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About the Competition



The Symposium celebrates excellence in research by high school students who have recently completed their Online Research Projects through Immerse Education.

The three shortlisted projects were chosen based on their:

- Quality and depth of research, including the use of relevant sources.
- Clarity, structure, and referencing of the written paper.
- The ability to clearly outline and summarise research and ideas.
- The ability to engage their audience with thought-provoking topics and detailed explanations of complex concepts.
- Skillful use of the support and guidance received from tutors as part of the research process.

Each shortlisted participant presented to a live audience. You can view their presentations [here](#).

Immerse's Online Research Programme



The Online Research Programme offers an unparalleled opportunity for students aiming to refine their research and study skills ahead of university. This bespoke programme stands out by allowing participants to immerse themselves in a subject of their choice, under the guidance of esteemed tutors from top institutions.

Tailored to each student, the programme promises an intensive academic journey. Participants engage in a rigorous academic research project, receiving one-on-one supervision alongside workshops aimed at enhancing academic skills including personal study, academic writing, and independent research. The objective is clear: to produce a university-level piece of work that not only demonstrates the student's ability to think critically but also their passion for their chosen field. This unique creation could range from an essay to a practical work or an interactive presentation, depending on the subject. Participants receive invaluable, subject-specific advice and detailed feedback.

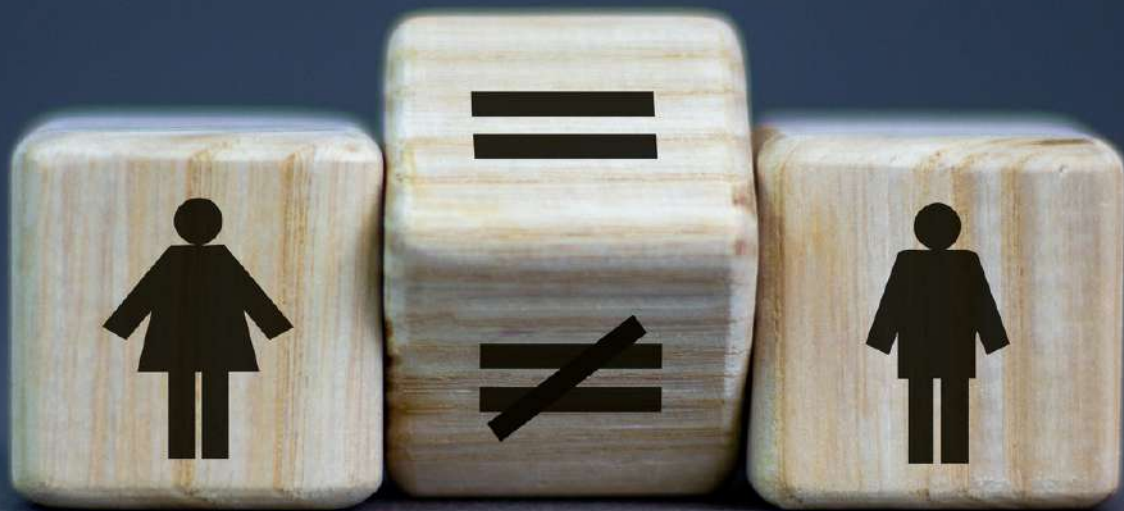
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Flexible time commitment:

Engage over 4, 10, or 20 hours depending on your study style and goals.

Challenges To Solving Gender Inequality In The Global System: A Case Study Of The UN's Efforts Over Time



Reika's Bio:

- Reika is an alumna of the International Relations Online Research Programme. She graduated from the International School of Düsseldorf in 2023, where she achieved a bilingual International Baccalaureate (IB) Diploma. She is currently pursuing a degree in Social Sciences at University College London.

CHALLENGES TO SOLVE GENDER INEQUALITY IN THE GLOBAL SYSTEM: A CASE STUDY OF THE UN'S EFFORTS OVER TIME

Achieving gender equality and empowering all women and girls by 2030 is the Sustainable Development Goal five that the United Nations established in September 2015. The UN Women states that “women’s leadership and political participation are restricted” (UN Women, 2020). In the economic field, women are paid 24 % less on a global average compared to the wage of men. (United Nations, n.d.). This essay seeks to examine the causes and nature of gender inequality within the contemporary political and economic field at the global level from a Feminist perspective. Furthermore, it will explore intergovernmental organisations’ efforts and challenges to ameliorate this inequality challenge. This desk-based research will source data and literature from extant research. To investigate the above-stated objective, the essay will address these three critical questions: 1. What are the causes and nature of gender inequality in the global system? 2. What are the role and efforts the UN has taken to alleviate political and economic gender inequality? 3. What challenges have these efforts encountered in achieving gender inequality. I define gender inequality as the state where the rights and opportunities that women and men have in the political and economic fields are not equal in this essay. The subsequent section will capture the nature and the cause of gender inequality.

Nature and Causes of Gender Inequality

Gender inequality is multifaceted and ubiquitous. It transcends beyond politics to all aspects of human activities. Gender inequality in the economic sphere is noticeable in the global system. For instance, an analysis of the labour market reports the unequal distribution of employed persons and the gender pay gap in the global system by indicating women are more likely to be employed as technical employees, while men hold job opportunities as skilled workers with tools (Mashtalir et al., 2022). Statistically, about 86% of men are employed as skilled workers compared to only 14% of women who work as skilled workers in the labour market (Mashtalir et al., 2022). The percentage of women who are employed in a paid position increased from 40% in the 19th century to 50% in contemporary society at the global level (ibid, 2022). In addition to that problem, another challenge that women workers are likely to face is the gender pay gap, as the UN Women show women earn 24% less than men for the same work. This is attributed to the fewer percentage of women holding higher work positions than men.

The gender inequality in the economic sphere is not revealed only by the statistics, but the labour workforces themselves are feeling the gender gap. One question, “World Values Survey” asked both men and women, if they agree with the statement, “On the whole, men make better business executives than women do”, more respondents from poorer states agreed with the statement (Jayachandran, 2014). This trend can also be seen in a question asking “how much freedom of choice and control over the way your life turns out”. The

answer highlighted that women in developing countries have comparatively less control over their lives than those in developed countries (Jayachandran, 2014). Especially women in developing countries are confronted with relatively greater gender inequality in both economic aspects and their decision-making process. However, the gender gap in the economic sphere can be seen globally, therefore the issue has prevailed in both developed and developing countries.

The gender gap in leadership and political participation in the global system is also evident. For instance, the European Institute for Gender Equality revealed that women hold less domain of power. This is shown by the women's percentage of share of ministers is 34%, women's share of members of parliament is 33%, and women's share of members of regional assemblies is 30% in Europe (European Institute for Gender Equality, 2021). The percentage indicates that the representation of women in national parliaments, government and local assemblies are not equal and thereby women are not equally represented as men in the sovereign states which are part of the European Union. The gap in women's political participation is not only evident in the European Union but also in a global system. The average percentage of women holding representation in the executive branch of government remains only 16 per cent in the global system in 2010 (Bureau of International Information Programs, 2012). This number is half of the percentage that the UN called a "critical mass" which is 30%, that women should have in the parliamentary seats to bring sufficient representation and changes in national politics.

The causes of gender inequality in the political sphere have long been established in the historical advantage men enjoy in the electoral system. (Bureau of International Information Programs, 2012). Such disadvantages women face are rooted in stereotypes and traditional gender roles in society. Both are often difficult to change immediately as social norms are transformed and acquired subconsciously in the community, and thus everyone in the community believes the standard that men dominate government is the proper shape of the political decision-making process in the state. For instance, many states historically have higher human capital investments in males than females (Jayachandran, 2014). Girls tend to have fewer opportunities to acquire policy and leadership skills at school, the workplace, and even at home. In addition to the women's disadvantage in attaining the same human capital investments, the political arena is often subject to the rule of the "old-boy network" and thus, difficult to exercise gender equality (Bureau of International Information Programs, 2012).

Gender inequality in the economic space has largely been attributed to the existing legal mechanism that does not prohibit the gender pay gap and traditional gender roles that distance women from the same economic opportunities as men (Charles, 2020). For instance, on a global scale, about 54 per cent of the sovereign states do not explicitly prohibit gender discrimination in wages (Gaddis et al., 2020). The non-presence of such law protecting women's rights in equal employment directly disadvantages them in the acquisition of their own property. The burden of completing household chores is also a factor that limits women from accessing the same economic opportunities (Charles, 2020). In the case of the US, social feminists explain that a dual system consisting of capitalism and patriarchy has led women to be economically exploited by society (Cottais, n.d.). In fact, women only earn 70% of men's salary on average in the US (Department of Philosophy, Stanford University, 2004).

Since capitalism produced private and public property, many women were forced to be in the private sphere depriving them of the opportunity to hold public paid work positions as men (ibid, nd). As social feminists' view demonstrates, a particular economic system and the traditional gender role which is a byproduct of the system are the factors that cause gender inequality in the economic sphere. The final paragraphs will then take a critical look into the United Nations' effort into alleviating gender inequality. The United Nations is an international governmental organization established in 1945 consisting of memberships from 193 sovereign states.

The United Nations' Efforts Toward the Alleviation of Gender Inequality

Intergovernmental organisations such as the UN have been taking actions to alleviate gender inequality in the global system to achieve SDG five. For instance, the UN has hosted four world conferences on women, which first took place in 1975 (UN Women, 2020). One of the influential conferences is the 1995 Fourth World Conference on Women in Beijing, it set an extensive vision called the Beijing Declaration and Platform for Action. The declaration stated aims and strategic actions to achieve gender equality in different critical areas. Two main strategic objectives were made to reduce gender inequality in the political sphere. The platform for Action called on each sovereign state to implement a measure that ensures women's equal access to and full participation in the power structure and decision-making process. To achieve gender equality, the UN also publish reports which reflect on the implementation of the declaration made in the past to bring changes. For instance, a summary of the Secretary General's report on the 20-year review and appraisal of the implementation of the Beijing Declaration and Platform for Action. In the report, it is revealed that women's representation in national parliaments is increasing compared to the percentage of women involved in the parliaments in 1995 (UN WOMEN, 2015). However, the reports also explain that women's involvement in senior decision-making roles in both private and public sectors are remaining low to achieve gender equality in political participation globally. In the end, it provides solutions to further change the situation of gender inequality in the global system. For example, the UN advocates and suggests sovereign states change the system of public financing in political parties to allow each party to advance gender equality.

Furthermore, the aim, situation, and further solutions to empower women in the economic sphere are also stated in the Platform for Action and the Secretary General's report. The report reveals that the gender gap in the labour market of the global system has been narrowed, even though regional variation of women's labour force participation remains (UN Women, 2020). The UN suggests that States should put policies such as minimum wages legislation, and a system for maternity and parental leave as further actions.

The UN's effort to achieve gender equality can be also seen in adopting gender equality as a part of international human rights law by the Universal Declaration of Human Rights in the UN's general assembly in December 1948 (United Nations, n.d.). As the implementation of the international human rights law aims at the acceptance of the fundamental norms of human rights that everyone should respect and protect by the global system, incorporating the importance of maintaining gender equality in the law is a significant measure (The Office of the High Commissioner for Human Rights, n.d.). This is

because gender inequality in both the economic and political spheres is deeply rooted in stereotypical views toward women, traditional gender roles, and social norms that people share. Including the protection of gender equality in such law will enhance people to recognise the importance of equal treatment of men and women in the global system which will gradually change their traditional views and social norms toward women.

To sum up, the UN makes a wealth of decisions to influence State actions in tackling gender inequality as a serious global issue and reflect on global achievements by providing statistical data to educate the present conditions and further actions that each state should take. In addition, they also incorporate new laws in the international human rights law to alter the social norms that the global system shares but what is making women from holding equal rights and opportunities in both economic and political spheres. The subsequent sections will capture the challenges that the UN and sovereign states are confronted with to achieve gender equality.

Challenges to solving gender inequality

One of the challenges that each nation-state and intergovernmental organisation are facing to achieve SDG five is the women's low representation in national parliaments which does not satisfy the "critical mass" to change the traditional men dominating government. Since women are given fewer opportunities, investments, and education, they experience fewer opportunities to acquire and improve leadership skills at home and in school making it difficult for them to become representatives in the political arena (Bureau of International Information Programs, 2012). Gender inequality in political spheres is intertwined with gender inequality in their education. Therefore, the challenges of solving gender inequality start with solving gender inequality in girls' education. However, attempting to solve the inequality in education becomes problematic due to the low number of women represented to solve the inequality in education to implement effective measures. Namely, the UN and sovereign states are required to attempt to eliminate gender inequality in particular aspects by tackling gender inequality in all aspects including the inequality in education, politics, etcetera, which makes it challenging for them to take the first action.

The UN' Platform for Action suggests each state government commit itself to protect and promote the equal rights of women and men to engage in political activities. However, some states have failed to effect such action. For instance, in Nigeria, the Gender and Equal Opportunity bill was rejected in 2016(Eniola, 2018) because only seven members of 109 senators were women. Yet, the bill has still not passed in 2022 after three times of the consideration and passage were frustrated (Iroanusi, 2022). This challenge corroborates the argument of the Social Dominance Theory which states that "a combination of political conservatism, prejudice, a belief in meritocracy, and the assumption of the inferiority of marginalized groups leads to the formations of persistent ideological myths" (Islam, 2014:1779). It further explains that, these "legitimising myths" (Pratto, 1999) become codified and institutionalised and serve to convince people that existing structures of

inequality are just and desirable. As such, institutions become reluctant to implement policies which are meant to advantage the marginalised individuals which in this case are women (Islam, 2014). The UN with the view of Liberalism, society is capable of cooperating to maintain peace and secure the dignity of individuals, it needs to by some means, change the realists' view gender inequality would not be solved as long as particular groups continue to pursue their own interests to achieve women's equal representation in the political sphere. Both are the UN's challenges to suspend the dominant groups from pursuing their own desire of dominating marginalised subdominant groups which are women in the political sphere and to change the people's convinced belief about women being subdominant groups in politics. Overcoming these two challenges will allow girls to gain the same level of education and investment as boys, which will eventually allow more women to be represented in the political sphere.

This case illustrates the challenge the UN is confronted with that their efforts to achieve gender equality are sometimes ineffective because states fail to affect them, particularly because those who are supposed to effect such a crucial decision are dominated by men. In essence, patriarchy which has permeated states' decision-making organs is frustrating efforts made by the UN to alleviate gender inequality. As the UN cannot make decisions for a sovereign state's administrative entities, the challenge to solve gender inequality remains unless each state reflects on the suggestions made by the UN.

Efforts toward gender equality in the economic sphere have to some extent, failed to mark significant milestones. Among the numerous reasons for this is the inherent cultural and social roots of the inequality challenge. It has long been established that gender inequality is deeply ingrained in the culture and norms of societies which serve as the roots of people's beliefs and identities. Hence challenging gender inequality principally translates into changing people's long-held beliefs and norms which is to a large extent impossible to achieve. Society has historically been structured to exclude women from the economic spheres of life. This has since influenced society's unacceptance of women as crucial economic contributors. It becomes impossible to change culture, social norms and identity overnight.

Liberal Feminists argue that men and women are equal meaning they should both have equal access to economic opportunities (Nsengimana & Naicker, 2021). However, in reality, women face discriminatory access to these opportunities. The UN's Platform for Actions states that women's economic development challenges (poverty) are directly related to the lack of access to education, access to economic resources, and their minimal participation in the decision-making process (UN Women, 1995). Liberal Feminists have attributed this existing discriminatory gap against women to patriarchy. In fact, this remains a challenge in our world today. The platform for action recommended states revise laws and administrative practices to ensure women's equal rights and access to economic resources in 1995. As of 2020, some states had still not considered this recommendation by the UN. For instance, about 23 per cent of sovereign states still implement statutory inheritance law that limits women's inheritance rights as children and spouses contributing to the gender gap in ownership (Gaddis et al., 2020). The underlying patriarchy is supported by such laws in some states, as opposed to the UN's suggestions to achieve gender equality in the economic sphere. The challenges to solving the gender gap in economic opportunities are the patriarchy,

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the economic structure status quo which excludes women from active economic activities and the UN' limited ability to make decisions for sovereign states that still implement laws supporting the patriarchy.

Gender inequality is a complex chain of discrimination in all aspects of societal activities. It is a multifaceted challenge making it difficult to solve by simply implementing a new policy. Especially, in the case of women's low representation in the political sphere rooted in the girls' disadvantage of receiving the same education as men, both inequality needs to be solved to alleviate one another. However, solving one of the two is challenging because both inequalities are deeply interconnected and the traditional state governmental system is less amenable to bringing a change. Furthermore, altering people's beliefs, social norms, and stereotypical views toward women is also difficult because they are transformed and acquired by individuals subconsciously. The challenges of solving multiple interconnected gender inequality, suspending the dominant groups' exploitation of women, and changing people's subconscious thoughts are the major challenges that hinder the global system from achieving gender equality.

Conclusion

The cause of gender inequality prevailing in the global system is not attributed to one factor. In fact, multiple different factors are intertwined and disadvantage women from having the same economic opportunities and representation in the political arena. The UN has been making a significant influence to achieve SDG 5 by publishing the Platform for Actions and incorporating gender equality into international human rights law. However, since the cause of the inequality is multifaceted and the inequality in different aspects is related to the other gender gap, UN and sovereign states are still confronted with many challenges to achieving gender equality in both political and economic space in the global system.

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- **Judge Feedback:**

“Reika’s paper was praised for its exemplary research, drawing from a variety of relevant sources. It was commended for being well-written, thoroughly referenced, and logically structured. Her presentation effectively highlighted the main points from her research, detailing her research process and the formulation of her ideas. It was described as an engaging and comprehensive presentation on a significant and thought-provoking topic.”

- **Reika’s Tips:**

Incorporate multiple perspectives or theories to support your argument: while researching your topic, you’ll encounter a diverse array of arguments. Integrating these different perspectives not only offers a comprehensive view of the subject but also adds depth and criticality to your writing.

Actively ask questions and seek feedback from your tutor; the tutors are experts in the field and their support is valuable throughout the course, from project topic selection to academic research and writing.

Winner, Akshan Raina

The Ethics of Artificial Intelligence



Akshan's Bio:

- Akshan successfully completed the Artificial Intelligence Online Research Programme whilst in year 12 at Eton College whilst studying for A-Levels in Economics, Politics, Maths, and French. Akshan is deeply involved in social and environmental causes, participating in Eton's Environmental Club and serving as a Committee Member for 'Eton Action,' the school's Social Action Society.

The Ethics of Artificial Intelligence

Akshan Raina, 18th August 2023

Abstract

The advent of Artificial Intelligence has raised many questions about the ethical implications thereof. This paper begins by explaining intersection between Artificial Intelligence and Ethics and the necessity of examining this. Through analysis of many economic and social consequences of Artificial Intelligence, this paper develops some ideas concerning political and economic solutions to the foreseen obstacles. With the implementation of these ideas (or any protective measures), the paper concludes that Artificial Intelligence is, or at the very least, has the capability to be ethical. It can even be said that Artificial Intelligence has the potential be ethically good – such will be shown through the positive consequences outlined below (and the assumption of the prevention of the negative implications).

Introduction

§1. The need to consider 'The Ethics of Artificial Intelligence'

As technology continues to advance, it is inevitable that Artificial Intelligence (AI) shall become increasingly prominent in our modern society through its gradual incorporation into many additional aspects of our lives. While the integration of AI with our lives will be done

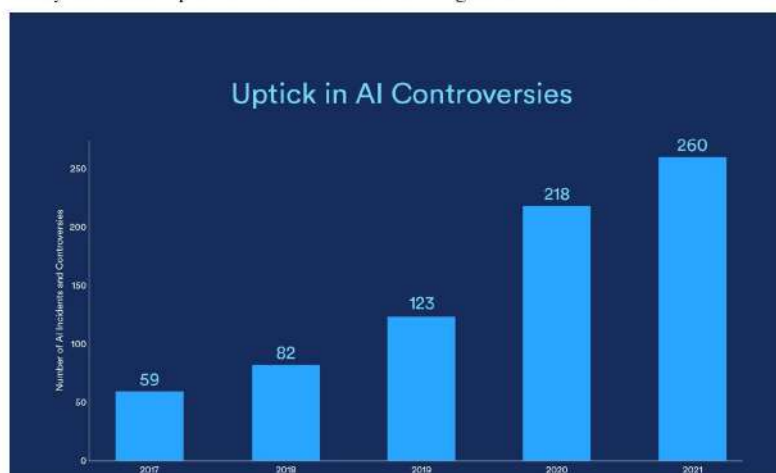


Figure 1. A Chart to show the increase in reported AI-related incidents (2017-2021)

with the opportunities in mind, it is undeniable that these opportunities shall also be accompanied by a number of challenges.

¹ AIAAIC Repository (2022). Available at: https://docs.google.com/spreadsheets/d/1Bn55B4xz21-Rgdr8BBb2l0n_4rzLGxFAADMVW0PYT/edit#gid=888071280

One of the challenges will be the consideration of ethics in matters concerning AI. Due to its inanimate nature, a common concern is whether AI can be constructed in such a way as to maintain the ethical integrity of a sentient human. This is of greater concern now than ever before due to the rapid growth of the research and development occurring as pertains to AI. Furthermore, as AI continues to become more advanced - due to its nature tending towards independence - it also becomes more difficult to control as it will lose considerable transparency (due to the more complex processes it shall employ). This accelerated development of AI (and subsequent rapid adoption of AI into society) warrants the immediate necessity to consider the ethics of AI, enabling greater control and understanding for the future.

This is evident from Fig 1. (compiled from data on the AIAAIC [AI, Algorithmic, and Automation Incidents and Controversies] Repository), which displays the sharp increase in the amount of reported AI-related incidents. The basic correlation suggests that, as time goes on, the amount of AI controversies increases (depicted by the steadily growing bar). Aligned with what was written in the paragraph above, the advancement of AI, combined with its greater prominence in society over time shall invariably lead to a further (continued) increase in amount of 'controversies'. Thus, it is important to understand the implications of AI, so as to be able to begin seeking solutions that may maintain (rather, instill) the ethicality of a human.

§2. Paper Format

This paper shall begin by outlining many of the major concerns regarding AI such as bias, privacy and accountability (alongside many others); these will swiftly be analysed from an ethical perspective. Following the many negative implications, a few positive consequences shall also be briefly outlined in order to show the (AI's) capacity for 'goodness'.

The next section of the paper shall delve into some theoretical solutions to create and sustain an ethically good state (concerning AI). Solutions will range from political ones that seek to prevent the problem from its roots to the use of economic instruments in an attempt to offset any negative externalities.

After considering the ethical management of AI through political and economic policy, the paper will culminate with a conclusion that determines whether or not Artificial Intelligence is an ethically viable construct – or how to make it so.

Brief Background

§1. 'The Ethics of Artificial Intelligence'

Before even considering to ponder this paper title, it is of utmost importance to have a sound grasp of the terms of the statement. Below the main terms shall be concisely defined and explained. There are two aspects to consider i) 'Artificial Intelligence' – this shall be defined, and as it is of particular importance, briefly explained as well; ii) 'Ethics' – this shall be defined and subsequently framed in such a way that suits the purpose of this paper.

Naturally, both topics have innumerable intricacies and are by no means simple, however, they shall be explained swiftly and at a high level as an act of abstraction to retain the comprehensibility of this paper to all.

§1.1. Artificial Intelligence

Before considering ethical implications and management solutions, it is important to fully understand what Artificial Intelligence actually is. AI refers to the humanisation of machines or computer systems through the simulation of human intelligence - abstract as it may be (McCarthy 2007). AI aims to mimic human cognitive functions with the hope that it will be able to complete tasks much more efficiently and effectively than humans ever could. The launch of OpenAI's 'ChatGPT' on 30th November 2022 led to the increased popularisation and universal recognition of the term 'Artificial Intelligence'.

Weekly Registrations of .ai Domain Names

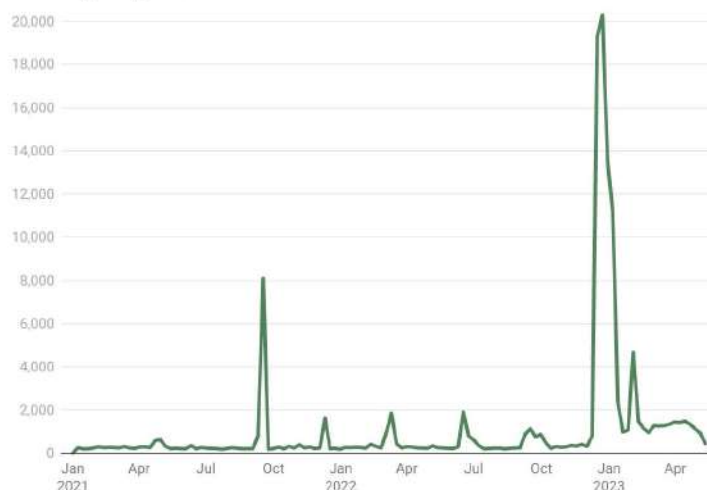


Figure 2. A Chart to show the number of Weekly Registrations of Domain Names that end in '.ai' (2021-2023) 2

This is evident in the Fig. 2 which clearly displays the sharp increase (going from under 1000 to over 20000) shortly after the launch of ChatGPT. This hype has brought a lot of traction and attention to the field of AI of late. Hereby accelerating development and advancement of AI (through increased research within the area).

The reason for the interest in the development and advancement of AI stems from the broad array of opportunities it presents for society. Alongside being driven by the practical usage it brings, there is also an aspect of scientific curiosity (a further interest in testing the limits and capacity of complex advanced AI models).

² Newcomer (2023). Available at: <https://www.newcomer.co/p/14-charts-that-tell-the-story-of>

§1.2. Ethics

Ethics is a branch of philosophy that concerns itself with questions of morality. It focuses on the ideas of 'good' or 'bad' and 'right' or 'wrong'. Ethics is often used to evaluate human decisions through the consequences and implications. In a similar manner, it will be used in this paper to evaluate Artificial Intelligence (through its consequences and implications) from the standpoint of whether it is an ethically (alternatively, morally) 'good' concept. With this in mind, for the purpose of this paper, it can be taken as a 'measure of goodness' (undeniably an oversimplification of this complex abstract concept yet fitting for the paper nonetheless).

Ethical Concerns with regards to Artificial Intelligence

§1. Negative Impacts

Invariably, there are many problems (or negative impacts) associated with the use of AI. Many of these are outlined and explained below.

§1.1 Bias

One of the major concerns when it comes to AI is 'bias'. 'Bias' refers to the production of outputs by an AI system that reflect unjust prejudices. Although AI is expected to improve decision-making due to its objective nature – brought about by a lack of sentiment, the presence of bias significantly detracts from the reliability of any such model.

Biases are most commonly brought about by the use of a biased dataset in the training stages of an program. AI systems learn from historical data - if this data contains biases, the AI will inadvertently perpetuate those biases in its own results. This, in turn, can be brought about by biased collection methods – a simple example being underrepresentation of an ethnic group through the lack of surveying said group.

Bias within AI has several societal consequences. Firstly, it can lead to discrimination – through the perpetuation of historical patterns, the AI system will effectively be living in the past and so will also perpetuate historical inequalities. Bias could also lead to the reinforcement of stereotypes through the amplification of any biases present in the training data.

Needless to say, this is harmful to societies and can detract from the ideal of equality which is currently being sought.

§1.2 Privacy

Another grand concern is privacy (or the lack thereof). Many people don't even realize how much data of theirs is being collected and used by AI systems. This means that there is a lack of consent – disabling individuals from extending control over their own personal information.

Secondly, the vast amount of data being collected means that a data breach would be much more severe. Possible repercussions being: identity fraud, financial losses and damaged reputations (via identity misuse).

Finally, AI has the capability to create highly detailed profiles of people with these vast pools of information it can receive. Through this profiling, AI can theoretically predict future actions. This is known as predictive analytics and was incorporated by statistician Andrew Pole at Target, enabling Target to identify pregnancies before the (soon-to-be) mothers themselves (Duhigg 2013). It is evident how this can be seen as an invasion of privacy. Furthermore, it also opens many possibilities for manipulation, after all, would you feel safe if a corporation knew your future before you lived it?

§1.3 Accountability

Accountability is yet another of the major concerns. It refers to the attribution of responsibility for the actions, and consequent outcomes, produced by AI technologies. There are many problems associated with accountability. Primarily, AI often operates via ‘opaque decision-making’, this refers to a black box approach, wherein inputs go in... and outputs, out. Essentially, the operations that occur, and decisions that take place cannot be easily understood. If it is difficult to ascertain why certain decisions are made, it would also be difficult to ascertain the whole picture (of what may have occurred and why), hence one could not determine culpability.

Secondly, there can often be ‘emergent behaviours’; since the AI is learning from a dataset, it could potentially pick up on patterns that weren’t intended. Hence “behaviours” and outcomes “emerge” that were not originally expected. This was portrayed in the recent film *M3GAN* (Scott 2022) wherein she developed an unintended aggressive nature due to an unforeseen emergent behaviour. Here it was evident that emergent behaviours can be dangerous due to the random nature of the adopted behaviour(s). Once again, due to the non-sentient nature of the AI, it remains to find someone culpable – yet no-one actually programmed the aggressive behaviour; once again, leading to an accountability dilemma.

Finally, expanding on this accountability dilemma, AI systems are mostly brought about through much collaboration between many different parties – such as stakeholders, developers, and the dataset providers. The sheer size of the team behind the AI models (and breadth in differences in their roles) makes it near impossible to pin the blame to a single team, let alone individual. Determining who should be held accountable for unintended outcomes can become even more complex in larger-scale contexts.

§1.4 Job Market Disruption

AI is being developed with the hopes that it will be able to perform many of the tasks of humans, yet with near-perfect accuracy and efficacy. A consequence of this will be the complete upset of job markets globally. As more jobs become automated, it leaves many more people (and their skills) redundant. In order to survive in this economy, the displaced people will have to seek new skills and find a suiting new job. However, how long until AI advances enough to consume those roles too?

Looking ahead, a loss of jobs en masse would also lead to decreased consumer spending (as people have less money to spend). This decreased spending can cause an economy (and its GDP) to shrink; thereby igniting the harmful flames of a recession which could set an economy into a vicious positive feedback loop (recession leading to more people losing jobs, then less spending and a shrinking economy, and so on, ad perpetuum). Invariably this would

place a much larger percentage of a population into poverty – certainly not a desirable outcome.

§1.5 Environment

The environment is a finite resource that must be looked after and cared for. AI has many negative externalities on the environment. Naturally, the running of such ‘high-tech’ machinery requires great amounts of energy. This is not such a great worry, provided the industry uses renewable energy resources – else, it would amount to vast carbon emissions released into the atmosphere; in turn, this severely damages the ozone layer through the enhanced greenhouse effect.

Secondly, the production of AI devices requires the extraction of rare minerals (for components of the AI). This can have adverse environmental and social impacts in mining regions. For example, sand is currently a depleting resource (Peduzzi 2014). Sand is used in the manufacture of computer chips and, remains finite. It may seem as though there is no shortage for sand, but desert sand cannot be used due to the difference in construct. This extraction of sand has many further impacts for the environment - such as the erosion of land and destruction of habitats.

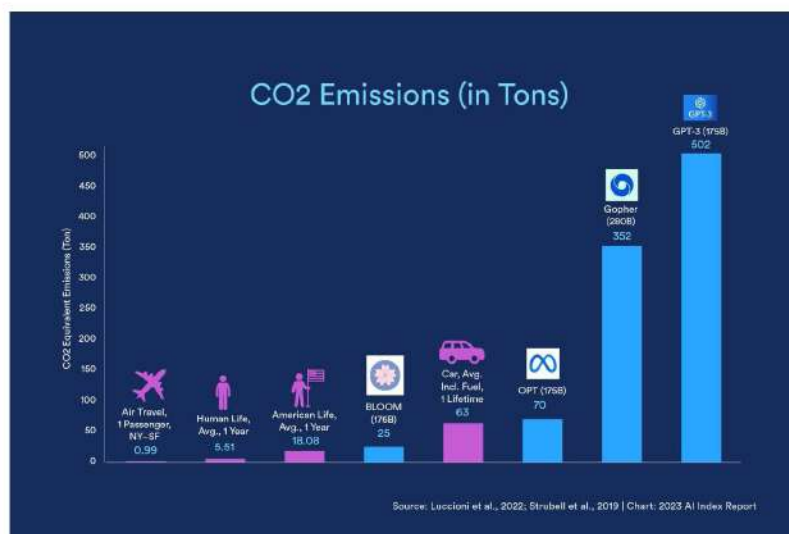


Figure 3. A Chart to show the tons of CO2 Emissions produced by each of the variables

Finally, the training phase of AI models, requires extensive computational resources, can result in significant carbon emissions if not managed efficiently. This is evident from Fig 3. Which visually displays the sheer amount of CO2 emissions expended by GPT-3 in comparison to average American metrics (such as 1 car's lifetime). This shows how

³ Stanford University HAI (2023). Available at: <https://hai.stanford.edu/news/2023-state-ai-14-charts>

unsustainable such approaches are, and demands greater effort be put on making such processes eco-friendly.

The environment is of great concern and must be addressed before the situation gets too dire. Currently, AI is causing many unnecessary negative environmental externalities which can be offset by the incorporation of eco-friendly practices.

§1.6 Social Manipulation

Social manipulation through the use of artificial intelligence (AI) has become a concerning phenomenon with far-reaching implications. As mentioned above, AI-powered algorithms can analyse vast amounts of personal data from all sorts of platforms to create detailed profiles of individuals, enabling highly targeted and often persuasive content delivery. One notable case illustrating the potential consequences of such manipulation is the Cambridge Analytica scandal. In this instance, personal data from millions of Facebook users were harvested without their consent and used to create tailored political messages to influence voter behaviour. This manipulation exploited psychological vulnerabilities and highlighted how AI-driven tactics could sway public opinion, impact elections, and undermine the integrity of democratic processes. The incident serves as a stark reminder of the emphasis needed for robust regulations, data privacy measures, and public awareness campaigns in an effort to mitigate the potential use of AI technologies for nefarious purposes.

§1.7 Academic Integrity – loss of meritocratic society

The creation of tools such as ‘ChatGPT’ has led to worries about academic integrity. Tools such as this have reduced hours of hard work into the simple click of a button. There is greater emphasis now than ever to maintain ‘academic integrity’ as students. While this doesn’t seem like a grand concern in respect to a few of the other topics that have been outlined; it is very important to consider the ramifications of this.

Tools such as ChatGPT discourage hard work and effort, this could result in a generation that is dependent on technology and cannot think of its own. Being reliant on technology is certainly a bad thing as technology can be subject to events such as thunderstorms or blackouts.

The gradual loss of academic integrity may also seem small on the grand scale of things; however, it bears the consequence of the loss of the meritocratic society. Once again, discouraging hard work and effort over laziness and inactivity.

§1.8 Robotics

AI is also closely related to the field of robotics (which focuses on the intersection between engineering and computer science and concerns itself with robots). Through a combination of AI and robotics, concepts such as self-driving cars are possible. Self-driving cars are very morally ambiguous; one of the most interesting considerations to be made is how it would approach that of an ‘ethical dilemma’ – for example, would it save passengers or passers-by, how would it allocate value to different lives?

Another area of interest within the field of robotics is the idea of ‘killer-robots’ ie. autonomous drones and perhaps even a real-life Robocop. Once again, this reverts to the

problem of accountability, since these machines will be operating of their own, who is culpable for the results of their actions?

§1.9 Deepfakes

These AI-generated synthetic media, most often in the form of videos, can be so convincingly realistic that they can make it appear as though individuals themselves are saying or doing the things in the video (when, in reality, they never did). While they may seem like a bit of harmless fun, they must be approached warily. The ease with which they can be created raises concerns about misinformation and deception. Deepfakes can be exploited for various malicious purposes, including spreading fake news, defamation, and identity theft. For example, recently, there was a deepfake of President Zelenskyy⁴. While it may not have been the most realistic, as time goes on, the deepfakes will only become more difficult to distinguish from reality. This is rather disturbing, as if someone were to impersonate a head of state (as done here) without anyone realising it was a mere deepfake, it could have immense consequences.

§2. Possible Positive Implications

Having considered at length the negative implications, to give a whole view, it is necessary to mention some possible benefits. Naturally, there are many positive implications – embodied by the opportunities presented, however, as is fitting with the paper, the focus shall be on ethical benefits.

§2.1. The Judicial System

Logically thinking, AI seems to be very fitting for judicial tasks. Due to its non-sentient nature it stands to reason that it shall be capable of providing objective judgements based purely off the facts of a given case. The use of AI would also bring a regularity to judicial sentences. The current situation (pertaining to the sheer volume of judges [and juries] globally) invariably leads to slight inconsistencies due to different subconscious biases that they may be harvesting.

Talking of bias, it is necessary to address bias within AI; Surden (2019) states that AI is unsuited to make such decisions (yet) due to bias. Earlier it was seen that a biased dataset can lead to perpetuation and magnification of this bias. In this way, stereotypes could be enforced – meaning an unjust judicial system.

On the other hand, Surden (2019) points out the ability of AI to assign a “likelihood to reoffend score” which has proven useful to judges. This reflects the process-driven success that AI can have.

Similarly, AI could be useful in the clerical aspect of law (of which there is much). Legal research and analysis often take up great amounts of time for solicitors and lawyers, yet, an AI system would have the capability to accelerate this by quickly sifting through vast amounts of legal texts, court cases, and precedents to provide lawyers with relevant information and insights.

⁴ New Scientist (2022). Available at: <https://www.newscientist.com/article/2350644-deepfake-detector-spots-fake-videos-of-ukraines-president-zelenskyy/>

Secondly, an AI system would be able to manage resources much better and in a much more organised effort than a human (with the same efficiency). In this way, lawyers would be able to access and identify key information, potential risks, and discrepancies much more quickly and accurately (due to the abstraction of irrelevant documents).

Finally, an AI system would be able to automate many of the routine and mundane that a lawyer normally has to do - such as document drafting, data entry, and legal documentation – this would give a lawyer more time to focus on urgent aspects of a case and enable them to direct their efforts more complex and strategic work.

§2.2. Healthcare

AI also has great utility in the field of healthcare and medicine. Once again, it can bring automation to many aspects of the sector. Healthcare is notorious for the heavy paperwork that must be completed and organised. An AI system would be able to streamline all administrative tasks (incl. billing, appointment scheduling, and record keeping), relieving healthcare staff of these administrative burdens. This prevents such staff from being severely overworked and ensure they can direct their time and efforts towards wholeheartedly looking after patients.

AI can easily automate analyses as well due to its statistical aptitude. A good example is ‘medical imaging analysis’ wherein the AI model will analyse a medium such as an X-Ray to search for any abnormalities, tumours, or diseases; the AI model could also be taught to perform ‘disease diagnostics’ by reviewing a patient’s medical history in order to provide accurate diagnoses for the patient. Furthermore, using AI to complete such tasks will lead to a consistent accuracy (presuming the AI has been trained correctly) due to the objective nature of its determinations. This once again relieves healthcare staff of these time commitments allowing them to channel their energies elsewhere.

Furthermore, (relatively) recent advancements in wearable technology can incorporate AI systems to facilitate remote monitoring. These devices can collect and compile data in real time, alerting healthcare professionals should anything indicate the requirement for medical attention. As is known, hospitals and medical centres are incredibly busy places, in this way, one would be able to drastically decrease a hospital’s patient turnover time without the worry of sacrificing the quality of care for any patients.

Finally, if methods similar to those used by Target (Duhigg 2013) were to be implemented in the healthcare sector, diagnoses could be made ahead of time (thereby increasing the chances/time of successful treatment. This is especially useful in the case of progressive diseases such as Huntington’s Disease, Dementia, MND (Motor Neurone Disease) and Muscular Dystrophy. Evidently, this could be particularly prominent in the identification of neurological disorders - a niche in which a particular problem is late diagnoses that don’t allow for much preventative measures to be taken (as there don’t tend to be cures for such neurological disorders). In contrast, an AI model that learns to detect such diseases through the analysis of genetic data (genomic analysis) and tracking of habits (through remote monitoring as detailed above) would be invaluable to human society. It could save innumerable lives and increase the standard of living (as there aren’t any well-known cures for many such diseases yet) for countless more.

§2.3. Equality (and Education)

While not strictly a consequence of AI, it has facilitated the diversification of the computer science landscape. A work(/research) landscape that was predominantly white male (Fig. 4, Fig. 5, Fig. 6) has gradually eroded over time. Fig. 4 and Fig. 5 illustrates the tendency towards gender equality; Fig. 4 shows the growing interest in CS Bachelor's Degrees from female candidates, Fig. 5 displays the increased recognition for females within the field (a story told by the number of faculty hires) – alternatively, it could also be a consequence of the increased concentration of females entering the field (Fig. 4); another win for gender equality, nonetheless.

Secondly, Fig. 6 shows the ethnic infiltration of the Computer Science Scene (admittedly, predominantly Asian). This is another positive as it [Fig. 6] highlights the growing interest within the Computer Science sector from other ethnicities. Fig. 4, Fig. 5 and Fig. 6 collectively show the diversification of the work environment – a positive and desirable effect.

Concerning equality, AI also presents the opportunity for equality of opportunities – this is well-represented by the education sector. AI tools and platforms (eg. ChatGPT) can provide personalized learning experiences, giving everyone access to the similar resources and teaching. This can narrow the educational achievement gap by ensuring that students receive the support they need to succeed, regardless of their background.

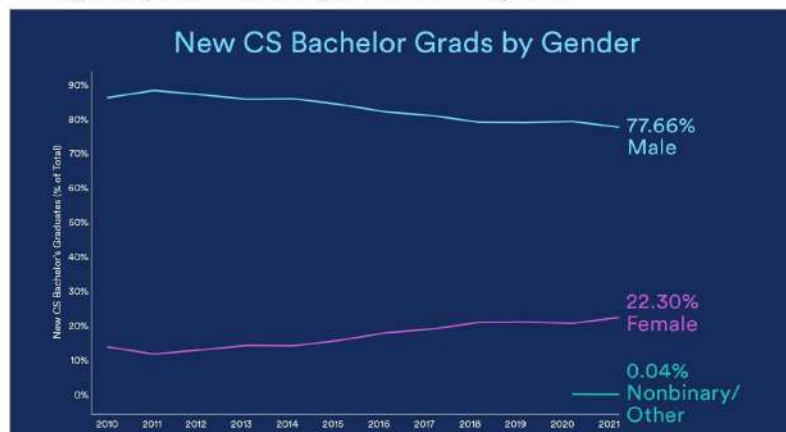


Figure 4. A Graph to show the percentage of Computer Science Bachelor's Degree Graduates by Gender (2010-2021)

⁵ CRA Taulbee Survey (2022). Available at: <https://cra.org/crm/wp-content/uploads/sites/7/2023/05/2022-Taulbee-Survey-Final.pdf>

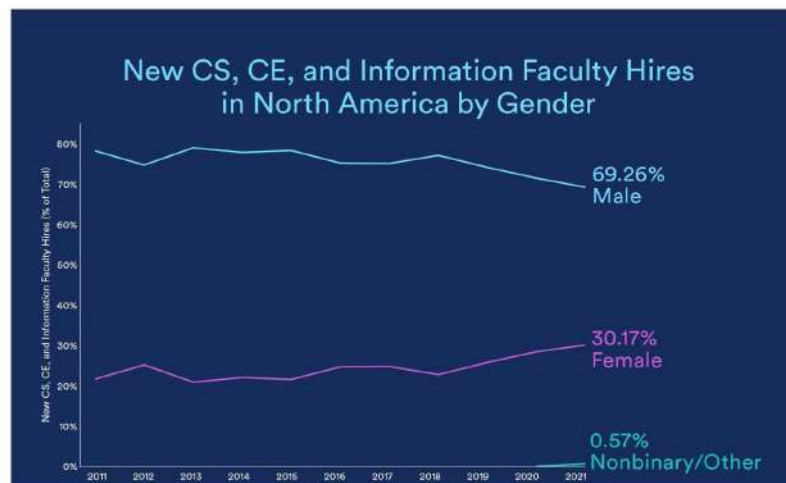


Figure 5. A Graph to show the percentage of new Computer Science related Faculty Hires by Gender (North America, 2011-2021) ⁶

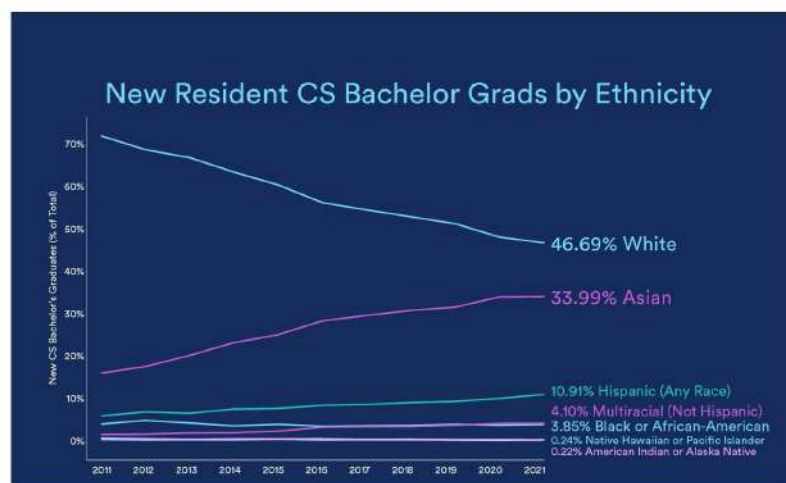


Figure 6. A Graph to show the percentage of Computer Science Bachelor's Degree Graduates by Ethnicity (2011-2021) ⁷

⁶ CRA Taulbee Survey (2022). Available at: <https://cra.org/crn/wp-content/uploads/sites/7/2023/05/2022-Taulbee-Survey-Final.pdf>

⁷ CRA Taulbee Survey (2022). Available at: <https://cra.org/crn/wp-content/uploads/sites/7/2023/05/2022-Taulbee-Survey-Final.pdf>

Ethical Management

Having looked at many of the negative implications produced by considering the ethics of AI, this paper shall now suggest possible solutions that aim to maintain the ethical integrity of AI while allowing it to progress. Solutions shall be split into two basic sections i) political, these are regarding AI policy and making AI more ethical with a forward-looking angle; ii) economic, these focus on addressing current problems and offsetting these ad infinitum, thus these can be considered comparatively more retrospective.

§1. Political Solutions

AI has quickly become a political matter due to its far-reaching implications for society (a few of which were outlined above). Since it has rapidly become a matter of national importance (due to privacy concerns, potential further economic impact, and ethical concerns alongside other factors), it is only right to consider political solutions.

§1.1. Regulations

Perhaps the most sure-fire way to manage AI is the introduction of regulations and laws. Such regulations will ensure that all AI produced and evolved will abide by the desired set of rules lest they risk a lawsuit.

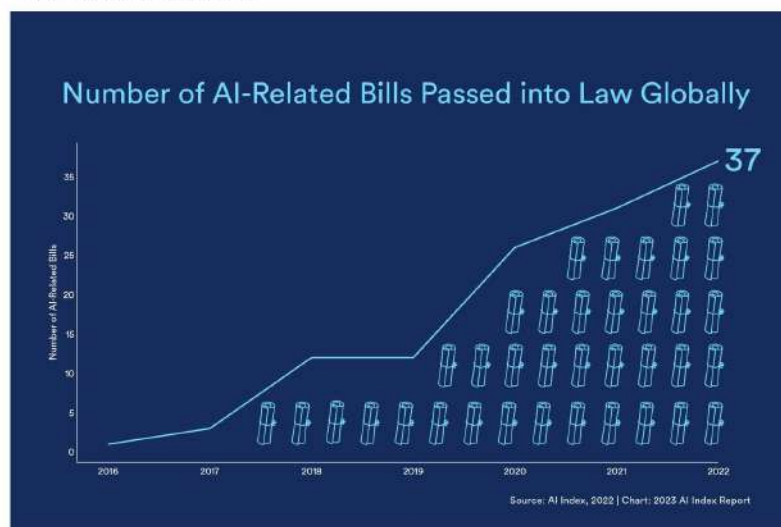


Figure 7. A Chart to show the increase in the number of AI-Related Bills Passed (2016-2022)

⁸ Stanford University HAI (2023). Available at: <https://hai.stanford.edu/news/2023-state-ai-14-charts>

Fig. 7 shows the increase in the production of AI-related legislature globally; the correlation displayed is that, as time goes on (and AI becomes more advanced), the amount of AI-related legislature increases. This embodies the aforementioned point wherein it was suggested that regulations and laws seem to be effective ways to manage AI systems as desired.



Figure 8. A Chart to show the Increase in submissions to FAccT (2018-2022)

FAccT is the Conference on Fairness, Accountability, and Transparency, depicted in Fig. 8, the increase in annual submissions implies growing interest in such topics. Having explained accountability above (and with fairness being fairly self-explanatory), here the focus shall be on transparency. Transparency refers to the intelligibility of an AI's decision-making process by humans. A good way to implement transparency is through 'XAI'.

XAI is a contraction for 'Explainable AI'. The idea behind XAI is that it provides humans with an insight into the inner workings of the AI. As earlier mentioned, AI tends to operate with a 'black box' (opaque decision-making), XAI provides a window into this mysterious box, creating greater levels of transparency. By understanding why an AI makes the decisions it does, the problem of accountability can be addressed. It also enables any bias or errors to be detected. In this case, a developer could address this issue – leading to more robust and trustworthy technology. XAI also helps to prove compliance with any regulations by explaining the AI's decisions. Consequently, there should certainly be a law that obliges AI developers to produce Explainable AI.

Having tackled the problem of accountability, privacy and bias (of the big three) remain. In response to data privacy regulations are quite simple. Firstly, the AI developers must ensure that they only use and access someone's data with their informed consent. This should

⁹ FAccT (2022). Available at: <https://faccconference.org/>

include a brief explanation of what the data will be used for. Once the data is in their hands, they must take it upon themselves to protect any personal information and prevent unauthorized data access or theft. Should regulations detailing such rules be enforced, the problem of data usage and privacy will be much reduced.

Concerning bias, Omer et al. (2017) uses the analogy of the 2001 film ‘Shadow Hal’ to conclude that the solution to biased results is to educate against the bias (ie. [in the case of AI] an unbiased training dataset). This is as an alternative to forcing the result (ie. tampering with the outputs to attain the desired result). In this way, the problem will be solved at the root, and so, the program can then be trusted to consistently produce unbiased results; in the other case, the programmers will have to constantly interfere with the results to force an unbiased output set – in this way, it is highly likely that their own (inherently) flawed human nature will lead to subconsciously biased outputs. Therefore, regulations of some sort should be implemented to ensure datasets used are unbiased. To ensure this, the regulation should address data collection and concepts such as representation; if the collection of data is unbiased, it is noticeably less likely for the training dataset to be biased – hence leading to unbiased results. A combination of unbiased datasets, and the monitoring of inner-workings (by use of XAI) should greatly diminish biased results (or, at the very least, lead to an explanation of certain results).

§1.2. Education

To create a secure foundation for the future, the best approach is to instil understanding and ethics into the youth.

Hence, Goldsmith et al. (2017) proposes the incorporation of ethics into the syllabus of an ‘AI class’:

“Because AI work has enormous effects on society — including the ways in which individuals interact, on our economies, on the practice of medicine and the uses of leisure, to name a few — we believe that all AI practitioners, and those that reason about AI technology, should be able to frame discussion in terms of ethics. Further, we believe that popular culture promotes a very limited understanding of how to frame and analyze ethical decision making. Thus, we advocate that ethics be taught in AI classes, and that we develop materials and courses for teaching ethical frameworks and reasoning to people working in AI (Burton, Goldsmith, and Mattei 2016).”

By teaching the ‘AI developers of the future’ ethics, they shall find it easier to align their AI (alignment of AI refers to the alignment with human values and ethics) due to their heightened understanding of both topics. Furthermore, they will also understand the need for such action to take place due to the deep-rooted public awareness within the society of the future.

This investment in the future generations is an extremely sustainable and efficient solution to the pressing concern of immoral (unethical) AI.

§2. Economic Solutions

The solutions provided here are more focused on offsetting and preventing the negative externalities brought about by the use of AI. Economic solutions include fiscal policy and economic incentives.

One of the greater problems with AI is the environmental negative externalities. Many of the economic instruments outlined below shall be focused on reducing these due to the importance of the environment and the apparent simplicity of the solutions.

§2.1. Subsidies

Governments could allocate funds and grants to support ethical AI initiatives. These could encourage innovative research and development of ethical AI technologies. Such subsidies could also be used to help AI projects and companies that are focused on having a positive social impact by solving social challenges. The existence of such subsidies can further incentivise other AI businesses to consider ethical implications of their doings.

§2.2. UBI

One of the major economic concerns detailed earlier was the replacement of many jobs by AI systems. A potential solution to this is the introduction of a 'UBI'. 'Universal Basic Incomes' would be an annual guaranteed salary received by all members of a population.

There are many benefits to UBI such as: the prevention of poverty, social security and support for unrecognised and unpaid labour (such as caregiving and community service). It also has the capability to act as an economic stimulus by facilitating consumer spending.

This being said, there are various problems associated with the concept too. Firstly, the cost of the program will be mighty – funding would either come from excessive taxation or the increasing of national debt. Secondly, it reduces work incentives – this would lead to a stagnant economy with no growth (with impending eventual economic shrinkage). Finally, since UBI is distributed to a whole population, it could potentially exacerbate income inequality.

All in all, the positive benefits of UBI do not outweigh the problems. It is unquestionably a 'utopian concept' and can only exist in a perfect society.

§2.3. Pigouvian Tax

A Pigouvian tax is levied on the negative externality of a business' (or individual's) activities. As seen above, one of the major concerns with AI is the energy needed to run such models. For the facilitation of these activities, fossil fuels are often used in place of renewable energy sources. The burning of fossil fuels release carbon dioxide (a greenhouse gas) into the atmosphere – this is the negative externality. Thus, the tax would be levied on the mass of carbon dioxide produced. This works to dissuade superfluous energy-demanding activities (as it would result in more CO₂, and so, more tax).

§2.4. Cap and Trade

To further manage the CO₂ production of corporations, a cap-and-trade system should be put in place. This would place a limit on the total amount of emissions any given business can produce (thence the 'cap'); the 'trade' aspect enables businesses who don't use their allowance may trade their carbon credits (emission permits) for money. This ensure that unnecessary carbon emissions don't take place as the businesses will be conscious about how they spend their carbon credits. The fundamental idea is that the 'cap' is gradually reduced over time. This will eventually lead to a great decrease in carbon emissions.

§2.5. Tax Credits

The final economic instrument in this series of reducing carbon emissions is tax credits. Tax credits (benefits of sorts) reduce the amount of tax to be paid. In this case, tax credits should be allocated to compensate unused carbon credits. In this way, it is in a corporation's best interest to save as many of their carbon credits (emit as little) as they can. Once again, this will greatly benefit the environment and encourage companies to find more renewable alternatives. Eventually, they shall be very well acquainted with renewable energies and will be prepared (and in a good place) to make a complete transition.

Secondly, tax credits can also be allocated to AI systems that produce positive impacts for societies such as some of the ideas mentioned above concerning healthcare. Moreover, tax credits can be used to endorse and encourage developments regarding the intersections between the fields of ethics and AI – this could be anything from substantial research into alignment of AI to effective bias mitigation mechanisms.

Conclusion

§1. Is AI ethical?

The lack of morality and consciousness prevents AI from being both, ethical, and unethical. Thus, in response to the question, AI is not inherently ethical. On its own it has no capability to distinguish between right and wrong.

Due to the programmable nature of AI, it can only emulate that which it has learnt and so cannot come to conclusions beyond the context of the training data. AI systems optimize their outputs based on the objective function which is defined by developers. If this function itself doesn't prioritize ethical considerations, the AI will likely make decisions that maximise contextual objective success of the outputs but can be seen as ethically questionable.

Alternatively, while 'AI' may not be ethical, the 'concept of AI' (ie. the [perhaps unattainable] imagined ideal) is ethically good – this is because the ultimate reason behind the creation of AI was to enable scientific and technological advancements that could make life easier and better for humanity. Taking a utilitarian approach (the greater good for the greater number) AI can only be seen as an ethically correct idea due to the immensely valuable (and large number) of positive implications it can facilitate (for a very, very large number of people)– a few of which were outlined above. This betterment that it (ideally) brings to society suggests that the concept of AI is, certainly, ethically good.

§2. Can AI become (and remain) ethical?

The real question, however, is whether AI (in itself) can be made to be ethical.

After outlining the main problems associated with the use and incorporation of AI with everyday life, it is evident that there are many things to consider. The large quantity of problems associated with AI suggests that it cannot be ethical. However, this paper also suggested a number of different solutions (political and economic) to many of the aforementioned problems.

Having also outlined a few possible positive implications of AI, it is also very clear that there are innumerable positive opportunities that can prove invaluable to humankind (such as those related to the early diagnosis of neurological disorders). Needless to say, AI definitely has the capability to do a lot of social good (which would prove it ethical).

Through the enforcement of some of the management techniques listed and explained in this paper, the negative aspects can be significantly offset and prevented. Alongside this, the rapid growth and evolution of Artificial Intelligence means that many of desired positive characteristics can be quickly realised; thereby enabling the 'good' to outweigh the 'bad' and rendering AI: "ethical".

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- **Judge Feedback:**

“In terms of the research project, Akshan promptly selected a topic of interest related to the ethics of AI. This demonstrated clear vision and the ability to define research goals. Akshan meticulously defined a high-level structure for the document, resulting in a well-organized essay.”

- **Akshan's Tips:**

Perform thorough research; having a sound understanding of your topic is vital to writing a good essay.

Come up with a clear structure before even beginning to write. In this way, you can make sure that you avoid repeating yourself and also ensure that the essay maintains a coherent central thesis throughout.

Make the most of your amazing tutors! All the tutors are experts in their field and have vast amounts of knowledge relating to their subjects. You should make sure you heed their advice and consider their thought processes by regularly asking their thoughts on your work so far.

Runner Up, Kathryn Holland

Food Allergies: The Basics



Kathryn's Bio:

- Kathryn participated in the Medicine Online Research Programme and is currently a senior at Edmonds-Woodway High School in Washington State, USA, where she is enrolled in the IB programme. Kathryn aspires to delve into the Natural Sciences, especially biological sciences, as a foundational step towards her goal of attending medical school.

Food Allergies: The Basics

By Kathryn Holland

Word Count: 1,683

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What are Food Allergies?

Food allergies are immune reactions to proteins of specific food. They can be immunoglobulin E (IgE) mediated or non-IgE-mediated. Non-IgE-mediated allergies are inflammatory disorders of the gut, and can be either subacute or chronic. IgE-mediated food allergies, on the other hand, are more commonly recognized. They are characterized by the fast onset of symptoms after the ingestion of a food antigen (Zhang, et al.). Food allergens tend to be water-soluble glycoproteins resistant to breakdown. They are readily transported across the intestine's mucosal membrane. The immune system of patients with food allergy interpret the antigens in these foods as harmful substances. In response to exposure, IgE antibodies specific for the given food antigen are released. These bind to basophils, macrophages, mast cells, and dendritic cells. The release of these mediators induce the contraction of smooth muscle, vasodilation, and mucus secretion. Eosinophils and lymphocytes are activated by macrophages, which release cytokines along with mast cells (*Figure 1*). The result is prolonged inflammation in the skin, the respiratory tract, the gastrointestinal tract, and the cardiovascular system. If left untreated for long enough, an allergic reaction can result in anaphylaxis, which entails the constriction of airways, rapid but weak beating of the pulse, severe blood pressure drops, and loss of consciousness or even death.

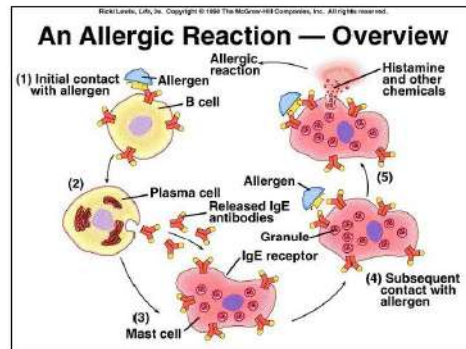


Fig 1. When a food allergen enters the digestive system and the mucosal membrane, contact triggers B cells to differentiate into plasma cells, which release IgE-antibodies. These antibodies bind to white cells, such as the mast cell in the diagram, via IgE receptors. Subsequent contact with the allergen would trigger the white cells to release histamine and other chemicals, inducing inflammation in an allergic reaction.

The following are other possible symptoms of an allergic reaction to food:

- Flushing – reddening of the face
- Angioedema – swelling of the body
- Urticaria – a skin reaction causing itchy welts; "Hives"
- Rhinorrhea – the dripping of mucus from the nose
- Sneezing
- Dyspnea – struggled breathing
- Laryngeal edema – abnormal accumulation of fluid in the tissues of the larynx
- Wheezing
- Nausea/vomiting

- Abdominal pain
- Diarrhea

(Lopez, et al.)

Over 170 foods are recognized as triggers for food allergy. Out of all food allergies, the most common ones include milk, eggs, fish, shellfish, tree nuts, peanuts, wheat, sesame, and soy (Canani, et al.). Some allergies such as milk, egg, wheat, or soy, usually recover within the first few years of life as the patient gains clinical tolerance. Others, such as those to peanuts and seafood, are more persistent, and tend to last for the rest of one's life (Lopez, et al.).

Diagnosis and Treatment

Diagnosing food allergy is frequently carried out via skin prick tests and allergy blood tests. In the skin-prick test, the skin is pricked with a lancet carrying the extract of an allergen. After fifteen minutes, if the site of the prick is raised and red, the person will be diagnosed with food allergy. An allergy blood test, on the other hand, measures the level of IgE antibodies in the bloodstream. Abnormal levels of IgE antibodies indicate an allergy to the specific food or protein. However, these tests do not always accurately diagnose a food allergy. Oftentimes, the test result may be a false positive, leading to unnecessary food restrictions being placed upon the patient, and potentially malnutrition, poor weight gain, and reduced quality of life. Getting false positives is especially common for individuals with atopic dermatitis, who can often have high total IgE levels irrespective of food allergy (*National Institute of Allergy and Infectious Diseases*). In order to prevent misdiagnosis, an National Institute of Allergy and Infectious Diseases (NIAID) clinical trial was begun in 2019 to identify threshold IgE levels to peanut and milk (or a component of these foods) that determine whether an individual has a food allergy. This would clarify the right time to perform an oral food challenge for a certain diagnosis. Those taking part in the trial have atopic dermatitis who may have high total IgE levels and allergy to

milk, peanuts, or both. The study is expected to go on until 2027 (*National Institute of Allergy and Infectious Diseases*).

Individuals diagnosed with food allergy must take extensive precautions when eating. Parents and children must be able to properly read food labels in case the item they would like to consume contains an allergen. Those at risk for anaphylaxis should carry epinephrine and antihistamines at all times, be trained to recognize the initial symptoms immediately, and learn how to self-administer auto-injectables (Lopez, et al.).

Theories as to Why Food Allergy Incidence has Increased

The precise reason for why there has been such a significant rise in food allergies remains unknown. Over the years, however, there have been many studies pointing to different hypotheses. One of the most well-known theories is the "Hygiene Hypothesis," proposed by Dr. David Strachan in 1989. It states that there may be a link between the rise in allergic diseases and reduced microbial exposure due to measures implemented as a means of protecting against infection. The Hygiene Hypothesis has gone through many refinements, leading to the proposal of the "Old Friends Mechanism," proposed by Graham Rook in 2003. This theorizes that instead of humans gaining vital microbial exposures through crowd infections (ie. colds, measles), that microbes have been present since primate evolution. These microbes include those inhabiting both indoor and outdoor environments, as well as commensal microbes acquired from skin, gut, and respiratory tract from other humans. They help shape the human microbiome, the community of microbiota in the body (Bloomfield et al.) (*Figure 2*).

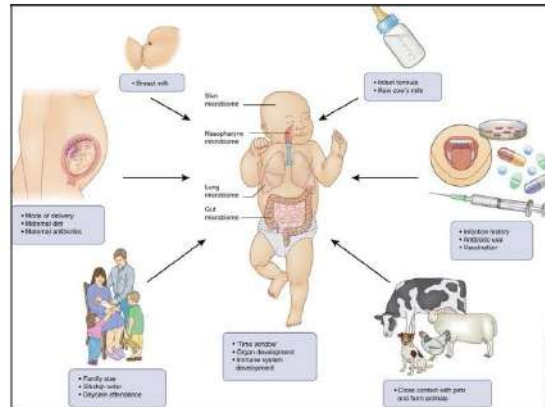


Fig 2. The early stages of life are the most important when it comes to developing the immune system, and hence determining food allergy risk. Factors such as breast milk and consumption of antibiotics are key to shaping the microbiome, as these affect the type of microbiota that will prevail in the gut. Other factors such as mode of delivery and family size have previously been found to be related to the onset of allergy, but they do not share a causal relationship.

In 2011, the "Biodiversity Hypothesis" was introduced. It states that contact with natural environments enriches the human microbiome. This in turn promotes immune balance. In the rapidly urbanizing world experiencing global warming, biodiversity is being lost, and this is said to be connected with the increase in inflammatory disorders, including allergies (Haahtela).

Accumulating evidence over the years has shown the Hygiene Hypothesis to be inaccurate, and epidemiological studies now confirm that childhood infections do not protect against allergic disorders (Bloomfield et al.). Research has instead provided more support for the Old Friends

Mechanism and the Biodiversity Hypothesis. The early stages of a newborn's life are the most impactful for the shaping of the immune system and the microbiome, particularly the microbiome of the gut (Haahtela).

Role of the Microbiome

The microbiome's composition affects the function, development, and differentiation of regulatory T (Treg) cells, which regulate adaptive immune responses. Recently, there has been increasing interest in how dysbiosis, or dysregulation of resident microbial communities, may be associated with allergy risk.

Many studies have directly measured microbial diversity and composition in subjects with and without food allergy, and they find that gut microbiota differs in subjects with food allergy (Bunyavanich, Berin). One study on 141 children either with or without egg allergy from the multi-center, US-based Consortium for Food Allergy Research, found that genera from *Lachnospiraceae*, *Streptococcaceae*, and *Leuconostocaceae* were differentially abundant in the gut microbiome of egg allergic children compared to the controls (Fazlollahi, et al.).

Another study examined 226 infants with milk allergy for 8 years, and found that taxa from the Firmicutes phylum were enriched in the gut microbiome of milk-allergic infants 3-6 months old. These infants' allergy resolved by the end of 8 years. These bacterial trends were not present in 3-6 month old infants who exhibited persistent milk allergy after 8 years, nor in infants at more than 6 months old (Bunyanich, et al.). The findings of this study and many more indicate that certain types of microbiota are associated with the development of food allergy, as well as further emphasize the importance of timing in the shaping of the microbiota.

There are also some species of bacteria which have been discovered to be protective against food allergy through the production of peripheral antigen-experienced regulatory T cells, particularly the strains of the *Clostridia* species (Bunyavanich, Berin). In some studies, *Clostridia* has been observed to be enriched in allergen-sensitized subjects, which may seem counter-intuitive (Han, et.al). However, many studies, such as one mice study on gnotobiotic mice from 2014, have found that *Clostridia* enrichment plays a role in regulating lymphoid cell function in the immune system as well as intestinal epithelial permeability (Stefka, et al.). Regulation of these actions may prevent food allergy.

Future Directions and Preventative Treatments

There is ongoing research on microbiome therapy, which may provide a means of food allergy prevention and treatment. One aspect of this entails the use of prebiotics. Prebiotics are typically high-fiber foods that act as food for the human microflora, aiming to improve the balance of microorganisms (Sestito, et al.). Regarding food allergy, there is evidence to suggest that consumption of prebiotics provides more favorable microbial colonization patterns. This could potentially prevent allergy through the acquisition of tolerance (Bunyavanich, Berin). Currently, there are limited studies on the role of prebiotic supplementation in food allergy prevention, and more research is needed to evaluate the benefits.

Another aspect of microbiome therapy involves probiotics, which are live organisms possessing health benefits when administered into the body (Sestito, et al.) (Figure 3).

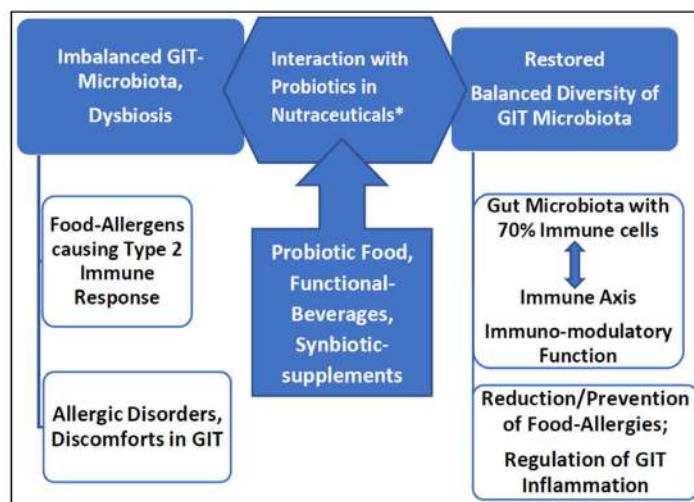


Fig 3. Probiotics aim to restore balanced diversity in the microbiota of the gut. If an individual has a food allergic disorder, this may be because of the imbalance of the microbiome. Taking probiotics may therefore result in reduction or prevention of food allergies.

There have been few clinical trials investigating the beneficial effects of probiotics on the development of food sensitization. However, when it comes to fully developed food allergy, research implies that probiotics may accelerate tolerance to foods. In a study on 55 infants with cow's milk allergy, either an extensively hydrolyzed casein formula (EHCF) or an EHCF supplemented with *Lactobacillus* GG (LGG) was given to the subjects. Those fed the EHCF supplemented with LGG exhibited augmented development of tolerance to cow's milk protein compared to the control group (Canani). There was another study looking at probiotics' effects on individuals with peanut allergy. Children with the allergy were given daily peanut oral immunotherapy (POIT), in addition to being given either a supplement of the probiotic

Lactobacillus rhamnosus CGMCC 1.3724 or with a placebo (control). The majority of those given POIT and the probiotic eventually became desensitized compared to those receiving POIT plus the placebo (Hsiao, et al.). There still needs to be further investigation into probiotics' role as a preventative or therapeutic agent for food allergies, and their use is currently only recommended for treatment of eczema.

New methods and approaches are being implemented in the field of the microbiome to better understand its role in food allergy. This involves analysis of diseased and healthy microbial populations to investigate commensal microbes and their influence on disease pathology, gut homeostasis, and immune response. There have been advances particularly in metabolomics, the study of metabolites in biofluids, tissues, or organisms. A method called untargeted metabolomic profiling has proved to be a powerful technique for dissecting altered pathways contributing to complex diseases. It is useful in that it reveals the genetic-environment-health relationship, as it can identify beneficial bacteria associated with a disease using their metabolomic "fingerprint." The bacteria can then be cultured and administered to the patient as treatment (Bunyavanich, Berin). The development of therapeutics for food allergy is still undergoing research, but areas such as targeted bacterial therapies so far look promising as treatments or preventatives.

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- **Judge Feedback:**

"Kathryn's work was recognized for its in-depth research, coherent structure, and clear, concise writing style. The feedback noted that her presentation clearly articulated her research process and the support she received from her tutor, summarizing her paper effectively. It was mentioned that her presentation was thoroughly enjoyable." You can check out the presentation [here](#).

- **Kathryn's Tips:**

If you have a tutor, take full advantage of their expertise — they can help you a lot in whatever you are researching.

Pick a topic that you are genuinely interested in. The more you invest yourself in the project, the better product you will put out.

Getting Involved: Steps to Complete an Online Research Project

1



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3



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