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Greenwheel Insights

Rage against the AI machine? The impact of AI systems on workers

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Executive Summary

Over the last years, artificial intelligence (AI) has become a fixture of our lives. Amidst the new AI boom, an emerging concern for investors is AI's potential social impact; one key stakeholder group that will inevitably be impacted is workers.

While investors are familiar with the human rights risks in the extractive industries or electronics manufacturing required to run AI products and services, new risks emerge for the "invisible workers" that are critical to the development and deployment of AI systems.

AI systems are likely to lead to labour market disruptions. Though there is a lack of consensus on the scale and pace of the disruption, there is a general agreement that AI will change the nature of jobs through automation, augmentation, and transformation. The disruptions will likely vary significantly across developed and emerging markets.

Given the impact on workers, it is important for investors to understand the human rights risks for workers across the AI value chain. Whether it is a holding company that is developing AI products and services or deploying AI systems, investors should consider these new risks when conducting their pre- and post-investment due diligence.

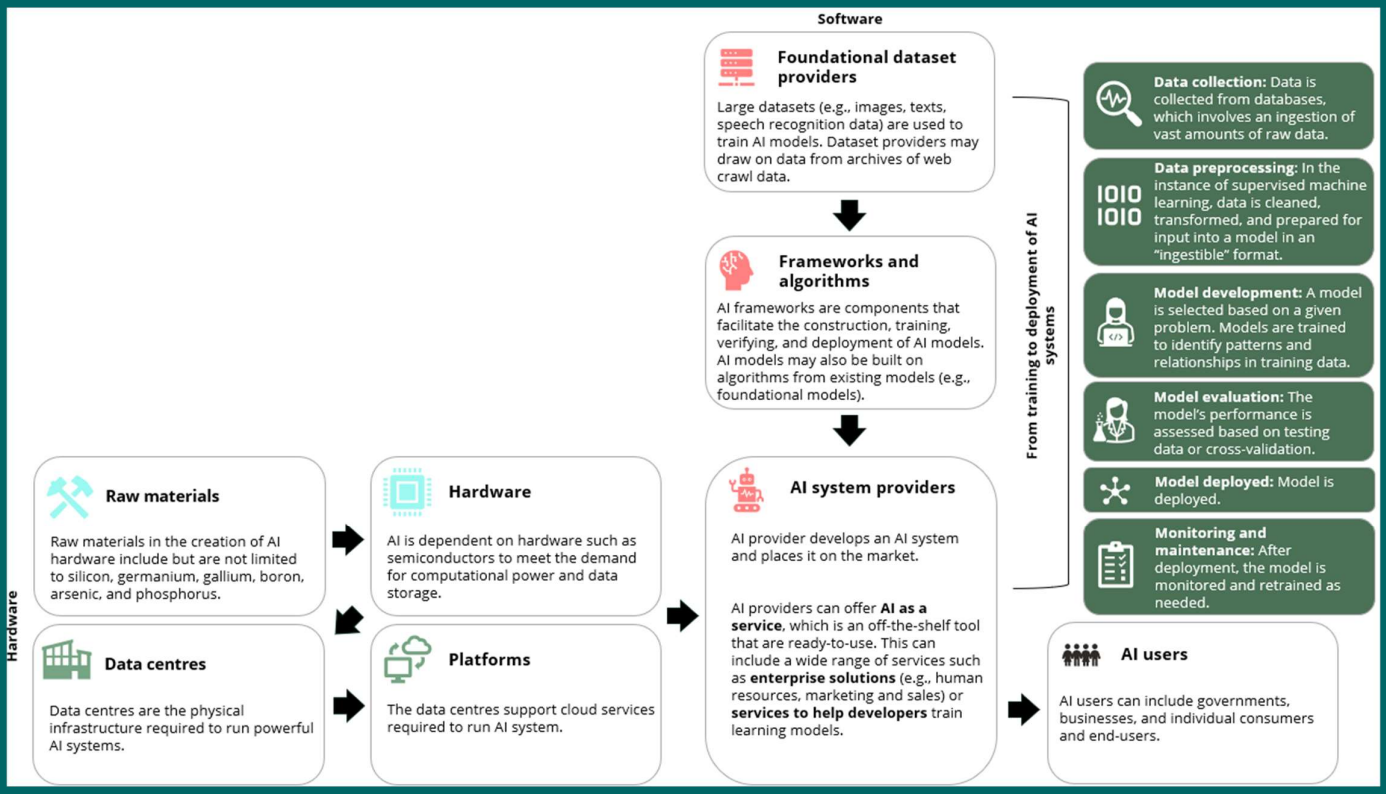
To help investors in this endeavour, Greenwheel has mapped the AI value chain and its human rights risks for workers, from raw materials through to hardware, infrastructure, software, and deployment. Investor exposure through investee companies can be through:

- ***Causing*** **adverse impacts**: A company may cause adverse impacts when it contracts microtaskers under poor working conditions for AI processes including preparation, modelling, or output check. In such cases, the company is responsible for ceasing, preventing, and remedying the impact.

- ***Contributing*** **to adverse impacts**: A company may contribute to adverse impacts when it uses business processing outsourcing centres for tasks (i.e., review of traumatic content). If adverse impacts occur, the company is responsible for ceasing or preventing the impact as well as using its leverage to mitigate remaining impacts.

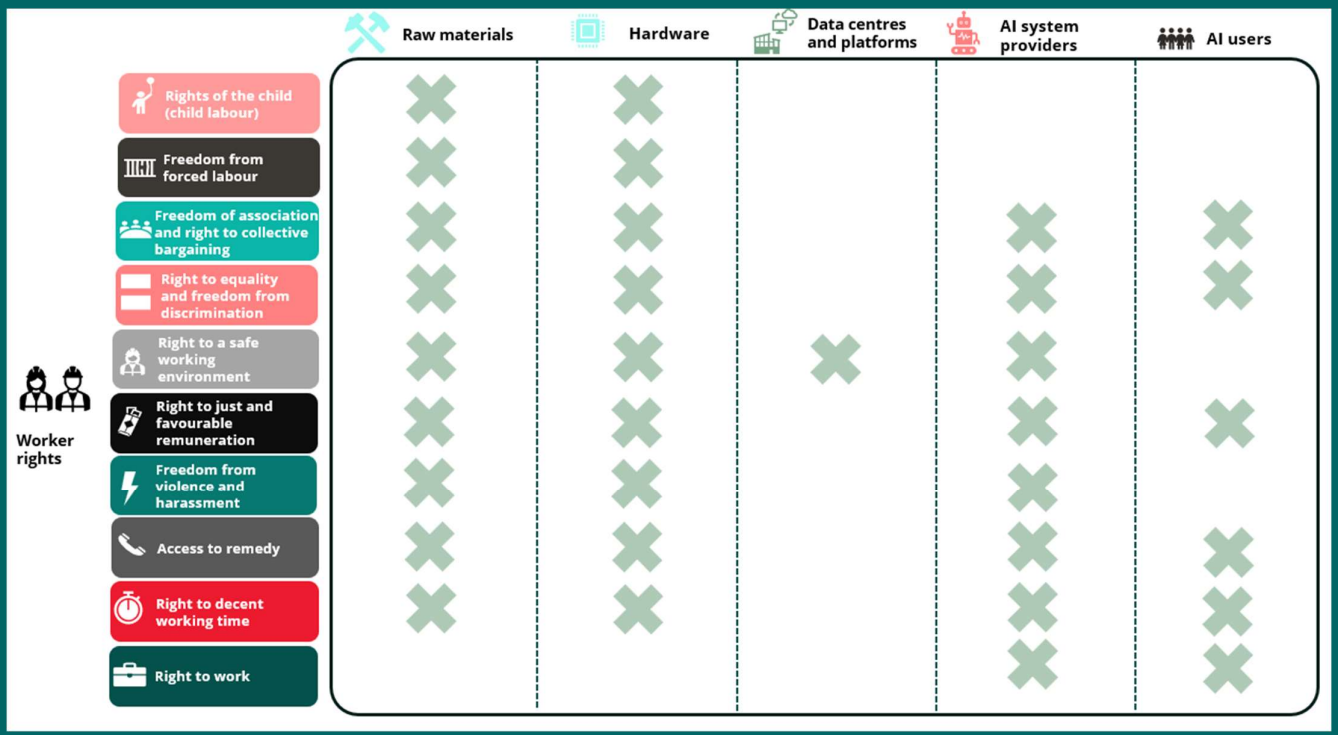
- ***Directly*** **linked to adverse impacts**: A company may be directly linked to adverse impacts by purchasing AI products that are made with poor labour rights practices. Under these circumstances, the company should be encouraged to use its leverage to influence the supplier causing the impact to prevent or mitigate the impact.

Mapping of the AI value chain



Source: Argus, 2023, BMC, 2021, Eckerson Group, 2023, Hash Collision, 2023, IBM, 2020, IBM, 2024c, McKinsey, 2018, Technology Magazine, 2024, and The Forecast - Nutanix, 2023. as of 2024; created by Greenwheel. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice.

Mapping of key human rights risks for workers



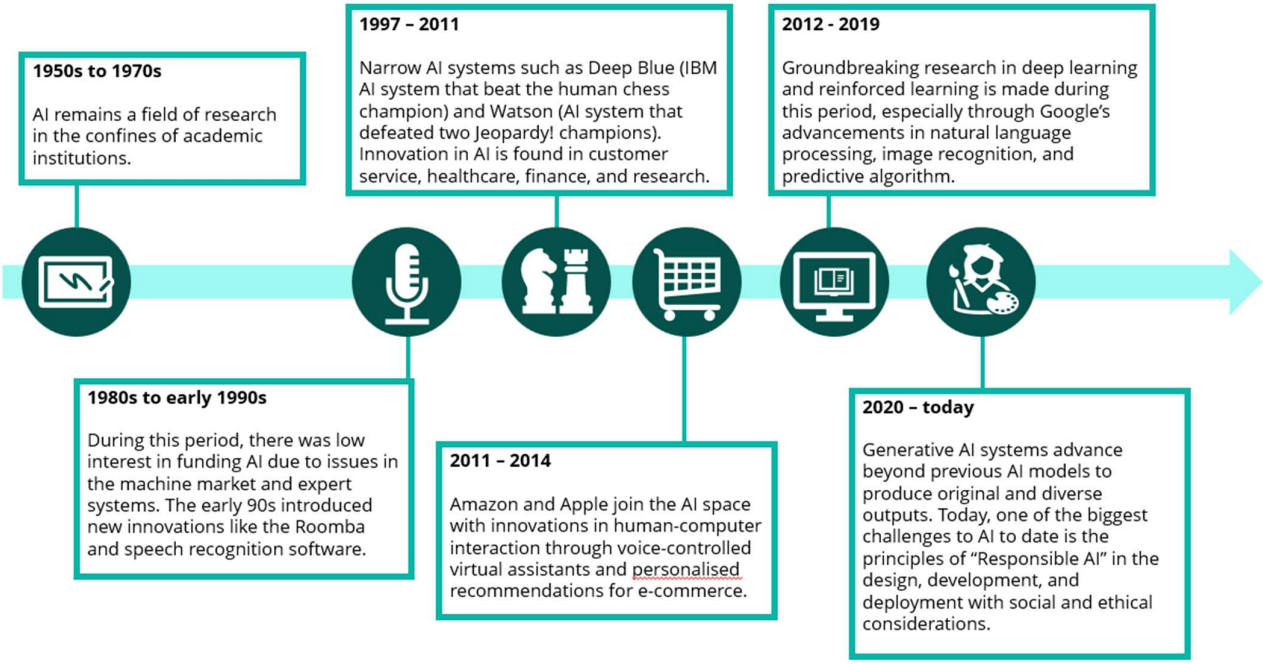
Source: Make ICT Fair, 2021, Popular Science, 2022, ILO, 2024, Fairwork, 2023, Tubaro et al., 2020 as of 2024; created by Greenwheel.

1. AI through a social lens

Although the history of artificial intelligence (AI) can be traced back to the 1950s in the confines of academic research, AI has rapidly become a part of our day-to-day lives in recent years (Figure 1).[1] The "hype" around AI has been exponential. In 2022, artificial intelligence (AI) was a little searched term on Google (with a score of 11 out of 100, with 100 being the most searched term). By 2024, AI has surged to a score of 100 as one of the hottest topics.[2]

There is no shortage of information on both the risks and opportunities on AI systems.[3] However, their impact on workers is not fully understood in the investment context.

Figure 1: The evolution of AI: from academic pursuit to everyday life



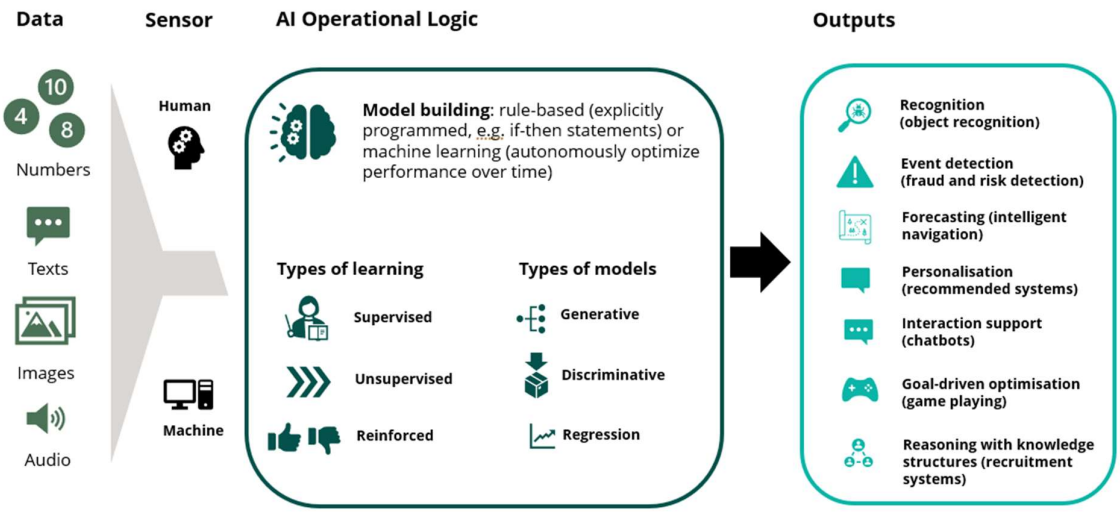
Source: Forbes, 2023 as of 2024; created by Greenwheel.

2. Defining artificial intelligence

An AI system is a machine-based system that can make inferences based on inputs it receives, through which, content, decisions, predictions, and recommendations are generated. Outputs from AI systems can influence physical and/or virtual environments (Figure 2).[4]

Whereas traditional programming is more "deterministic" as programmers are required to provide explicit instructions to follow for all possible scenarios, AI systems can learn from data, including unlabelled data, and can improve their performance over time.[5] Depending on the type of AI system deployed, they will have varying levels of adaptiveness after deployment; for instance, a voice recognition system can adapt to a user's voice or a navigation system can adjust estimated arrival time (e.g., accounting for historical traffic, type of road).[6]

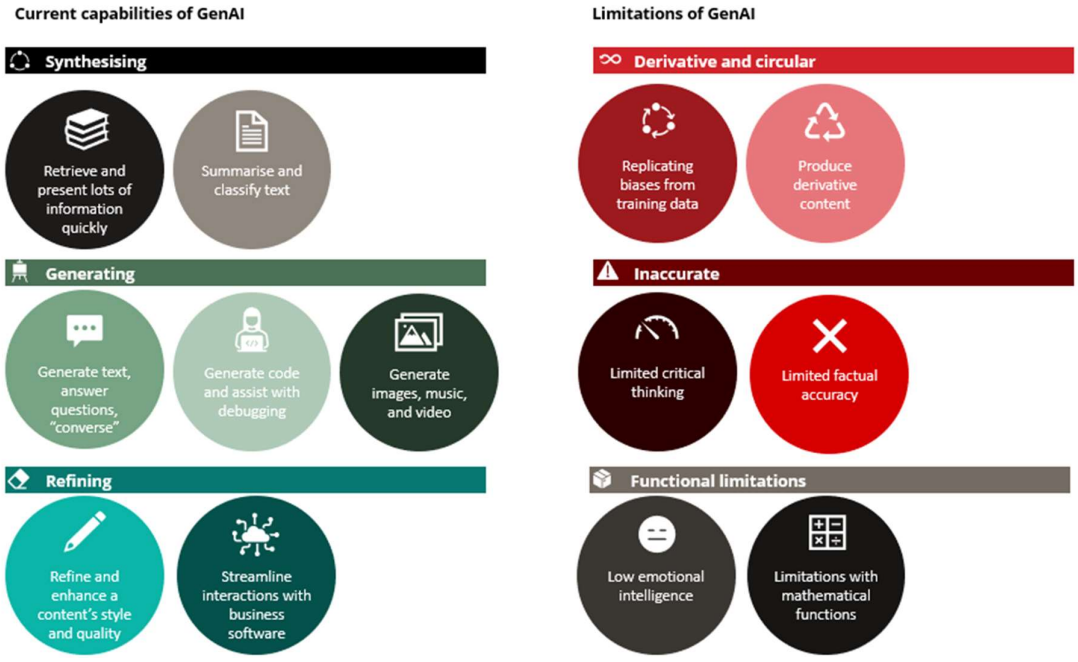
Figure 2: AI systems



Source: OECD, 2019, as of 2024; created by Greenwheel.

Generative AI (GenAI) is class of machine learning that can generate original code, images, speech, text, or video beyond the patterns and structure of a broad set of training data.[7] As the most recent advancement in AI, GenAI is expected to drive improvements and efficiencies in business processes in addition to spurring innovation given its capabilities.[8] Currently, GenAI is capable of replicating certain human capabilities whilst encountering limitations in performing certain tasks (Figure 3).[9] This is the area that gets the most focus in the context of workers but as we will highlight, is far from the only way in which GenAI affects workers.

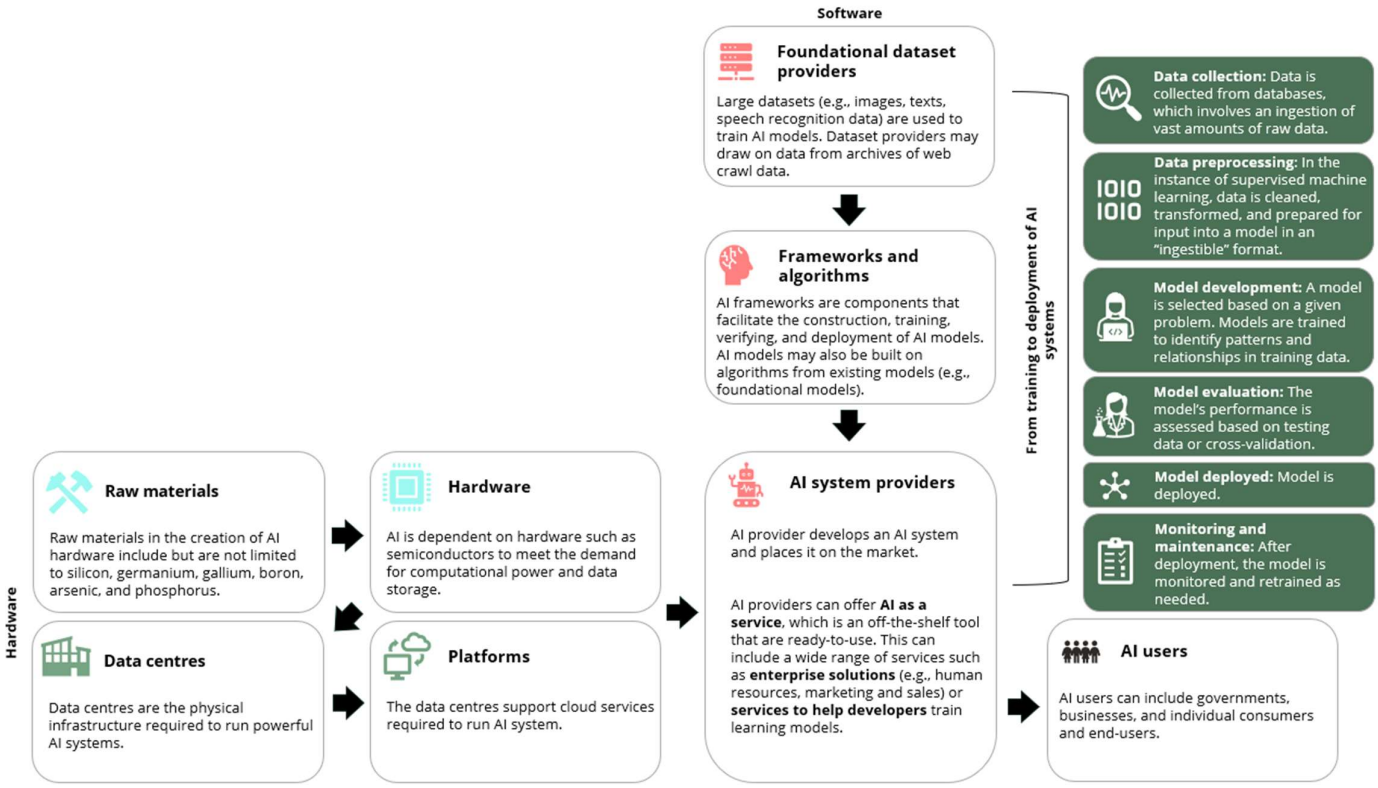
Figure 3: Current capabilities and limitations of GenAI



Source: SHRM and Burning Glass Institute, 2023, as of 2024; created by Greenwheel. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice.

3. The AI value chain

Figure 4: The AI value chain



Source: Argus, 2023, BMC, 2021, Eckerson Group, 2023, Hash Collision, 2023, IBM, 2020, IBM, 2024c, McKinsey, 2018, Technology Magazine, 2024, and The Forecast - Nutanix, 2023. as of 2024; created by Greenwheel. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice

In order to understand the implications for workers, we need to evaluate the AI value chain. The value chain begins with the raw materials that form specialised semiconductor chips (Figure 4).[10] Whereas consumer electronics rely on more general-purpose semiconductors, AI functionality demands more advanced chips to run computational and data storage processes. In tantum, to run AI systems, **global data centre infrastructure is required to meet growing demand**, particularly as businesses begin to integrate more powerful systems such as GenAI into its processes, products, and services.[11]

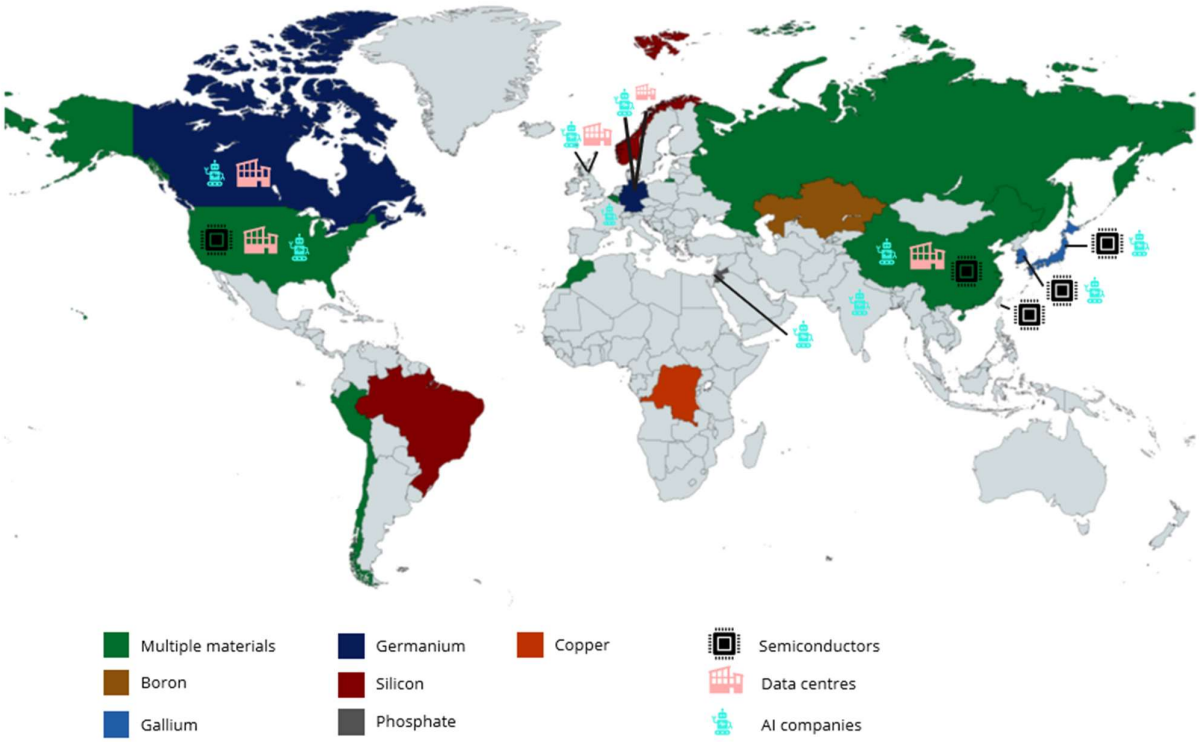
Moving to the "software" side of the AI value chain, **AI systems are built on large foundational datasets that are used to "train" AI systems**. Datasets are compiled through a web scraping for data. The data is then pre-processed to be inputted into a model – this involves cleaning and transforming, through which, some datapoints may be excluded (e.g., based on accuracy).[12] Thereafter, a model is selected to address a given "problem" that the AI system is intended to

solve. The model is then trained on the pre-processed dataset. As opposed to creating new models, AI systems may use foundation models, or a set trained neural network that can draw patterns and features from large datasets. These basic building blocks are sometimes referred to "general purpose AI".[13]

Prior to deploying an AI system, the model is tested using a testing dataset or through cross-validation. Once a model is deployed, it will be monitored for its performance, through which, adjustments may be made to ensure that a given model is accurate and reliable in the real world. Finally, the AI system becomes a service or product that can be used by end-users.

The AI value chain is global

Figure 5: The global AI value chain[14]



Source: Global AI Index, 2024, Macro Polo, 2024, and USGS, 2024, as of 2024; created by Greenwheel using Mapchart. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice. This is not an exhaustive map of the AI value chain. We have only included the top five producers of raw materials in 2023 (except germanium where no production data is publicly available). The mapping of AI systems is limited to a combination of the countries with the highest number of AI companies and the share of global investments. The most recent data is used to produce this map (2024 or latest available).

Today, the **raw materials in the AI value chain are concentrated in 16 countries**, with China being a key producer of all six raw materials in semiconductors (e.g., arsenic, boron, gallium,

germanium, phosphate, and silicon) (Figure 5).[15] Copper is an essential material for power distribution, grounding and interconnections, and the plumbing and heating, ventilation, and ai conditioning (HVAC) systems in data centres.[16] Though production is widespread, the biggest producers are Chile, China, Democratic Republic of Congo, Peru, and the United States. Global production of semiconductors are overwhelmingly concentrated in China (28.6%), Taiwan (19%), South Korea (17%), Japan (15.7%), and the United States (10.3%).[17]

As of December 2023, **there are approximately 10,978 data centres globally**.[18] Almost half of the world's data centres (49.0%) are located in the United States, followed by Germany (9.5%), the United Kingdom (4.7%), China (4.0%), and Canada (3.0%).

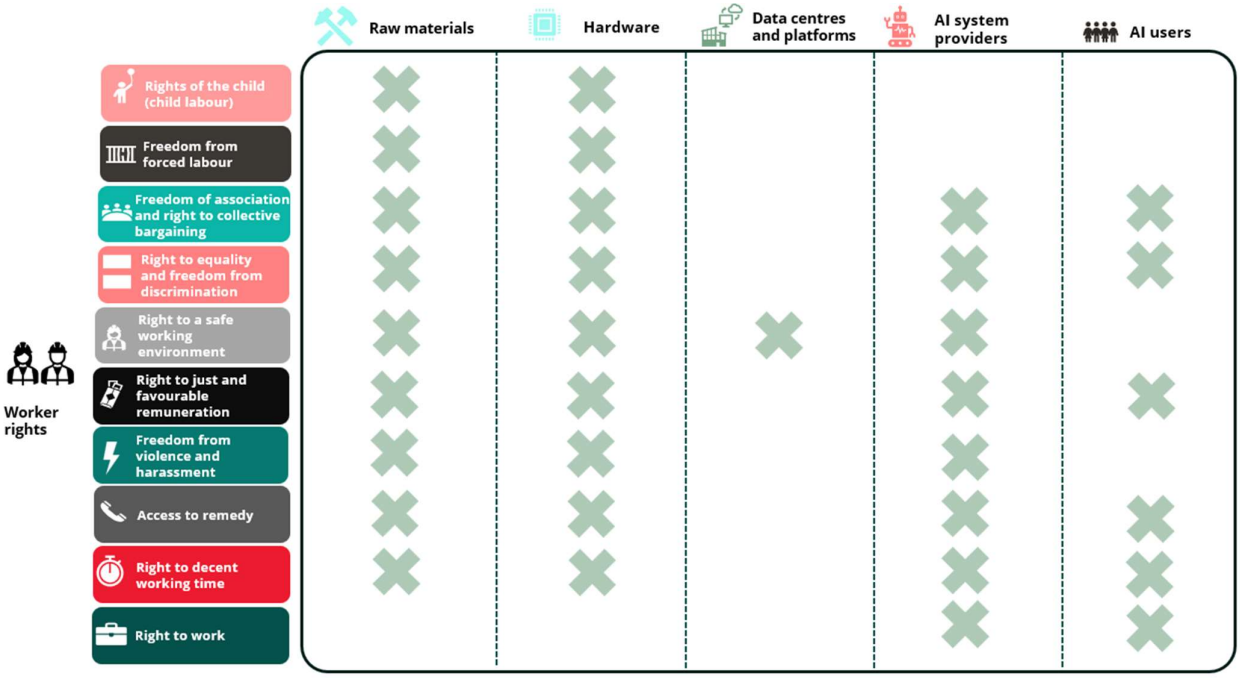
Currently, the United States host the largest number of AI companies (17,670) followed by the United Kingdom (3,321), and India (2,683).[19] The **global share of AI investment is concentrated in the United States (52.8%), China (10.3%), the European Union (9.3%), and the United Kingdom (5.6%)**.[20] While the number of AI companies and investments are concentrated in a handful of countries, the data pre-processing and training of AI systems occur globally through business processing outsourcing (BPOs) vendors and crowdwork platforms.

China and the United States remain the dominant players in the AI value chain, as both countries host the majority of the processes (raw materials, semiconductor manufacturing, data centres, and the development of AI systems). Across emerging markets, most AI opportunities remain heavily concentrated in China and India. Aside from China and India, AI solutions in emerging and frontier markets are predominantly found across sectors such as healthcare, finance, and agriculture.[21]

4. Viewing the AI value chain through a social lens: impact on workers

Drawing from a wide breadth of research from the United Nations, human rights expert organisations, industry research, and academic research, Greenwheel has mapped the key human rights risks facing workers (Figure 6).

Figure 6: Key human rights risks facing workers



Source: Make ICT Fair, 2021, Popular Science, 2022, ILO, 2024, Fairwork, 2023, Tubaro et al., 2020 as of 2024; created by Greenwheel.

The social considerations in the "hardware of AI"

The human rights risks in the extractives industries are well documented.[22] **While the risks of child labour and forced labour are more commonly associated with artisanal and small-scale mining, large-scale operations nonetheless face labour rights risks** in relation to occupational health and safety, freedom of association and the right to collective bargaining, discrimination, wages and working time, and access to remedy.

Electronics manufacturing is commonly linked to human rights risks, including but not limited to child labour, forced labour, discrimination, health and safety risks, low wages, excessive overtime, and anti-union activities.[23]

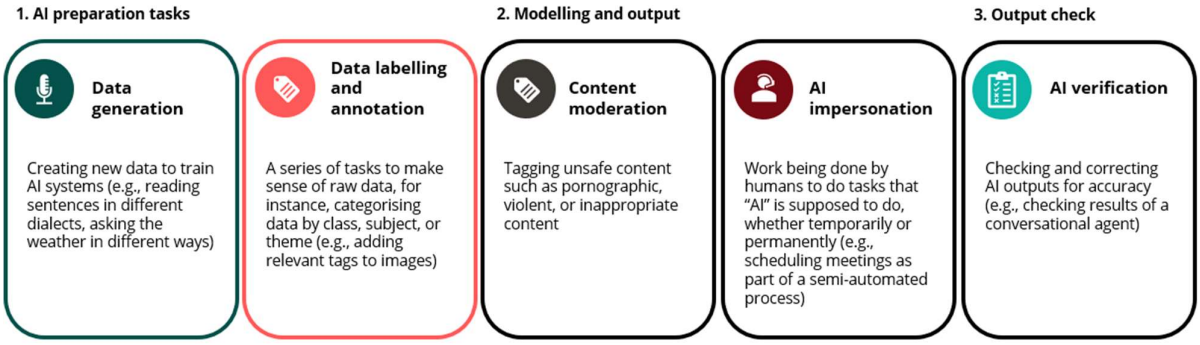
Compared to more general electronics manufacturing, high-end semiconductors require more skilled labourers; as such, **semiconductor manufacturing is associated with risks to health and safety and freedom of association and right to collective bargaining**.[24] Semiconductor facilities use chemicals that are known human carcinogens such as toluene, acetone, methylene chloride, xylene, chloroform, isopropyl alcohol, amongst other chemicals; some chemicals used in semiconductor manufacturing can lead to health issues such as skin irritation, eye damage, headaches, and digestion issues.[25] There are recent cases of birth defects due to exposure to harmful chemicals for pregnant workers.[26]

The social considerations in development of AI systems

Behind the hype: the invisible workers in AI

Although many AI processes are automated by algorithms and learning models, as of today, **AI systems are best characterised as semi-automatic with "humans-in-the-loop"** (Figure 7). "Humans-in-the-loop" refer to the often hidden or invisible workers that are performing tasks that are part of AI preparation (data generation, data annotation, content moderation) and checking the quality of AI outputs (AI verification). In some "AI" systems, workers are AI impersonators or performing tasks that an AI system is supposed to carry out; this can be fully manual or semi-automated depending on the given system (Figure 8).

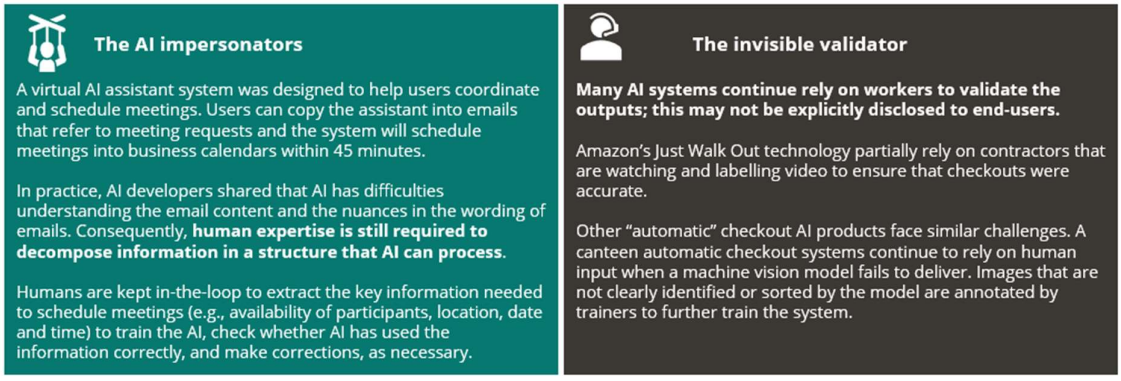
Figure 7: Humans-in-the-loop in AI systems



Source: Tubaro et al., 2020, as of 2024; created by Greenwheel.

These workers are referred to as the invisible workers of AI because their roles are often hidden to end-users, as products are marketed as "automatic". The invisible workers of AI systems can be in-house services (e.g., data trainers for a tech company) or can be outsourced through BPOs or microtask platforms.[27] Microtask platforms are web-based crowdwork platforms that offer AI developers, from startups to big tech companies, a global pool of workers. As "independently employed" workers, microtaskers complete short gigs through these platforms and have direct "contracted" work with developers and companies. Many clients prefer to use crowdwork platforms as provides a wide pool of talent globally at a lower cost than salaried workers.[28]

Figure 8: Is it AI or is it the Mechanical Turk?

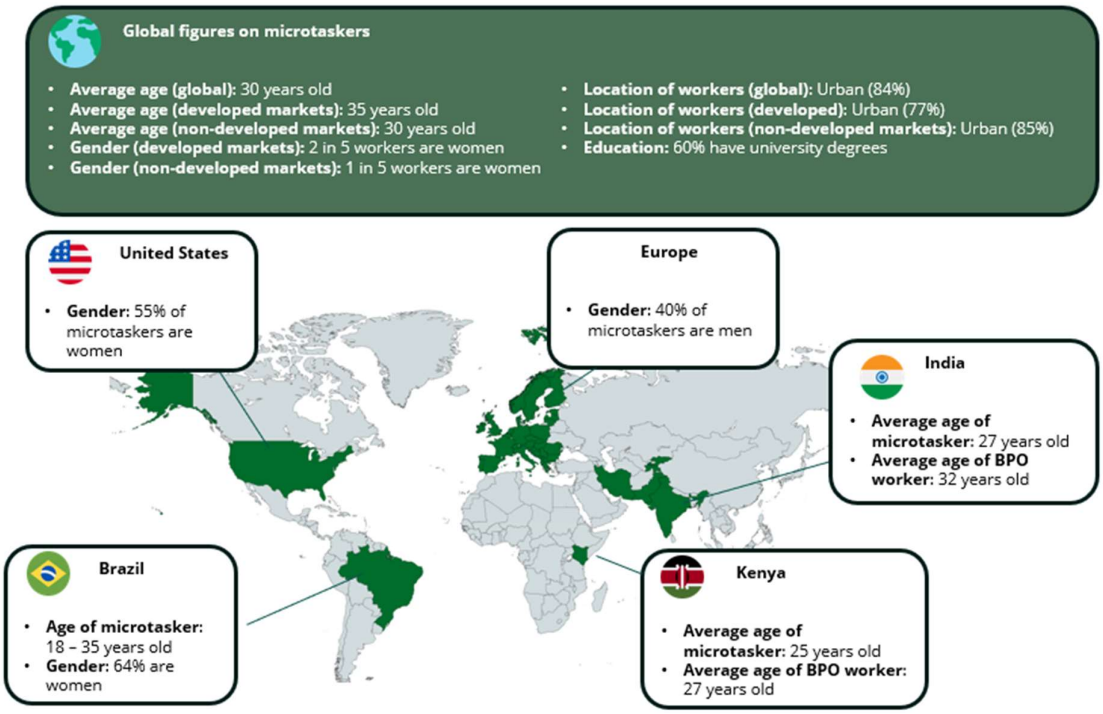


Source: ILO, 2021, Bloomberg, 2024, Ludec et al., 2023, as of 2024; created by Greenwheel.

Microwork platforms offer workers an opportunity to supplement their existing income and flexibility; some workers shared that they find the work enjoyable (Figure 9).[29] Microtask work can also provide an alternative to other forms of precarious and informal work; for example, in Brazil, where 39 million people work informally (39% of the labour market), microtask can offer workers employment from home.[30] In India, the new roles created in the AI value chain provide employment opportunities for rural workers.[31] For some women workers, microtask work can provide income while providing care responsibilities.[32]

Despite the critical role data workers play to ensure that AI systems function, their activities are often perceived as menial compared to that of data scientists and software engineers.[33] This is reflected in **the working conditions for the invisible workers that is characterised as low paid and underpaid**. Workers on crowdwork platforms can encounter difficulties finding well-paid tasks and clients. Competition can be strong as in the case of China, a single task or project can attract up to 100 – 200 workers. Because the platforms operate across national boundaries, the "internationalisation" of microtasks can further drive down remuneration.[34]

Figure 9: Who are your AI workers?



Source: ILO, 2021, Viana Braz et al, 2023, and ILO, 2024 as of 2024; created by Greenwheel using Mapchart. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice

Based on the ILO's global survey on microtask workers, for every hour of paid task, worker average 20 minutes of unpaid work looking for tasks.[35] Workers' wages can be further driven down by the commissions taken by platforms and the exchange rate offered by the platforms.[36]

The flexibility of microwork leads to precarious and discriminatory working conditions. Tasks assigned on platforms follow the time zone of clients, where some emerging markets may be disadvantaged; in response, workers may end up working late at night or through the night.

Women workers may also be disadvantaged if they are taking on microwork activities as part of a "third shift" between work and care responsibilities.[37] Where outputs are rejected by clients, workers have little transparency in accessing feedback or justification; they also have little to no recourse through the platforms as they are considered independently employed, even though they are paying commission to use the platforms.[38]

Although the majority of microtaskers are educated, the type of work can be repetitive and offer minimal career progression.[39] For example, data annotators for an AI system for driverless cars may be assigned entail endless hours of tasks such as drawing boxes around targets (e.g., cars, trees, pedestrians).

Tasks assigned to microtaskers and BPO workers can be harmful to workers. A microtasker in Brazil reported taking on a task where they had to produce training data for a vacuum cleaner robot by taking more than 250 pictures of cat and dog faeces in different locations of her home.[40] As part of helping ChatGPT build a tool to detect toxic content, Kenyan workers paid two dollars an hour to label violent, sexist, racist, and other abusive content.[41]

The deployment of AI

AI and the next Great Transformation

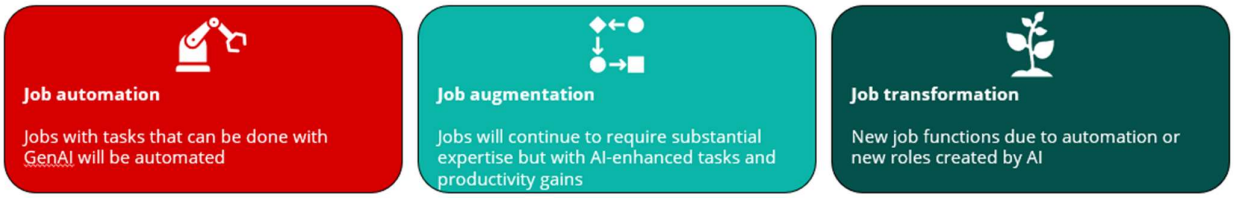
It is unsurprising that AI systems, particularly GenAI, will change the nature of jobs that will inevitably lead to automation, augmentation, and transformation which affects the human right to work (Figure 10). However, there is no consensus across existing research on the scale and pace of the disruption:

- Goldman Sachs claims that two-thirds of current jobs in Europe and the US are exposed to some degree of AI automation; globally, they predict that 300 million full-time jobs are exposed to automation with GenAI.[42]

- Based on the jobs in the US, Accenture says that approximately 40% of all working hours could be impacted by large language models (LLMs).[43]

- The IMF predicts that 40% of global employment is exposed to AI, with the greatest risks in advanced economies (60%) followed by emerging markets (40%) and low-income countries (26%).[44]

Figure 10: How AI will change the nature of jobs

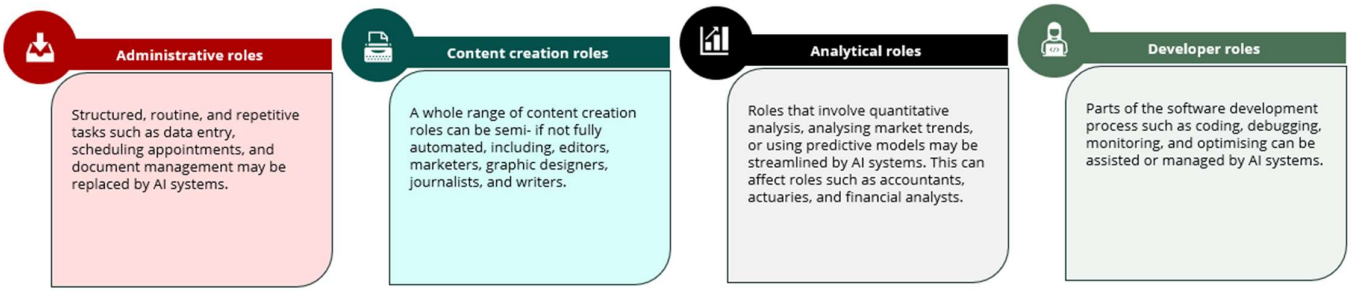


Source: SHRM and Burning Glass Institute, 2024, as of 2024; created by Greenwheel. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice

Despite the lack of agreement on the precise number of jobs lost or affected, there are a few key trends that are consistently reflected across the literature. **Businesses are already integrating AI systems into their processes, with or without an assessment of the social implications of these changes**. In 2022, McKinsey found that 50% of businesses surveyed globally adopted AI in at least one function, increasing from 20% in 2017. The most deployed AI systems include robotic process automation, computer vision[45], natural-language text understanding, and virtual agents or conversational interfaces.[46]

Unlike previous waves of automation, **AI is likely to displace higher-wage earning desk-based jobs** (Figure 11).[47] The industries that are most likely to see the biggest impacts are finance and insurance, professional services, and information systems.[48]

Figure 11: Examples of roles that AI may partly or fully displace



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Given the types of jobs that are affected, the impact on developed and emerging markets differ. Depending on the uptake of AI systems and how they are deployed by businesses, developed markets are likely to see more widespread labour displacement while emerging markets may see impacts in globally outsourced services roles such as customer care; the loss would be more significant for emerging markets that have these industries established and less developed markets may lose the opportunity to attract these service roles. Despite the uneven impact, developed markets are better placed to leverage the gains from AI growth opportunities (e.g., higher paid AI developer jobs, automation of repetitive tasks instead of technical tasks).[49]

Without adequate policy intervention, AI can exacerbate inequality based on income, education, age, and gender. AI may increase gender inequality in the labour market given that women tend to be in occupations that have higher AI exposure. Although AI risk exposure is higher for occupations that require higher education, the impact is offset by high complementarity (i.e., how AI complements but not replaces roles); as such, AI is likely to disproportionately impact lower skilled desk roles while benefiting those in higher paid roles. Younger workers, however, may be adversely affected as lower-complementarity roles often serve as entry-level roles before they move into higher-complementarity and more senior roles.[50]

Greenwheel notes that there is an **additional type of inequality which stems from the creation of precarious work**. Despite the advances in AI, many systems still have humans-in-the-loop and in some instances, AI impersonation. **The onboarding of AI systems to replace repetitive tasks is a new form of off-shoring**. With the rise of crowdwork platforms, workers in both developed and emerging markets are taking up roles with lower pay and under more precarious contractual

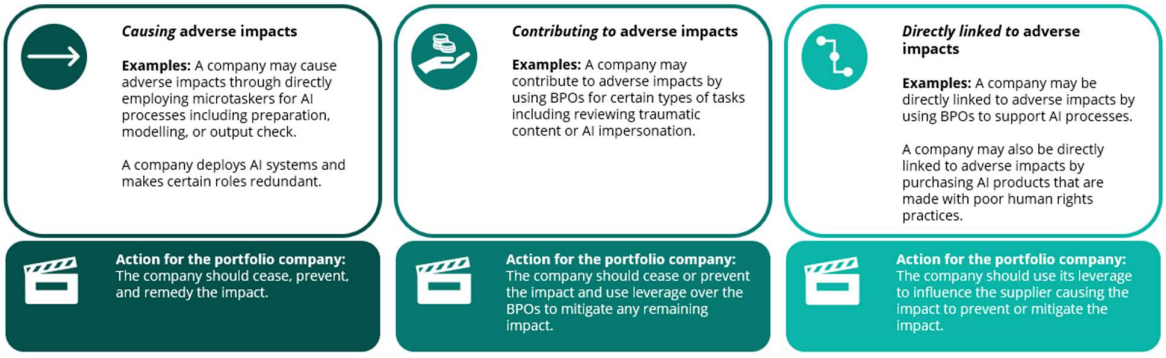
terms in lieu of formal roles. Instead of hiring a full-time administrative role, a business may use a "virtual assistant" platform; in reality, the scheduling of meetings and other tasks are fulfilled by microtaskers or workers in a BPO.

Regarding the pace in which AI will replace and complement roles, **emerging research shows that AI may not be the "silver bullet" in harnessing productivity and augmenting roles**. BCG conducted an experiment (on their own staff) on the use of GenAI in professional services. BCG found that although GenAI improved performance related to ideation and content creation (around 90% of participants). Their level of performance was 40% higher than those who performed the same tasks without GenAI. GenAI was not supportive in business problem solving, where participants performed 23% worse with GenAI; GenAI was unable to detect wrong answers.[51]

While GenAI benefited the individual performance of both the lowest and highest-ranked baseline performers in more creative tasks, GenAI reduced the participants' diversity of thought as a group by 41% - participants also shared concerns regarding the long-term impact the use of GenAI has on creativity (e.g., similar to the overreliance on GPS systems).[52] The implications of this study is that there are indeed business benefits to using GenAI, however, new systems should be cautiously tested and employees may require training to maximise the benefits of these new tools.

5. Possible Implications for investors

Figure 12: How investors are exposed to human rights risks through their portfolio companies[53]



Source: OECD, 2018; Created by Greenwheel. The information shown above is for illustrative purposes only and is not intended to be, and should not be interpreted as recommendations of advice

Understanding the human rights risks for workers across the AI value chain can help investors in conducting their pre- and post-investment due diligence (Figure 12). The risks to workers in the hardware part of the AI value chain (e.g., extractives, electronics manufacturing) are well documented; however, **there is increasing attention and scrutiny on the risks facing "invisible workers" in the development of AI systems**.

As such, if a holding company is developing an AI system, **investors may be exposed to human rights risks through the company's direct operation and/or their supply chain**. A company may be ***causing*** adverse human rights impacts through crowdwork platforms for tasks including

AI preparation, modelling and output, or output check. A company may also cause human rights impact through deploying AI systems leading to redundancies.

Given the risk of AI impersonation, human rights due diligence may support investors in identifying misleading claims about "autonomous" AI systems. If a company is using services through BPOs, they may be ***contributing to*** (e.g., assigning data annotation work on traumatic content) or ***directly linked*** to adverse impacts.

Although companies deploying AI systems are not causing or contributing to the impacts associated with the development of AI products, they may nonetheless be **linked to adverse impacts using products made with poor human rights practices**.

Given the potential labour disruptions linked to the deployment of AI systems, investors may consider **assessing how a holding company is planning to incorporate AI into its businesses processes**, particularly, in **ensuring that a company has conducted a form of social impact assessment**. As productivity gains from AI systems are not clearly understood, investors may evaluate how holding companies are integrating AI processes (i.e., worker consultation, piloting rollout, testing, and collecting feedback from workers).

[1] Forbes, 2023.
[2] BBC, 2024.
[3] BBC, 2024.
[4] OECD, 2019 and OECD.AI, 2024a.
[5] IBM, 2024a.
[6] OECD.AI, 2024a.
[7] IBM. 2023 and OECD.AI, 2024b.
[8] WEF, 2024a
[9] Despite the enthusiasm in some tech communities, current systems have yet to reach Artificial General Intelligence (AGI), would require AI systems to mimic human cognitive abilities, including the intricacies and contexts of actions. Forbes, 2024.
[10] For a detailed dive into the semiconductors supply chain and the manufacturing processes, please refer to Greenwheel's briefing on Chipping Away at Semiconductor Decarbonisation.
[11] Argus, 2023.
[12] Knowing Machines Project, 2024.
[13] Newo, 2024 and ERM media, 2024.
[14] This is not an exhaustive map of the AI value chain. We have only included the top five producers of raw materials in 2023 (except germanium where no production data is publicly available). The mapping of AI systems is limited to a combination of the countries with the highest number of AI companies and the share of global investments. The most recent data is used to produce this map (2024 or latest available).
[15] Commodities data compiled from the United States Geological Survey and Marco Polo.
[16] Copper Development Association, 2023.
[17] Global production of semiconductors is estimated at approximately 30 million wafers per month (wpm). The numbers projected for the top producers are: China (8.6 million wpm), Taiwan (5.7 million wpm), South Korea (5.1 million wpm), Japan (4.7 million wpm), and the United States (3.1 million wpm). These figures are forecasts for 2024. Semi, 2024.
[18] Brightlio, 2024.
[19] The Global AI Index, 2024.
[20] Share of global investment as of 2023 for the year 2022. The Global AI Index, 2023
[21] IFC, 2021.
[22] See the human rights risks in the extractives industry in existing Greenwheel research.
[23] Make ICT Fair, 2021
[24] IndustriALL, 2023 and The Guardian, 2023.
[25] All About Circuits, 2021.
[26] Korea Bizwire, 2024.
[27] ILO, 2024.
[28] Ludec et al., 2023.
[29] ILO, 2021.
[30] Viana Braz et al, 2023.
[31] ILO, 2024.
[32] Viana Braz et al, 2023.
[33] ILO, 2024 and Ludec et al., 2023.
[34] Tubaro et al., 2022.
[35] ILO, 2021.
[36] Viana Braz et al, 2023.
[37] Tubaro et al., 2022.
[38] Viana Braz et al, 2023.
[39] Tubaro et al., 2022 and ILO, 2024.
[40] Viana Braz et al, 2023.
[41] Time, 2023.
[42] Goldman Sachs, 2023.
[43] Accenture, 2023.
[44] IMF, 2024.
[45] Computer vision derives information from visual inputs (images, videos) to make recommendations or take actions. For instance, computer vision is used in the training or inspection of products. IBM, 2024c.
[46] Stanford Institute for Human-Centered Artificial Intelligence, 2023.
[47] IMF, 2024.
[48] SHRM and Burning Glass Institute, 2024.
[49] IFC, 2021 and IMF, 2024.
[50] IMF, 2024.
[51] This experiment was conducted using ChatGPT-4. BCG et al., 2023.
[52] BCG et al., 2023.
[53] A company causes an adverse impact when its activity materially increases the risk of a specific impact; the company's activity is sufficient, in and of itself, in leading to the impact. A company contributes to an adverse impact where its activity materially increases the risks of an impact even if it is not sufficient, in and of itself, in leading to the impact. A company is directly linked to an impact when a mutually and commercially beneficial relationship is established with a state or non-state entity that materially increases the risk of impact.

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