Introduction

The growing hype around artificial intelligence (AI) and its potential societal benefits have burgeoned a significant focus of government spending worldwide. In 2016, the AI market accounted for $4,065.0 million worldwide, and the forecast for 2025 is $169,411.8 millions (Allied Market Research 2018). AI holds a huge promise to alleviate global concerns over global warming and healthcare access, providing advances in digital technologies (King and Roberts 2018; Nolan 2018). This notwithstanding, many scientists and policymakers have raised concerns about the ethical, societal and legal aspects of AI due to its fast-paced advancements, spanning from human-machine interactions and autonomous cars (Elsevier 2018). However, these ethical concerns mostly align with inequity from the perspective of the distribution of benefits from the use of AI and do not address inequity concerns related to the capacity for AI development and commercialization. Along these lines, the concerns over "inclusive AI" also revolves around the former rather than both aspects, which sheds light accounting for diversity (of gender, age, race, origin, etc.) in algorithms, datasets, and other learning mechanisms. This research tries to fill this void and address gender inequity concerns from the latter perspective: the scientific and technological development of AI.

Objectives

This study tries to address gender-related concerns around the scientific and technological development of artificial intelligence. It also provides a large scale, cross-country and disciplinary homogeneous gendered analysis of the scientific and technological productivity and impact of researchers involved in the development of the artificial intelligence technology. More specifically, this study maps to what extent women are involved in AI-related scientific and inventive activities by years, disciplines, high impact research, country and sector of affiliation, and collaboration types. Moreover, this study analyzes gender differences in the citation and journal impact AI-related articles when women are assigned to leading authorship positions. AtlC 2019

Methods

Article data is extracted from the Web of Science (WoS) database using the AI-related keyword dictionary (consulted with AI experts from the Institute for Data Valorisation (IVADO)) and patent data is extracted from the United States Patent and Trademark Office (USPTO) using the International Patent Classifications concordance for US class 708 (Data Processing: Artificial Intelligence). Field classification for articles is based on journals discipline by the U.S. National Science Foundation's (NSF) Science and Engineering (S&E) classification scheme, which assigns each journal to only one discipline. Gender will be further assigned to authors and inventors using the universal and/or their affiliated country name and gender lists, including U.S. Census, WikiName, Wikipedia, African lists, France and Quebec lists and other country-specific lists (more details can be found in (Larivière et al. 2013)). Author's affiliations and patent's assignees will be further categorized into academic, governmental, and industrial sectors using the keywords introduced in (Ghiasi et al. 2015). Since the full name of authors is only available starting from 2008 in WoS (which is essential to assign gender), we analyzed AI-related publications from 2008 onward.

This research relies on bibliometric indicators of scientific (and technological) output and impact and uses the number of scientific publications (and patents), normalized citations, and normalized journal Impact Factor (IF) to evaluate, respectively, scientific and technological productivity, scientific (technological) and journal impact. The proportion of the scientific (or technological) output of authors of each gender is defined as a fractional count of papers (or patents), according to which each author (or inventor) is given a 1/x count of authorships (or inventorships) where x account for the number of co-authors (or co-inventors) for which gender is assigned on given paper (or patent). This research defines authorship (inventorship) as these gendered fractions while being aggregated at country, discipline, and sector level. The citation impact of a paper (or patent) is measured as the average yearly number of citations received by a paper (patent) divided by the average yearly number of citations to all the papers from the same year, in the same discipline (or the same IPC) and of the same document type. The normalized journal IF is defined similarly, considering the IF of the journal in which a paper is published.

Findings

In this study we identified 69,675 total AI-related articles (from 2008-2017) and 83,520 AI-related patents (from 1976- 2016). Our findings reveal that women account for 23% of AI-related authorships. This share has constantly been increasing over the past few years (from 21% in 2008 to 25% in 2017) and is more pronounced in the field of Electrical engineering and electronics, applied mathematics, and neurology and neurosurgery. When women are in leading positions, either the first author or corresponding author, their publications are published in lower impact journals and receive lower citation rates. However, gender differences in journal ranks are less pronounced than those in citation rates. Most interestingly, women first-authored papers receive a higher rate of citations and are published in higher ranked journals than men first-authored papers, when the corresponding author (a proxy for supervisor of the research project) is a woman and vice versa. Our analysis of patents reveals that although there is a substantial increase in the number of patents, female inventorship is increased insignificantly (3% increase in 15 years). A higher share of women is involved in patents assigned to universities. Our results show that women are at a disadvantage when conventional scientific indicators (publication, patent and citation measures) are applied for evaluative purposes in the field of artificial intelligence. Although policy efforts around inclusive AI have become more significant in the science and technology discourse, initiatives to involve and retain women in AI R&D have not been effective. This study could serve as a baseline from which to strengthen gender mainstreaming in AI-related scientific and inventive activities.

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