RESEARCH ARTICLE

THE ECONOMIC IMPACT OF AI TECHNOLOGY

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ABSTRACT

This research paper goes over the definition of AI, and its macroeconomic and microeconomic impacts in terms of economic and productivity growth, and labor demand. AI (Artificial Intelligence) technology is widely being developed and expected to be used more broadly. Thus, many experts and papers are estimating its economic value and possible impact. Many reports state that AI technology will bring in considerable revenue. The revenue will increase due to improved productivity which will reduce costs, and advance the quality of products. First, the installment of AI technology will greatly increase both labor and firm productivity. According to a report, innovation induced by this technology is classified as a skill-biased technical change. When labor productivity increases, those who are high-skilled and highly educated can improve their jobs, but those who are not educated will be displaced. Also, AI technology can improve the productivity of firms by assisting various functions. Second, product personalization, quality of products, and utility of consumers will be improved and consumption will be facilitated. This research paper will go over both theory and empirical research to figure out if AI technology will influence economic growth. Economic growth is measured by estimating real GDP globally and comparing data from prior years. Many people worry that AI technology will replace their jobs. In this report, the possibility of AI replacing jobs done by humans and generating new occupations with a new paradigm will be discussed.

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INTRODUCTION

AI technology has been portrayed both positively and negatively in various media; portrayed both as an efficient assistant that works more effectively than humans as well as a being that develops its own characteristics to destroy human-kind. Unlike our concerns, AI is being used daily in our society. Despite this, use of AI technology is still controversial. In fact, Stephen Hawking stated that AI could potentially replace humans entirely, and warned that it could invent its own duplicating algorithm to threaten human-kind. In order to understand the economic effects of AI technology, it must be defined. John McCarthy first suggested the term Artificial Intelligence in 1956, which is still being used today. Currently, AI is under the category of computer science. According to the Oxford English Dictionary, AI is defined as "The theory and development of computer systems able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages." To be more specific, Merriam Webster defined AI as "A branch of computer science dealing with the simulation of intelligent behavior in computers and the capability of a machine to imitate intelligent human behavior." In this paper, AI will be defined as "A subfield of

computer science that pursues a building system that imitates human intelligence such as learning, problem solving, and pattern recognition". This definition encompasses a developing system that is human-like by referencing human reasoning. According to IDC, International Data Corporation, worldwide revenues for AI technology reached 12.5 billion dollars in 2017, which is a 59.3% increase from the prior year. Also, the global spending on AI technology will increase at a compound annual growth rate of 54.4% through 2020, by whichrevenue will reach more than 46 billion dollars. The important point is that the economic scale of AI technology in terms of investment and revenue is continuously growing. The IDC report states that quality management investigation and recommendation systems, diagnosis and treatment systems, automated customer service agents, automated threat intelligence and prevention systems, and fraud analysis and investigation systems are the five biggest sections invested in among AI technology. Also, natural language generation, speech recognition, virtual agents, machine learning platforms, AI-optimized hardware, decision management, deep learning platforms, biometrics, robotics process automation, text analytics, and NLP are the ten flourishing AI technologies according to Forbes. Although AI technology has been widely used and invested in, worries around the technology being developed have not vanished. There has been an increase of "technophobes", who are vigilant or even scared of technological advances. Such fears and worries mostly stem

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from technology being automatic, especially in areas where robots or AI software can replace jobs.

Economic Impact of AI in terms of Advancement in Technology

Effect of Technological Advance on Labor Productivity Historically: In the 19th century, technological advancement reduced relative labor productivity of skilled workers and enhanced labor productivity of some unskilled workers. With this background, this innovation is called unskilled-biased technical change. As people, especially skilled workers thought the mass production using machines was a threat to their lives, they participated in the Luddite riots and destroyed machines. Despite their efforts, the Luddite riots failed. The Industrial Revolution's sudden technological advancement led to a decline of high skilled workers but an increase in labor productivity of low skilled workers. Therefore, although many high skilled workers lost their jobs, average labor productivity highly increased through division of labor and automation. However, the sudden technological advance in the 20th century was totally different. Computers and the Internet have highly increased the relative productivity of high skilled workers, while labor-intensive workers, who just repeat simple routine tasks, lost their competitiveness. That is, firms demand workers with a high level of education rather than low educated ones. In fact, Nir Jaiimovich and Henry Siu stated that the recent decline in manufacturing is responsible for the low labor demand for less educated workers. Moreover, Autor, Levy, and Murnane found that approximately 60 percent of the estimated demand preference to college-educated workers can be explained by the reduced labor demand for workers with routine tasks and increased labor demand for workers with cognitive, problem-solving, creative tasks. The advent of computer and the internet drove productivity increase of highly skilled workers. Therefore, the overall productivity increased, but profit andthe utility of increased productivity havenot been equally distributed.

AI and Labor Productivity: As mentioned above, advances in technology showed a linear increase with labor productivity. Like the digital revolution caused by the development of computers and the internet, AI technology has a high chance of becoming a skill biased technical change. In fact, according to Statista.com, labor productivity growth with AI technology is estimated to be around 30 percent. Due to AI technology, by 2035, labor productivity is expected to grow over 30 percent. According to CNBC, thanks to AI technology based industries, which include lots of industries such as the hotel business and banks, the labor productivity of The United States, may even grow over 40 percent. The report stated that AI can learn workers' capabilities, help them understand best practices and do higher-skilled jobs with a higher quality and productivity.

Promotion of Productivity of Firms: AI technology is not just a 'single' technology but rather is a collective group of different technologies. Having such a diverse spectrum, it affects many parts of the economy in various ways. Firms, one of the components of an economy, are composed of many sectors. First, firms should decide their strategies and build business models to sell products and services, which include offering, pricing and go-to-market strategies. Then, AI can reduce the risk, time, and capital spent while a company moves from strategy to execution by simulating market conditions and creating a digital virtual model of product features based on

successful models in the past and user preferences. Moreover, firms should discover and reflect new information and trends of their products through Research and Develop (R&D). In this case, AI can reduce runways required before insights are generated. For example, AI can scan scientific data to identify whether there is another use for a drug which has been approved. It can also manage systems to make more or better output using limited resources. For instance, AI can automate the production line with robots and it can adjust systems immediately to produce goods based on spontaneous orders. Firms have to move resources to the production line, and move final products to customers. AI can reduce the time and resources required in this process by automatically ordering raw materials based on sales patterns and production time. For marketing, sales and customer service with increasing customer engagement is crucial. AI can reduce the information asymmetry between the firms and consumers and let firms reflect trends and consumers' preferences. For example, companies can provide personalized recommendations of products and services by developing AI chatbot consumer service agents, and monitoring sales practices. Lastly, AI can execute back-office supporting activities by costs and reducing risks with better planning and forecasting. Likewise, AI can increase productivity of firms by supporting various tasks. Then, what does increased productivity imply about production? With an increase in productivity by AI, productivity increases as well as factor payments. This leads to increases in income and GDP since the sum of income and GDP are equal. However, income increases as a result of a capital share income increase, not labor share income. Therefore, some labor forces will be more productive and will remain in their occupations, while others will be discarded from the workplace. The latter will be discussed in the labor section of this report. Viewing micro-economically, when income is increased, budget constraint moves upward. Therefore, utility will be gained at the next isoquant level. Viewing macro-economically, the income increase will allow more goods to be bought. Therefore, consumption will be increased and private saving will increase depending on Marginal Propensity to Consume (MPC). Therefore, investment and imports will increase but net exports will decrease.

This effect is explained by the IS-LM model. The IS curve is the combination of points where Y=C+I+G+NX. And when income is increased the IS curve will shift upward. This is because the amount decreased by an increase in imports cannot offset the amount increased in consumption. Therefore, the new equilibrium shows that the real interest rate and real GDP will increase linearly.
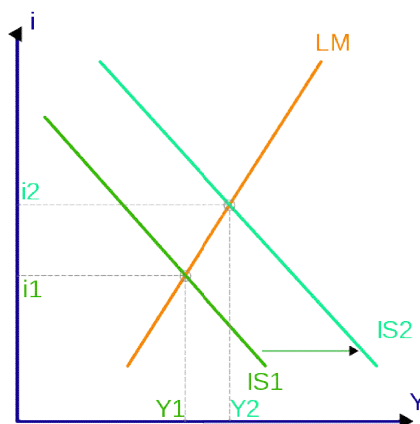
Promoting Utility on Consumption Perspective by AI Technology: AI technology can promote the utility of consumers in various ways. First, AI technology can provide product personalization. Firms can provide product personalization by gathering lots of personal data, and making a meaningful result that indicates personal preferences. In this process, AI can help firms gather consumers' data and analyze it. When firms personalize their products, product choices for consumers will increase. Therefore, marginal utility of consumption will rise since the marginal utility of buying various goods rather than buying lots of single items is higher. Therefore, it generates an increase of consumption. AI technology can promote the quality of products in two ways. First, the scope of functionality of the product can be expanded. Second, utility yielded can be increased while the scope remains the same. That is, with AI technology, products with various functions can be developed. The increased scope of functionality and versatility of products will create more consumption. Finally, AI technology can save time. Since AI technology highly increases productivity, it can allow people to have enough time to consume more. AI technology can also reduce consumers' efforts to search for an item that they want, which ultimately saves search costs. Furthermore, as AI offers recommendations to customers by analyzing consumer's characteristics, it can help consumers achieve maximized utility or find little utility level with minimized searching costs and effort.

Economic Growth Through AI Technology

Theoretical Background: Solow-Swan Model: According to the Solow-Swan model, real GDP, which is represented as Y, is equal to the production function of capital and labor, which are factors of production.

$$Y = F(K, AL)$$

There can be three possible scenarios: economic state without population growth and without technological advancement, economic state with population growth but not with technological advancement, and economic state with population growth and technological advancement. The economic steady state is when change in capital person equals the saving rate multiplied by production per person minus the depreciation rate multiplied by capital per person (Saving rate = s, depreciation rate = δ, population growth rate= n, technological advancement rate = g)

$$\Delta k = s * f(k) - (\delta + n + g)k$$

Since Y equals consumption(C) plus investment (I), assuming that there is no government spending and net export, (Y = C+I) Y minus C is equal to I. Since I is equal to S(saving), Y minus C is equal to S. Therefore, Y-C=S, which corresponds to our intuition. So, we can simply say that s (saving rate) times Y is equal to I. And investment is the sum of $\Delta K, \delta K, nK$, and gK when $\Delta K = new\ capital$, δK= depreciation of old capital, nK = capital for new workers, and gK= new capital for improved ability for each worker. So, $s*Y = \Delta K + \delta K + nK + gK$, and $\Delta K = sf(K) - \delta K - nK - gK$. To divide the whole equation by L, which is the number of population assuming that all people are employed, $\Delta k = sf(k) - \delta k - nk - gk\ is\ the\ result$. And 'k' represents capital per person. If sf(k) is larger than $\delta k + nk + gk$, k changes since Δk is larger than 0. On the other hand, if sf(k) is smaller than $\delta k + nk +$

gk, k also changes since Δk is smaller than 0. Therefore, the steady state is when $\Delta k = s * f(k) - (\delta + n + g)k$.

First of all, when there is no population growth and no technological advancement, n equals 0, and g equals 0. Therefore, the steady state is when Δk equals 0. And since it is fixed in steady state Y and y does not change at all. So, we cannot explain economic growth by this model.

Secondly, when there is population growth and no technological advancement, n>0 and g=0. In the steady state, y(real GDP per capita) is fixed, so Δy=0. However, since y=Y/L, and L increase at the rate of n, Y also increases at the rate of n in order to satisfy the condition of Δy=0. Therefore, this model can explain economic growth in real GDP, but not economic growth in real GDP per capital.

Lastly, when there is both population growth and technological advancement, n>0 and g>0.And Y=F(K, AL), which is labor augmenting production function, states that technological advance can improve the production skill of each worker by letting them work with more capital stocks. Since production function is Constant Returns to Scale (CRS), we can say that Y/AL=F(K/AL, 1).

In the steady state, Δ(Y/AL) equals 0. Moreover, since A increases by rate of g, y should increase by the rate of g since Y/L equals y. Therefore, Δy = g, and ΔY= n+g. So, this model explains both real GDP growth and growth of real GDP per capital of the economy. In conclusion, economic growth per capital can be explained if and only if technology is developed. Therefore, AI technology as technological advancement will bring us an increase in productivity, which will increase production, and economic growth.

Empirical Research: According to the report written by Susanto Basu, John G. Fernald, and Matthew D. Shapiro, the increased productivity in the 1990s was led by technological growth, which corresponds with theoretical analysis explained in the prior section. Moreover, in 2004 Romain and Van Pottelsberge found that the marginal value of one dollar invested in AI can increase to 1.99 dollars. Using their discovery, since 14.9 billion dollars was invested in AI technology in 2014, approximately 296.5 billion dollars of economic growth is estimated over the next ten years from 2014 to 2024. However, the amount invested in AI technology keeps growing at a linear rate. According to the report by Romain and Van Pottelsberge, since investment in AI technology grows by about 3.3 billion dollars per year, the estimated AI industry will produce approximately 657.7 billion dollars by 2024. Private investment in AI will yield the same economic output as general private sector R&D. Furthermore, according to the PwC report, global GDP could rise by14 percent, which is equivalent to 15.7 trillion dollars, in 2030. To put it into perspective, 15.7 trillion dollars is more than the currency output of China and India combined. Therefore, we can conclude that technological advancement directs economic growth based on previous incidents as well as theory. In addition, reports by PwC, Romain, and Van Pottelsberge suggest that AI technology will especially bring us economic growth, which is estimated to be 15.7 trillion dollars globally.

AI technology and the Labor Market

Jobs Displaced by Automation: Although the technological development of AI technology has made society better in terms

of productivity and economic growth, whether the benefit is shared broadly has not been determined. Rather, considering that most technological innovation nowadays is skill-biased technological change, the benefit of economic growth is likely to be shared unevenly. According to Oxford University researchers Frey C.B. and Osborne M.A. and a sample of occupations from the US Department of Labor, about 47 percent of jobs in the United States are at high risk due to AI job automation by 2030. However, Arntz M. Gregory, T. and Zierahn, M. suggested that 9 percent of jobs in the US are at high risk in 2015, which used an OECD-compiled dataset. Furthermore, according to the report of Frey and Osborne, about 83 percent of jobs whose hourly wage is less than 20 dollars are at risk of job automation, while 31 percent of jobs whose hourly wage is between 20 dollars to 40 dollars are at risk, and only 4 percent of jobs whose hourly wage is more than 40 dollars are at risk of being dismissed by job automation. Also, according to Arntz M. Gregory, T. and Zierahn, M., about 44 percent of workers with less than a high school degree are at risk of job automation while only 1 percent of workers with a Bachelor's degree are at risk. This result shows us that jobs which require less education are at a higher risk of job automation than workers with less education. Using "drivers" as an example job, a White House report predicted what will happen if automated vehicles came out. Although the report predicted that many jobs will disappear by the advent of the automated vehicle, various driving jobs with less-automatable tasks might not disappear. For example, school bus drivers have various tasks including driving, which is automatable, and attending to children, which is less automatable. That is the reason why the report states that only 30 to 40 percent of drivers for special clients, such as students going to school, are going to be displaced while nearly 100 percent of heavy truck drivers are going to be displaced by automated vehicles.

Job Creation due to AI Technology: Despite the fact that AI technology might bring massive job unemployment by job automation, AI technology has potential to create job opportunities. In fact, Arntz, Gregory, and Zierahn stated in their report that new technologies may bring positive effects on labor demand by improving competitiveness and a positive effect on worker's income which was mentioned in section 2.3. Moreover, Autor suggested that previous research ignored "strong complementarities between automation and labor that increase productivity, raise earnings, and augment demand for labor". Also, AI technology itself requires new jobs. Someone has to develop, maintain, applicate, operate, and regulate the technology in order to gain benefits and alleviate negative impacts on the technology that it might give. In the initial stage of development, highly-skilled software developers and engineers are needed. Then, since AI has to be "educated" in order to function well, workers who manage, collect, and generate data are needed. Furthermore, to alleviate all the possible negative impacts that AI can bring, sociologists who will investigate the impact on specific populations, and philosophers who will review frameworks for ethical evaluation are needed. Moral dilemmas and ethical questions are too hard to solve, decide, or be judged by computer algorithms. Therefore, AI should only learn relatively simple ethical questions, while others can be answered case by case from philosophers. That is, philosophers are needed in the AI developing step when making manuals or algorithms of AI. Furthermore, to minimize the negative impacts on real people and to maximize the benefits shared by each component of our

society, sociologists should investigate the sociological impact on real people. In addition, we have to focus on why AI is called "Artificial Intelligence", and "Augmented Intelligence". That is, AI technology's role is to assist individuals and enhance their productivity, rather than replace them. Thus, since human work is still needed to complement AI technology, labor demand will not suddenly shrink. Rather, labor demand for those who can complete tasks while using AI's support will be generated. Furthermore, people to supervise AI will be needed. In order to use the technology in both a beneficial and safe way, we need to regulate, control, and supervise the technology and people using the technology. Especially for those cases that need ethical judgement, morality, and social intelligence, AI technology needs real time supervision. Lastly, since there are paradigm shifts as technologies are developed, people who can reflect the social need and 'Zeitgeist' into the technology and continue developing the technology in better ways are needed.

Conclusion

In conclusion, AI technology will cause a major impact on our society. First, advances in AI technology will have a great effect on economic growth. As mentioned previously, technological advances have the tendency to increase productivity; especially in a company, AI technology will be used in versatile ways, thus helping overall productivity. This kind of productivity will induce increases in minimum wage, product quality, consumption and expenditures and allow product personalization. In addition, AI technology advances cause an increase in consumer utility by conserving time and reducing cost. Through the Solow-Swan model, increases in real GDP growth and real GDP per capital growth by technological advance were shown to be theoretically possible. This report showed what happens if experimental research corresponds with the theoretic outcome. According to research outcomes, effects of technological advances during the 1990s in productivity and economic growth are apparent. Dissertations that analyzed relations between AI technology and investment and economic growth state that one dollar invested in AI technology will come back as 1.99 dollars economic growth. Much more research also agrees with this claim. On the other hand, it is true that worries about AI technology replacing the human labor force have increased. In this report, the possibility of both gaining and losing jobs due to AI technology has been discussed. First, according to Frey and Osborne's report, 47% of US jobs will disappear by 2030. Importantly, since AI technology is a skill-biased technical change, employees with less education, and lower-income earners are at a higher risk. Thus, technological advances have an unequal effect on society. Despite the common belief that AI technology only reduces jobs, it can, in fact, create new jobs for people to invent, manage, maintain and restrict such innovation. Arntz, Gregory, and Zierahn's report states that AI technology can induce a positive effect on the demand of labor if there were increases in wage and product competitiveness. The main focus is that AI should help humans' labor skills rather than replace them, which means that "humans" have to learn from such technology to be better.

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