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# Evaluating The Feasibility Of Replacing Human Workforce With Physical Artificial Intelligence.

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***Abstract:*** The following study evaluates both the feasibility of replacing human workforce with Physical Artificial Intelligence (PAI), a term that has been developing rapidly over the past several years. **Materials and Methods:** We designed and utilised a "Feasibility Index" in order to accurately determine how possible it is to replace human workforce with PAI. In the Feasibility Index Formula, we would combine several crucial factors such as productivity gain, cost efficiency, reliability (R), quality (Q), safety (S), ethical/social acceptance (E) and technological maturity (T). We also analysed multiple published data and, in order to derive the required input values, conducted a custom public survey in regards to PAI in various roles, such as Robotaxis, Manipulators, Humanoids. **Results:** The results indicate Feasibility Index (FI) of 0, which is largely caused by low scores in adaptability (A=0) and social acceptance (E=0). Although Physical Artificial Intelligence shows significant advantages in cost efficiency (score of 2.75) and provides productivity gain (score of 1.30) for repetitive tasks, these scores are nullified due to the current technical immaturity and societal disapproval of Physical Artificial Intelligence. **Conclusion:** The obtained results strongly suggest that the widespread replacement of the human workforce is not currently feasible due to a low Feasibility Index, but it would be strongly beneficial and thus would need an extended period of time before it is accepted by the society, as it was the case with the adoption of the internet. **Index Terms -** Physical Artificial Intelligence, Workforce Automation, Feasibility Index, Social Acceptance, Robotic Adaptability.

## I. INTRODUCTION

The roots of Artificial Intelligence can be traced back to the 1940s, when a famous science-fiction novelist Isaac Asimov published a short story called the "Runaround". The story is about an artificially intelligent robot, developed by engineers, that evolves around the "Three Laws of Robotics". This story inspired many other future and contemporary scientists to contribute to the field of Artificial Intelligence [1]. The concept of Artificial Intelligence refers to entities that: a) did not occur biologically, unlike humans, animals, plants, etc.,which means that they were intentionally created and were created in a certain way to be intelligent; b) meet the condition of intelligence, that is, the ability to learn from past experience and to successfully respond to new ones, as per Webster Dictionary's definition of "intelligence" [2]. Another event that sparked great interest among scientists, specifically Alan Turing, is when the first "The Bombe", an Enigma code-breaking machine, was developed during the Second World War by Alan Turing. "The Bombe" was one of the first electro-mechanical computers and was able to break the Enigma code. This made Alan Turing question the potential intelligence of Computers and later prompted him to publish a seminal article "Computing Machinery and Intelligence".

In the first few decades of development of AI (1950s-1970s), major successes occurred. For example, in the 1960s, a famous ELIZA computer was created. ELIZA was able to simulate a conversation with a human and it was one of the first programs attempting to pass the Turing test. Another major success was the development of the General Problem Solving program that was able to automatically solve certain types of problems such as the Towers of Hanoi [1]. Later, in 1985-1995, as the concept of AI grew bigger, people started to have split opinions on Artificial Intelligence, generally dividing into 2 groups of "Scoffers" and "Boosters". "Scoffers" would find the idea of Artificial Intelligence ridiculous, denying the possibility of anything like a smart car, whereas the "Boosters" would actually believe that reaching the state computers with minds is inevitable and very close [3]. But how has Artificial Intelligence been doing since then? How much development has there been to this day and what is the current known state of AI? Ever since such great interest in AI was established, major developments have been made, which, over the course of many years, has benefited economically and also in other aspects of life [4]. One of the most notable examples is the use of Artificial Intelligence for administrative tasks within a clinic, which is something that an average nurse in the U.S. spends 25% of her/his time on [5]. However, the pros of AI also come at a cost. For example, AI chatbots like ChatGPT have been confirmed to greatly negatively affect one's brain engagement, cognitive abilities and creative thinking and the ability to think independently [6]. Having said that, there is another closely related field named "robotics", the main purpose of which was to help humans with heavy or dangerous labor. First, let's understand what Robotics is. The word "Robot" is derived from the Czech word "robota", which translates to "forced labour". The earliest form of Robotics emerged in the 1960s, when George Devol created a computer-controlled robotic arm that was used for heavy and dangerous tasks such as lifting or in car assembly lines, thus aiming to already replace humans [7]. Over the course of many years, robotics has advanced greatly and has already succeeded in overtaking some jobs. For example, robots are currently being used in household roles such as vacuum cleaners or pool cleaners, and in medicine as surgical robots or rehabilitation robots [8]. Evidently, these applications Robots as well as their development have greatly benefited the people, in most aspects of life, and it allowed people to explore areas that otherwise would have been difficult to explore, for example handling objects with High radiation. Further down the line in history, we are now in the era of Physical Artificial Intelligence (PAI), which is a combination of Artificial Intelligence and Robotics. PAI is a relatively new concept that, introduced in 2020 by Miriyev and Kovač and later redefined by Jensen Huang in 2025, focuses on exploring and developing robots that harness the power of AI in order to independently analyze circumstances, reason, plan, and execute tasks without continuous human involvement [9]. Some potential modern examples of PAI embody robotaxis that navigate safely, manipulators that perform complex industrial tasks in places like factories, and humanoid robots that work collaboratively or independently to perform human-like tasks. Let's dive in more detail about some of the most prominent uses of PAI in the modern world.

Robotaxis. The concept of a taxi, first emerged in the 17th century, has been around for about 4 centuries. The core concept of a taxi is the ability for the public to hire transportation services in a car or a horse-carriage, depending on what in the history we are looking at. The job of a taxi driver is simply to get the hirer to the final destination, which is something that Physical Artificial Intelligence is capable of learning and completing. For example, Artificial Intelligence can map out the routing, the specific operations done at a precise time, the turns made, the speed and other elements of the ride. Whereas the Physical "house" for AI can allow AI to embody and materialize the pre-determined actions. Major countries like Qatar are already actively implementing Robotaxis due to their reduced operational costs, labor savings, and electrification gains [10]. However, despite all the potential benefits of implementing robotaxis, in major countries like Qatar, there are also several key challenges to successfully implementing them, such as lack of proper infrastructure and charging stations [10]. Currently, one of the largest investments of the United States is the manufacturing of autonomous vehicles by companies like GM, Tesla and Ford, while in Europe they are Mercedes, Volvo and Audi.

Manipulators. As previously mentioned, the first form of robotics was a robotic "arm" created by George Devol in the 1960s. This was also one of the very first versions of manipulators that are used in the factory assembly lines nowadays, mostly used by industries like car manufacturing. These manipulators have been created with the purpose of accomplishing heavy, repetitive and sequential tasks that humans often would require more effort completing. Evidently, these manipulators have provided significant benefits to the human workforce. Rather than being deemed as a negative tool by overtaking some human jobs, industrial manipulators have increased the safety measures in contemporary factories, which is something that was undervalued in the 1940s-1980s. In addition to this, they have also allowed humans to complete tasks much faster, for example transporting heavy car parts or metal elements. However, as with any other invention, they come at a cost. Such industrial manipulators have high acquisition and maintenance costs, thus enabling mostly big businesses to utilize industrial manipulators, whereas the Small and Medium Size companies have to rely on human workforce, even for heavy and repetitive tasks.

Humanoids. Ever since the human gained consciousness about being, early in the history they have also tried creating artificial humans. This concept of an artificial human can also be seen in some fictional stories like the Pinnoccio. The concept of an artificial human describes a "thing" that resembles the traits of a biological, naturally-occurring human but is created in a non-biological or non-natural way. For example by carving out an artificial human from wood, as depicted in Pinnoccio. However, the concept of a humanoid is slightly different. A Humanoid is referred to as a "thing" that resembles a human being, was not created in a natural or biological way and is mostly composed of robotic elements. A Humanoid is simply a robot that has

Artificial Intelligence engraved into the program of it. The robot itself is used to resemble the physical aspect of a human being, whereas the AI is used to resemble the mental, thinking aspect of a human being. The physical aspect of an actual human being is composed of stability and strength. Stability is used mostly for movements like walking or running, whereas Strength is mostly used for activities like lifting or applying pressure. In the beginning, Humanoids did not possess the capacity to be as strong or stable as humans. However, in recent years, multiple universities have been making continuous improvements in Humanoids. For example, students at a Chinese University managed to successfully create a humanoid that became more stable than most human beings. The humanoid is capable of maintaining and regaining balance without falling to the ground even after being kicked in the back with strong force. This development, made in such a short amount of time, truly shows potential humanoids hold in overcoming physical human capabilities in the span of a few decades. However, regardless of the presence of such developments in humanoids, these humanoids are still not being used effectively in sectors like medicine, military and public service, and that is for a few reasons. Firstly, these humanoids cost a lot of money to produce and conduct research & developments on, and this is something that most companies are not able to afford. Secondly, these humanoids are not yet developed enough. Although there are physical advancements, there are also other aspects that need to be developed a lot in order to fully resemble a human being. These traits include critical and creative thinking, ability to quickly respond to tasks, mental sharpness and accuracy, conscience, ethical values, etc. Some of these aspects, such as conscience or mental sharpness, may even take much more time to implement into humanoids, due their nature of complex definition and lack of concrete guides.

## II. METHODOLOGY

In this study, a survey was conducted in order to measure the peoples' current thoughts in regards to Physical AI, and openly available sources were used to obtain and measure the feasibility of replacing human workforce with Physical Artificial Intelligence.

To measure the Feasibility index, the following symbols were used.

$P_H$ - Productivity of Human Workforce (I.e. the output per unit of time)
$P_{AI}$ - Productivity of AI/robotic system (I.e. the outputs per unit of time)
$C_H$ - Cost of Human Workforce (Salaries, training, benefits, etc.)
$C_{AI}$-Cost of AI workforce (Purchase, maintenance, energy, depreciation)
R - Reliability index of AI/robot system (Uptime percentage or mean time between failures)
Q - Quality consistency (Defect rate or error rate)
S - Safety Factor (Risk index or incidents per year)
E - Ethical/Social Acceptance (Scored 0–1 based on public and organizational tolerance)
T - Technological Maturity (Readiness level (e.g., 0–1 normalized from TRL scale))
FI - Feasibility Index

In order to understand the necessity of replacing human workforce with Physical AI, we must first understand if it provides any productivity gains and/or Cost Efficiency. We measure them using the following formulas:

1. Productivity gain = $\frac{PAI}{PH}$
2. Cost Efficiency = $\frac{CH}{CAI}$

Next, we need to calculate the actual feasibility of replacing the human workforce with PAI, using the following formula:

$$3. \quad FI = (\frac{PAI}{PH}) \times (\frac{CH}{CAI}) \times R \times Q \times S \times E \times T$$

Where if:

- FI > 1: AI replacement is feasible and advantageous
- FI = 1: AI replacement is neutral
- FI < 1: AI replacement is not currently feasible

Key Inputs:

1. Barosz, P., Gołda, G., & Kampa, A. (2020). Efficiency analysis of manufacturing line with industrial robots and human operators. *Applied Sciences*, *10*(8), 2862.

## III. RESULTS

In order to conduct a fair comparison of human and robot production, we must set them in equally advantageous environments. A parts manufacturing simulation [12] found out that robots produced about 867 pieces whereas humans produced about 664, both within 24 hours, therefore showing a 30% increase in production outcomes when robots are used. Using the productivity gain formula, we can deduce that:

$$Productivity\ Gain = \frac{PAI}{PH} = \frac{864}{664} = 1.30$$

Another study [13] measured and compared the cost of human labor and robotic labor, in a task where they had to dismantle a mobile phone. The study found out that the human workforce cost 3.31 eurocents per mobile phone, whereas the robot workforce cost 1.20 eurocent per mobile phone, thus showing a 36% increase in costs when it comes to the human workforce. Using the Cost efficiency formula, we can deduce that:

$$Cost\ Efficiency = \frac{CH}{CAI} = \frac{3.31}{1.20} = 2.75$$

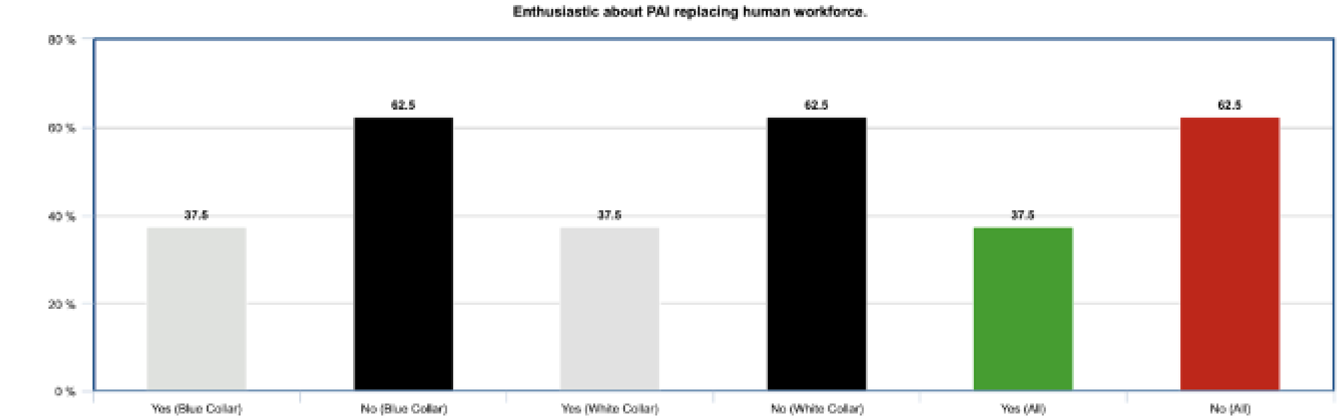
A survey conducted about industrial robots in Canada [14] shows that industrial robots had a MTBF (Mean Time Between Failures) of about 500-1000 hours with 1-8 hours being spent on repairs of robots. This gives an uptime percentage of about 99.2% for robots, which we can count as the R (Reliability index) of 0.992.

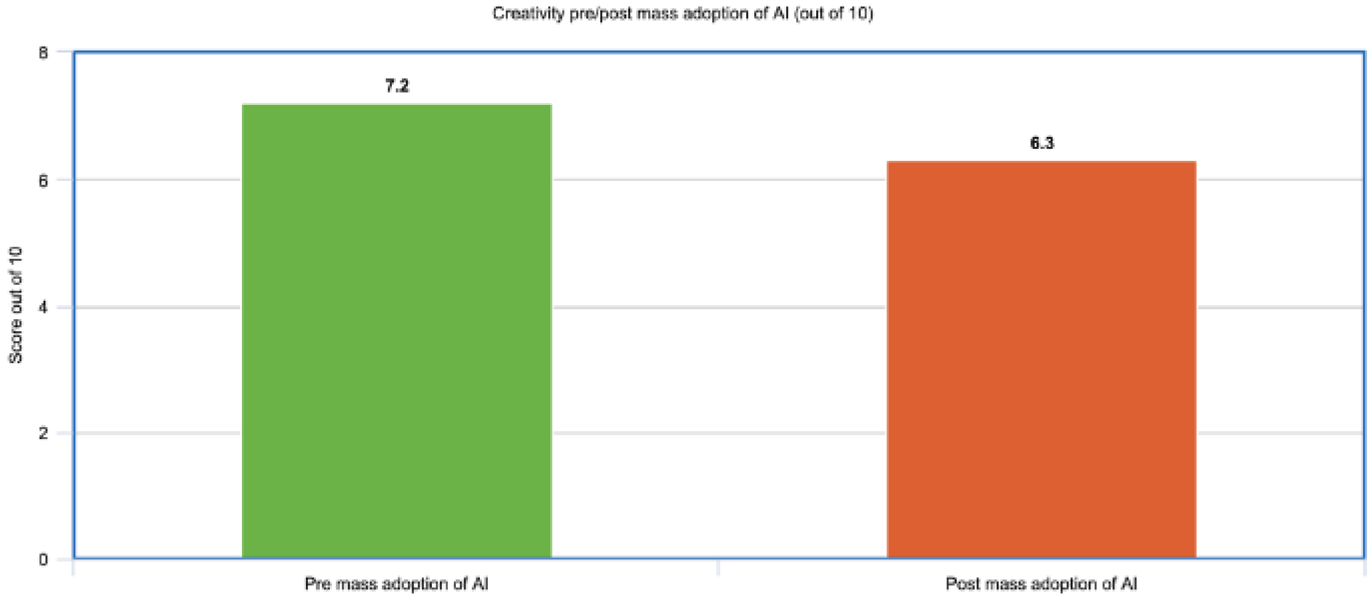
The Quality index (Q) of robots was considered as 99.9%, considered as a score of 0.99 [12]. As for the Safety Index of Robots (S), they tend to cause an average of 38 incidents per year [15], but we must convert it to a usable value of 0 or 1. To do this, we can use the following formula:

$$S = 1 - \left(\frac{Amount\ of\ Incidents}{Limit\ of\ Incidents}\right) = 1 - \left(\frac{38}{50}\right) = 1 - 0.76 = 0.24$$

Where, the Limit of Incidents indicates the acceptable amount of incidents that can occur before a workplace is deemed unsafe. Usually, a value of 50 (~1 Incident per week) incidents per year makes a workplace unsafe. From the formula, we see that the Safety index (S) is 0.24.

To measure the "E" (Ethical/Social Acceptance) of robots, a survey was conducted. The survey asked the following questions, where we scored 0 if the majority of people answered with a "No" and 1 if the majority of the people answered with a "Yes":




After the survey was conducted, following findings were made:

1. 62.5% of respondents had negative feelings towards robots replacing people both in blue-collar and white-collar jobs, with only 37.5% of respondents being enthusiastic. This gives it an "E" score of 0.37.
2. On a scale of 1-10, on average, people rated their creative and critical thinking skills as 7.2 (before mass adoption and access to AI). Compared to a score of 6.3 after mass adoption of and access to AI, this is a 12.5% drop in creative and critical thinking skills. This further outlines the negative effects of AI on people's mental independence.

3. On a scale of 1-10, people believed that people are not technologically prepared for mass adoption of Robots and Humanoids, giving an average score of 3.5, converted to the "T" score of 0.35.

To make the findings visually readable, we can present them in a table.

**Overview of findings**

| **Metric** | **Score** | **Source** |
|---|---|---|
| Productivity Gain $(\frac{PAI}{PH})$ | 1.30 | Barosz et al. [12] (867 vs 664 units) |
| Cost Efficiency $(\frac{CH}{CAI})$ | 2.75 | Šebo et al. [13] (3.31 vs 1.20 euro cents) |
| Reliability Index (R) | 0.992 | Canadian Industry Survey [14] |
| Quality Consistency (Q) | 0.99 | Barosz et al. [12] |
| Safety Factor (S) | 0.24 | Lee et al. [15] (Average of 38 incidents per year) |
| Social/Ethical Acceptance (E) | 0.37 | Primary Survey (62.5% negative sentiment) |
| Technological Maturity (T) | 0.35 | Primary Survey (Avg score 3.5/10) |

Using the Feasibility Index Formula, we can calculate that:

$$FI = (1.30) \times (2.75) \times 0.992 \times 0.99 \times 0.24 \times 0.37 \times 0.35 = 0.10$$

## VI. CONCLUSION

The finding suggests that the replacement of human workforce with Physical Artificial Intelligence is currently not feasible at this very moment, although it does provide slight signs of mass adoption, it would require an extended period of time before it becomes socially acceptable. Most likely, Physical AI has yet to go though the "Technology Trigger Phase" and reach the Peak of Inflated Expectations in the Gartner Hype Cycle, as we still have not seen a mass recognition of Physical AI. There are, however, robot-humanoids that have been recently developed, and are slowly entering the "Technology Trigger Phase" as more and more people are finding out about it.

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