ISSN 2520-6303

Economics, Management and Sustainability
journal home page: https://jems.sciview.net

Sarker, P. K. (2022). Macroeconomic effects of artificial intelligence on emerging economies: Insights from Bangladesh. *Economics, Management and Sustainability, 7*(1), 59-69. doi:10.14254/jems.2022.7-1.5.

Macroeconomic effects of artificial intelligence on emerging economies: Insights from Bangladesh

Provash Kumer Sarker

School of Economics and Management, Wuhan University, 430072, Hubei, China
provash.sarker@whu.edu.cn

Article history:
Received: January 09, 2021
1st Revision: March 22, 2022
Accepted: April 24, 2022

JEL classification:
O40
J23
J24

DOI:
10.14254/jems.2022.7-1.5

Abstract: Artificial intelligence (AI) has the potential to increase economic growth substantially across the world. This paper explores the predicted potentials of AI from macroeconomic perspectives, employing theoretical analysis and contextualizing Bangladesh. The study employs time series data to examine the effects of AI on the labor market and productivity. The findings indicate that Bangladesh was yet to realize the expected economic merits though the integrated number of AI-induced industry robots has been insignificant. For AI to be effective in Bangladesh, the country shall adopt more AI robots across the various sectors, mainly manufacturing and service. Besides, the country may complement the human labor force with AI labor instead of relying on only one as a source of labor.

Keywords: artificial intelligence, macroeconomic effects, Industry 4.0

1. Introduction

Humankind entered the steam era in the 18th century, the electrical era in the 19th century, and the information and Internet era in the 20th century. With the maturity of artificial intelligence technology in the future, the 21st century will enter the era of intelligence**.** Whenever the world has undergone any reframing changes in its dynamics that usually has resulted from unprecedented technological progress. However, while technological progress often develops exponentially, it competes with human intellectual abilities. Robotics, big data, advanced analytics, 3D printing, the Internet of Things (IoT), nanotechnology, machine-learning, and biotechnology make seismic changes worldwide. Now, the machine can supplement humans for a wide range of jobs. That supplementary proposition of machines has critical macroeconomic implications, which Industry 4.0 is now experiencing. The intelligence technology industry has become the cornerstone of the smart era and has a radiating effect on the overall economy, and is also the commanding height of current and future scientific and technological competitions. Whether we can seize the opportunities for change in the intelligent age is the key to fostering economic growth in emerging economies. This paper aims to explore and examine the potential impacts of AI on economic growth.

Corresponding author: *Provash Kumer Sarker*
E-mail: *provash.sarker@whu.edu.cn*

1.1. Background

The world is undergoing a higher level of technological transition, thanks to the implementation of AI in different aspects of economic production or activities. Many developed economies have integrated AI into their long-term economic development policy to ensure that innovation in technology will help promote their economic growth. In line with that, the emerging economies are also incorporating automation technologies into their production functions. In contrast, some other emerging economies are yet not ready to adopt AI or adopt it at a slow pace due to their respective economic structures and limitations. However, the impact of AI adoption depends not only upon the way an economy develops but also on the extent of adoption. Developed, least developed, or emerging economies cannot harness the same benefits induced by AI. As technology is getting extensive coverage, it multiplicatively affects human life. One of the most significant technological innovations that have changed people's way of life is the innovation and use of AI (Li et al., 2017). The term artificial intelligence, also known as machine intelligence, means intelligence demonstrated by machines. The term "artificial intelligence" is to imply to computers or machines with abilities that mimic human cognitive functions such as "problem-solving" and "learning" (Frey & Osborne, 2017; Patrício & Rieder, 2018). The use of AI, especially in economic sectors, has led to significant shifts in terms of economic production and labor, thus changing the nature of economic development in the world. In developed nations such as China, Japan, the USA, and most developed European countries, AI technology has dramatically been applied to the production process in many industries, including manufacturing and agriculture (Makridakis, 2017). In developing countries, however, the expected positive impacts of the application of AI in their economies are much lower than their effects on developed countries (Lu et al., 2018). Therefore, it is essential to examine why the use of AI in emerging countries may not realize the anticipated economic growth similar to those in developed nations. The reasons may be the underlying economic structure and particular limitations. For Bangladesh, the current applications of AI have not been quite extensive and, in fact, fewer in numbers to produce the predicted results.

1.2. Research objectives and questions

The fundamental motivation of this research paper is to investigate the effects of AI on the gross domestic product through AI-induced automation in the production of goods and services.

Below are the other research questions we seek to address in this paper:

(a) how does the adoption of AI technology impact Gross Domestic Product in emerging economies? (b) what adverse effects AI adoption may cause to the labor market? (c) how may the application of AI fail to cause the opportunities as predicted by economic theories?

1.3. Literature review

Recently, the world has experienced a dramatic change in technological innovations. The fourth-generation industry is currently undergoing a significant shift in its economic production. The onset of the technological revolution, thanks to the innovation associated with digital technology and computers and computer microchips, has seen the creation of highly efficient artificial intelligence machines (Dirican, 2015; Makridakis, 2017). Artificial intelligence machines have significantly become helpful in industrial products because they increase production efficiency and reduce the number of human labor required for production (Hodges, 2018). The future application of AI in economic production makes this technology the most appropriate means for helping the developed countries realize economic development similar to the industrialized countries (Bhagawati et al., 2016). Many developing countries, such as Bangladesh in South Asia, have embraced AI hoping that AI will propel the country's economic growth.

Two theories example the reasons and the impact of the use of AI in economic activities. These theories are the neoclassical production functions (Lankisch et al., 2019; Wang et al., 2021) and the task-based model (Acemoglu & Restrepo, 2018; 2019). According to the "neoclassical production functions theory", using AI in economic growth is to improve production functions by incorporating the elasticity of substation between capital and labor. By improving Cobb-Douglas production, (Russell & Norvig, 2016) found out that labor and computer capital complement each other, while the employment of artificial intelligence displaces the effect of labor and the comprehensive diffusion of AI technology augments economic growth. On the contrary, (Aghion et al. 2017) enhance the "CES production function" by analyzing the effect of the changes in the elasticity of substation on the changes in the share of technologically produced goods. The study's findings indicate that as the productivity of automation improves, its overall share in the Gross Domestic product declines. On the

other hand, the task-based model theory argues that automation takes away the current task in the production process and replaces them with new tasks, thus creating changes like jobs in the economy. A recent investigation of this theory by (Acemoglu & Restrepo, 2018; 2019) found that AI has a displacement effect on labor as its downside.

On the positive side, it led to capital accumulation, creating new job opportunities, increasing productivity, and deepening automation (Hasan, 2016; Furman & Seamans, 2019). Both the developing and the developed countries have relied on these two theories in determining the potential impacts of the use of AI in their economies (Aghion et al., 2017; Jha et al., 2017; Agrawal et al., 2018). The expected positive benefits of using only accrue to the developed countries but not developing countries. However, both groups have similar expectations of the application of AI (Korinek & Stiglitz, 2017). The actual difference in the outcomes of using AI clear between developing and developed countries arose curiosity on the reasons for the difference in the results (Cockburn, Henderson, & Stern, 2018). With the continuous increase in poverty in many developing countries, it became essential to critically analyze why AI has failed in most developing countries, such as Bangladesh in South Asia, while China is doing well (Frey, C. & Osborne, 2017).

From the review of the above literature, it is apparent that several factors determine the optimum outcome of AI in any economy. This study contributes to the existing literature by unearthing why AI technology may fail in emerging economies despite the mainstream theories indicating otherwise. Besides, the paper also contributes to revisiting the effects of AI on employment and production through complementarity and substitution effects in an emerging country.

The paper presents the sections as follows. Section two defines the methodological design and statistical approach to the research problem. Section three presents the result and interpretation in detail, while section four discusses the results based on economic theory and relates them to recent research. Section five illuminates the theoretical impacts of AI employment. Section six goes on, concluding the study with future research prospects.

2. AI status in emerging economies

An emerging economy is an economy that is recognized to have a significant GDP growth (and a substantial contribution to the global value chain) and a potential for rapid growth and investment. Over the decades, emerging economies have produced around two-thirds of the world's GDP and more than 50% of new consumption. They are the growth centers of the globe, contributing nearly 60% of global production. As far as production is concerned, AI technology integrated into the industry can help foster worldwide growth. The paper has considered the emerging economies' AI state to assess how they may shape the global production in the future 4.0 Industry revolution. The study has grouped 24 countries listed by the IMF as the world's emerging economies.

AI has the dynamism to reshape how governments deliver public services. This could significantly improve citizens' experiences of government. Governments are already adopting and integrating AI in their operations and service delivery to improve efficiency and deliver better quality public services. We used the Global Innovation Index (GII), and Government AI Readiness ranks to understand countries' current AI readiness and innovation status to support economic trends. The overall score is made up of 11 input metrics grouped under four high-level clusters: governance, infrastructure and data, and government and public services, skills, and education. According to the Index's findings, the leading countries in Asia are Inda (17) and China (20), respectively, with over 6% growth rates. While Russia (29), Malaysia (32), the Philippines (50), Thailand (56), and Indonesia (57) are also on the front line of the readiness index. We found a positive correlation between the growth rates, global innovation index, and AI readiness ranks among the emerging countries except for Argentina, Brazil, and South Africa. They record comparatively low growth rates but rank in the front line. However, Bangladesh has the highest economic growth rate of 7.86%, while it ranks substantially lower in the AI readiness index (103) and (116) in GII. As the research finds, Bangladesh is not yet ready to adopt AI and integrate it into economic production because of its cheap labor advantage. It uses the abundant cheap labor in the ready-made garment (RMG) sector, which remarkedly contributes to economic growth. It has employed a few AI robots in the service industry, primarily in medical, banking, digital marketing, and e-commerce. The country is getting ready at a slow pace to fit into Industry 4.0. Although China ranks low in the readiness index compared to India, it beats India (61) in the innovation index (26), meaning China is well approaching exploiting its comparative advantages.

Table 1: Global AI Readiness and Innovation Status of the emerging economies

SL	Country	2018*	2019	2019
		GDP %	Government AI Readiness Index	Global Innovation Rank
1	Argentina	-2.48	51	72
2	Bangladesh	7.86	103	116
3	Brazil	1.12	40	66
4	Bulgaria	3.08	47	45
5	Chile	4.03	39	43
6	China	6.57	20	26
7	Colombia	2,.56	44	67
8	Hungary	5.09	48	39
9	India	6.81	17	61
10	Indonesia	5.17	57	87
11	Malaysia	4.74	22	39
12	Mexico	2.14	32	55
13	Morocco	2.99	80	66
14	Pakistan	5.83	84	89
15	Peru	3.98	71	86
16	Philippines	6.24	50	54
17	Poland	5.15	27	37
18	Romania	3.95	55	54
19	Russia	2.26	29	59
20	South Africa	0.79	68	68
21	Thailand	4.13	56	43
22	Turkey	2.83	46	49
23	Ukraine	3.34	63	47
24	Venezuela	-19.62	134	NA

Source: World Bank, World Intellectual Property Org., and Oxford insights & IDRC.

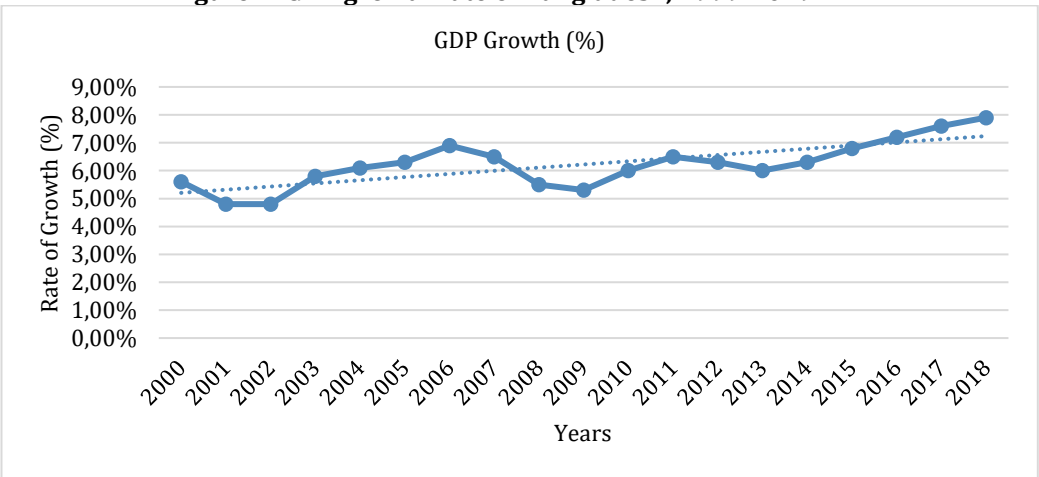
However, while they will reap the potential benefits of AI, there may exist global inequalities of AI benefits. Emerging technologies offer a particular set of opportunities to improve the future governments and citizens' experience of government. As we experience the advent of automation, governments must ensure that they are ready to capitalize on the potential power of AI. This analysis of AI readiness aims to help policymakers everywhere evaluate the performance and in which sectors they need to target their attention going forward. The age of AI is advancing; through the Index, our intended contribution is to encourage all governments in emerging economies to be as prepared as possible to help their citizens take advantage of the benefits of automation.

2.1. Perspectives of Bangladesh

In this section, the paper illustrates the growth trends of the variables from 1999 to 2019 except for GDP, as the study used the predicted value for 2019 for it. For other variables like investments, workforce, and robot density, the study used trend analysis to interpret the changes that may be significantly interlinked.

2.2. Gross domestic product growth

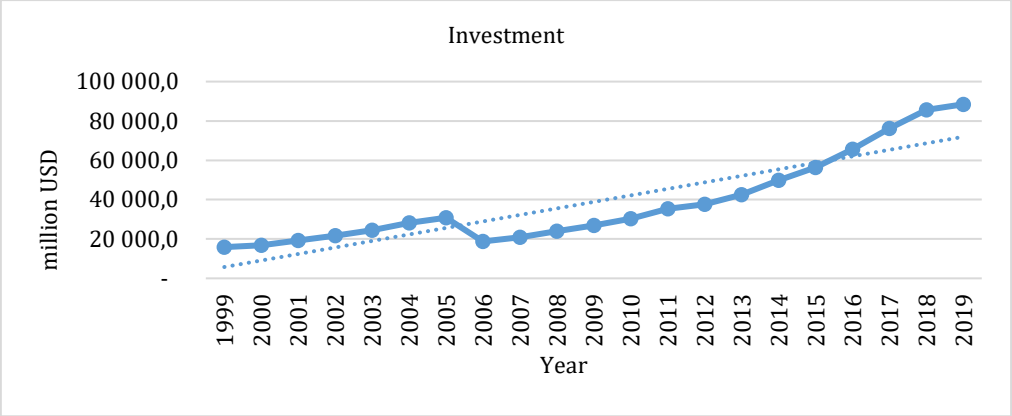
Figure 1: GDP growth rate of Bangladesh, 1999-2019



Bangladesh records stable growth rates forming a linear trend over the periods. The global recession in 2007-08 caused slow growth. However, after that period, Bangladesh continued an upward trend to date. The economic growth rate has over a 5% growth rate, which correlates with massive investment and workforce participation.

2.3. Investment growth

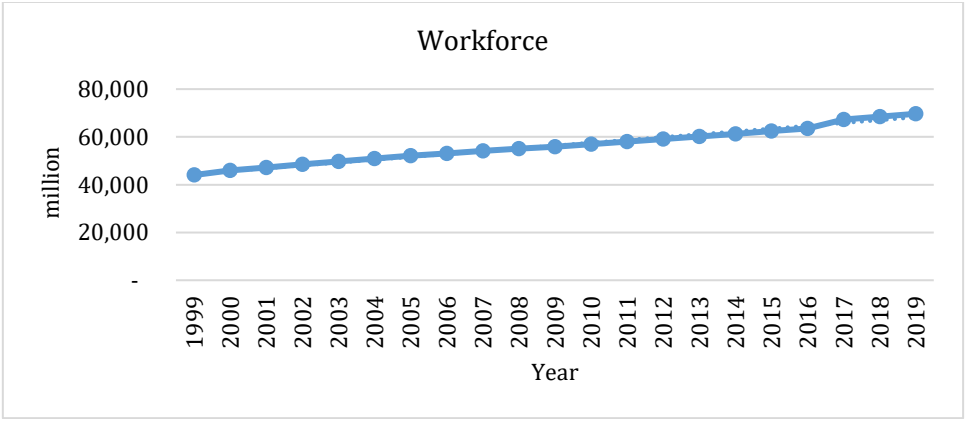
Figure 2: Investment in Bangladesh, 1999-2019



Investment is the essential driver of economic growth for any economy. Being an emerging economy and as warranted by the policy targets, Bangladesh invested in bolstering the target growth. Over this period, the country has experienced massive investment. The graph shows that the investment only fell sharply between 2005 and 2006 thanks to the global financial crisis. However, it later maintained an upward trend to date.

2.4. Workforce growth

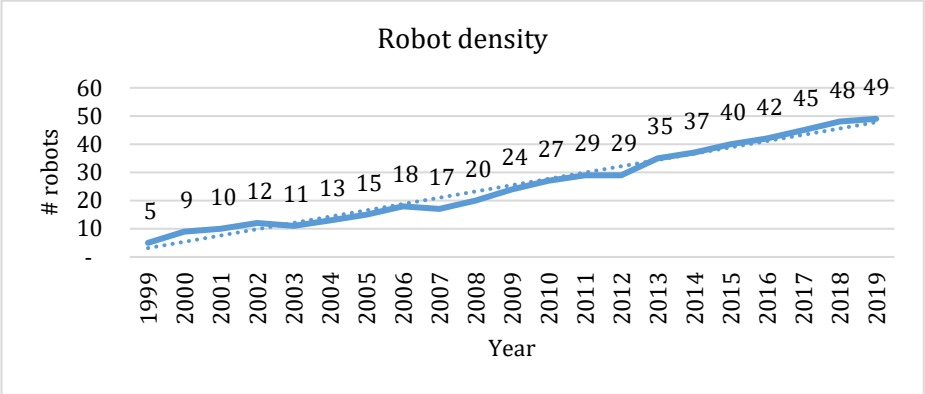
Figure 3: Workforce growth of Bangladesh, 1999-2019.



The economic growth potential may result from shifts in a population's age structure, mainly when the share of the working-age population is larger than the non-working-age share of the population. At present, more than 65% of the population in Bangladesh is of working age, between 15 and 64. The graph shows a shape rise between 2016 and 2018 and a continued increase throughout the periods.

2.5. Robot density

Figure 4: Robot density in Bangladesh, 1999-2019



The adoption of Robots, which are AI technology tools, has been on the rise over the years. It correlates with investment GDP growth rates during the period. Bangladesh has integrated a few numbers of industrial robots. This impact on GDP will be explained using correlation and regression analysis.

3. Discussion

The finding of the study demonstrates that there is a positive relationship (0.009) between artificial intelligence (robot density) and economic growth (changes in GDP) in Bangladesh. George & Michaels (2015) found that, based on the data of 17 nations from 1993 to 2007, the rising wages and total factor productivity and robotic technology resulted in a rise in the yearly gross domestic growth rates of these nations by 0.37 percentage points. It also falls in line with the prediction of (Krishnan et al., 2018) that as AI diffuses throughout the USA, labor productivity growth would average 2 percent per year for a decade or so, around four times higher than in the recent past. However, many studies mention that AI may cause potential job loss. (Frey & Obsorne, 2017) contend that 47% of over 700 occupants in America can be replaced in the short term. Other studies have predicted the substitution of labor by artificial intelligence. The disadvantage of this approach is - it is double-edged. Initially, the outcome of the estimation is not large enough. The framework overestimates the market response of labor to technology, leading to a new equilibrium.

Artificial intelligence is considered human capital. It impacts the income per capita for both random and fixed effects regressions. This aligns with previous studies conducted on the adoption and the economic impact of the adoption of AI. A study by (Acemoglu & Restrepo, 2018a) articulates employment impacts on smart manufacturing. Such effects are subject to capital interest rate and the relative level of labor price, whereas the latter impacts artificial intelligence applications. Another study grounded on German data did not discover that artificial intelligence will cause unemployment (Acemoglu & Restrepo, 2018a). The study (Autor & Salomons, 2017) demonstrates the reinstatement effect of an Uber effect. Good consumption rises due to the price decrease, and its quality enhances due to automation or when automation increases. It results in the decreasing prices for the fundamental goods, which increases the current income to be spent on other products, and a cost effect in which some processing sectors raise their efficiency because of automation and this is conveyed to other sectors that are using this as an input (Autor & Salomons, 2018).

Huang & Dong (2019) remarked that the development of artificial intelligence capital augmenting technology allows the thriving of the technology, per capita output, artificial intelligence capital, and traditional capital. They address that a higher savings rate is linked with a higher economic and population growth rate. On the other hand, a decrease in savings slows economic growth (Hanson, 2001). In a period of market equilibrium, the wages rise with artificial intelligence capital, whereas capital prices rise with the advancement of technology. The concern of the growth model is to enhance the technology of artificial intelligence capital. When the artificial intelligence capital is complementary to labor, Baumol's cost disease will be incurred, which implies that the rise in the productivity of one sector will result in a decrease in share (Aghion et al., 2017). It is presumed that the advancement in artificial capital augmenting technology would increase the assistance to humans, decrease workload, and enhance wage rates (Huang & Dong, 2019). The enhancement of labor augmenting technology reduces the work that is decreased by automation; more work is designated by humans and decreases wages. However, when artificial intelligence and, consequently,

the artificial intelligence labor and capital replace each other, humans will compete with robots. Wang et al. (2021) mention that artificial intelligence can promote economic growth in emerging economies if implemented and leveraged appropriately.

However, the technological progress of artificial intelligence will make laborers lose their work or experience poor rewards and shared labor. The advancement of labor-based technology make laborers competitive, thus giving more merits and more job; as a result, it boosts both salaries and the share workers. Finally, we check the work-based version to find the effect of the manufacturing of new work on salaries and share of work. It is indicated that the establishment of new jobs can increase returns and the share of workers. Moreover, we assess the long-run economic growth rate, the advancement of any artificial intelligence may result in a stable state of equilibrium of economic growth. Ultimately, total growth rates of per capita income, per capita traditional capital, and artificial capital are equally positive. In this scenario, the technological advancement of labor-based technology can make a stable state equilibrium of economic growth in the long run. In contrast, the development of artificial intelligence can lead to firm economic growth (Acemoglu & Restrepo, 2018b). In the next section, the impacts of AI on employment will be illustrated in detail.

4. Theoretical effects of AI on employment

Since the Industrial Revolution, every technological progress and revolution has triggered a substitution effect in employment. Jenny textile machines and steam engines have replaced handicraftsmen and laborers. The emergence of machines such as cars and ships has eliminated the careers of horse riders, boatmen. The development of artificial intelligence technology has made some mental workers work, such as Car driving, disease detection, and data analysis, and have also been gradually replaced. Mechanisms of artificial intelligence affecting employment include the substitution effect, compensation effect, and creation effect. The substitution effect leads to the direct disappearance of jobs, the compensation effect attracts employment through the expansion of its industrial scale, and the creation effect employs the creation of new types of jobs and new industrial models.

4.1. Substitution effects

Artificial intelligence can replace both physical and mental work. This "universality" feature is something that the previous scientific and technological revolutions could not achieve. Some studies believe that in the next 10 to 20 years, artificial intelligence will expose 30% -50% of current jobs to high substitution risks. It is predicted that 47% of the jobs will be replaced by artificial intelligence in the next 10 to 20 years, mainly production activities, administrative office support jobs, sales services, and other related positions (Frey Osborn, 2013).

4.2. Compensation effects

The compensation effect is mainly that the efficiency improvement brought by the substitution of artificial intelligence will lead to the expansion of the scale o related industries, and the expansion of scale will make up for the reduction of jobs per unit of output. It also refers to the fact that, on the one hand, artificial intelligence directly creates new jobs through new industries and services.

Artificial intelligence compensates for the decrease in job opportunities per unit of output through scale expansion, divided into three situations. First, positions that are not easily replaced on the production line have increased with the substantial increase in productivity. The second is that artificial intelligence is the most cost-effective, and the company has the conditions to expand production, increase the production line, and increase the number of jobs; the third is that the increase in efficiency leads to lower prices for the company's products. Lower product prices will increase consumer demand and drive enterprises to expand production scale. It can be seen that the use of intelligence and other new technologies has dramatically improved the platform's operating efficiency and order volume, and total employment has risen instead of falling.

Such would boost automation and ensure more substantial quality control of processes and products in the manufacturing industry. Improved manufacturing capabilities will, in turn, improve GDP and, in turn, the economic growth of Bangladesh. Other industries, such as the processing industry, automotive, power and service industries, among others, are expected to improve their economic performance with the adoption of AI. Though the adoption of AI across the various industries in an economy varies, the country needs to make policies and strategies to ensure that AI is fully adapted to the most applicable industries.

5. Conclusion

The paper examined the impact of AI on the economic growth of Bangladesh by employing multivariate regression analysis. It also analyzed the pairwise correlation between the variables to indicate the correlation intensity. To depict the macro-perspective of AI in the emerging economies, the study took an overview of AI status and evaluated it for future policy toolkit. The paper has demonstrated that the macroeconomic impact of AI is likely to be substantial. Employment impact analysis indicates that although initial job displacement will occur through replacement automation, creating new roles in the economy could potentially offset the jobs lost through innovation automation. This analysis estimated the upwards pressure on GDP due to AI under the ceteris paribus assumption. The study also found that despite the use of AI-induced automation technologies across the economies, the impact of AI on economic growth would vary among the emerging. The difference is thanks to the particular economic textures of the emerging economies. Many emerging economies like Argentina, Bangladesh, Morocco, Pakistan, Peru, South Africa, Ukraine, and Venezuela are yet to integrate AI technology into the production system, particularly in manufacturing and service. They suffer from a shortage of technological logistics and state-of-the-art technical expertise, as observed by the differences in Government AI Readiness Scores and the Global Innovation Index.

As AI is getting widely adopted, leading to automation, economic modeling suggests that potential job losses in the short term will be compensated by countervailing mechanisms through which increasing productivity leads to higher demand for labor in the long term. A sophisticated policy toolkit can help harmonize the short-term and long-term effects of adopting AI. Bangladesh, for instance, now needs policy gear to capture the potentials that it may harness from adopting and integrating more AI robots into industries that need them. As the statistical result indicates, Bangladesh shall begin to prepare for the possible threats from AI developed countries to its labor advantage and productivity. The AI-enabled economy will perform better than many emerging economies quite shortly, and thus, growing economies will face the challenges of global value chain participation. Therefore, the government and the policymakers of emerging economies shall proactively adopt AI and seize its benefits.

5.1. Future research prospects

The literature on artificial intelligence and its impact on the economy is growing. The following points can motivate further research to enrich the literature.

(1) Labor market polarization

If most jobs are replaced by artificial intelligence, the labor market will face significant disruption. From routine jobs to semi-skilled jobs may get replaced by AI. What kind of actions the government can take to address this problem. One solution is to tax robots and subsidize the unemployed. However, taxation will undoubtedly result in the loss of efficiency and international transfer of artificial intelligence capital. Moreover, over subsidizing may cause more people to stay at home while working. Therefore, the concern is making reasonable and effective policies for this market polarization.

(2) Aging of the population

In most developed and some developing countries, the aging problem has become severe. Economically, the aging problem exacerbates the labor shortage. The labor shortage will prompt the country to adopt smart manufacturing. Smart manufacturing tends to positively impact the local gross domestic product and assist the sluggish economy. Whether artificial intelligence can solve this problem to keep economic growth and social welfare is another exciting topic.

Conflicts of interest

The author declares no conflict of interest.

Citation information

Sarker, P. K. (2022). Macroeconomic effects of artificial intelligence on emerging economies: Insights from Bangladesh. *Economics, Management and Sustainability, 7*(1), 59-69. doi:10.14254/jems.2022.7-1.5.

References

Acemoglu, D., & Restrepo, P. (2019). Automation and new tasks: how technology displaces and reinstates labor. Journal of Economic Perspectives, 33(2), 3-30. Retrieved from https://www.aeaweb.org/articles?id=10.1257/jep.33.2.3

Acemoglu, D., & Restrepo, P. (2018). Artificial intelligence, automation, and work. In *The economics of artificial intelligence: An agenda* (pp. 197-236). University of Chicago Press. https://doi.org/10.3386/w24196

Acemoglu, D., & Restrepo, P. (2018). The race between man and machine: Implications of technology for growth, factor shares, and employment. *American Economic Review*, *108*(6), 1488-1542. https://doi.org/10.1257/aer.20160696

Acemoglu, D., & Restrepo, P. (2020). Robots and jobs: Evidence from US labor markets. *Journal of Political Economy*, *128*(6), 2188-2244.

Aghion, P., Jones, B. F., & Jones, C. I. (2018). Artificial intelligence and economic growth. In *The economics of artificial intelligence: An agenda* (pp. 237-282). University of Chicago Press. https://doi.org/10.3386/w23928

Aghion, P., Jones, B. F., & Jones, C. I. (2018). Artificial intelligence and economic growth. In *The economics of artificial intelligence: An agenda* (pp. 237-282). University of Chicago Press. https://doi.org/10.3386/w23928

Agrawal, A., Gans, J., & Goldfarb, A. (2019). Economic policy for artificial intelligence. *Innovation Policy and the Economy*, *19*(1), 139-159. Retrieved from https://www.journals.uchicago.edu/doi/pdfplus/10.1086/699935

Agrawal, A., McHale, J., & Oettl, A. (2018). Finding needles in haystacks: Artificial intelligence and recombinant growth. In *The economics of artificial intelligence: An agenda* (pp. 149-174). University of Chicago Press. Retrieved from https://www.nber.org/papers/w24541

Autor, D., & Salomons, A. (2017, June). Robocalypse now: Does productivity growth threaten employment. In *Proceedings of the ECB Forum on Central Banking: Investment and Growth in Advanced Economie* (pp. 45-118). Retrieved from http://www.centralbank.eu/pub/conferences/shared/pdf/20170626_ecb_forum/D_Autor_A_Salomons_Does_productivity_growth_threaten_employment.pdf

Bhagawati, K., Bhagawati, R., & Jini, D. (2016). Intelligence and its application in agriculture: techniques to deal with variations and uncertainties. *International Journal of Intelligent Systems and Applications*, *8*(9), 56-70. Retrieved from https://pdfs.semanticscholar.org/6e08/7108aa8048da8cfc82cdecb7071a55bab488.pdf

Brynjolfsson, E., Mitchell, T., & Rock, D. (2018, May). What can machines learn, and what does it mean for occupations and the economy?. In *AEA Papers and Proceedings* (Vol. 108, pp. 43-47). https://doi.org/10.1257/pandp.20181019

Cockburn, I. M., Henderson, R., & Stern, S. (2018). The impact of artificial intelligence on innovation (No. w24449). National Bureau of Economic Research. Retrieved from https://www.nber.org/papers/w23928

Dirican, C. (2015). The impacts of robotics, artificial intelligence on business, and economics. *Procedia-Social and Behavioral Sciences, 195*(1), 564-573. Retrieved from https://www.sciencedirect.com/science/article/pii/S1877042815036137

Ernst, E., Merola, R., & Samaan, D. (2019). Economics of artificial intelligence: Implications for the future of work. *IZA Journal of Labor Policy*, *9*(1). Retrieved from https://doi.org/10.2478/izajolp-2019-0004

Ertel, W. (2018). *Introduction to artificial intelligence*. Springer. Retrieved from https://books.google.co.ke/

Frey, C. B., & Osborne, M. A. (2017). The future of employment: How susceptible are jobs to computerisation?. *Technological forecasting and social change*, *114*, 254-280. Retrieved from https://www.sciencedirect.com/science/article/pii/S0040162516302244

Furman, J., & Seamans, R. (2019). AI and the Economy. *Innovation policy and the economy*, *19*(1), 161-191. Retrieved from https://www.journals.uchicago.edu/doi/abs/10.1086/699936

Garnham, A. (2017). *Artificial intelligence: An introduction*. Routledge. Retrieved from https://www.taylorfrancis.com/books/9780203704394

Graetz, G., & Michaels, G. (2015). Robots at work. Centre for Economic Performance. *CEP Discussion Paper*, (1335). (http://cep.lse.ac.uk/pubs/download/dp1335.pdf).

Hanson, R. (2001). *Economic growth given machine intelligence*. Technical Report, University of California, Berkeley. Retrieved from http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.70.7007

Hasan, S. (2016). Reaching the unreached: Strategies and challenges of public service delivery in 'Digital Bangladesh'. *Dynamics of Public Administration*, *33*(2), 200-212. Retrieved from http://www.indianjournals.com/ijor.aspx?target=ijor:dpa&volume=33&issue=2&article=007

Hodges, B. D. (2018). Learning from Dorothy Vaughan: artificial intelligence and the health professions. *Med Educ, 52*(1), 11-23. Retrieved from https://www.cfpc.ca/uploadedFiles/About_Us/Commentary-Brian-Hodges.pdf

Huang, X., Hu, Y., & Dong, Z. (2019). *The macroeconomic consequences of artificial intelligence: A theoretical framework* (No. 2019-48). Economics Discussion Papers. Retrieved from http://hdl.handle.net/10419/203115

Jha, S. K., Bilalovic, J., Jha, A., Patel, N., & Zhang, H. (2017). Renewable energy: Present research and future scope of Artificial Intelligence. *Renewable and Sustainable Energy Reviews, 77*(1), 297-317. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S136403211730518X

Korinek, A., & Stiglitz, J. E. (2018). Artificial intelligence and its implications for income distribution and unemployment. In *The economics of artificial intelligence: An agenda* (pp. 349-390). University of Chicago Press. Retrieved from https://www.nber.org/papers/w24174

Korinek, A., & Stiglitz, J. E. (2017). Artificial intelligence, worker-replacing technological progress and income distribution. *NBER working paper*, *24174*. Retrieved from https://www8.gsb.columbia.edu/faculty/jstiglitz/sites/jstiglitz/files/AI_labor.pdf

Krishnan, M., Mischke, J., & Remes, J. (2018). Is the Solow Paradox Back?. *The McKinsey Quarterly*.

Lankisch, C., Prettner, K., &Prskawetz, A. (2019). How can robots affect wage inequality?. *Economic Modelling, 81*(1), 161-169. Retrieved from https://doi.org/10.1016/j.econmod.2018.12.015

Lu, H., Li, Y., Chen, M., Kim, H., & Serikawa, S. (2018). Brain intelligence: Go beyond artificial intelligence. *Mobile Networks and Applications, 23*(2), 368-375. Retrieved from https://link.springer.com/article/10.1007/s11036-017-0932-8

Li, B. H., Hou, B. C., Yu, W. T., Lu, X. B., & Yang, C. W. (2017). Applications of artificial intelligence in intelligent manufacturing: a review. *Frontiers of Information Technology & Electronic Engineering, 18*(1), 86-96. Retrieved from https://link.springer.com/article/10.1631/FITEE.1601885

Makridakis, S. (2017). The forthcoming Artificial Intelligence (AI) revolution: Its impact on society and firms. *Futures, 90*(1), 46-60. Retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0016328717300046

Meltzer, J. P. (2018). *The impact of artificial intelligence on international trade*. Brookings Institution, Thursday, December 13, 2016. Retrieved from https://www.andrewleunginternationalconsultants.com/files/brookings---meltzer---ai-and-trade_report-dec-2018.pdf

Patrício, D. I., &Rieder, R. (2018). Computer vision and artificial intelligence in precision agriculture for grain crops: A systematic review. *Computers and Electronics in Agriculture, 153*, 69-81. Retrieved from https://www.sciencedirect.com/science/article/pii/S0168169918305829

Russell, S. J., & Norvig, P. (2016). *Artificial intelligence: a modern approach*. Malaysia; Pearson Education Limited. Retrieved from http://thuvien.thanglong.edu.vn:8081/dspace/handle/DHTL_123456789/4010

Strusani, D., & Houngbonon, G. V. The Role of Artificial Intelligence in Supporting Development in Emerging Markets. *World Bank Other Operational Studies*.

Wang, L., Sarker, P., Alam, K., & Sumon, S. (2021). Artificial Intelligence and Economic Growth: A Theoretical Framework. *Scientific Annals of Economics and Business*, *68*(4), 421-443. https://doi.org/10.47743/saeb-2021-0027

Zeira, J. (1998). Workers, machines, and economic growth. *The Quarterly Journal of Economics*, *113*(4), 1091-1117. https://doi.org/10.1162/00335539855

Economics, Management and Sustainability (ISSN: 2520-6303) is published by **Scientific Publishing House "CSR", Poland, EU** and **Scientific Publishing House "SciView", Poland**
Publishing with **JEMS** ensures:
• Immediate, universal access to your article on publication
• High visibility and discoverability via the JEMS website
• Rapid publication
• Guaranteed legacy preservation of your article
• Discounts and waivers for authors in developing regions
Submit your manuscript to a JEMS at http://jems.sciview.net or submit.jems@sciview.net