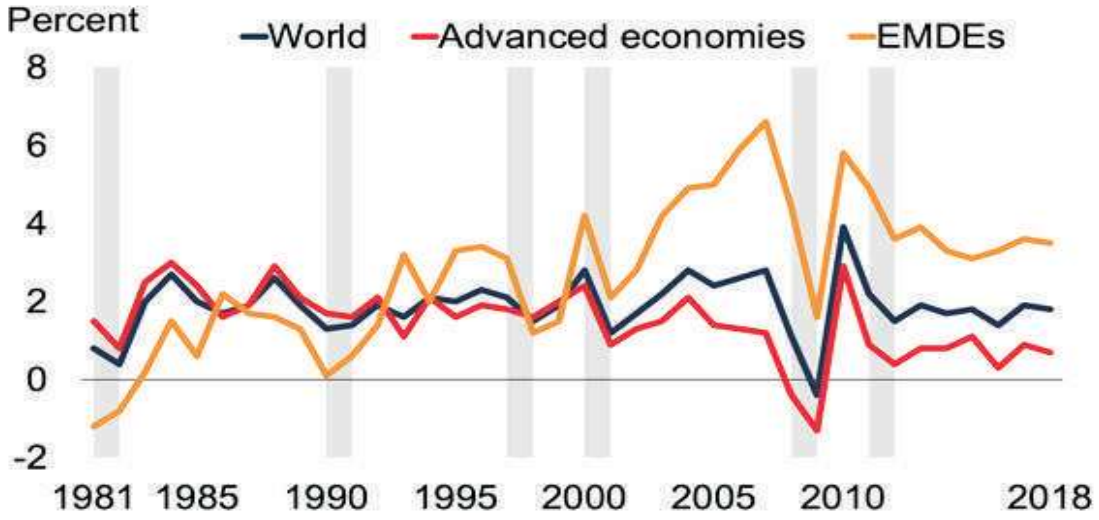

Figure 1.1 Global, AE, and EMDE productivity growth

Figure 1.1 (World Bank & Dieppe, 2021, p.4) illustrates the trends in productivity growth globally, in advanced economies (AE), and in emerging markets and developing economies (EMDE) from the early 1980s to 2018, just before the COVID-19 pandemic. Before the global financial crisis around 2009, productivity growth in advanced economies had been trending downwards for several decades while EMDEs were on an upward trajectory. After the global financial crisis, both advanced economies and EMDEs saw a brief recovery in productivity growth, but the overall trend in both economies has been downward since then. At the global level, productivity growth was sluggish, hovering around 1.8% between the end of the global financial crisis and 2018. (World Bank & Dieppe, 2021, p.4)

The COVID-19 pandemic swept the globe in early 2020, prompting many countries to implement shutdown measures that restricted movement and forced many businesses to close. As a result, the economies of various countries experienced a significant slowdown in 2020. However, in 2021, a glimmer of hope emerged through increased productivity growth after several years of lackluster performance. After experiencing an average annual labor productivity growth rate of 1.4% over the 12 years (2007-2019) before the pandemic, on June 3, the United States Bureau of Labor Statistics reported that labor productivity in the U.S. had risen by 5.4% in the first quarter of 2021 (U.S. BUREAU OF LABOR STATISTICS, 2021; Nielsen, 2023). Erik Brynjolfsson, director of the Stanford Digital Economy Lab, and Georgios Petropoulos (2021) subsequently wrote in the MIT Technology Review that this was "not merely a blip but rather a harbinger of better times to come: a productivity surge that would match or surpass the boom times of the 1990s." The authors attributed their optimism to three factors:

1. Technological breakthroughs over the last decade that had included advances in AI, the continuously decreasing cost of computing power, and progress in medical treatments like mRNA, among others;

2. A compressed timetable for restructuring digital innovations, thanks to remote working induced by COVID-19; and

3. An economy trending towards full capacity.

As Brynjolfsson and Petropoulos (2021) asserted in the same article, technology alone is usually not enough to increase productivity; it needs to be combined with factors such as business processes, human skills, and other intangibles. The latest technological advancements, powered and led by AI, had been taking time to make a difference in productivity, and that time had perhaps come (Brynjolfsson & Petropoulos, 2021). AI, with its potential to automate tasks, enhance decision-making, and improve efficiency, could be the key to unlocking a new era of productivity growth.

Brynjolfsson & Petropoulos were optimistic about the productivity growth in the US. However, their optimism turned out to be premature. While the quarterly labor productivity growth rate shot up to around 6% between the second quarter of 2020 and the first quarter of 2021, it fell in the second quarter of the same year. It remained between -2% and 2% for the rest of the period until the end of 2023 (CEIC Data, an ISI Emerging Markets Group Company, n.d.).

In late 2022, OpenAI's generative AI (GenAI) solution, ChatGPT, was launched and reportedly gained 100 million users within just two months (Curry, 2024). ChatGPT is a large language model (LLM) that can generate text similar to human-like language based on the input it receives. It can be used to assist users by answering questions, providing explanations, engaging in conversation, and helping with various tasks, such as writing assistance, summarization, generating computer code, and more. GenAI offerings, such as ChatGPT, Google's Gemini, Anthropic's Claude, and Meta's Llama, have the potential to boost productivity in many industries.

Although the nonpartisan Congressional Budget Office (CBO) predicted that US productivity growth would be at an annual rate of 1.7% in the 2020s (Congressional Budget Office, 2020), many experts have predicted that GenAI will significantly impact productivity growth. For example, Goldman Sachs predicted that GenAI would improve

productivity growth by 1.5 percentage points over ten years (Goldman Sachs, 2023). If Goldman Sachs' prediction turns out to be true, it means that the overall productivity growth in the US can be lifted to above 3% in the rest of the 2020s. This paper will explore how AI can be used to supercharge productivity and will focus on both opportunities and challenges.

2. The Evolution of AI in Productivity

AI, a field that traces its roots to the Turing Test developed by British mathematician and computer scientist Alan Turing in 1950 (Oppy & Dowe, 2003), has come a long way. The term "Artificial Intelligence" was coined by emeritus Stanford professor John McCarthy in 1955, referring to the "science and engineering of making intelligent machines" capable of performing tasks that typically necessitate human intelligence (Manning, 2020; McCarthy, n.d.). These tasks include understanding natural language, recognizing patterns, solving problems, developing recommendations, and making decisions. AI can replicate cognitive functions to enhance or automate various processes across numerous industries by harnessing algorithms, data, and computational power. The technology spans basic automation to advanced machine learning and deep learning, leading to transformative innovations in almost all sectors, such as healthcare, finance, and transportation.

The 1956 Dartmouth Summer Research Project on Artificial Intelligence (DSRPAI) hosted by John McCarthy and Marvin Minsky is often considered the beginning of the AI journey in the science community (Ahlawat, 2024). Even though the conference produced little desired results, it ignited a frenzy of AI research that has flourished ever since. Great minds like Allen Newell, Herbert Simon, and Edward Feigenbaum entered the arena in the early days (Anyoha, 2017). Governments also took an interest in the field by making investments. However, due to many challenges, such as the limitation in computing power, AI research through the 1980s still needed to go a long way toward achieving the goal of human-like intelligence.

In the 1980s, AI research was characterized by two distinct camps with different approaches (Lee, 2018, p.7- p.10). One camp, known as the 'rule-based' methodology, used predefined rules to teach computers how to "think." The other camp, the "neural networks" approach, envisioned a system that emulated the human brain with "neurons."

During the 1990s and 2000s, AI made significant strides in demonstrating limited-purpose use cases (Narrow AI). For instance, IBM's Deep Blue computer defeated world chess champion Gary Kasparov in 1997 (IBM, n.d.), while Stanford's robot vehicle, Stanley, won the DARPA Grand Challenge by autonomously driving across California's Mojave Desert for 132 miles in 2015 (Stanley Racing Team, 2005). One of the most significant events in AI history happened in 2016 when Google's AlphaGo, a software developed using deep learning technology, defeated Go world champion Lee Se-dol (Waters, 2023). By that time, the world had realized that the "neural networks" approach was more scalable and adaptable than the "rule-based" method, while the computer industry had made exponential progress in improving computing power since the 1980s.

Despite the remarkable advancements in AI technology, its utilization in production is still very limited. In a blog post published on the Federal Reserve Bank of St Louis's website in April 2024, Aakash Kalyani and Marie Hogan (2024) estimated that the use of AI in production by firms had only increased from around 3% in 2018 to around 4.4% on average across sample waves in 2023-2024. They predicted that the benefits of AI in terms of productivity gains might take a while to realize due to the slow adoption by businesses, just like in previous technologies such as computers, cloud computing, and 3D printing. The question remains whether the emergence of GenAI will change the game.

3. Opportunities Presented by AI

When we talk about AI today, people often conjure up a chatbot that can talk to you and answer your questions. However, as we have seen in the evolution of AI, industries have been experimenting with many narrow AI applications over the past several decades. For example, in the financial services industry, AI has been frequently used to gauge a borrower's creditworthiness before a bank extends a loan offer. On e-commerce websites like Amazon.com, AI predicts

the products you might like so Amazon can present you with recommendations. Similarly, streaming video services like Netflix use AI to personalize your viewing experience. Companies also leverage AI for cloud operations optimization to maintain uptime and ensure the reliability of the services in their systems. Nevertheless, as mentioned in the previous section, AI usage in production remained low as of early 2024 (Kalyani & Hogan, 2024), whereas labor productivity growth in the U.S. hovered around 0% in the past several years (CEIC Data, an ISI Emerging Markets Group Company, n.d.).

Ever since OpenAI unveiled GenAI to the world in late 2022, the outlook on AI's potential impact on productivity growth has become increasingly optimistic, although the numbers vary widely. Here are a few notable predictions from the past year that paint a compelling picture:

- Goldman Sachs (2023) predicted that GenAI technologies could contribute to a 7% increase in global GDP, equivalent to nearly $7 trillion, and boost productivity growth by 1.5 percentage points over the next decade.

- McKinsey (2023) estimated that GenAI could improve labor productivity by 0.1% - 0.6% annually through 2040. Additionally, GenAI-powered work automation could add 0.5% - 3.5% to annual productivity growth when combined with other technologies.

- According to Ernst & Young (2024), GenAI was expected to have a significant impact on the economy, potentially adding $650 billion over the next decade and increasing real GDP by 2.5% by 2033.

- According to the Nielsen Norman Group (2023), AI has the potential to enhance employee productivity significantly. They claimed that GenAI "tools increased business users' throughput by 66% when performing realistic tasks" based on three recent studies on AI and productivity.

- MIT Professor Daron Acemoglu (2024) is a lot more conservative in his prediction. He stated that, despite AI's potential, productivity gains over the next ten years were expected to be modest, with total factor productivity (TFP) growth estimated at around 0.71% over 10 years and potentially lower.

GenAI is poised to revolutionize various industries. McKinsey (2023) predicted that sectors like banking, high-tech, and life sciences will likely experience the most significant effects relative to their revenues. According to the research, in the banking industry, fully implementing GenAI use cases could add an estimated $200 billion to $340 billion per year, and similarly, the retail and consumer packaged goods sector could see an annual impact ranging from $400 billion to $660 billion. Among the different functions within a company, about 75% of the value that GenAI use cases could deliver falls across four areas: customer operations, sales and marketing, software engineering, and R&D (McKinsey & Company, 2023).

Let's examine a few use cases. First, take a look at customer operations. In a recent paper, Erik Brynjolfsson, Danielle Li, and Lindsey R. Raymond (2023) reviewed the impact of a GenAI-based conversational assistant among more than five thousand customer support agents. They found that the software increased productivity by 14% on average, with a 34% improvement for lower-skilled workers but minimal improvement for experienced workers. Moreover, the study revealed that AI assistance enhances customer sentiment, boosts employee retention, and facilitates worker learning.

GenAI is transforming every phase of the software development process, including requirement gathering, system design, testing, and deployment. Boston Consulting Group (BCG) claims that, when implemented at scale, GenAI can significantly enhance the quality, speed, and cost-effectiveness of innovation within the software industry (Ahlawat, 2024). In its survey, respondents saved anywhere between 1.1 days and 2.5 days in software development per week, with mid-level developers (with 2-4 years of experience) saving the most time. The survey also indicates that the

adoption of GenAI tools in software development is still in its infancy.
On May 23, 2024, OpenAI launched its latest large language model - GPT-4o, a unified model that processes text, vision, and audio inputs and outputs through a single neural network (OpenAI, 2024). It is capable of chatting with the user in a natural voice. The LLM can accomplish tasks such as analyzing spreadsheets, summarizing meeting minutes, giving interview advice, translating languages in real-time, and teaching math, among other use cases (OpenAI, 2024). The possibilities offered by GenAI are boundless.

In short, AI has the potential to significantly enhance businesses' ability to innovate, develop new products, create personalized offerings, and expand into new markets by providing actionable insights, improving efficiency, and enabling better decision-making.

4. Challenges and Ethical Considerations

Although AI, especially GenAI, has exhibited significant potential in enhancing productivity, challenges abound. This section looks at four AI challenges:

- The impact on the labor market and inequality
- Hurdles in driving adoption
- Difficulty in measuring AI's impact on productivity
- Security, privacy and other ethical implications

Impact on the Labor Market and Inequality

The disruption AI is causing in the labor market, primarily through task automation and subsequent worker displacement, is an urgent reality. In 2017, Kai-fu Lee, a well-known venture capitalist, made a bold prediction, envisioning AI replacing 50% of human jobs by 2027 (Yan, 2017). He reiterated this claim in a recent interview with Fortune Magazine (Ma, 2024). Many other researchers and analysts have echoed these concerns, albeit with less audacity. Goldman Sachs' Briggs and Kodnani warned that technological advancements in AI systems could significantly impact global employment markets by reshaping workflows and potentially automating the equivalent of 300 million full-time jobs (Goldman Sachs, 2023).

In the past, when technological breakthroughs like electricity, computers, and the Internet displaced workers, other types of jobs were created after the fact. Today, there is concern that the recent wave of AI has come so fast and on such a massive scale that society may be unable to create new jobs quickly. Moreover, unlike previous technological innovations, which predominantly displaced workers at the mid-to-low end of the spectrum, AI can extend the displacement to high-wage earners.

However, there is some encouraging news. A recent International Monetary Fund (IMF) (2023) working paper explored how AI influences labor markets in advanced and emerging economies. The paper suggested that while AI risks displacing labor through automation, it also enhances productivity and complements human work, particularly in cognitively demanding and highly skilled occupations.

AI is expected to exacerbate income and wealth inequality, particularly in advanced economies, as their exposure to AI is higher than in emerging economies. The technologies could disrupt employment in all spectrums of labor groups, but high-income workers may also benefit more from AI, leading to increased labor income inequality (International Monetary Fund et al., 2023). Additionally, enhanced capital returns due to AI could further increase wealth inequality.

The solution to the risks of labor market disruption is multi-faceted. First, researchers and businesses should focus more on developing AI solutions that augment human capabilities than simply automating human tasks. In a paper titled The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence, Erik Brynjolfsson (2022) argued that

augmentation, where AI complements human labor, tends to preserve human roles and distribute economic benefits more equitably than substitution.
Secondly, businesses and employees should prepare for the impact of AI as it continues to automate tasks. Companies should explore new ways to enhance customer experience and create new business opportunities by leveraging human skills that are challenging to automate. For example, Kai-fu Lee suggested that as AI surpasses human doctors in diagnosing and treating diseases, doctors may transition into "compassionate caregivers" (Lee, 2018, p.212). Companies need to support their employees by retaining them. Meanwhile, employees displaced by AI should seize opportunities to acquire new skills and knowledge and adapt to new jobs.

Lastly, at the policy level, governments should play an active role in combating the adverse impact of AI by investing in AI innovation, updating regulatory frameworks, supporting labor market transitions, and ensuring social protection for affected workers (International Monetary Fund & Cazzaniga, 2024).

Hurdles in Driving Adoption

The number of businesses adopting AI to produce goods and services still needs to grow. A 2023 Business Trends and Outlook Survey (BTOS) published by the United States Census Bureau (USCB) revealed that only 3.8% of American companies used AI in production, with the highest use in the information sector, where close to 14% of the companies reported using the technology (Breaux & Dinlersoz, 2023). We must note that the percentage of U.S. firms adopting AI has remained the same since 2018, when it was 3.2%. The survey also found that, nationally, 6.5% of all firms planned to use AI in the next half a year, which is still tiny.

Globally, large enterprises have shown better progress in AI adoption than the U.S. national average. According to the IBM Global AI Adoption Index 2023, a survey of more than 8,500 IT professionals worldwide, 42% of large organizations had actively deployed AI, with an additional 40% exploring its use (IBM, 2024). Moreover, 38% of IT professionals surveyed were implementing generative AI, while another 42% were considering it. About half of the financial services industry's IT professionals reported active AI deployment, and 37% of those in the telecommunications sector said their companies were also deploying AI. In addition, most of the surveyed companies actively deploying or exploring AI had increased the pace of their rollout or investments in the past two years.

What are the hurdles to AI adoption? The main obstacles organizations exploring or implementing AI often cite include a shortage of AI skills and expertise, excessive data complexity, ethical issues, difficulties integrating and scaling AI projects, high costs, and insufficient tools for developing AI models (IBM, 2024). In the GenAI space, firms are also concerned about data privacy, trust, and transparency (IBM, 2024). In addition to technical hurdles, there are organizational challenges. For example, a firm may need to make necessary cultural and organizational changes to adapt to the wider use of AI technologies.

Difficulty in Measuring AI's Impact on Productivity

Quantifying AI's impact on productivity growth is difficult due to several factors. One key issue is measuring intangible benefits, such as improved decision-making and customer experiences, which do not easily translate into traditional productivity metrics. As Erik Brynjolfsson (2023) wrote on World Economic Forum (WEF), the most common productivity measure, non-farm business productivity, effectively captures industrial sector productivity where inputs and outputs are tangible, but measuring the productivity of cognitive labor is more challenging. Additionally, there is often a lag between AI implementation and observable productivity gains, as businesses need time to adapt and optimize new technologies, making short-term impacts challenging to assess.

The relationship between AI and human labor is complex. AI can both complement and substitute for human work, and its effects vary across industries and roles. It can lead to diverse impacts that are difficult to summarize. Differences between sectors make it even harder to measure AI's impact, as it may be more noticeable in certain industries, such as

manufacturing, while more subtle in others, like services.
Data limitations pose another challenge. Comprehensive and high-quality data on AI adoption and its impact are often needed. Due to the influence of other technological and organizational changes, it isn't easy to directly attribute productivity gains to AI. Additionally, the broader economic and social context, including factors such as workforce education, regulatory environments, and market conditions, also significantly shapes AI's impact on productivity. This adds further variability and uncertainty to the measurement process.

Security, Privacy, and Other Ethical Implications

Driving AI adoption involves security, privacy, and ethical considerations. Security concerns are paramount, as today's AI systems often require large datasets that can be vulnerable to cyberattacks. Organizations ought to take robust cybersecurity measures to protect sensitive data. In addition, the integrity of AI systems must be safeguarded against malicious attacks that could alter their functioning or outcomes, such as adversarial attacks designed to trick large language models.

Privacy considerations are crucial for AI systems, as they often handle massive amounts of personal data. This raises concerns about how the data is collected, stored, utilized, and shared. It's essential to comply with data protection regulations such as the General Data Protection Regulation (GDPR) and the California Privacy Rights Act of 2020 (CPRA) to address these concerns. Anonymizing personal data in AI systems is a best practice to safeguard individual identities and ensure data privacy.

Ethical issues in AI adoption encompass bias, fairness, transparency, accountability, and informed consent. AI may perpetuate or even worsen existing biases in data, which can lead to unfair or discriminatory outcomes (Chen, 2022). Ensuring fairness and minimizing bias in AI models is a significant ethical concern. Understanding the reasoning behind the decisions made by AI systems can be challenging due to the need for more transparency in their decision-making processes (Camacho, 2023). Therefore, transparent AI systems and clear accountability mechanisms are necessary. Users should be informed about how their data is used and provide explicit consent, especially in cases involving sensitive information. Intellectual property issues related to the ownership and use of AI-generated outputs must also be addressed.

Finally, building trust and public perception is vital for AI adoption. Gaining public trust involves addressing concerns about AI misuse and demonstrating AI systems' benefits and reliability. Promoting ethical guidelines and standards for AI development helps ensure that AI technologies are used responsibly. Organizations can foster a more responsible and sustainable approach to AI adoption by addressing these security, privacy, and ethical considerations.

5. Policy and Regulatory Considerations

The previous section outlined numerous security, privacy, intellectual property, and ethical challenges associated with AI. Governments worldwide have been contemplating AI regulations to various extents. In March 2023, Italy swiftly banned ChatGPT due to privacy concerns (McCallum, 2023), reflecting the urgency and complexity of AI regulation. (OpenAI has since restored its service after making changes to satisfy the Italian regulators, The Verge reported in April 2023.) However, most governments have adopted a more cautious approach, recognizing AI technology's dynamic and evolving implications. There is increasing collaboration between the public and private sectors and among international communities to address these challenges.

As of now, no country has enacted comprehensive AI or GenAI regulation. Nonetheless, significant legislative initiatives are underway in Brazil, China, the EU, Singapore, South Korea, and the US, according to a recent report by McKinsey (2023). The report noted that these countries are taking different regulatory approaches, from broad AI regulations based on existing laws to sector-specific guidelines, and a common theme in global AI regulation is the focus on transparency, human oversight, accountability, technical reliability, fairness, privacy, and social well-being.

A 2024 report titled The Artificial Intelligence (AI) Global Regulatory Landscape: Policy Trends and Considerations to Build Confidence in AI by Ernst & Young examined the regulatory efforts of eight key jurisdictions: Canada, China, the EU, Japan, Korea, Singapore, the UK, and the US. The report identified six regulatory trends: adherence to OECD principles, risk-based regulation, sector-specific rules, integration with other policies, regulatory sandboxes, and international collaboration. These trends underscore the global nature of AI governance and aim to balance oversight and innovation.

As AI continues to evolve and integrate into various sectors, it is crucial to establish robust regulatory frameworks that mitigate risks while fostering responsible innovation. Governments and regulatory bodies must collaborate to ensure that industries develop and deploy AI solutions in alignment with societal values and ethical standards. The identified regulatory trends provide a pathway to achieving this balance and emphasize the importance of global cooperation in navigating the complexities of AI governance.

6. Conclusion

The launch of ChatGPT in late 2022 marked a significant milestone in artificial intelligence, capturing global attention and highlighting the transformative potential of GenAI. Although AI research and development began over 70 years ago, businesses and countries have only recently fully recognized its potential. AI, particularly GenAI, holds immense promise for driving productivity growth across almost all industrial sectors in the coming decades.

However, the journey toward widespread AI adoption is fraught with challenges. Technical, cultural, and organizational hurdles must be overcome, and critical security, privacy, and ethics issues must be addressed.

It is crucial to recognize that AI is not a panacea. Technology alone cannot solve all of humanity's problems, such as world hunger, geopolitical conflicts, social harmony, or authoritarianism. Despite the increasing capabilities of machines, they lack the uniquely human qualities of emotion, empathy, free will, and the capacity for love. As Kai-Fu Lee aptly stated in his book, AI Superpowers: China, Silicon Valley, and the New World Order, "Let us choose to let machines be machines and let humans be humans. Let us choose to simply use our machines and, more importantly, to love one another" (Lee, 2018, p.232).

Ultimately, the true power of AI lies in its ability to augment human capabilities, allowing us to focus on what makes us inherently human. By leveraging AI responsibly and thoughtfully, we can harness its potential to drive productivity while ensuring that human values and compassion remain at the forefront.

References

Acemoglu, D. (2024, April 5). The Simple Macroeconomics of AI.pdf. MIT Economics. Retrieved May 27, 2024, from https://economics.mit.edu/sites/default/files/2024-04/The%20Simple%20Macroeconomics%20of%20AI.pdf

Ahlawat, P. (2024, May 17). The Art of Scaling GenAI in Software. Boston Consulting Group. Retrieved May 27, 2024, from https://www.bcg.com/publications/2024/the-art-of-scaling-genai-in-software

Anyoha, R. (2017, August 28). The History of Artificial Intelligence. Science in the News. Retrieved May 27, 2024, from https://sitn.hms.harvard.edu/flash/2017/history-artificial-intelligence/

Boussour, L., & Ernst & Young Global Limited. (2024, January 22). The productivity potential of GenAI. EY. Retrieved May 30, 2024, from https://www.ey.com/en_us/insights/ai/productivity-potential-gen-ai

Breaux, C., & Dinlersoz, E. (2023, November 28). How Many U.S. Businesses Use Artificial Intelligence? U.S. Census Bureau. Retrieved May 27, 2024, from https://www.census.gov/library/stories/2023/11/businesses-use-ai.html

Brynjolfsson, E. (2022, April 19). The Turing Trap: The Promise & Peril of Human-Like Artificial Intelligence.

American Academy of Arts and Sciences. Retrieved May 27, 2024, from https://www.amacad.org/publication/turing-trap-promise-peril-human-artificial-intelligence

Brynjolfsson, E. (2023, May 10). Can artificial intelligence actually increase human productivity? World Economic Forum. Retrieved May 27, 2024, from https://www.weforum.org/agenda/2023/05/can-ai-actually-increase-productivity/

Brynjolfsson, E., Li, D., & Raymond, L. R. (2023, April). NBER WORKING PAPER SERIES GENERATIVE AI AT WORK Erik Brynjolfsson Danielle Li Lindsey R. Raymond Working Paper 31161 http://www. National Bureau of Economic Research. Retrieved May 27, 2024, from
https://www.nber.org/system/files/working_papers/w31161/w31161.pdf

Brynjolfsson, E., & Petropoulos, G. (2021, June 10). The coming productivity boom. MIT Technology Review. Retrieved May 27, 2024, from https://www.technologyreview.com/2021/06/10/1026008/the-coming-productivity-boom/

Camacho, A. M. (2023, June 6). Demystifying explainable AI: Understanding the basics. Outsource Accelerator. Retrieved May 27, 2024, from https://www.outsourceaccelerator.com/articles/explainable-ai/

CEIC Data, an ISI Emerging Markets Group Company. (n.d.). US Labour Productivity Growth, 1949 - 2024. CEIC. Retrieved May 27, 2024, from https://www.ceicdata.com/en/indicator/united-states/labour-productivity-growth

Chen, Z. (2022, January 8). Ethics and discrimination in artificial intelligence-enabled recruitment practices. Nature. Retrieved May 27, 2024, from https://www.nature.com/articles/s41599-023-02079-x

Congressional Budget Office. (2020, January 28). The Budget and Economic Outlook: 2020 to 2030. Congressional Budget Office. Retrieved May 27, 2024, from https://www.cbo.gov/publication/56073

Curry, D. (2024, January 15). Home App Data ChatGPT Revenue and Usage Statistics (2024). Business of Apps. Retrieved May 27, 2024, from https://www.businessofapps.com/data/chatgpt-statistics/

Ernst & Young Global Ltd. (2024, January 12). Artificial Intelligence Regulation, Global Trends. EY. Retrieved May 27, 2024, from https://www.ey.com/en_gl/insights/ai/how-to-navigate-global-trends-in-artificial-intelligence-regulation

Goldman Sachs. (2023, April 5). Generative AI Could Raise Global GDP by 7%. Goldman Sachs. Retrieved May 27, 2024, from https://www.goldmansachs.com/intelligence/pages/generative-ai-could-raise-global-gdp-by-7-percent.html

IBM. (n.d.). Deep Blue. IBM. Retrieved May 27, 2024, from https://www.ibm.com/history/deep-blue
IBM. (2024, January 10). Data Suggests Growth in Enterprise Adoption of AI is Due to Widespread Deployment by Early Adopters, But Barriers Keep 40% in the Exploration and Experimentation Phases. MultiVu. Retrieved May 27, 2024, from https://www.multivu.com/players/English/9240059-ibm-2023-global-ai-adoption-index-report/

International Monetary Fund & Cazzaniga, M. (2024, January 14). Gen-AI: Artificial Intelligence and the Future of Work. International Monetary Fund (IMF). Retrieved May 27, 2024, from https://www.imf.org/en/Publications/Staff-Discussion-Notes/Issues/2024/01/14/Gen-AI-Artificial-Intelligence-and-the-Future-of-Work-542379?cid=bl-com-SDNEA2024001

International Monetary Fund, Pizzinelli, C., Panton, A., Tavares, M. M., Cazzaniga, M., & Li, L. (2023, October 4).

Labor Market Exposure to AI: Cross-country Differences and Distributional Implications. International Monetary Fund (IMF). Retrieved May 27, 2024, from https://www.imf.org/en/Publications/WP/Issues/2023/10/04/Labor-Market-Exposure-to-AI-Cross-country-Differences-and-Distributional-Implications-539656

Kalyani, A., & Hogan, M. (2024, April 4). AI and Productivity Growth: Evidence from Historical Developments in Other Technologies. Federal Reserve Bank of St. Louis. Retrieved May 27, 2024, from https://www.stlouisfed.org/on-the-economy/2024/apr/ai-productivity-growth-evidence-historical-development-other-technologies

Lee, K.-F. (2018). AI Superpowers: China, Silicon Valley, and the New World Order. Houghton Mifflin Harcourt.

Ma, J. (2024, May 25). Wikipedia. Retrieved May 27, 2024, from https://fortune.com/2024/05/25/ai-job-displacement-forecast-50-percent-2027-kai-fu-lee-chatgpt-openai/

Manning, C. (2020, September). Artificial Intelligence Definitions. Stanford HAI. Retrieved May 27, 2024, from https://hai.stanford.edu/sites/default/files/2020-09/AI-Definitions-HAI.pdf

McCallum, S. (2023, April 1). ChatGPT banned in Italy over privacy concerns. BBC. Retrieved May 27, 2024, from https://www.bbc.com/news/technology-65139406

McCarthy, J. (n.d.). What is AI? / Basic Questions. John McCarthy. Retrieved May 27, 2024, from http://jmc.stanford.edu/artificial-intelligence/what-is-ai/index.html

McKinsey & Company & Cui, M. (2023, June 14). Economic potential of generative AI. McKinsey. Retrieved May 27, 2024, from https://www.mckinsey.com/capabilities/mckinsey-digital/our-insights/the-economic-potential-of-generative-AI-the-next-productivity-frontier#key-insights

McKinsey & Company & Kremer, A. (2023, December 21). Governance and regulation as generative AI advances. McKinsey. Retrieved May 27, 2024, from https://www.mckinsey.com/capabilities/risk-and-resilience/our-insights/as-gen-ai-advances-regulators-and-risk-functions-rush-to-keep-pace#/

Nielsen, J. (2023, July 16). AI Improves Employee Productivity by 66%. Nielsen Norman Group. Retrieved May 27, 2024, from https://www.nngroup.com/articles/ai-tools-productivity-gains/

OpenAI. (2024, May 13). Hello GPT-4o. OpenAI. Retrieved May 27, 2024, from https://openai.com/index/hello-gpt-4o/

Oppy, G., & Dowe, D. (2003, April 9). The Turing Test (Stanford Encyclopedia of Philosophy). Stanford Encyclopedia of Philosophy. Retrieved May 27, 2024, from https://plato.stanford.edu/entries/turing-test/

Robertson, A. (2023, April 28). ChatGPT returns to Italy after ban. The Verge. Retrieved May 30, 2024, from https://www.theverge.com/2023/4/28/23702883/chatgpt-italy-ban-lifted-gpdp-data-protection-age-verification

Stanley Racing Team. (2005). Stanley. Robot car "Stanley" designed by Stanford Racing Team. Retrieved May 27, 2024, from https://cs.stanford.edu/group/roadrunner/stanley.html

U.S. BUREAU OF LABOR STATISTICS. (2021). Long term labor productivity by sector for selected periods : U.S. Bureau of Labor Statistics. Retrieved May 27, 2024, from https://www.bls.gov/productivity/charts/long-term-labor-productivity-by-sector-for-selected-periods.htm

Waters, R. (2023, February 17). Man beats machine at Go in human victory over AI. Financial Times. Retrieved May 27, 2024, from https://www.ft.com/content/175e5314-a7f7-4741-a786-273219f433a1

World Bank & Dieppe, A. (2021). Global Productivity: Trends, Drivers, and Policies. World Bank. Retrieved May 27, 2024, from https://www.worldbank.org/en/research/publication/global-productivity

Yan, S. (2017, April 27). Kai-Fu Lee: Robots will replace half of all jobs. CNBC. Retrieved May 27, 2024, from https://www.cnbc.com/2017/04/27/kai-fu-lee-robots-will-replace-half-of-all-jobs.html