From Creators to Adopters. The Role of AI in Driving Economic Growth

Irina Vélez López[1,*]

Abstract

This paper explores the potential of artificial intelligence (AI) and Language Models (LLMs) as general-purpose technologies (GPTs) that can drive growth and development. AI and LLMs have the capability to redefine the ways in which businesses operate, improve productivity, and contribute to long-term economic progress. The generalization of tools, particularly in the realm of AI, enhances the potential for productivity improvements and opens up new possibilities for value creation. However, the coexistence of forward-looking optimism and backward-looking disappointment is a natural aspect of transformative periods. Grounded expectations are crucial in these periods, as there can be a discrepancy between optimistic expectations and actual outcomes. The integration of new technologies takes time, and creators and adopters play a critical role in realizing the potential benefits of AI. It concludes by highlighting the importance of grounded expectations and the value of intangible assets in the process of economic transition.

Keywords: General Purpose Technology, Artificial Intelligence, Creative destruction

1. Introduction

The generalization of tools is a crucial factor in harnessing the potential for growth and development. When a tool can be widely used for various purposes, its value increases significantly. In the realm of artificial intelligence (AI), Language Models (LLMs) serve as a foundational technology for other tools, such as AI-powered software. This opens up new possibilities and enhances the potential for productivity improvements in the workforce. As mentioned by (Eloundou et al., 2023), LLMs like Generative Pre-Trained Transformers (GPTs) exhibit characteristics of general-purpose technologies, which can have profound economic, social, and policy implications.

The emergence of new capabilities and the widespread adoption of LLMs as enablers of new AI-based tools, coupled with the increasing number of users utilizing tools like ChatGPT, signifies a future that has not been seen before. This accelerated expansion and pushing of boundaries and limits hold the potential for transformative changes.

In light of these dynamics, it is important to recognize that while there may be optimism surrounding new technologies, there can also be a discrepancy between expectations and

[*]Corresponding author
Email address: irina.velezlopez@student.hanken.fi (Irina Vélez López)
[1]Exchange Student.

actual outcomes. This coexistence of forward-looking optimism and backward-looking disappointment is a natural aspect of periods of transformative change. It reflects the human desire to witness the fulfillment of expectations within their lifetime, while also acknowledging the time required for society to fully integrate and benefit from these innovations.

2. General Purpose Technology, AI, and Large Language Models

General Purpose Technology is a transformative technology with a strong improvement process at the begining and eventually becoming widely adopted for its multiples uses, while producing many spillover effects (Brynjolfsson et al., 2017). As such, it have a pervasive impact on society as a whole, mainly due to its capability to redefine the ways in which businesses operate, improve productive and contribute to long-term economic growth. Some well-know examples are steam power, electricity, semiconductors, and internet.

Most GPTs play the role of enabling technologies, opening up new opportunities rather than offering complete, final solutions (Bresnahan and Trajtenberg, 1995). Therefore, their contribution depends on the ability to successfully use GPTs as enablers. The generic function or general concept behind AI is to simulate human cognitive abilities, which can be applied in many sectors.

Artificial intelligence a term coined by emeritus Stanford Professor John McCarthy in 1955, was defined by him as "the science and engineering of making intelligent machines".[2] These systems are designed to simulate human cognitive abilities, such as learning, reasoning, problem-solving, perception, and language understanding. Within the realm of AI, Large Language Models (LLMs) are a specific type of AI model that utilizes deep learning techniques, particularly neural networks, to process and generate human-like language. LLMs are trained on vast amounts of text data and can perform tasks like language translation, text summarization, and question answering.

In the past, computer programs were developed by painstakingly encoding human knowledge, following a precise set of instructions that mapped specific inputs to desired outputs. This approach required programmers to meticulously define every step of the process. However, machine learning systems operate differently. They utilize general algorithms, such as neural networks, which enable them to independently determine the appropriate mapping between inputs and outputs. This is achieved through exposure to extensive datasets containing numerous examples. By analyzing and learning from these examples, machine learning systems can identify patterns and make accurate predictions or classifications without explicit programming instructions.

2.1. Key factors contributing to the widespread adoption of a technology as a GPT

In the case of LLMs, emergent abilities such as text understanding, generation, problem-solving, mathematics, and data classification have arisen due to the increased computational power required to train these models (10^23 training FLOPs). As research progresses, understanding how emergence occurs in LLMs could provide new insights into

[2]Available at: `https://hai.stanford.edu/sites/default/files/2020-09/AI-Definitions-HAI.pdf`

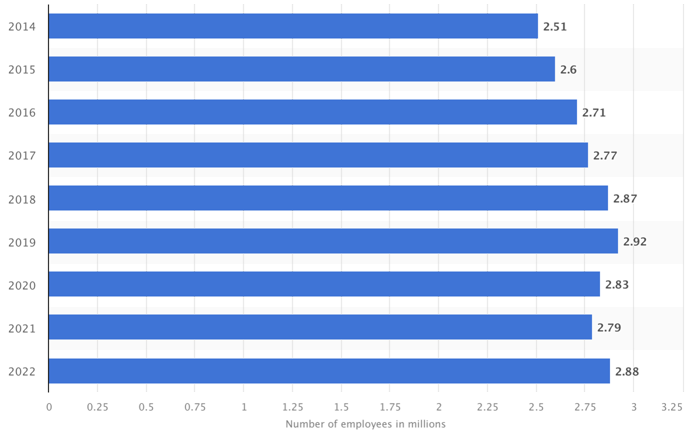

Figure 1: Number on contact center employees in the United States from 2014 to 2022.

training more-capable language models. This emergence of new abilities is one of the key factors in the widespread adoption of LLMs as a GPT.

AI as a General Purpose Technology has transformative potential, versatility, and wide-ranging applicability across various sectors and industries. By simulating human cognitive abilities, AI systems can tackle complex tasks and make accurate predictions or classifications. AI's scalability, adaptability, and capacity to integrate with other technologies enhance its impact and expand its applications.

3. What is the potential economic impact of AI?

Considering the AI as a new General Purpose Technology, assessing its possible contribution to economic growth is worthwhile in times of dizzying change such as the present. The winds of uncertainty are blowing everywhere and it would be useful to set expectations. Given the conditions of uncertainty and the low accuracy of predictions, the assessment of its potential impact seems to be addressed only by a retrospective approach, which means that the performance of previous general-purpose technologies, such as steam power, electricity or the Internet, could provide a more realistic answer to this question.

However, this topic has already been addressed by (Brynjolfsson et al., 2017) and (Crafts, 2021), in a context where there are optimists and pessimists about technology and growth. A real dichotomy emerges between the higher profit expectations of forward-looking entrepreneurs and the poor growth performance reflected in retrospective statistics.

One example mentioned by (Brynjolfsson et al., 2017) is the call center industry, which had approximately 2.2 million agents in 2015 in the United States. It was plausible at that time to anticipate that voice recognition systems like IBM's Watson could potentially reduce the number of workers by 60%. However, in hindsight, it is evident that the expectations have not been fully met, as shown in Figure 1, which illustrates the statistics.

As (Brynjolfsson et al., 2017) explains, this apparent incongruity is due to the time lag between the creation of the technology and the full realization of its benefits in the economy and society. It takes time to build up the stock of the new technology, develop the necessary human capital skill set, undergo the process of re-engineering business process transformations, and develop complementary innovations for full realization in the real economy.

To support this explanation of the lag, the Schumpeterian growth model could offer a good perspective, taking as a starting point that the real contributions to growth are value creation and cost optimization, so AI should serve these growth contributors.

3.1. Assessing the potential economic impact of AI in terms of value creation and cost optimization.

From an economic perspective, one of the fundamental problems in understanding corporate behavior is the pursuit of profit maximization by firms. This objective drives economic growth and leads to two main objectives in the private business sector: adjusting the production function to obtain the right quantities to supply the market, while coping with constraints, often in the form of a limited budget.

The firm's goal of maximizing profits can be represented as follows:

$$Profit = Total\ Income - Total\ Costs : \Pi = PX - C(X)$$

$$Maximization\ Problem : \max_{x} \Pi(X) = PX - (wL + rK)$$

Where PX represents the revenue generated by production function X, and C(X) represents the corresponding costs associated with labor and capital costs. Thus, on one side of the coin, value creation contributes to increasing profits by adjusting the output of production function X, while on the other side, cost optimization aims to mitigate not only budget constraints but also resource constraints. Therefore, AI must be oriented towards achieving one or both of these objectives to promote growth.

To exemplify value creation through AI, consider the use of deep neural network systems in skin cancer diagnosis (Esteva et al., 2017), fraud detection and risk assessment in the financial sector, and inventory forecasting automation, as seen in Amazon's AI-powered inventory management product. On the other hand, from a cost optimization perspective, AI is used in predictive maintenance and quality control to anticipate equipment failures[3].

3.2. Shumpenter's concept of creative destruction

Creative destruction refers to the process of creating and developing new technology that continuously disrupt and replace the existing obsolete technology in order to drive economic progress and growth.

Thus, let us consider two types of companies, those that are creators of new technologies and major investors in R&D, such as big technology companies like Apple, Amazon, Meta or Google, called "creators" of technology, and on the other hand, companies that adopt and implement the new technology released by the creators, called "adopters" of technology.

In addition, knowledge or innovation is considered a **public good**, one you have invented something , it is almost free to spread it around the world. Thus, the first initial

[3] Available at: `https://www.ge.com/research/project/predictive-maintenance`

cost of producing the technology has to be covered through monopoly profits (Creators), because this has been the mechanism that the market system has found to cover the huge initial costs[4].

Once the new technology has been widely launched in the market at an almost affordable or even free price, as in the case of ChatGPT, the maturity level or readiness of the adopter must be high in order to take advantage of the full potential of the new technology. From the adopter's point of view, it takes time to evolve and incorporate the new technology into their business process in a way that is effective and beneficial to the business. This evolution requires developing new business processes, adjusting their production functions to add value to their bottom line, and reallocating skilled human capital to address the transformation.

Destruction is represented in the Schumpeterian Growth Model as the expected years that firms will remain in the market, if they do not adapt. And this adaptation process is mainly promoted by the creation of new ideas E[A]. This time expectation is represented by the following equation

$$Firm\ Lifetime : E[\tau] = 1/E[A]$$

$$Firm\ Lifetime : E[\tau] = 1/\gamma N$$

Where: New ideas corresponds to $E[A] = \gamma N$

The life of the company is reduced by the increase in productivity (γ) and the deployment of new technologies (N). This leads to two transition scenarios

1. If the adopter is not able to incorporate the new technologies or take advantage of them, its profit will be decreasing until a possible exit from the market, when its profits will be zero, and therefore, this company will not contribute to the growth of the economy.
2. If the adopting company is able to incorporate the new technology or take advantage of it, its profit will increase, which in turn will ensure its permanence in the market. However, this benefit is not immediately reflected in the aggregate accounting statistics. The process of adaptation takes time, due to the development of new business processes, the upgrading of the skills of its human capital, the time required for the reallocation of more qualified human capital from less capable firms to firms with more potential for growth or success.

This reallocation of human capital can be seen in one of the key statistics in the labor market: Job postings.The number of AI related job postings has increased on average from 1.7% in 2021 to 1.9% in 2022 according to (Maslej et al., 2023). This increased trend can be seen in Figure 2. In 2022, the top three countries with the higher percentage of AI job postings were the United States (2.1%), Canada (1.5%), and Spain (1.3%).

Thus, in times of structural change like the present, it is challenging to observe the results of new technologies, as the contributions to growth made by successful firms are often offset by the declining profits of firms in decline. Therefore, it is reasonable to think that current statistics may not yet reflect the potential benefits of using AI.

[4] Insights taken from this Bilkent Üniversitesi lecture

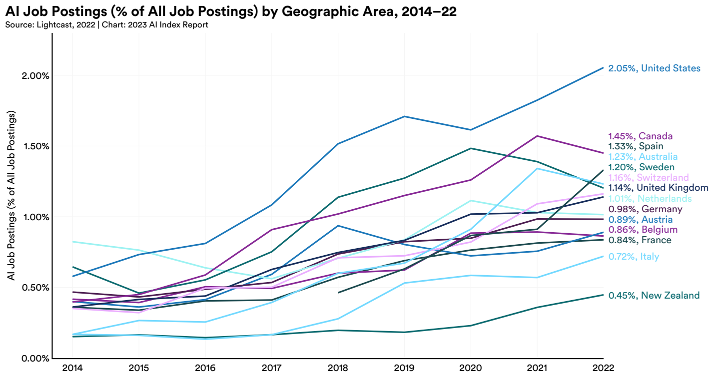

Figure 2: Percentage of all job postings that require some kind of AI skill by Geographic Area, 2014 to 2022.

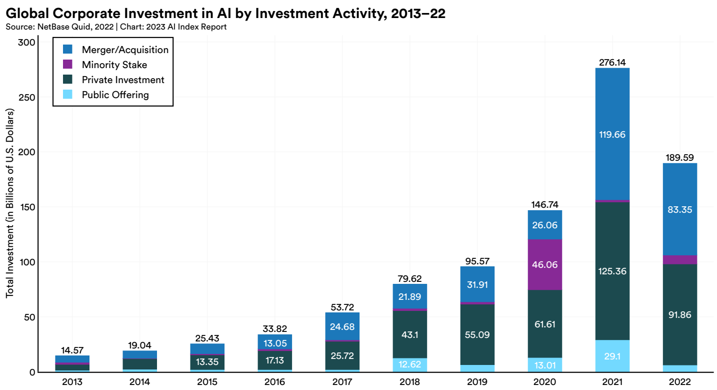

Figure 3: Global Corporate Investment in AI by Investment Activity, 2013 to 2022.

This can be illustrated by reviewing the investments in AI over the last decade and the historical behavior of the Multiple Factor of Productivity.

Figure 3 shows an upward trend in global AI investments over the last decade, with the exception of 2022, when, for the first time since 2013, global business investment in AI has declined.

However, these investments have not yet translated into increases in the Multi Factor of Productivity (MFP), as can be seen in Figure 5 and Figure 4.

Figure 5 shows a decreasing trend in MFP since 1996, while Figure 4 shows the average behavior of the MFP by continent. Despite investments in AI since 2013, this trend has not changed. Therefore, this is an indicator that new technologies such as AI may not yet have reflected their benefits in the economy.

Nevertheless, this result may not be entirely accurate, as the measurement tools available to us today may not be capturing the real impact of these technologies. Mainly because multifactor productivity growth is measured as a residual, i.e., the part of GDP growth that cannot be explained by growth in labor and capital inputs.Traditionally, TFP growth has been considered to reflect technological progress, but in practice this

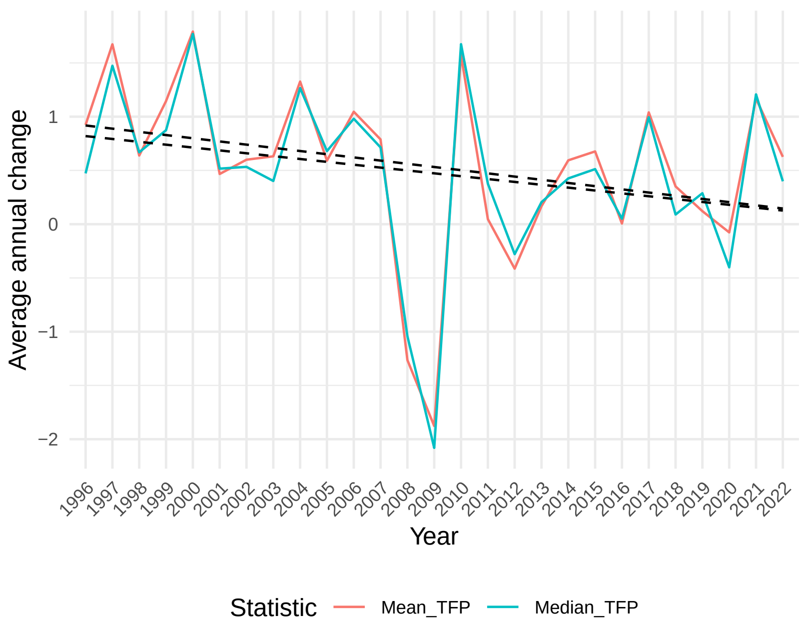

Figure 4: Mean and median Multifactor Productivity per year for OECD countries, 1996 to 2022. The dashed black lines represent the mean and median trend line

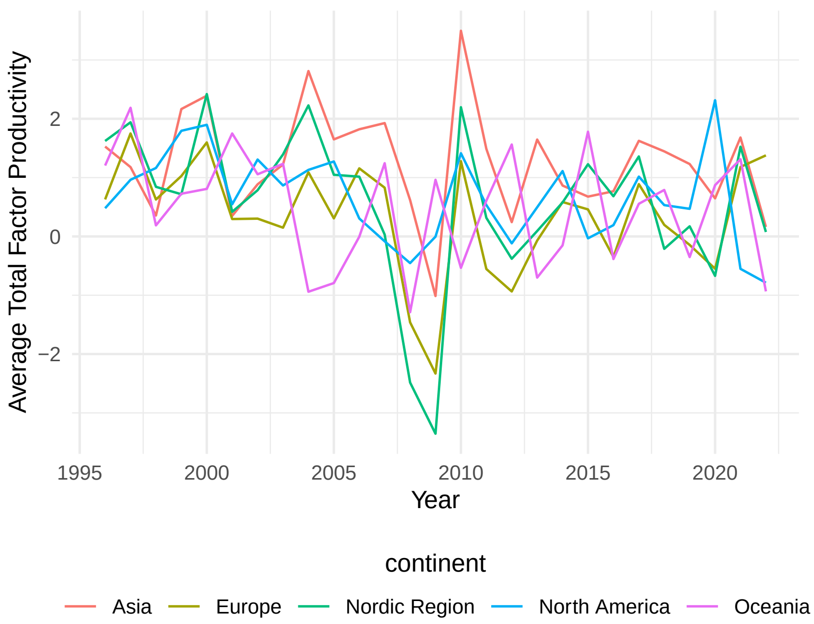

Figure 5: Average of Multi Factor Productivity by Continent, 1996 to 2022.

does not mean that this parameter reflects all the benefits.

However, in aggregated terms or in a wide country perspective, Multi Factor of Productivity is a good approach to assess the technological contribution. MFP also captures other factors, such as adjustment costs, economies of scale, and effects from imperfect competition.

3.3. A country-level perspective: Creators and Adopters

To ilustrate better the concept of creative destruction and its challenges measuring the economic impact of AI, let's consider a country like Colombia. Suppose that Colombia has a fixed amount of resources, R, that it can allocate towards different economic activities. The country can divide these resources in the following way:

Creators: Proportion n does R&D: nR. A proportion n of the resources are allocated towards Research and Development (R&D) activities. R&D is the process of creating new knowledge and technologies that can be used to improve productivity and create new products and services. Examples of R&D activities include developing new AI algorithms, creating new software, and conducting experiments to test new business models.

Adopters: The remainder goes to produce X: $(1-n)R$, are allocated towards producing a certain level of product or result X. Adopters are individuals or firms who use existing technologies to produce goods and services. While they may not be involved in creating new technologies, they play a critical role in bringing new products and services to market.

Those resources are organized by companies as a composite of human capital, creators are individuals with the necessary skills to create new technologies and a deep understanding of the underlying technologies, while adopters are individuals with sufficient skills to produce X in the traditional business model. Now, adopters need to acquire new skills in order to incorporate the benefits of technology, creating new business processes and successfully transitioning their production from the old schemes to the new schemes. These adopters are investing in intangible assets that the metrics are not reflecting. More importantly, adopters need the help of creators to facilitate the adoption process in their industries, because it stands to reason that creators are the most skilled human capital part of the available resources.

At the firm level, adapting firms can benefit from adopting a similar approach to resource allocation. Firms that allocate a portion of their resources towards R&D are more likely to be successful in transitioning to a new business model. In practical terms, from the perspective of an adopting company:

Business Transformers: The ratio n avoids exiting the market and are responsible for leading the firm's successful transition to a new business mode: nR. Change assimilators: This ratio continues to maximize profit in the new business model: $(1-n)R$.

Since consumers are not part of the production process, they have been left out of this analysis. However, their acceptance towards the consumption of AI-based products and their expected increase in the consumption of AI-based services will have a positive impact on economic growth.

It is important to note that there are intangible assets associated with the transformation process that are not yet quantified. In the last wave of computerization, the value of these intangibles was about ten times greater than the direct investments in computer hardware (Brynjolfsson et al., 2017). Given the complexity and novelty of AI-based technologies, it is plausible that the intangibles associated with AI are of comparable or greater magnitude. Examples of intangible assets associated with AI include data, algorithms, access to massive data, training and organizational capabilities.

4. Conclusion

The positive expectations surrounding new technologies, such as AI, are often accompanied by optimism from industry leaders, technology experts, and venture capitalists, leading to speculative investments and forecasts of future corporate wealth in the financial sector. However, as (Brynjolfsson et al., 2017) suggest, there is no inherent contradiction between forward-looking technology optimism and backward-looking disappointment. The two can coexist, especially in periods of transformational change, due to human nature, as individuals want to see their expectations fulfilled throughout their lives. But the time it takes for society to fully incorporate and benefit from new technologies could be longer, resulting in a slower rate of assimilation.

Although I am not concluding anything new to what has been mentioned before by several authors, it has been worthwhile to review especially the position of (Brynjolfsson et al., 2017) from the vision of the Schumpeterian growth model, and some metrics such as the Multifactor productivity and investments in AI, which allow us to have more grounded expectations of these new technologies. I have also emphasized the value of intangible assets that are part of the economic transition process.

While optimism and speculation around new technologies are common, it is essential to approach them with a nuanced understanding of the complexities and challenges of economic transition. By considering both the tangible and intangible aspects of this process, we can better understand the potential benefits and limitations of new technologies and make informed decisions about their adoption, implications and integration into society.

References

Timothy F. Bresnahan and M. Trajtenberg. General purpose technologies 'engines of growth'? *Journal of Econometrics*, 65(1):83–108, 1995. ISSN 0304-4076. doi: https://doi.org/10.1016/0304-4076(94)01598-T. URL `https://www.sciencedirect.com/science/article/pii/030440769401598T`.

Erik Brynjolfsson, Daniel Rock, and Chad Syverson. Artificial intelligence and the modern productivity paradox: A clash of expectations and statistics. Working Paper 24001, National Bureau of Economic Research, November 2017. URL `http://www.nber.org/papers/w24001`.

Nicholas Crafts. Artificial intelligence as a general-purpose technology: an historical perspective. *Oxford Review of Economic Policy*, 37(3):521–536, 09 2021. ISSN 0266-903X. doi: 10.1093/oxrep/grab012. URL `https://doi.org/10.1093/oxrep/grab012`.

Tyna Eloundou, Sam Manning, Pamela Mishkin, and Daniel Rock. Gpts are gpts: An early look at the labor market impact potential of large language models, 2023.

Andre Esteva, Brett Kuprel, Roberto A. Novoa, Justin Ko, Susan M. Swetter, Helen M. Blau, and Sebastian Thrun. Dermatologist-level classification of skin cancer with deep neural networks. *Nature*, 542(7639):115–118, January 2017. doi: 10.1038/nature21056. URL `https://doi.org/10.1038/nature21056`.

Nestor Maslej, Loredana Fattorini, Erik Brynjolfsson, John Etchemendy, Katrina Ligett, Terah Lyons, James Manyika, Helen Ngo, Juan Carlos Niebles, Vanessa Parli, Yoav Shoham, Russell Wald, Jack Clark, and Raymond Perrault. Artificial intelligence index report 2023, 2023.