

AEGON INSIGHTS

ESG Megatrends: AI & Automation

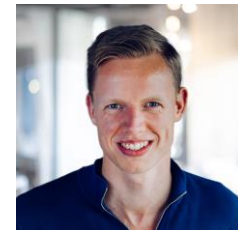
With recent advances in the field of artificial intelligence (AI) and the increasing use of automation across many industries, there is potential to revolutionize the economy as we know it. Simultaneously, these technologies raise various important Environmental, Social and Governance (ESG) issues that need to be addressed. This paper explores the challenges and opportunities presented by AI and automation, discussing the potential impacts on the real economy and investors' portfolios.

Executive summary

- AI and advanced workplace automation carry the potential to revolutionize the economy by enabling machines to perform tasks previously only possible for humans.
- As AI technologies advance, they raise significant Environmental, Social, and Governance (ESG) considerations. These factors should be integrated into the investment decision-making process.
- The effects of AI and workplace automation developments on the labor market will be strongly contingent on the willingness and ease of AI adoption across organizations.
- Investors should adopt a long-term perspective. The full potential of AI may not be realized in the short term, but over the long term, they could significantly disrupt the economic landscape.
- The impacts of AI on the real economy may prompt investors to incorporate these developments into their strategic asset allocation (SAA) process.

This article is part of the [ESG Megatrends: Implications for Strategic Asset Allocation \(SAA\)](#) series in which we discuss the consequences of key ESG developments across the global economy that we believe will affect investors' portfolios.

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Igor Quint
Investment
Strategist

Igor Quint, is an investment strategist within the Fiduciary Services & Investment Solutions team. He provides strategic advice on the investment policy of institutional investors.



Jelmer Kuiper
Investment
Strategist

Jelmer Kuiper, is an investment strategist within the Fiduciary Services & Investment Solutions team. He provides strategic advice on the investment policy of institutional investors.

Automation

Technological improvements such as automation have existed for a long time. Where automation used to refer to technologies more physical in nature, such as dishwashers or robotization, nowadays the term implies a much wider range of technologies, including robotic process automation (RPA), machine learning (ML) models as well as certain applications of artificial intelligence (AI).

Historically, automation has had a profound effect on labor markets, significantly reducing demand for workers performing routine-based activities. In the 20th century, industries like agriculture and car manufacturing were prime examples of this transformation. In many of these cases, machines were able to displace workers entirely, while these shifts also created new, more skilled positions for those capable of operating and servicing these machines.

The impact of automation today appears to be vastly different. Although job displacement is still a likely consequence, this effect is no longer limited to work more physical in nature. In fact, recent developments of software-based automation and AI have the potential to actually displace or reduce knowledge-based work.

Artificial intelligence

Artificial Intelligence (AI) refers to a field in computer science dedicated to the creation of machines capable of performing tasks that typically require human intelligence. These tasks include problem-solving, understanding natural language, recognizing patterns, learning from experience, and making decisions. Contrarily, automation involves the use of technology to carry out repetitive tasks without human intervention. While AI systems are designed to simulate human intelligence and decision-making, automation is primarily about streamlining and replicating predefined procedures. Consequently, automation can be seen as a subset of AI; it can utilize AI to enhance its functions, but it doesn't inherently require learning or problem-solving capabilities. In other words, AI involves smart systems capable of learning and adapting, whereas automation is about executing repetitive tasks efficiently and accurately.

Text generated by AI on 30/06/2023 (ChatGPT 4, OpenAI)

Unlikely as it seems, the paragraph above was written by a Large Language Model (LLM) called "GPT 4", developed by OpenAI.¹ The only input required was a short prompt: "Explain AI and differentiate it from automation in one paragraph".

With the public preview of ChatGPT late 2022, the progress made in LLMs became visible to the large public. At the time of this writing, LLMs are making headlines every week. But the current AI boom is not limited to language models; another example of a generative AI model is Midjourney,² which can generate unique and new images based on given keywords or descriptions. The outputs can range from oil paintings to clipart images or even seemingly real photographs, as demonstrated in the images in Box 1. The practical applications of these models include designing artwork for games and magazines or creating copyright-free stock photographs for publications. Beyond the examples already mentioned, generative AI models can also be employed for many other use cases including coding, composing music, drafting essays, and summarizing text.

Box 1: Examples of generative AI used for images



"British double decker bus driving past the Eiffel tower"



"Charging bull of Wall Street painted in van Gogh style"

Source: Midjourney v5, 24-03-2023. The images above are generated with the prompts below the images.

¹ A Large Language Model (LLM) is a model that is trained on large amounts of textual data such that it is able to understand and generate output in a human-like way. See for example OpenAI (2019) for a more technical explanation of LLM's (<https://openai.com/research/better-language-models>).

² Midjourney, www.midjourney.com

Disruption on the horizon?

The impact and reach of advanced automation and specifically AI are not clear as of yet. As technologies progress continuously, new opportunities and threats appear on the horizon. The public preview of ChatGPT is being characterized as the “iPhone moment” for AI. Since OpenAI launched the preview in late 2022, tech firms around the world have raced around the clock to deliver their own AI implementations.

New AI-driven tools and applications are dominating discussions in the tech industry every day. Tech giants Google and Microsoft are leading the charge in the current wave of AI developments. While Microsoft has invested heavily into OpenAI, Google (Alphabet) owns their AI-specialized subsidiary Google DeepMind.³

Generative AI

It is important to note that the current wave of AI developments mainly involve applications of generative AI. While AI itself is an umbrella term involving many specific fields and applications (see Figure 1), generative AI represents models that are able to generate text, images or even video from a simple user text prompt. Current developments stretch this by adding other media such as music and 3D-models as outputs or take other images as inputs. The public launch of models such as GPT4 (text-to-text, Large Language Model) and Midjourney (text-to-image) have created awareness of the power and general usefulness of generative models. Other fields within AI, such as computer vision (CV) - important for applications such as self-driving cars – are not developing at the same pace as some generative AI applications are. So even though we might talk about an AI revolution, it is generally wise to distinguish between various fields within AI as not all fields develop at the same pace. A key difference is that generative AI has an enormous target audience due to its variety of use cases, while above discussed examples are more specific.

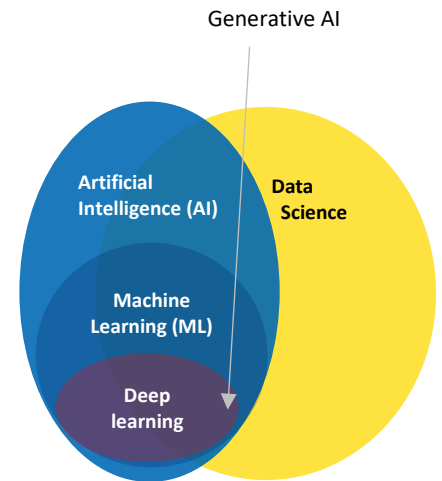



Figure 1: AI and how it relates to Data Science, Machine Learning & Deep Learning

AI & ESG considerations

The above-described use cases of automation and (generative) AI underline the power these technologies could have as potential disruptive force within different segments of our society. Aside from the endless opportunities, it also carries risks. In this paragraph, several risks are discussed and linked to the Environmental, Social and Governance (ESG) pillars. To lay-out a foundation for providing insights into implications and consequences, main ESG risk factors are addressed in Table 1.⁴

Table 1: ESG topics of importance under the increasing use of AI

<p>Environmental: Energy use & climate</p> 	<p>Adverse environmental effects of AI models, such as substantial energy use, is an often-stated problem of AI. For instance, the training of GPT3 used an amount of energy equal to power 121 homes in the US for a year.⁵ With newer models like GPT4 being exponentially larger, this energy consumption is likely to have increased significantly. On the flip side, recent research points out that AI models can be deployed to optimize energy usage, benefitting the environment.⁶ From this perspective, energy-hungry AI models could have a two-sided environmental impact: they can benefit green energy solutions (e.g., smart grid design), while also being a significant emitter.⁷</p>
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³ Google released its own Large Language Model and chatbot, Bard, which is considered as one of the main competitors of ChatGPT.

⁴ The ESG risk factors in Table 1 are commonly cited risk factors of AI and automation.

⁵ <https://www.economist.com/interactive/science-and-technology/2023/04/22/large-creative-ai-models-will-transform-how-we-live-and-work>

⁶ <https://arxiv.org/abs/2211.07357>

⁷ <https://www.nature.com/articles/s41467-019-14108-y>

Social:
Fairness of AI



Among the risks of AI, there is the potential of bias and discrimination. There is growing emphasis on the fairness of AI among regulators and developers to prevent discriminatory decision-making or bias, especially related to age, gender, or ethnicity. As can be seen from Figure 2 below, the amount of misuse incidents with AI and automation has sharply increased in recent years, also mirroring increasing use and adoption of AI.

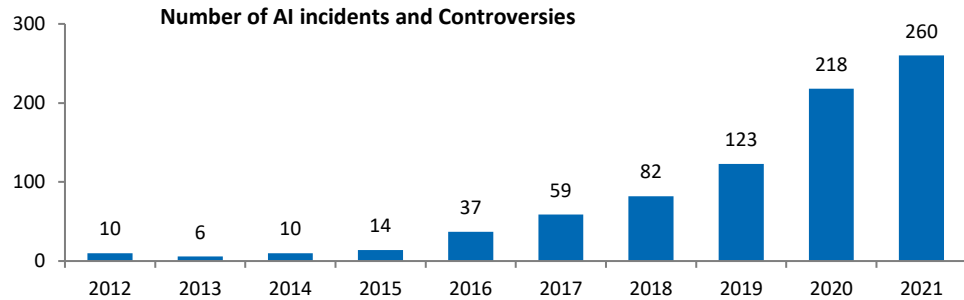


Figure 2: AI incidents and Controversies Source: AIAAIC repository and AI Index Report 2023 (Stanford University)

Along with this trend there is increasing focus among practitioners and researchers on fairness of AI. BIG-bench is an initiative to test language models for their future capabilities but also potential harmful effects.⁸ In our view AI fairness is crucial, particularly as the adoption of these technologies expands across organizations.

Social:
Job displacement



Advancements in Large Language Models (LLMs), other aspects of generative AI and automation more broadly, have sparked debate about the future of work. As progress has been outpacing expectations, it is challenging to make any accurate predictions. Nevertheless, preliminary academic studies on the impact of LLMs, specifically GPT-4, on the US job market provide an interesting first glimpse,⁹ claiming that:

- At least 19% of current occupations have more than 50% of their daily work activities exposed to LLMs.
- Exposure to LLMs correlates with higher wages, implying that contrary to previous consensus, higher-skilled occupations tend to be more displaceable in the future.

As an example, the invention of the steam engine did not instantly trigger wide-spread unemployment. As the machines became more affordable and reliable, a gradual shift in employment within these sectors began to occur.

Given that AI is software-based, it carries fewer physical constraints of implementation and is distributable much faster than physical automation. As such, we argue that future developments in AI could potentially provoke a more abrupt change in the labor market, though the extent of these changes strongly relies on the willingness and ease of implementing these technologies.

Governance:
Market power of tech firms



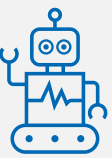


Due to the substantial costs for computing power, development of large language models (LLMs) is highly capital intensive. At the same time, companies with more data and inhouse knowledge regarding AI are in the front-seat with respect to adaptability in this field.

We expect that only a handful of LLMs will dominate the marketplace. However, smaller AI developers can leverage the use of application programming interfaces (APIs) to construct specialized business-specific applications on top of these LLM platforms. This facilitates smaller companies to create AI-driven solutions without the necessity for extensive in-house expertise on AI. As a result of this scenario, the competition amongst smaller AI developers may be intense

⁸ BIG-bench is a community wide initiative to get better insights into capabilities and limitations of (large) language models. See for a more detailed explanation the original paper: *Beyond the Imitation Game: Quantifying and extrapolating the capabilities of language models* (<https://openreview.net/forum?id=uyTL5Bvosj>).

⁹ GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models, Eloundou et al. 2023. Derived from <https://doi.org/10.48550/arXiv.2303.10130>

	<p>whereas the creators of the most powerful LLMs could ascend to a monopolistic position in the marketplace.</p> <p>The semiconductor industry stands to gain significantly from the AI revolution due to the high computing power and expertise needed for developing large language models. Currently, especially the producers of graphical processing units (GPUs) benefit from AI-related investments.¹⁰ In the future, more producers within the semi-conductor industry may benefit when application specific integrated circuit (ASIC) chips are designed with AI applications in mind.</p>
<p>Governance: Regulation</p> 	<p>Regulating AI is a complex topic for lawmakers to address. Technological developments often outpace regulatory efforts, for instance, when the European Union’s (EU) April 2021 proposed AI regulation package¹¹ was ambushed by the rapid developments of ChatGPT.¹² The emergence of advanced AI applications has brought along issues such as the possible spread of fake news, ethical dilemmas of AI decision making and copyright concerns. Traditional copyright does not directly apply to outputs of generative AI models, but this raises the question whether these models are free to be trained on copyrighted material in the first place.</p> <p>In June 2023, the EU announced it was finishing up the final draft of the EU AI Act, requiring models such as OpenAI’s GPT-4 to comply with various conditions. In response to this law, 150 executives of European firms have expressed their fear of heavy regulation on foundational AI models, which in their eyes would diminish the competitive position of European firms.¹³</p>
<p>Governance: Accuracy & facts</p> 	<p>LLMs are known to produce seemingly plausible yet inaccurate information, a phenomenon referred to as hallucination. The root of this problem lies in the algorithm's training, which prioritizes predicting the next word based on learned patterns rather than adhering to a definitive ground truth. This results in the model generating text that is coherent and contextually appropriate, but not always factually correct.¹⁴ Given this propensity, the need for human intervention to verify and validate AI-generated outputs becomes critical, thus tempering the immediate potential for worker replacement.</p>
<p>Governance: Self-conscious AI</p> 	<p>One of the most widespread concerns regarding AI has been the potential emergence of self-conscious AI, also dubbed Artificial General Intelligence (AGI), that could potentially act against human interests. This notion of “sentient AI” is at the center of debate surrounding AI safety. Last year, Google engineer Blake Lemoine stated that Google’s chatbot LaMDA was showing signs of consciousness.¹⁵ Identifying potential consciousness of AI models is complicated and will surely remain subject of debate.</p>

¹⁰ For example NVIDIA, one of the leading chip manufacturers for AI applications experienced a surge of the share price in early 2023.

¹¹ <https://digital-strategy.ec.europa.eu/en/policies/european-approach-artificial-intelligence>

¹² <https://www.politico.eu/article/eu-plan-regulate-chatgpt-openai-artificial-intelligence-act/>

¹³ <https://www.ft.com/content/9b72a5f4-a6d8-41aa-95b8-c75f0bc92465>

¹⁴ <https://labelbox.com/blog/what-does-it-mean-when-an-llm-hallucinates/>

¹⁵ The Washington post (2022), <https://www.washingtonpost.com/technology/2022/06/11/google-ai-lamda-blake-lemoine/>

Modelling AI adoption and macroeconomic consequences

The field of AI is developing at a staggering pace,¹⁶ making it challenging to oversee and capture all consequences in the short term, let alone the long term. Presuming that technology and society are able to address the (ESG) risks defined in the previous section, the increasing attention on AI regulation, adoption and implementation could significantly influence future developments of AI. Through a framework of adoption pathways, we aim to provide insights into the possible relationships and consequences of AI within the economy.¹⁷

The willingness to adopt AI and the ease of AI implementation will drive the competitive advantage that firms are able to achieve. In the figure below we present four pathways which firms could take with respect to AI adoption. We provide examples of each of these pathways and link these pathways to short- and long-term implications on a macroeconomic level.

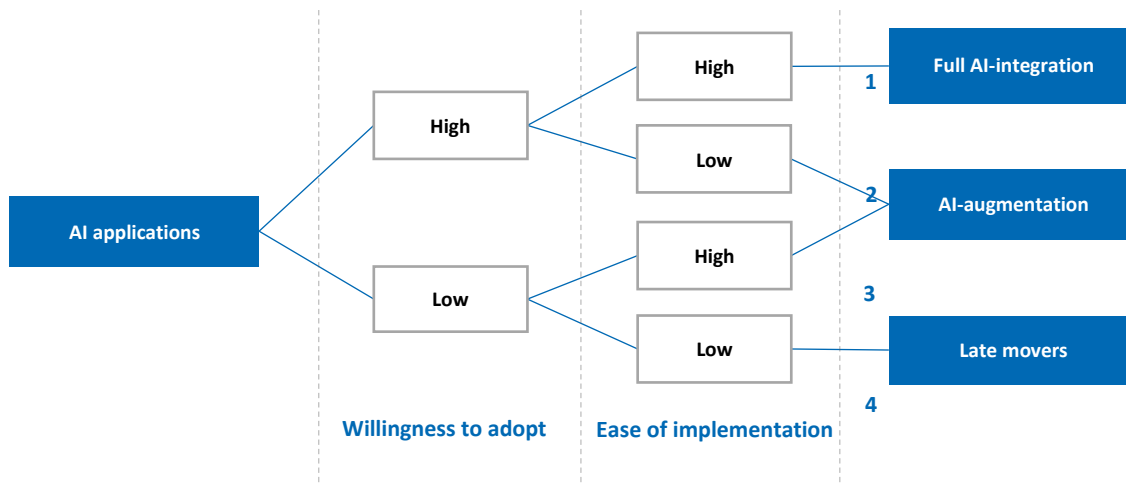


Figure 3: Hypothetical model of AI adoption pathways Source: Aegon Asset Management

The four pathways presented above depend on the willingness to adopt AI and ease of AI implementation. We expect that pathway (1) is rarely seen at this point in time. Pathway (2) and (3) result in work augmented by AI applications. Even though management may be unwilling to adopt AI, workers will try to integrate AI into their duties if they get the chance (pathway 3). We expect most companies to follow pathway (2) and (3) in the short term.

Box 2: A hypothetical tale of two construction firms

Let's imagine a competitive landscape with two hypothetical construction firms. The first one, Build Inc. was **eager to adopt** AI, although they found implementation was hard. Even though the role of AI in construction may appear limited, they employed an AI-driven system for drafting and reviewing contracts with suppliers and customers, reducing errors and speeding up negotiations. AI was also integrated into their customer service, automating inquiries, preparing detailed technical summaries for construction projects, and improving response times. These implementations resulted in **increased** operational efficiency and customer satisfaction.

On the flip side, Construction Inc. **shied away** from any AI integration. Their manual contract review process was slower and more prone to errors. Their response to inquiries took several days and customers grew annoyed by longer response times compared to its competitors. The **reluctance** of Construction Inc. in adopting AI resulted in a competitive **disadvantage** compared to Build Inc.

The story in Box 2 illustrates how a firm following pathway (4) could be faced with a competitive disadvantage against a peer following (2).

¹⁶ https://aiindex.stanford.edu/wp-content/uploads/2023/04/HAI_AI-Index-Report_2023.pdf

¹⁷ The field of AI and automation is rapidly developing, and effects and implications may strongly differ across countries, sectors, or organizations. Therefore, this model should only be used as an indication of possible pathways or relationships resulting from the rapid rise in the last months.

Short-term implications

We anticipate that the short-term economic effects of automation and AI, heightened by the recent advancements in the field, will primarily depend on the willingness of individuals and organizations to adopt these practices into their way of working. Figure 3 shows possible adoption pathways with the drivers being adoption willingness and ease of implementation.

Implementation of advanced AI is not uniform across organizations, due to a variety of reasons. First, adoption readiness can differ heavily across sectors, countries or even within organizations. Firms with a high ease of implementation, as our model in Figure 3 suggests, are more agile in embracing these new technologies. For instance, organizations with robust digital infrastructure are less likely to face implementation hurdles. However, novelty of recent AI developments may also lead organizations to postpone adaptation, opting to observe competitors' moves first.




In the short term, organizations might show hesitance regarding AI adoption for reasons such as regulatory concerns, high implementation barriers (e.g., due to unstructured data) or limited understanding of AI and its automation potential. Keeping these drivers in mind, it is likely that in the short term, many organizations will align with pathway 2 or 3 of our derived adoption model (the **AI-augmentation scenario**). Under this scenario, AI is mainly implemented to serve workers in executing their work more efficiently and with higher consistency. Microsoft Copilot,¹⁸ for instance, allows users to offload repetitive tasks. Similar software is also being developed by other firms such as Google.

Real economy effects associated with short-term AI augmentation scenario

Considering that in the short term, most organizations will primarily be exploring the use and implementation of AI as a way to augment their workforce, we **anticipate marginal short-term labor market effects** of AI. Quantifying job creation and replacement due to these technologies remains challenging, although early indications suggest that even in the short term certain occupations are already becoming redundant.¹⁹

Early adopters who effectively implement AI within their organization, could gain a competitive edge over their peers who are less willing to adapt. If implementation, albeit with varying impact, leads to increased efficiency and the automation of laborious tasks, this is likely to have a positive impact on the Gross Domestic Product (GDP). However, as we expect that most companies are still exploring the potential of AI in the short term, this is likely to only produce incremental productivity gains and therefore **minor GDP growth**.

Economic theory suggests a positive relationship between economic growth (GDP increase) and the level of the real interest rate curve. That said, until recently interest rates have been historically low, leaving some to wonder whether markets have truly priced in future growth due to AI.²⁰ Due to these conflicting theories, in our view the **short-term effect of AI and automation on interest rates are unclear**.

Short-term effects	Unemployment	GDP	Real Interest Rates
AI-augmentation scenario			

Under the AI augmentation scenario, AI is mainly implemented to serve workers in executing their work more efficiently and with higher consistency.

¹⁸ Microsoft Copilot is a GPT4 powered extension to be released in 2023. It claims to assist and automate several tasks commonly performed by humans within the Office 365 suite.

¹⁹ <https://www.washingtonpost.com/technology/2023/06/02/ai-taking-jobs/>

²⁰ <https://forum.effectivealtruism.org/posts/8c7LycgtkypkgYjZx/agi-and-the-emh-markets-are-not-expecting-aligned-or>

Long-term implications

The outlined scenario for short-term AI adoption does not capture the possible long-term trajectory of AI and automation. Overall, we expect a clearer overview of the landscape once the dust settles in the medium to long term (5-15 years). During this timeframe, organizations will have ample opportunity to discern valuable AI implementations. Moreover, the regulatory landscape is adapting rapidly and it is likely that regulations get better aligned with these technologies over time.

Unlike the short-term expectations, we expect less hesitation and lower implementation barriers in the long run. While AI-augmentation (pathway 2 and 3) was considered the most likely short-term scenario, we foresee more organizations making an upward shift towards the more widespread **AI-integration scenario** (pathway 1) in the long term. This shift can be explained by various factors. First, it is likely that organizations are better informed on where or how to use AI implementations in their way of working. Second, organizations can overcome existing implementation barriers (e.g., unsuited data structures) over time. Additionally, we expect a more stable regulatory landscape in the long term. The likely enforcement of the EU AI Act within Europe,²¹ along with comparable measures in other markets, should provide organizations with more certainty with respect to regulation.

The future course of AI implementation is strongly tied to factors like sector characteristics and the country of operation. For instance, differences across regulatory regimes may result in competitive advantages or disadvantages. Furthermore, it is challenging to quantify the number of organizations that remain under pathway 4 (late movers), as this heavily depends on the adaptability of less data-driven industries. Under high competitive pressure, even these companies may be forced towards quicker adoption.²² These factors could also prove to be effective SAA drivers for investors, see Box 3.

Real economy effects associated with long-term AI integration

As businesses become increasingly familiar with the potential of AI and workplace automation, we foresee more profound effects on the real economy as opposed to the short term. A full AI-integration scenario may be accompanied by **significant changes in the labor market**. The number of new occupations resulting from AI integration may be outpaced by the number of redundant jobs, such as early literature suggests.²³

Research in the field of AI illustrates that integration could have **(strong) positive effects on global GDP**. A study by PWC (2018) stressed these possible effects by arguing that AI adoption could lead to an increase of 14% of global GDP by 2030.²⁴ Recently, Goldman Sachs stated that generative AI could lead to a rise of global GDP by up to 7% and increase productivity by 1.5%-point over a 10-year period.²⁵ They further estimate that two-thirds of US occupations are exposed to some degree of automation by AI. Organizations at the early stages of implementing AI and workplace automation may face significant capital expenditures. However, the long-term returns from these investments are likely to outweigh the initial costs and create significant potential to gain competitive edge over late movers.²⁶ As a result, in the long run, we expect the differences across organizations to

Box 3: AI & Strategic Asset Allocation

In the long run, AI adoption may become an essential factor of strategic asset allocation (SAA). Investment decisions could be influenced by factors such as sector characteristics, geographical location, and regulatory regimes. The adaptability to AI and the potential economic impacts such as shifts in labor markets and GDP growth should drive SAA. Early AI adopters, despite incurring initial capital expenditures, could realize significant returns and a competitive edge. With a potential long-term upward trend in real interest rates due to positive GDP effects, the impact of AI requires active long-term investment planning.

The long-term returns from AI investments are likely to outweigh the initial costs and create significant potential to gain competitive edge over late movers

²¹ <https://www.europarl.europa.eu/news/en/press-room/20230609IPR96212/meps-ready-to-negotiate-first-ever-rules-for-safe-and-transparent-ai>

²² <https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy#/>

²³ GPTs are GPTs: An Early Look at the Labor Market Impact Potential of Large Language Models, Eloundou et al. 2023. Derived from <https://doi.org/10.48550/arXiv.2303.10130>



²⁴ <https://www.pwc.com/gx/en/issues/analytics/assets/pwc-ai-analysis-sizing-the-prize-report.pdf>

²⁵ <https://www.goldmansachs.com/intelligence/pages/generative-ai-could-raise-global-gdp-by-7-percent.html>

²⁶ <https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-modeling-the-impact-of-ai-on-the-world-economy#/>

widen due to the beneficial impact of early capital expenditures that facilitate rapid AI implementation. Overall, the ultimate real-world significance relies primarily on how these implementations benefit productivity.²⁷

In accordance with economic principles, a positive GDP effect of the full AI-integration scenario is expected to result in real-interest rates trending upward over the long run. However, according to the unbiased forward rate hypothesis, current forward rates can be interpreted as unbiased predictors of future spot rates.²⁸ If that view is followed, given the fact that current yield curves are flat or inverse at the time of this writing (Q2 2023), the forward rates do not imply higher spot rates in the future. As interest rate dynamics are complex to forecast and heavily depend on central bank policy, we expect the **effect of AI & automation on interest rates in the long run to remain uncertain**.

Long-term effects	Unemployment	GDP	Real Interest Rates
Full AI-integration scenario			

Conclusion

Workplace automation enabled through AI holds tremendous potential to transform the global economy at a rapid pace. Artificial intelligence has fueled the broader trend of automation to incorporate a wider scope of worker activities. While current AI applications are not perfect, recent developments in fields such as generative AI have shown us that these technologies will improve over time and already have the potential to radically impact the way people work. In certain sectors this impact is already visible today.

In this paper we provided an outlay of possible AI adoption pathways across organizations and how this could impact the broader economy on both short- and long-term horizons. In our view, AI adoption is not a linear path but dependent on a multitude of factors including the willingness to adopt, ease of implementation, regulatory concerns, and competitive pressures. From a SAA standpoint, investors should be mindful of the potential impacts of AI on their portfolios. Based on the discussed framework, it is expected that well-prepared, data-driven sectors are best positioned to benefit from AI.

AI safety concerns and regulations have the potential to steer AI developments in an unpredictable direction. With the recent debate on the EU AI Act amid times of deglobalization, the impact of these drivers on AI implementation remains hard to predict. Therefore, we anticipate organizations may initially lean towards AI augmenting workers rather than replacing workers. On the long term, as AI expertise within organizations grows, the quality and power of AI applications expands and competitive pressures intensify, we expect a shift towards full AI integration on certain domains. Although new jobs may arise, we expect this scenario will result in a net job loss compared to the current labor market, while GDP is likely to trend upward due to net-increase of productivity.

In a rapidly changing economy, with increased focus on cost competitiveness, sustainability and mental wellbeing, AI and advanced workplace automation may become an integral part of society. Despite valid concerns surrounding AI safety, regulation and risks, there is a general consensus that these technologies eventually have the ability to impact productivity and the economy in a positive way. Organizations and economies that are able to adapt smoothly and effectively are likely best positioned to reap a competitive advantage.

²⁷ <https://insight.kellogg.northwestern.edu/article/how-much-ai-will-transform-our-economy>

²⁸ <https://www.panagora.com/wp-content/uploads/Do-Forward-Rates-Have-Anything-to-Do-with-Future-Rates.pdf>

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