American Journal of Modern Physics and Application
2018; 5(3): 48-52
http://www.openscienceonline.com/journal/ajmpa

Open Science

Future of Artificial Intelligence: Japan's Path to Growth

Doaa Salman Abdou*, Nadeen Nustafa Kamal

Department of Economics, October University for Modern Sciences and Arts (MSA), Giza, Egypt

Email address

dsalman@msa.eun.eg (D. S. Abdou)

*Corresponding author

To cite this article

Doaa Salman Abdou, Nadeen Nustafa Kamal. Future of Artificial Intelligence: Japan's Path to Growth. *American Journal of Modern Physics and Application.* Vol. 5, No. 3, 2018, pp. 48-52.

Received: May 25, 2018; **Accepted**: June 24, 2018; **Published**: July 26, 2018

Abstract

This paper conducts a research on the importance of Total Factor Productivity (TFP) while focusing on the Artificial Intelligence (AI) trends adapted in Japan. We answer the question of, "Is Japan utilizing AI as a driver for (TFP) or will they incorporate it as a new factor of production?" by looking at the TFP in Japan's booming industries while shedding insight on the governmental mindset of this phenomena. The mission of this paper is to reach a general consensus on TFP and how Japan's incorporation of AI in their factors of production changes the levels of marginal productivity of labor. The objective is to provide policymakers, wage setters and decision makers with a clear correlation between Japan's high TFP and their use of AI.

Keywords

Artificial Intelligence, Total Factor Productivity, Japan

1. Introduction

As economists, a large fraction of our studies is devoted to research and development and any sector's boom in an economy relies greatly on the amount of planning, expenditure and research that it has received. Lately, there has been an emerging sector that has had a vast impact on the productivity of the leading sectors in developed countries. Artificial Intelligence is now considered one of the main inputs to increase total factor productivity (TFP) and has been receiving mass amounts of funding in developed countries. So as the race for crude oil gets aggressively heightened between developing countries, Japan seems to be exerting high efforts in increasing the quality of labor and production productivity by adapting new technologies.

The discrete adaptation of AI by countries such as Russia, South Korea, Taiwan and Japan is accelerating and is real; this raises the question of: Does artificial intelligence increase TFP? And if so, should the rest of the world adapt AI as one of its important inputs to increased output? The EU-Japan Commission defines AI as a technology that utilizes machine intelligence and human-thinking ability to process various data to make predictions, recommendations and decisions. This technology is adapted in machines to provide higher levels of total factor productivity, even if this means the replacement of human labor for higher growth rates. This is one of the greatest shifts in modern economics which has a great effect on the marginal rate of technical substitution. As Japan starts to face economic stagnation after its major incline in GDP growth, many officials from the EU-Japan center for Industrial Cooperation believe that AI is the new blueprint for enhanced economic development.

Japan, out of the "four tigers", has had the highest proportionate contribution to Total Factor Productivity Growth over the period of 1965-1990 (Singh & Trieu 1996); however as Purdy & Daugherty (2016) state, for Japan to reach its goal of driverless taxis and means of transportation it must expand its AI expenditure to reach $300 billion dollars by 2030. Aside from the automobile industry, in marketing AI can be applied to provide Japanese companies with data analysis, automated marketing and image recognition. Nonetheless, the correlation behind AI and enhanced TFPG is positive and can be viewed by economists

in the EU-Japanese Commission such as Purdy & Daugherty (2016) as the main solution for stagnant economies such as Japan's with the correct adaptation of market entry.

2. Literature Review

Total Factor Productivity (TFP) is the portion of output not explained by the amount of inputs used in production; it determines how efficiently and intense the inputs are utilized in production (Comin 2006). TFPG can be measured by using the Solow residual model in the existence of perfect competition in factor markets, accurate growth rates, and accurate measurements of input. In other words, TFP is vital to economic research and planning in sustenance of growth to evaluate the increase in input to achieve constant returns to scale in capital and labor. The idea argued here by Comin (2006) is that all output is exhausted by paying capital and labor, reinvestments, and finally research and development. Generally, the importance of R&D alongside skilled labor will increase rate of innovation development and therefore increase TFP growth rates. It must be acknowledged that, the great technological breakthroughs over the last century such as IT, electrical and solar energy all boosted productivity dramatically but did not create new workforces, which brings us to the debate of will AI become another driver of TFP or will it create an entire new factor of production? To answer this question, Purdy and Daugherty (2016) state that AI can be identified as a capital-labor hybrid. The statement is terrifyingly powerful, and fascinating in itself. For eample, virtual assistants can process thousands of legal documents in a matter of days rather than human labor in six months; this can change our traditional growth model from:

$$\Delta K + \Delta L + TFP = Growth$$

To form a new adapted growth model:

$$\Delta K + \Delta L + TFP + \Delta AI = Growth$$

An important finding by Solow (1956) is that cross-country differences in technology may generate important cross-country differences in income / capita; this means that the differences in cross-country technologies causes a large gap in income between rich developed countries and poor less developed countries. Comin (2006) continues to explain this by referring to TFP as the main player in why there are differences in income/capita across different countries and concludes that technology is positively correlated to income/capita. Nonetheless, from a macroeconomic perspective TFP is positively correlated with enhanced living standards and enhanced economic growth.

As TFP's purpose is to eventually reach a constant returns to scale (or in the case of overachieving countries such as Japan's efforts to acquire an increasing returns to scale) we must analyze the different types of returns to scale. The first is constant returns to scale, which can defined as for every increase in inputs, output increases by the same margin. As previously mentioned, to measure TFPG we must have an existing perfect competition in factor markets and accurate data; to add to this, the production function must be a neoclassical function so to relate to neoclassical growth theory. One of the most recognized functions are the Cobb-Douglas production function (1976) which can be illustrated by:

$$Q = K^{\alpha}L^{\beta} \text{ (with } \alpha \text{ and } \beta < 1)$$

As mentioned in section I, Japan's efforts to add AI into this equation soon may change the neoclassical growth theory as we know it. This is a phenomenon that is currently being adapted (see section III- Japan AI development goals) by great powers such as Russia, South Korea, and the United States. The second type of returns to scale is the increasing returns to scale, which can be defined as for every increase in input, output is doubled. This can be illustrated as:

$$4Q = 2\ K^{\alpha}2L^{\beta}$$

The final type of returns to scale is decreasing returns to scale, which is the sole purpose of using TFP as an indicator to reference any changes in input. This means that, for every unit increase in input there is a lower return on output. This case implies that operating costs are exceeding output, hence a decrease in TFP and a decrease in revenue (its opposite is increasing returns to scale where the margin of average cost of production is decreasing while output increases). So accordingly, countries or companies should decrease their inputs or shift the Solow curve upwards by increasing technological advancements to adapt new higher levels of output. So what can be defined as "efficient production" is when all resources have been fully allocated to the point where maximum output level can be reached.

Another measuring method for productivity is Multi-Factor Productivity (MFP). MFP is also known as "total factor productivity" however it is measured by dividing the output index by the combined input index. This will outline the index number (level) which will later determine growth rates. One of the input indices is labor productivity (LP), which can be defined as the amount of output / every unit of labor. LP can be measured by dividing output by the labor unit (labor hours or number of employees) Apostolides (2008).

3. Artificial Intelligence: Japan's New Factor of Production

Traditionally, capital and labor are the "factors of production" that drive growth in the economy while the growth that comes from innovations and technological change in the economy is captured in total factor productivity. The great technological breakthroughs over the last century have indeed boosted productivity levels, however as economist Robert Gordon states as cited in Purdy and Daugherty (2006), the past two centuries of "Great Inventions" such as telegraphy or cryptography will unlikely reoccur. At this point in history, technology will become the

main driver behind enhanced levels of production.

Japan's AI market amounted to 3.7 trillion yen, which is equivalent to $32.75 billion in 2015, while it is expected to grow to JPY 87 trillion by 2030 ($770 billion). The previous mentioned economic stagnation does necessarily mean low levels of TFP, but the sustenance of an increasing growth rate for continuous years is difficult to achieve with the same technological advancements. Japan's Prime Minister, Shinzo Abe, states the following powerful statement: "Japan has no fear of AI. Machines will snatch away jobs? Such worries are not known to Japan" – *Shinzo Abe (2016)*

The prime minister continues to state: "Japan may be ageing. Japan may be losing its population. But these are incentives for us. Why? Because we will continue to be motivated to grow our productivity through robotics, artificial intelligence and IoT (Internet of Things)"

3.1. Past, Current, Future Trends & Data

Reviewing the Japanese employment policy data shows that potential employment is declining as well decline in labor productivity may be as a result of the ageing population problem Japan is facing (with 27% of population over 60 years). Moreover, average real GDP growth range between 0.5% and 1% during the period from 2000 till 2014, see figure 1.

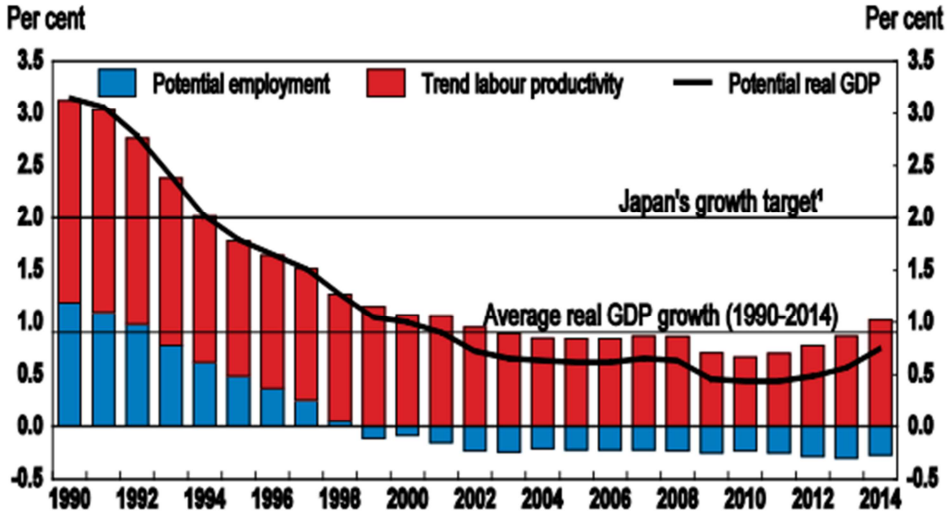

Figure 1. *Labor Productivity Growth Rate in Japan*

Source: OECD Economic Outlook Database

To Investigates for the reason of declining the multifactor productivity is referred to the stagnant economic growth.

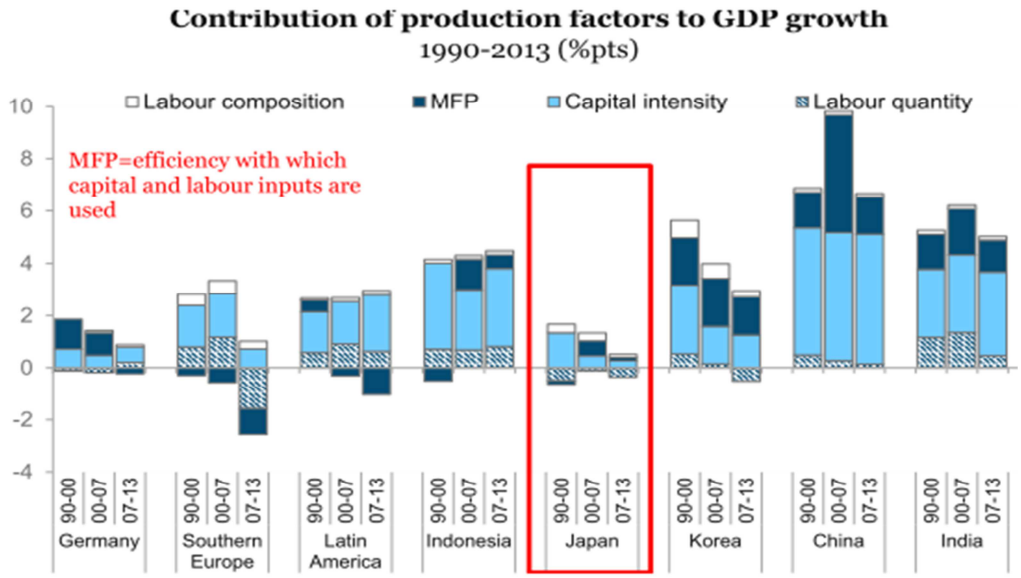

Figure 2. *Multi-Factor Productivity Growth Rates*

Source: conference Board Total economy data base

The consensus here, provided by Paul & Daugherty (2016) is that a significant part of the economic growth from AI will not come from replacing existing labor and capital, but in enabling them to be used much more effectively. Jones, R., & Jin, Y. (2017) refers this to the AI Augments labor by complementing human capabilities, offering employees new tools in addition to their natural intelligence.

For example, hotel staff spends lots of time making room deliveries. This routine can be eliminated by Relay; an autonomous service industry robot developed by Savioke Ltd. which is already being implemented in large hotel chains.

Table 1. *Japan's R&D Funding (2013).*

Source of funding	Allocated of R & D SPRENDING BY SETOR PERFORMING IT				
	Share of total R& D SPENDING	Government	Universities	Business enterprises	Total
Government	18.1	54.4	40.2	5.4	100
Universities	5.9	0.8	99.3	0.1	100
Business enterprises	7.5	0.6	0.5	98.9	100
Foreign sources	0.5	9.6	1.5	88	100

Source: OECD R& D statistics database

After observing figure 2 and realizing the MFP is decreasing, in order for Japan to increase its TFP it must reallocate its expenditure and increase R&D funding.

Table 2. *Japan's Domestic Market: AI spending per sector (in billions yen).*

Type of sector	2015	2020	2030
Agriculture, forestry & fishery	2.8	31.6	384.2
Manufacturing	112.9	2,965.8	12,175.2
Construction	79.1	1,215.7	5,922.9
Electicity , gas & communications	30.0	521.7	1,881.0
Information services	182.5	824.5	2,373.1
Wholesale & retail	1,453.7	4,684.4	15,173.3
Financial & insurance	596.4	2,261.1	4,731.8
Retail estate	4.9	242.6	485.3
Transport	0.1	4,607.5	30,489.7
Distribution	46.5	144.3	503.5
Technical services	9.0	244.0	614.9
Advertising	633.1	1,930.5	3,604.7
Entertainment	226.0	599.0	1,510.4
Education	203.0	503.9	928.5
Medical care and welfare	34.3	576.1	2,182.1
Living-related services	130.8	1,711.1	4,001.1
Total	3,745.0	23,063.8	86,962.0

Source: Ernst & Young Institute as cited in EU-Japan Centre for Industrial Cooperation

It is clear from table 2 that Japan's AI spending is high in its prominent sectors such as Manufacturing, Wholesale & Retail. A distinctive finding in table 2 is that in 2015 Japan's expenditure on transport was 0.1 billion yen, however in the long run forecasts, spending on AI seems to be the highest in transport with wholesale & retail following.

3.2. Empirical Analysis

To analyze the TFP in Japan, we look at the prominent sectors and determine the change in rates through the period 1981-1999. We can find that the majority of sectors during 1981 till 185 was declining except manufacturing and the retail industries, during the 1986 till 1991 all sectors were growing except the electric gas and water works and the services is declining. While reviewing each sector growth data shows that the construction, electric gas and water works and real estate sectors is decline during the period from 1986 till 2002. While manufacturing sectors is growing through the same period of time, see table 3

Table 3. *Conventional TFP Change Rates*

	All Industries	Construction	Manufacturing	Wholesale & Retail	Real Estate	Transport & Communications	Electric Gas, and waterworks	Services
1981-1985	-0.7	-1.7	0.2	0.8	-4.7	-0.4	-6.2	-3.0
1986-1991	1.9	3.2	2.5	4.2	2.3	0.1	-1.5	-0.1
1992-1995	-1.9	-4.3	-.01	0.0	-7.9	-2.3	-3.3	-3.7
1996-1999	-0.6	-3.7	0.2	-2.3	-4.2	5.3	-2.2	-3.4
1999-2002	-1.5	-2.2	0.2	0.3	-9.4	-1.6	-2.7	-3.0

Source: Kimura (2002a) as cited in Tatsuya and Schulz (2003): Industry in Japan

4. Conclusion

As financial specialists, a substantial portion of our examinations is given to innovative work and any segment's blast in an economy depends incredibly on the measure of arranging, use and research that it has gotten. Of late, there has been a rising segment that has vastly affected the productivity of other leading sectors in developed nations. Artificial Intelligence is presently viewed as one of the fundamental contributions to expand total factor productivity (TFP) and has been accepting mass measures of R&D in developed nations. So as the race for raw petroleum gets forcefully uplifted between creating nations, Japan is by all accounts applying high endeavors in expanding the nature of work and generation efficiency by adjusting new innovations.

The discrete adjustment of AI by nations, for example, Russia, United States and Japan is quickening and is genuine; this brings up the issue of: Will AI increment TFP? Also, provided that this is true, should whatever is left of the world adjust AI as one of its essential contributions to increase output? The EU-Japan Commission characterizes AI as an innovation that uses machine insight and human-thinking capacity to process different information to make forecasts, proposals and choices. This innovation is adjusted in machines to give more elevated amounts of aggregate factor profitability, regardless of whether this implies the swap of human work for higher development rates. This is one of the best moves in present day financial matters which greatly affect the marginal rate of technical substitution (MRTS). As Japan faces economic stagnation after its significant grade in GDP growth, numerous authorities from the EU-Japan place for Modern Collaboration trust that AI is the new outline for upgraded monetary and fiscal improvement.

Regardless, the findings of this study conclude that Japan's TFP has declined starting from 2013. This necessarily does not imply that resources are being misused or misallocated, but rather Japan has a growing problem of the ageing population. To respond to this issue, Prime Minister Shinzo Abe stated that Japan is not afraid of its ageing population problem, nor is it afraid of AI's powers; these are all rather incentives for the country to innovate and experience a take off stage into a new era of "Great Inventions".

References

[1] Abe, S., & Lee, C. H. (2001). 14 Economic Development in China and Its Implications for Japan. *Japan's New Economy: Continuity and Change in the Twenty-First Century*, 307.

[2] Apostolides, A. (2008) A Primer on Multifactor Productivity: Description, Benefits and Uses. Research and Innovative Technology Administration.

[3] Comin, D. (2006) Total Factor Productivity. New York University.

[4] Douglas, P. H. (1976). The Cobb-Douglas production function once again: its history, its testing, and some new empirical values. *Journal of Political Economy*, *84* (5), 903-915.

[5] Jones, R. (2016) Productivity: The Main Driver of Economic Growth for Japan. OECD. Research Institute of Economy, Trade, and Industry.

[6] Jones, R., & Jin, Y. (2017). Boosting productivity for inclusive growth in Japan.

[7] Kimura, M., Shibahara, N., Hikiami, H., Yoshida, T., Jo, M., Kaneko, M.,... & Shimada, Y. (2011). Traditional Japanese formula kigikenchuto accelerates healing of pressure-loading skin ulcer in rats. *Evidence-Based Complementary and Alternative Medicine*, *2011*.

[8] Lundin, M. Eriksson, S. (2016) Artificial Intelligence in Japan (R&D, Market and Industry Analysis) EU-Japan Centre for Industrial Cooperation pp. 1-39

[9] OECD: OECD. StatExtracts, http://stats.oecd.org/Index.aspx

[10] Purdy, M. Daugherty, P. (2016). Why Artificial Intelligence is the Future of Growth. Accenture Institute for High Performance.

[11] Singh, N. Trieu, H. (1996) Total Factor Productivity Growth in Japan, South Korea, and Taiwan. University of California Department of Economics.

[12] Solow, R. M. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, *70* (1), 65-94.

[13] Tatsuya, K. Schulz, M. (2003) Industry in Japan. Structural Change, Productivity, and Chances for Growth. Vol. Industrial Restructuring in Japan.