

Talos Reborn: Artificial Intelligence and the World Economy¹

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One of the key questions regarding Artificial Intelligence (AI) is how it will affect the global economy. AI represents the embodiment of intelligence in non-human agents. This includes machines and software that utilize various information or inputs (often big data), identify existing and new patterns based on some given objectives, and produce outcomes or perform tasks while learning from previous analyses or experiences. And even though its inputs, objectives and programming are created by humans, AI can execute tasks, make recommendations, or make decisions without direct human supervision.

How will the scientific and technological breakthroughs associated with AI change the world economy? It is the purpose of this article to show that the socioeconomic impacts of AI are likely to be deep, with potentially major effects on the world economy and society in general.

AI and Automation

The economic consequences of AI represent a topic that connects to a long-standing debate on the consequences of automation. However, AI differs sharply from traditional automation, constituting a much more encompassing and far-reaching phenomenon.

Automation refers specifically to technologies that automate tasks performed by humans. In the past, these tasks have been largely routine, that is, rules-based tasks that machines or robots can perform faster and more efficiently than humans. Economists have studied the consequences of this type of automation, focusing on its productivity effects, on the one hand, versus the substitution of machines for workers, particularly blue-collar workers, on the other.²

Most economic studies of the impact of AI so far have followed these, earlier, studies of automation, focusing on how AI-based machines and software can substitute workers in *both* routine and non-routine tasks, blue-collar *and* white-collar jobs,³ etc. These are important to consider. But the consequences of AI are much deeper than these. Its universe of impacts is likely to dwarf those of

¹ In Greek mythology, Talos was a bronze giant built by Hephaestus, the god of invention. It had autonomous intelligence and its objective was to protect the humans in the Island of Crete from invaders and from local injustices. See Adrienne Mayor, *Gods and Robots: Myths, Machines, and Ancient Dreams of Technology* (Princeton, NJ: Princeton University Press, 2018).

² See, for instance, Laura D'Andrea Tyson, "Automation and the Future of Work in Germany: A Summary of Research and Policy Recommendations" Governing Work in the Digital Age Project Working Paper Series (Berlin: Hertie Graduate School, 2021); and Daron Acemoglu, Claire Lelarge, and Pascual Restrepo, "Competing with Robots: Firm-Level Evidence from France," *American Economic Review*, Vol. 110, May 2020.

³ Didem Özkiziltan and Anke Hassel, "Artificial Intelligence at Work: An Overview of the Literature," Governing Work in the Digital Age Project Working Paper Series (Berlin: Hertie Graduate School, 2021).

traditional automation. The reason is because, as an extension of human intelligence, AI is bound to generate waves of new inventions and technological breakthroughs. And in contrast to most previous waves of innovation—such as in the motor vehicle, home appliances, aviation, and information technology revolutions—AI may be linked to technological change in a wider array of industries, from finance and financial security to medicine and pharmaceuticals, from automobiles and traffic congestion to national security and defense.

The Impact of AI on Innovation and Technological Change

Because it can allow human intelligence to surpass its limits, AI has the potential to greatly extend the frontiers of science, technology, and creativity. It is as if the number and efforts of human scientists and inventors dedicated to innovation were multiplied many times. Commenting on the power of AI in the field of mathematics, Oxford University mathematician András Juhász has stated that, when guided by human intelligence and intuition, "machine learning provides a powerful framework that can uncover interesting and provable conjectures in areas where a large amount of data is available, or where the objects are too large to study with classical methods."⁴ From this perspective, AI can help not only to create new theorems in mathematics but in many other fields.⁵ The potential is enormous.

The creation of new goods and services through the assistance of AI is already occurring. Electronics and engineering companies, such as General Electric, have used AI to create new designs for jet engines and for diesel motors that minimize emissions. Medical technology firms, like Medtronic and Philips-Biotelemetry, are focusing AI efforts to design more precise surgical equipment and robotics in orthopedics and to develop software that uses AI to provide more accurate diagnoses of various diseases, such as diabetic retinopathy, which is one of the main causes of blindness worldwide. These innovations are improving human productivity and well-being and stimulating economic growth.

Consider in more detail the pharmaceutical and biotechnology industries. The process of discovering new drugs and medicines is highly complex, involving the search for molecular combinations and structures that researchers often navigate during many years of costly efforts. AI, however, can accelerate this process by dozens or perhaps even hundreds of times, potentially leading to many more medicines.⁶ Such was the case of the antibiotic Halicin, discovered by an MIT-led team with the help of AI. The researchers constructed a neural network — an AI algorithm inspired by the brain's architecture — that learned the properties of molecules and then was trained to spot molecules that inhibit the growth of the bacterium *Escherichia coli*.⁷ The new antibiotic was discovered in a fraction of the time taken without AI and is quite distinct from existing antibiotics.⁸ AI is being used as well in the search for a range of medicines and vaccines, including mRNA vaccines of the type developed to combat COVID-19.

⁴ Alex Davies, Petar Veličković, Lars Buesing, Sam Blackwell, Daniel Zheng, Nenad Tomašev, Richard Tanburn, Peter Battaglia, Charles Blundell, András Juhász, Marc Lackenby, Geordie Williamson, Demis Hassabis and Pushmeet Kohli, "Advancing Mathematics by Guiding Human Intuition with AI," *Nature*, Vol. 600, 70–74, 2021.

⁵ For a discussion of the impacts of AI in the natural sciences, see Jack Leemng, "How AI is Growing a Foothold in the Natural Sciences," *Nature*, Vol. 598, 2021.

⁶ Bowen Lou and Lynn Wu, "AI on Drugs: Can Artificial Intelligence Accelerate Drug Development? Evidence from a Large-scale Examination of Bio-pharma Firms," *Marginal Information Systems Quarterly*, Vol. 45, September 2021.

⁷ Jo Marchant, "Powerful Antibiotics Discovered Using AI," *Nature*, News, February 2020.

⁸ J.M. Stokes, K. Yang, K. Swanson, W. Jin, A. Cubillos-Ruiz, N.M. Donghia, C.R. MacNair, S. French, L.A. Carfrae, and Z. Bloom-Ackerman, "A Deep Learning Approach to Antibiotic Discovery," *Cell*, Vol. 181, April 2020.

The promise of AI in generating new products can be remarkable and unexpected. This is the case of AI's involvement in the creation of artistic products, such as paintings, music, and prose. Think, for example, about the AI-based software programs which "study and learn" existing schools of art (their styles and patterns) in generating new images.⁹ The more advanced programs produce paintings that ordinary observers cannot differentiate from paintings created by humans, an accomplishment reached in music and prose as well. In October 2019, Christie's, the New York auction house, sold the painting Portrait of Edmond de Belamy, an AI-generated print in the style of 19th-century European portraits, for \$432,500.¹⁰

Another industry where AI is leading to substantial technological progress is the financial services industry and, more specifically, the financial technology sector (fintech). AI-guided software is being used to assist and improve the delivery of complex financial services to customers. For instance, by combining new client information with existing volumes of data on credit decisions, and quickly analyzing it, AI-assisted financial services can accelerate and make more accurate and faster credit decisions. AI software can also analyze big data sets and provide financial advisors with more sophisticated assessments of investments and portfolios.

It can be implied from these examples that the most significant economic effect of AI is likely to be its impact on the rate of technological progress, in increasing what economists call total factor productivity (TFP). This represents a major development for the world economy, as there has been a significant slowdown of TFP growth in the United States, Europe, and in an array of other countries in recent decades.¹¹ AI has the potential to reverse this trend.¹² Since TFP growth is at the core of improvements in income per-capita, AI can be a game changer in the world economy. Its potential accomplishments in health, medicine, finance, information, communications, transportation, climate change, and a range of other fields have the capacity to generate great wealth.

A New Era of Globalization?

AI is likely to propel globalization to a new stage. This is because of the boost it can provide to global value chains (GVCs), e-commerce, and the flow of information and ideas across borders.

Beginning in the eighties, world production was revolutionized by the computer and information technology (IT) revolutions. By allowing more efficient global management and coordination networks, the IT breakthroughs permitted a growing fragmentation/unbundling of production. As a result, the multi-country manufacturing referred to as global value chains (GVCs) boomed. All over the world, final products—from automobiles and cell phones to pharmaceuticals and medical devices—are now produced in one country using inputs from many others, organized mostly by large multinational

⁹ Marcus Du Sautoy, *The Creativity Code: Art and Innovation in the Age of AI* (Cambridge, MA: Harvard University Press, 2019).

¹⁰ See Ian Bogost, "The AI-Art Gold Rush is Here," *The Atlantic*, March 6, 2019.

¹¹ Emily Moss, Ryan Nunn, and Jay Shambaugh, "The Slowdown in Productivity Growth and Policies That Can Restore It," (Washington D.C.: The Brookings Institution, 2020).

¹² See Erik Brynjolfsson, Daniel Rock, and Chad Syverson, "Artificial Intelligence and the Modern Productivity Paradox: A Clash of Expectations and Statistics," Initiative on the Digital Economy Research Brief (Cambridge, Mass: Massachusetts Institute of Technology, 2018).

companies.¹³ According to United Nations (UN)-World Trade organization (WTO) data, close to 80 percent of global exports of goods and services now occur through GVCs. But the growth of GVCs has been slowing down during the last decade. The use of AI can reverse this recent trend. It can improve and speed-up the complex management and coordination of inputs, supply, inventories, warehousing, and transportation links within and among countries. By more accurately monitoring and responding to sudden demand changes, AI can increase the ability of multinational firms to move goods and services smoothly across the globe through GVCs.¹⁴ It is unlikely that the supply chain disruptions that plagued some countries in 2021 would have been so damaging with fully functioning AI systems.

And it is not just trade through GVCs that would benefit from AI. Cross-border e-commerce is growing at an astounding rate as well, and it is likely to propel cross-border trade to greater levels in the future. It is estimated that AI-based recommendation engines already account for 30 to 40 percent of sales among leading e-commerce companies.¹⁵ And AI-based digital platforms are allowing small and medium-sized businesses to export all over the world.

AI can also foster globalization by stimulating the flow of information and ideas. Digital data flows—from information about customer preferences to the results of research studies—have multiplied quickly in recent years. AI has contributed to these flows and their distribution worldwide. The value of trade in ideas has not been adequately recognized, but recent research suggests that it can provide significant growth benefits for both high-income and developing countries.¹⁶

The Challenges of AI

The promise of AI is only matched by its great challenges. It has the potential to increase inequality among nations and within countries, concentrate market power in a few firms, and be captured by governments to restrict human and civil rights and to generate dangerous and destabilizing military software and weapons.

First, AI is a highly human capital-intensive industry that requires substantial R&D investments. It also utilizes vast amounts of computer power. Only a few nations tend to be heavily active in the AI field, mostly high-income countries (such as the US, UK, Germany, and Japan) and a few middle-income countries (like China and India).¹⁷ This means that the income gains generated by AI will be concentrated in a few, mostly rich, nations that have access to the appropriate skilled labor and computing infrastructure. Furthermore, since AI itself and its inventions may not be freely copied, whether because of patents or intellectual property rights, most of the profits associated with AI will be highly

¹³ For a discussion of GVCs, see Mariana Spatareanu, ed., *Foreign Direct Investment and the Multinational Enterprise*, in Francisco L. Rivera-Batiz, ed. *Encyclopedia of International Economics and Global Trade* (Singapore: World Scientific Publishers, 2010).

¹⁴ See Joe McKendrick, "AI Adoption Skyrocketed Over the Last 18 Months," *Harvard Business Review*, September 27, 2021; Joshua P. Meltzer, "The Impact of Artificial Intelligence on International Trade," (Washington DC: Brookings Institution, 2018).

¹⁵ Jacques Bughin, Jeongmin Seong, James Manyika, Michael Chu and Raoul Joshi, Notes from the AI Frontier: Modeling the Impact of AI on the World Economy, Discussion Paper, McKinsey Global Institute, 2018.

¹⁶ Chang-Tai Hsieh, Peter J. Klenow and Ishan Nath, "A Global View of Creative Destruction," Working Paper (Palo Alto, CA: Stanford University, 2021).

¹⁷ Daniel Zhang et. al. *Artificial Intelligence Index Report 2021* (Stanford, CA: Human-Centered AI Institute, Stanford University, March 2021).

concentrated in a few countries and in a few hands, further increasing global inequality. It is true that the gains from AI can spillover to poor countries. For instance, the electronic use of fintech services can expand the access of financial transactions to areas that mainstream financial institutions do not serve, and it is being used by microlending institutions serving poor populations in developing countries.¹⁸ But the fact that those technologies are supplied by inventions and applications originating in high-income countries means their profits will largely go to the latter. Similarly, the development of new drugs or other AI-inventions is likely to face the same fate as that of COVID-19 vaccines, which have greatly benefited the inventors in high-income countries but have reached developing country populations only with great delay, despite significant global efforts.¹⁹

Second, some of the sectors where the new inventions are originating are highly concentrated, lacking competition. Whether one is talking about giants in the social network, internet, pharmaceutical, financial, or other industries, their oligopolistic nature fosters the proliferation of strategies involving the manipulation of information and prices in such a way that can reduce economic welfare.²⁰ Such is the case of price discrimination, in which firms charge different prices depending on the characteristics of consumers.

But perhaps of even more concern is the potential use of AI by governments to invade the privacy of individuals, violate civil and human rights, and manipulate political and social attitudes.²¹ AI software used for traffic control purposes can serve to reduce congestion and traffic accidents, which can save lives, raise worker productivity, and make more time available for leisure purposes. Many metropolitan areas have already deployed AI traffic technology solutions. In the US, 66 percent of cities are investing in smart city traffic technologies.²² In China, the digital cities plan, proposed back in the early 2010s, has led to a push towards the use of AI in traffic management, with China's leading high-technology companies --such as Alibaba, Tencent, Didi Chuxing, Baidu, and Huawei-- getting involved in what is a close private-public collaboration. But these technologies can also be used by governments to follow and track individuals without their knowledge or permission. Various forms of AI-produced software can be utilized to restrict freedom of the press, crush dissent, and suppress political opposition.

Over the centuries, human intelligence has produced revolutionary discoveries and inventions that have greatly increased the standard of living in most of the world. But they have also brought the world to the brink of nuclear war and to the verge of devastating global climate change. AI is not in a different category. For instance, consider its creative potential. Just as it can be used to generate marvelous new paintings and music it can also be utilized to create sophisticated fake images and videos that can sprout

¹⁸ See Davide Strusani and Georges Vivien Hounghonon, "The Role of Artificial Intelligence in Supporting Development in Emerging Markets," *Emerging Markets Compass* (Washington D.C.: The World Bank, 2019).

¹⁹ A. Michael Spence and Joseph Stiglitz, "The Pandemic and the Economic Crisis: A Global Agenda for Urgent Action," *Institute for New Economic Thinking Report*, March 2021.

²⁰ See Daron Acemoglu, "Harms of AI," NBER Working Paper 29247 (Cambridge, MA: National Bureau of Economic Research, 2021); Anton Korinek, Martin Schindler, and Joseph E. Stiglitz, "Technological Progress, Artificial Intelligence, and Inclusive Growth" Working Paper WP/21/166 (Washington D.C.: International Monetary Fund, 2021).

²¹ Shoshana Zuboff, *The Age of Surveillance Capitalism: The Fight for a Human Future at the New Frontier of Power* (NY: Public Affairs, 2019).

²² Darrell M. West and John R. Allen, "How Artificial Intelligence is Transforming the World, " (Washington DC: The Brookings Institution, April 24, 2018).

hate, conflict, and even civil war.²³ Most dangerous perhaps is the development and proliferation of AI-based military applications and weapons. Autonomous robots and weapons, intelligent defense software, and AI-based strategic military analyses are being developed by departments of defense and military agencies in the US, China, and Russia, among others. Their superiority over existing military systems serves as a great stimulus for countries to develop and deploy them. But they can give rise to serious dangers, as their performance is still based on the reliability of data collected, security systems that may subject to hacking, and software that can be reproduced or stolen by terrorist organizations or rogue states. It can also lead to a renewed race to develop new AI weapons and related systems, raising the risk of conflict and war, just as the proliferation of nuclear weapons did.²⁴

Conclusions

The serious negative consequences arising from AI need to be managed through policies that seek to counteract or minimize them. The impacts on the labor market require government policies that support those workers who are displaced. Increased investments in education, particularly in science, technology, engineering, and math (STEM) fields, can foster the nascent development of AI industries in developing countries, as they already have in China and India. Multilateral institutions, from the World Bank to the World Health Organization, need to be much more deeply involved in the low-cost transfer of AI technologies and infrastructure to developing countries. Public and/or non-governmental organizations must be empowered to control unethical uses of AI. International institutions, such as the United Nations, need to monitor and discourage the use of AI in the violation of basic human and civil rights. And new global treaties and accords will have to be developed to control the proliferation of AI-based military equipment and systems.

The AI revolution is rapidly enveloping the world economy.²⁵ Its promise is matched by its challenges. Still, AI is being created by humans and ultimately only high-quality domestic and international human governance --in the public and private sectors-- can ensure that the great possibilities opened by AI do not also open a Pandora's box of problems and inequities in the global economy, with potentially disastrous consequences.

²³ Kai-fu Lee and Chen Qiufan, *AI 2041: Ten Visions for the Future* (New York, NY: Currency Publishers, 2021).

²⁴ Forrest E. Morgan, Benjamin Boudreaux, Andrew J. Lohn, Mark Ashby, Christian Curriden, Kelly Klima, and Derek Grossman, *Military Applications of Artificial Intelligence: Ethical Concerns in an Uncertain World* (Santa Monica, CA: RAND Corporation, 2020).

²⁵ Richard Baldwin, *The Globotics Upheaval: Globalization, Robotics, and the Future of Work*, (New York: Oxford University Press, 2019).