Exploring Global Gender Gaps in the Blockchain Domain: Insights from LinkedIn Advertising Data

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***Abstract*—Blockchain technology has gained widespread attention through Bitcoin, but the blockchain domain is still striving to increase gender diversity and widely assess skills gaps by gender. There is limited awareness of women's participation in blockchain, prompting this study to assess and explore global gender gaps in interests, skills, and professions within the field. By analyzing gender-disaggregated data from LinkedIn's advertisement platform, we reveal that women are significantly underrepresented in blockchain compared to men, with the gender gap being even more pronounced than in the broader IT sector. This study delves into the volume, velocity, variety, veracity, and value that LinkedIn Ad data offers to assess gender gaps in the blockchain domain at a global level.**

***Index Terms*—LinkedIn Ad data; gender gaps in the blockchain interests; gender gaps in the blockchain skills; gender gaps in the blockchain jobs; mining of social media data.**

I. Introduction

The Blockchain technology uses cryptographic protocols to provide a decentralized ledger of transactions across a peer-to-peer network [1]. While it is probably best known for its application in decentralized finance, such as Bitcoin, the technology itself can be used for handling all sorts of transaction records and attributes [1].

The use of blockchain technology in areas outside of finance has been limited, and the technology is, understandably, often seen as being over-hyped. However, the blockchain technology has left footprints in multiple sectors with successful use cases [1]. While the long-term trajectory of blockchain technology remains uncertain, this domain has seen significant growth over recent years, with spending and funding expected to continue increasing [2]–[4].

The blockchain domain highlights significant shortcomings in diversity and inclusion, particularly in the USA context. A study of the top 100 blockchain start-ups revealed that merely 14.5% of blockchain start-up members are women, and only 7% are in leadership positions [5]. Recognizing these shortcomings, conducting a focused *blockchain skills gap assessment by gender* is crucial for several reasons. First, this assessment brings visibility and awareness to gender disparities within the blockchain workforce. Second, this assessment establishes a baseline for strategic workforce planning. Third, this assessment provides essential guidance for effective recruitment and training.

Previous studies have examined the blockchain skills gap by gender, focusing on areas such as blockchain use [6]–[8], blockchain ownership [9]–[12], and blockchain development [5], [13]. These assessment primarily relied on traditional data collection methods like surveys and interviews, which, while valuable, do not fully capture timely and scalable trends. As such, employing big data approaches, such as analyzing social media data, can provide a valuable perspective on the blockchain skills gap by gender.

This motivates us to conduct blockchain skills gap assessment by gender using innovative data source retrieved from LinkedIn Ad data. Given its widespread use, LinkedIn maintains an extensive database of expertise and skills, rendering it the optimal resource for examining and assessing skill proficiency [14]. Accordingly, this is the first initiative to assess the blockchain skills gap by gender using LinkedIn advertisement data[1].

To begin the assessment, we identified a lack of knowledge regarding the extent of participation in the blockchain domain, not only in terms of skills, but also in terms of interests and professions. Furthermore, the global scale of gender disparity in the blockchain field is not well-researched. Correspondingly, the aim of this paper is to build on previous work that looks at gender gaps in the blockchain domain [5], [7], [9], [13] by: 1) quantifying the magnitude of the gender gap in the blockchain domain, and 2) comparing global variations in gender gaps in the domain.

The contribution of this paper is to harness the potential of big data retrieved from LinkedIn advertisement data (LinkedIn Ad data) to assess gender gaps *globally* in blockchain interests, skills, and jobs. In this work, we place a strong emphasis on the *volume*, *velocity*, *variety*, *veracity*, and *value* that LinkedIn Ad data offer to derive purposeful insights into gender gaps in the blockchain domain.

II. Literature Review

A. Gender Gaps in the Blockchain domain

Researchers have highlighted the issue of gender imbalance in the blockchain domain. According to several studies, males are more likely to use cryptocurrencies than their female

[1]Learn more about LinkedIn advertisement data: https://www.linkedin.com/help/lms/answer/a427233.

counterparts. Research by the Pew Research Center shows that 22% of males have used cryptocurrencies, compared to only 10% of females [6], [7]. A study of 1193 people also found that the majority of cryptocurrency users were male [8]. Similarly, research found that women in India were less willing to use cryptocurrencies than men [15].

Several studies have revealed that males are more likely to own and invest in cryptocurrencies compared to their female counterparts. Researchers found that males are three times more likely than females to buy and use cryptocurrencies [9]. Studies have observed that males are more willing to invest in cryptocurrencies than females in China and Australia [10], Spain, [11], and USA [12]. Gender also appears to be a factor in cryptocurrency ownership and investment in the Czech Republic, the USA, and Germany [16]–[18], respectively.

Several studies have argued that males are more likely than their female counterparts to contribute to the development of cryptocurrency-related technologies [13]. For example, women constitute a small proportion of developers, enthusiasts, experts, and employees in blockchain startups, as well as in blockchain meetups and events panels [5]. Studies have also argued that, in the short history of blockchain, the male-dominated sphere has fueled stereotypes of wealthy "Blockchain Bros" [19]. Women might face barriers that prevent them from advancing in blockchain-related occupations including biases, lack of literacy, skills, confidence, or preferred personality traits [10], [18], [20]–[22].

B. Social Media Advertising Data to Assess Digital Gender Gaps

Prior research has demonstrated the value of social media advertising data, but has not explored its application to the blockchain domain. Researchers including [23] used Facebook advertising data to measure gender gaps in internet use across 193 countries and found strong correlations with official statistics on internet and mobile phone gender gaps. Similarly, research reported an association between the Facebook Gender Divide and indicators of economic, health, and education inequality [24]. In India, researchers measured digital gender gaps at the subnational level and found that more developed states had more gender-balanced Facebook usage [25]. Social media advertising data has also been used to reveal patterns related to gender gaps in skills, education, and employment. For example, researchers found that gender gaps in Facebook advertising data were correlated with digital skills such as sending emails with attached files or using copy-and-paste tools [26]. Research used LinkedIn advertising data to examine gender gaps in industries and skills across the USA and found that education and medical/health were female-dominated on LinkedIn [27], while industries and skills related to the technology domain were male-dominated in terms of user count [27]. Similarly, research found that globally, there were more men than women in IT on LinkedIn [28]. Additionally, gender inequality on LinkedIn is more significant among older individuals, those who have studied or worked in STEM sectors and industries, and among higher levels of job seniority [29]. In Italy, LinkedIn advertising data revealed that women are under-represented in the workforce [30]. These research studies aknowledged that LinkedIn advertising data could complement official statistics.

C. Gap in Knowledge

Since the inception of Bitcoin, the blockchain space has expanded significantly, redefining our interactions with both digital and physical worlds. Despite the gender disparity in tech careers is still glaring, blockchain technology offers a unique opportunity for women to be part of the next major leap in tech and finance. Although gender gaps in blockchain have been explored in terms of use [8], ownership [18], and development [13], global participation by women remains underexamined due to varying methodologies and frameworks. Moreover, the potential of novel data sources, such as digital trace data and social media, has not been fully harnessed to address this issue. Recognizing the value of such data, this research take a big data perspective by using LinkedIn advertising data (LinkedIn Ad data) to measure global gender gaps in blockchain interests, skills, and professions. By doing so, this paper aims to provide a more holistic understanding of women's participation in this emerging field, highlighting the value that LinkedIn Ad data grants.

III. Data and Methodology

We collected anonymous, aggregate estimates on the numbers of LinkedIn users with certain characteristics by querying the ad campaign manager [2] via its application programming interface (API). We relied on "query suggestions" to collect data on each characteristic [31]. We collected data on blockchain interests, skills, and job titles from LinkedIn using query suggestions as a basis [32]. For example, we included queries suggested by LinkedIn in the data collection process, such as when the platform suggested "Hyperledger Fabric" as a blockchain skill. In order to collect LinkedIn ads data, we sent API queries to LinkedIn advertising using an HTTP request[3]. This data was collected in July 2022 for 190 countries, two genders (female and male)[4] and the following attributes: Blockchain Interests, Blockchain Skills, Blockchain Job Titles, Relevant ICT Skills (reference skills), IT (reference domain), and Overall LinkedIn Users (reference baseline). Table I shows all the LinkedIn ads targeting attributes and sample size.

Using this data we compute gender gaps in terms of a gender gap index (GGI), defined as follows:

$$\text{GGI on LinkedIn} = \frac{\text{Number of female LinkedIn users with characteristic x}}{\text{Number of male LinkedIn users with characteristic x}} \quad (1)$$

The GGI was computed for blockchain interests, blockchain skills, blockchain job titles, reference skills, IT, and LinkedIn

[2]Learn more about targeting on LinkedIn: https://business.linkedin.com/content/dam/me/business/en-us/marketing-solutions/resources/pdfs/linkedin-targeting-playbook-v4.pdf.

[3]Data collection tutorial: https://worldbank.github.io/connectivity_mapping/linkedin_nbs/interface.html.

[4]LinkedIn's advertising platform offers these binary genders for targeting.

Attributes	Targeting Attributes of Interest	Sample size
Blockchain Interests	Interests and Traits → Member interest: Blockchain Technology	175 observations
Blockchain Skills	Job Experience → Member Skills: Solidity, Smart Contract, Hyperledger, Blockchain Analysis, Blockchain Architecture, Blockchain, Hyperledger Fabric, and Ethereum	78 observations
Blockchain Job Titles	Job Titles → Blockchain Consultant, Blockchain Developer, Chief Blockchain Officer, Blockchain Strategist, Blockchain Specialist, Blockchain Lead, Blockchain Intern, and Blockchain Analyst	4 observations
Relevant ICT Skills (Reference Skills)	Member Skills → Software Development, Data Mining, Data Analytics, and Algorithms	Software Development: 135 observations, Data Mining: 127 observations, Data Analytics: 151 observations, and Algorithms: 93 observations.
IT (Reference Domain)	Company → Company Industries: Information Service, IT service, Computer and Network Security.	165 observations
Overall LinkedIn Users (Reference Baseline)	LinkedIn Users	190 observations

TABLE I
LINKEDIN ADS TARGETING ATTRIBUTES AND SAMPLE SIZE

users. GGI values below 1.0 indicate that women are underrepresented relative to men, while values above 1.0 indicate that women are overrepresented. This measure is in line with the methodology used in the World Economic Forum Global Gender Gap Report [33] and other work modeling digital gender gaps using social media advertising data [26], [29]. We selected this the Global Gender Gap Index methodology because it facilitates meaningful comparisons between our measures and other measures within different datasets (including the World Economic Forum Global Gender Gap Index Indicators). By aligning with this established framework, we ensure that our analysis can be benchmarked against widely recognized global standards.

IV. FINDINGS AND RESULTS

A. *Gender Gaps in Blockchain Interests*

Figure 1 top shows the GGI in blockchain interests (y-axis) in relation to the GGI in LinkedIn users (x-axis) and GGI in general IT employment (Figure 1 bottom) for a total of 175 countries. Our dataset contains only two countries with GGI values in blockchain interests > 1 (Bhutan and Samoa), indicating a general male dominance on LinkedIn in blockchain interests. We collected data for 190 countries, but had to exclude countries with fewer than 300 women matching our criteria, the minimum reported by LinkedIn, due to sparsity. North America, Europe, and Australia/Oceania have the highest average GGI values in blockchain interests (0.60), while Africa has the lowest average GGI values in blockchain interests (0.40). The USA, Canada, and France have similar GGI values in blockchain interests (0.58), while Germany, Japan, and India have similar GGI values in blockchain interests (0.41). We also observed a strong positive correlation (r = .867, p $<$ 2.2e-16) between gender gaps in blockchain interests and gender gaps in LinkedIn users overall. Furthermore, only two countries have higher GGI values in blockchain interests than GGI values in LinkedIn users. Similarly, we observed a strong positive correlation (r = .933, p $<$ 2.2e-16) between gender gaps in blockchain interests and gender gaps in working in the IT domain. While exhibiting more similar values in general, a majority of countries (173 out of 175) showed a smaller, i.e. more male-dominated, GGI for blockchain interests.

B. *Gender Gaps in Blockchain Skills*

Whereas Figure 1 looked at blockchain *interests*, Figure 2 displays the GGI in blockchain *skills* (y-axis) in relation to the GGI in IT for a total of 78 countries. As employment in IT demonstrated a more similar gender gap pattern than overall LinkedIn usage, we only compare the GGI in blockchain skills with the GGI in IT in this section. There is a positive correlation between gender gaps in blockchain skills and gender gaps in working in the IT domain (r = .541, p = 3.097e-07). All the countries in our dataset have a GGI value in blockchain skills < 1. This illustrates that blockchain skills are predominantly male-dominated. Asia has the highest average GGI values in blockchain skills (0.36), while South America has the lowest average GGI values in blockchain skills (0.22). Among the most significant world economies, China has the highest GGI values in blockchain skills (0.48), followed by the USA (0.38), Canada (0.32), India (0.28), Japan (0.25), France (0.22), and Germany (0.21). As almost all countries in Figure 2 are below the identity line, this suggests that the gender gaps in blockchain skills are more pronounced than those of overall IT employment.

To gain a deeper understanding of blockchain-specific gender skill gaps, we collected audience counts for four "reference" IT skills as comparative baselines – Software Development (SD), Algorithms (ALG), Data Mining (DM), and Data Analytics (DA) – and computed the GGI for them. In each case, there was a positive and statistically significant correlation between the GGI in blockchain skills and the reference skill (SD: r = .760, p = 6.989e-16; ALG: r = .763, p = 2.627e-11; DM: r = .683, p = 5.164e-12, and DA: r = .463, p = 1.975e-05). Most countries have higher, i.e. more gender-equal, GGI values for reference skills than for blockchain skills.

C. *Gender Gaps in Blockchain Job Titles*

Viewed in a sequence of increasing engagement, having a blockchain-related job title is the culmination of the interest-

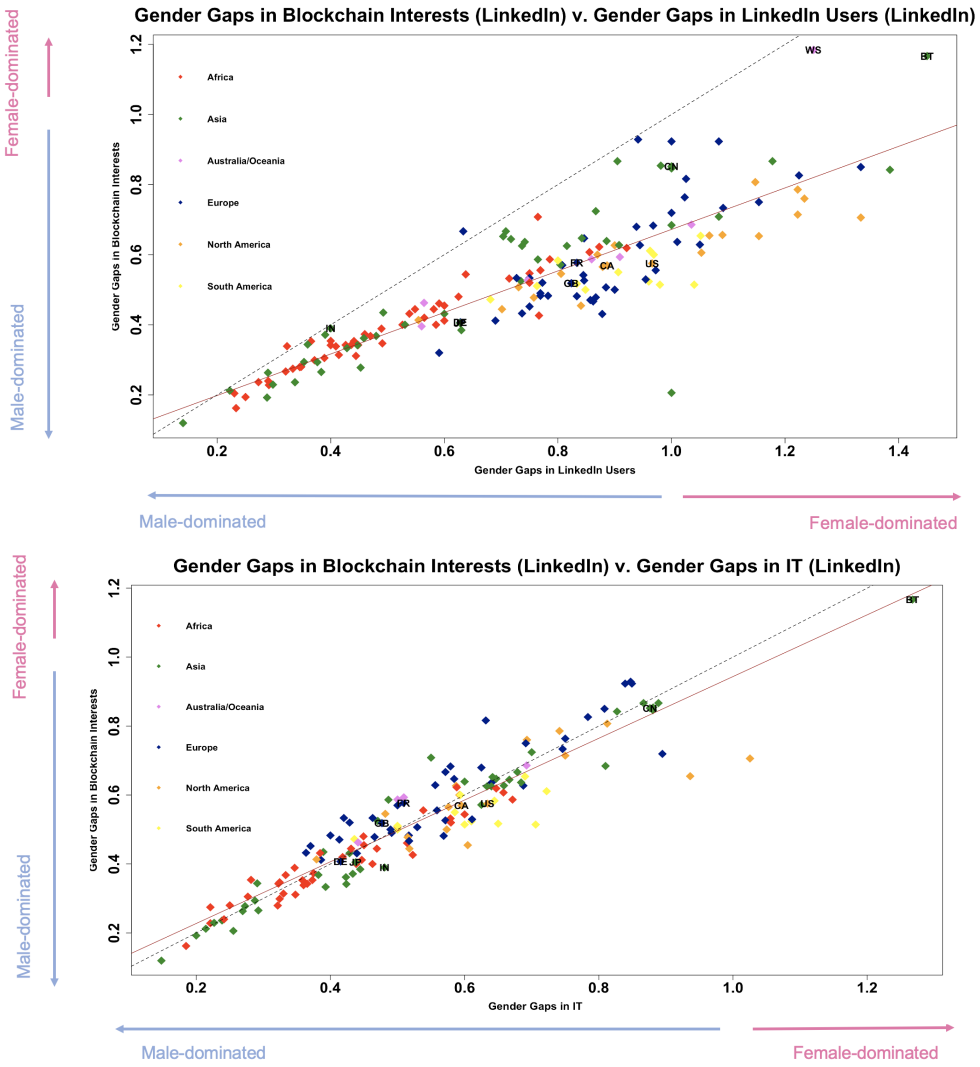

Fig. 1. Gender gaps in blockchain interests (y-axis) vs. (Figure 1 top) gender gaps in LinkedIn users (x-axis) and (Figure 1 bottom) gender gaps for working in IT on LinkedIn (x-axis): the dashed maroon line is the regression line, while the dotted diagonal line is the x=y identity line. The country code for the top economies by GDP and countries with GGI values in blockchain interests >1 is annotated. The figures show that blockchain interest is highly male-dominated on LinkedIn

to-skills-to-employment ladder. To understand the progression along this ladder, the dot plot in Figure 3 presents the GGI values for working in IT (the large grey dot) compared to the GGI values, in terms of delta, for blockchain job titles, blockchain interests, blockchain skills, and overall Linkedin users. For the four countries with a non-sparse GGI values in job title (US, UK, Canada, and India), the GGI is lowest, i.e. most biased against women, for the job titles, with slight improvements for the GGI for skills, and, finally, interests. Figure 3 also presents GGI values for the additional four countries with the biggest economies based on GDP, which are not included already (China, Japan, Germany, and France). Consistent with the previous finding, for all of these countries, the GGI for blockchain skills is lower than for blockchain interests.

D. Gender Gaps in the Blockchain domain Indices and Global Gender Inequality Indices

To test whether the gender disparities in our LinkedIn blockchain interests, skills, and job titles are more or less pronounced than other global gender inequality metrics, we analyzed additional datasets provided by The World Economic Forum and The World Bank. The first dataset is The World Economic Forum Global Gender Gap Indices 2022 [33], which includes measures of the overall Global Gender Gap Index along with additional subsets of gender gap measures covering educational attainment, health, political empowerment, and economic participation. We examined the correlation between the LinkedIn Gender Gaps in blockchain Interests (including 175 countries) and Global Gender Gap Indices (including 146 countries). We found a significant positive correlation between

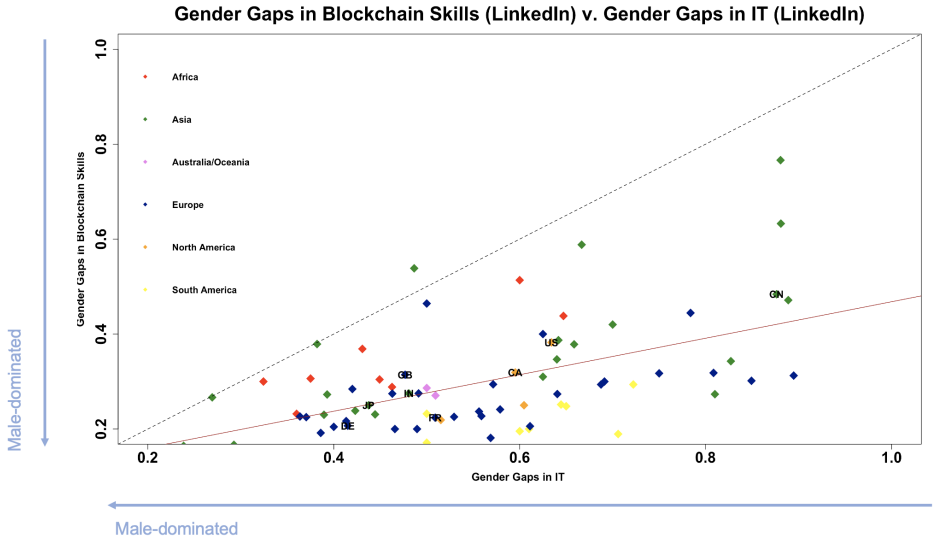

Fig. 2. Gender gaps in blockchain skills (y-axis) versus gender gaps for working in IT on LinkedIn (x-axis): the dashed maroon line is the regression line, while the dotted diagonal line is the x=y identity line. The country code for the top economies by GDP is annotated. The figure shows that the acquisition of blockchain skills is highly male-dominated on LinkedIn

the two variables (r = .416, p = 7.818e-07), suggesting that our gender gaps in our LinkedIn-based blockchain interests indices are aligned with the gender egalitarian countries. We also found a significant positive correlation between the gender gaps in blockchain interests and other subsets of gender gap measures of educational attainment (r = .503, p = 9.239e-10), health (r = .232, p = 0.008), and economic participation (r = .408, p = 1.318e-06). Upon closer examination of the professional and technical workers sub-indicator under economic participation, we found a positive association between the gender gaps in blockchain interests and the aforementioned indicator (r = .602; p = 1.808e-13). We looked at the correlation between the LinkedIn Gender Gaps in blockchain skills (including 175 countries) and Global Gender Gap Indices (including 146 countries). The results indicate a significant positive correlation between the Gender Gaps in blockchain skills and gender gap subset measure of educational attainment (r = .207, p = 0.041), suggesting that our gender gaps in our LinkedIn-based blockchain skills indices are aligned with the educational attainment measures in gender egalitarian countries. In addition, we assessed the relationship between the Gender Gaps in blockchain job titles on LinkedIn and the Global Gender Gap Indices. However, we did not find any significant association between these two variables. The second dataset is The World Bank GINI index dataset [34], which measures income inequality within a country based on primary household survey data obtained from government statistical agencies and World Bank country. After measuring the correlation between gender gaps between each of the blockchain indices and the GINI index across countries, we did not find any significant correlation between the variables (interests: r = -.133, p = .163; skills: r = -.154, p = .169; and job titles: r = .155, p = .566). These results suggest that our LinkedIn-based blockchain indices are not in line with the income inequality indices.

V. Discussion

This paper proposes using LinkedIn Ad data to assess gender gaps in the blockchain domain, particularly in terms of interests, skills, and professions at a global level. Building on previous work, less focused work that also used LinkedIn Ad data to monitor gender gaps [27]–[29], our work is the first to take a big data perspective using LinkedIn ad data, rather than relying on traditional methods such as surveys, to assess gender gaps in the blockchain domain. First, we focused on measuring gender gaps in blockchain interests, skills, and professions. Our findings align with previous studies that have revealed a higher-than-average level of gender inequality in blockchain usage [6], ownership [9], and expertise [5]. However, our research expands on these previous works by highlighting other vital dimensions related to gender gaps in participation in the blockchain domain, covering interests, skills, and professions. Our findings also confirm that these dimensions exhibit higher-than-average levels of gender inequality. The gender gaps in the blockchain domain (specifically in blockchain skills) that we observe are wider than the gender gaps in the more general IT domain on LinkedIn. Second, our work is the first to focus on gender gaps in the blockchain domain *at a global level*. Previous studies examining gender gaps in the blockchain domain have been limited in scope, as they have been conducted in only one country (such as USA only [18]). This has led to difficulties in drawing global conclusions due to the fragmentation in frameworks and methodologies used in each study. Therefore, our research enables comparisons to be made regarding gender gaps in the blockchain domain covering 190 countries. Validating our

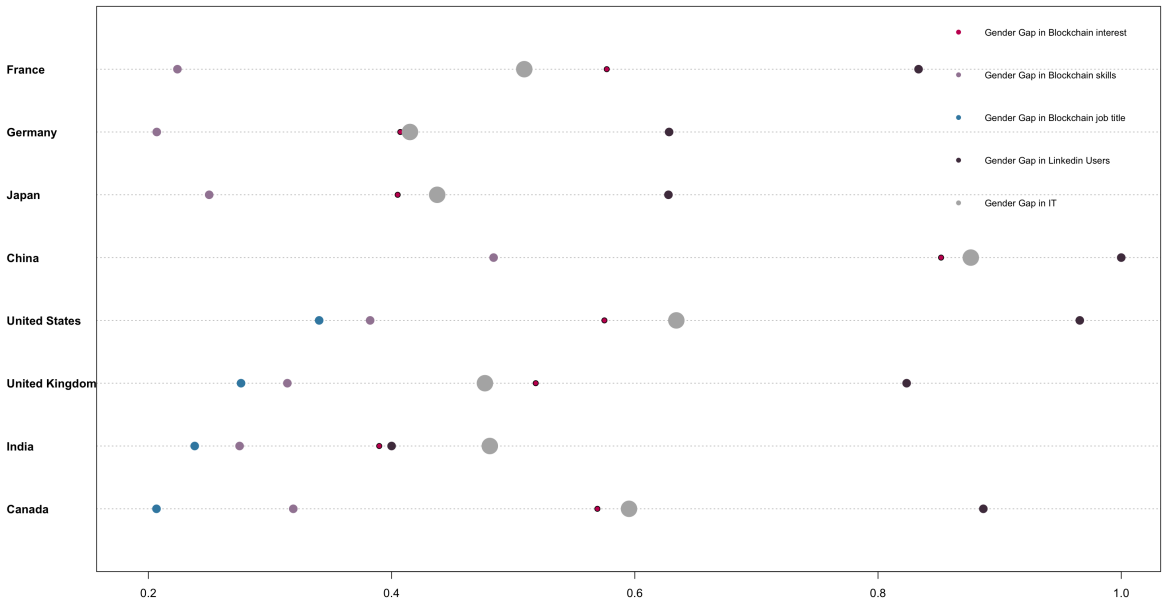

Fig. 3. Gender gaps in blockchain interests, skills, job titles, IT users, and LinkedIn users, relative to the GGI for working in IT (the large grey dot). The figure shows that blockchain employment is the most male-dominated

findings, the gender gaps we perceived in the LinkedIn-based blockchain data indices are associated with external global gender gap indices, significantly indices related to educational attainment. Consequently, our work contributes to previous work by zooming in on different dimensions and zooming out on the global sphere.

This research contributes by highlighting the potential of LinkedIn Ad data to provide: 1) *volume:* by collecting hundreds of data points related to blockchain interests, skills, and professions as well as reference ICT skills and domain. LinkedIn Ad data provides access to a vast amount of data to study the gender gaps in the blockchain domain, rather than relying on retrospective traditional data collection methods; 2) *velocity:* by streaming data points in real time to derive timely insights into the topic of gender gaps in the blockchain domain, rather than relying on periodic traditional data collection methods; 3) *variety:* By corroborating multiple data sources from LinkedIn and other official statistics, we specifically retrieve unstructured LinkedIn Ad data and organize it into structured data. The official statistics from the World Economic Forum and the World Bank were already available as structured data. As such, our research draws from a wide range of data sources (structured and unstructured); 4) *veracity:* by validating LinkedIn Ads data with other global gender inequality metrics—covering educational attainment, health, political empowerment, and economic participation—we were able to cross-check and corroborate our findings. Correlating data from sources such as LinkedIn Ads, the World Economic Forum, and the World Bank helped ensure that the gender gaps observed in the LinkedIn-based blockchain data indices align with external global gender gap indices; and 5) *value:* by uncovering and analyzing patterns and relationships within LinkedIn Ad data, we have gained valuable insights into assessing gender gaps in the blockchain domain across three different dimensions on a global scale. These insights encourage targeted actions to raise visibility and awareness of gender disparities within the blockchain workforce and to design effective strategic workforce planning, including recruitment and training.

A limitation of our data is that it relies on self-reported gender (reported as binary: female or male), and profiles of LinkedIn users. Hence, one could argue that we are merely measuring differences in self-presentation, not in actual interest, skill, or employment [35]. However, other work has experimentally shown a causal impact of using LinkedIn on job outcomes [36]. In a similar vein, we only considered LinkedIn ads data for this study, and this data may not accurately reflect the entire population interested in or working in blockchain. As another limitation, LinkedIn does not provide small audience estimate counts (< 300 users) to provide a kind of k-anonymity [37] and protect user privacy. This results in sparsity and the inability to look at blockchain employment gender gaps for most countries, as blockchain-related job titles are still rare on LinkedIn.

Future studies might focus on understanding gender gaps in the blockchain labor market by looking at other novel data sources, such as Twitter ads audience estimates, Google ads impressions, and Google trends. Additionally, it might be promising to collect data from LinkedIn and other sources to relate our findings with other dimensions, such as job

openings related to blockchain, soft and hard skills, and other educational and development indices. We might also consider expanding the set of attributes to provide a more comprehensive view of gender gaps by, for instance, including educational background or years of experience.

VI. Ethics

The data we collected is anonymous and consists of aggregate user counts. Data access will be granted solely for academic purposes.

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