Bridging the Gap: Industry 4.0's Role in Addressing the Gender Pay Disparity – A Literature Review

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ABSTRACT

This study addresses the persistent issue of gender pay disparities in the context of Industry 4.0, where technological advancements have the potential to both exacerbate and alleviate existing inequalities. This research aims to explore how the integration of Industry 4.0 technologies can promote gender equality in the workplace, particularly regarding pay equity. A comprehensive literature review reveals that while Industry 4.0 offers opportunities for increased productivity and efficiency, it also poses challenges, such as the risk of further marginalizing women if their contributions and needs are overlooked in technological adoption (Miah, 2024; Zervoudi, 2020). The main findings indicate that organizations that proactively implement gender-sensitive policies and practices alongside technological advancements are better positioned to reduce pay gaps. Additionally, fostering collaboration between academia, industry, and policymakers is essential for creating an inclusive ecosystem that supports equal pay initiatives. The implications of this study underscore the necessity for policymakers to design regulations that ensure transparency in pay structures and promote inclusive training programs in emerging technologies. By addressing these issues, stakeholders can leverage Industry 4.0 not only to enhance economic productivity but also to foster a more equitable labour market, ultimately contributing to broader societal goals of gender equality.

Keywords: Industry 4.0, Gender Pay Gap, Gender Equality, Automation, Female Workers.

INTRODUCTION

Industry 4.0, also known as the Fourth Industrial Revolution, represents a transformative shift in the industrial sector, marked by the integration of advanced digital technologies such as automation, artificial intelligence (AI), and the Internet of Things (IoT) into manufacturing and other industries. These technologies have reshaped the workforce by optimizing production processes, increasing efficiency, and fostering new job roles focused on data analysis and digital solutions (Rupp, 2021). However, this revolution has also prompted significant changes in employment patterns and wage structures, raising concerns about its effect on existing inequalities, particularly the gender pay gap. Historically, this gap, where women earn less than men for equivalent work, has persisted due to systemic biases, occupational segregation, and unequal access to opportunities (Pew Research Center, 2023). This article explores how Industry 4.0's technological advancements might influence wage inequality, potentially exacerbating or reducing the gender pay disparity through shifts in job roles, skill requirements, and employment practices.

Technological advancements such as automation, AI, and IoT, central to Industry 4.0, have transformed industries by boosting efficiency and productivity through interconnected, intelligent systems (SAP, 2024). Automation has led to new job roles in technology management, data analytics, and machine learning while

displacing traditional roles, especially in manufacturing. These changes have reshaped wage structures, often creating a divide between high-paying positions requiring advanced technical skills and lower-paying roles susceptible to automation (McKinsey, 2022). The effects of wage inequality are complex; while some sectors benefit from increased demand for skilled labour, others, particularly manufacturing, face increased inequality due to job displacement and reduced demand for unskilled labour (Pew Research Center, 2023). Consequently, Industry 4.0 has the potential to both reduce and widen wage gaps, depending on how these technologies are implemented across industries.

The adoption of Industry 4.0 technologies, particularly automation and AI, has significantly impacted wage disparities between men and women, especially in industries where these innovations are rapidly being adopted. Research indicates that increased robotization tends to widen the gender pay gap. For instance, a 10% rise in robotization correlates with a 1.8 percent increase in the gender pay gap in European sectors, as men typically dominate higher-paying technical roles while women remain underrepresented in these fields (Aksoy et al., 2021). In industries like manufacturing, wage polarization has occurred, with women often in lower-wage jobs more vulnerable to automation. Case studies highlight how women's underrepresentation in key areas of Industry 4.0, such as IT and AI, perpetuates wage inequality, as men continue to occupy most high-paying, skilled positions (Serrano, 2023). These findings underscore the need for targeted efforts to ensure women are not left behind in the technological revolution driven by Industry 4.0.

Despite these challenges, Industry 4.0 offers significant opportunities to address the gender pay gap by enabling flexible work environments, such as remote work, that can increase women's workforce participation. Automation of low-paying jobs can free women from traditional roles, enabling them to pursue higher-paying positions requiring specialised skills. Additionally, upskilling and reskilling initiatives focused on tech-driven roles, such as AI, data science, and cybersecurity, can help women gain a foothold in traditionally male-dominated fields. Various policies and initiatives support these advancements, promoting digital literacy among women and incentivising companies to ensure equal pay and opportunities in high-tech sectors (World Economic Forum, 2018). By fostering a more inclusive workforce and reducing barriers to entry in tech-heavy industries, Industry 4.0 could significantly contribute to narrowing the gender pay gap.

A critical research gap in existing literature lies in the limited data linking technological advancements in Industry 4.0 to wage disparities, particularly across sectors heavily integrating these technologies. While automation and digitalisation present opportunities to narrow the gender pay gap, challenges such as unequal access to STEM education, gender biases in hiring for tech roles, and the underrepresentation of women in leadership persist. This article aims to analyse how Industry 4.0 influences gender wage gaps, identify barriers preventing pay equity in tech-driven sectors, and propose policy recommendations to address these challenges.

The article is structured into six sections: an introduction to Industry 4.0 and the gender wage gap, a literature review summarising key findings on wage disparities and employment trends, an analysis of how Industry 4.0 technologies affect wage inequality, and an exploration of the potential challenges preventing full realisation of gender pay equity in tech-driven industries. The conclusion provides future research directions and actionable recommendations for governments, industries, and educational institutions, emphasising the need for targeted interventions, such as promoting equal access to digital education and implementing gender-sensitive hiring practices, to mitigate these disparities.

LITERATURE REVIEW

Industry 4.0, also called the Fourth Industrial Revolution, is a transformation in industries powered by emerging technologies such as artificial intelligence (AI), the Internet of Things (IoT), robotics, and data analytics. These advancements have drastically changed how companies operate, with automated and data-driven processes increasingly taking over traditional labour functions. The gender pay gap is the difference in earnings between men and women, typically expressed as a percentage of male earnings. Generally, the gender pay gap disadvantaged women through lower hourly earnings, fewer hours of paid work, and lower employment rates, which also can be explained by gendered sector affiliation and the high share of typical

employment among women (Landmesser, et al., 2020). Both global and Malaysian contexts highlight the need for comprehensive policies to harness Industry 4.0's potential to foster gender equality. These include gender-focused education initiatives, equitable access to digital training, and industry policies that encourage diversity in high-skill fields. By addressing these gaps, it is believed that Industry 4.0 can evolve from a driver of economic disparity into a tool for gender equity.

The gender pay gap has evolved over decades, influenced by societal norms, policy changes, and shifts in workforce participation. In the early 20th century, wage disparities were more severe as women had limited access to many professions. As women entered the workforce in greater numbers mid-century, particularly during World War II, there were incremental shifts, but discrimination persisted. Despite anti-discrimination laws and social movements advocating for gender equality, the pay gap has narrowed only gradually in recent decades. In some cases, industries with an influx of female workers have seen lower wage growth compared to male-dominated sectors, reflecting an undervaluation of "women's work" (Economic Policy Institute, 2016).

Industry 4.0 and Impact on Gender Pay Disparities

Globally, Industry 4.0 has a mixed impact on gender pay disparities. While it creates high-skilled job opportunities in fields such as IT, data science, and engineering, it also exposes a gap: women remain underrepresented in these fields. This underrepresentation often limits women's access to higher-paying jobs associated with Industry 4.0, which risks worsening the gender pay gap. Automation also tends to replace many lower-paid, routine jobs, particularly in sectors where women predominate, potentially exacerbating gender-based economic inequalities unless reskilling programs are prioritised (World Economic Forum, 2018). In Malaysia, Industry 4.0 has prompted significant investments in technology adoption and workforce upskilling. However, challenges similar to the global context persist despite the push for gender inclusivity in science, technology, engineering, and mathematics (STEM) fields, Malaysian women remain a minority in these industries. This disparity limits the potential for Industry 4.0 to effectively reduce the pay gap, as access to high-skill, high-paying roles remains constrained. Addressing this requires targeted government policies and initiatives to promote women's engagement in STEM and Industry 4.0 careers (Janis, 2020).

The gender pay gap negatively affects businesses and societies by reducing women's lifetime earnings and economic security, which can contribute to gender-based economic inequality in society. For businesses, a significant gender pay gap can indicate missed opportunities for talent utilization and impact organizational reputation. Moreover, it may affect employee morale and productivity, as fair pay is closely linked to job satisfaction and retention. Societal impacts include limiting economic growth, reducing women's spending power, and contributing to a cycle of poverty, particularly in later life due to lower savings and pension contributions (International Labour Organization, 2020).

Industry 4.0, with its emphasis on automation, data exchange, and advanced technology in manufacturing and service industries, has the potential to support gender pay equality by shifting job requirements toward digital and tech skills that can reduce traditional gender biases. Globally, Industry 4.0 can enhance job flexibility and remote work options, which may improve opportunities for women, particularly in high-demand roles such as data analysis, artificial intelligence, and engineering, thus narrowing the pay gap in these fields (Janis & Zulkifli, 2020). In Malaysia, Industry 4.0 initiatives, such as upskilling programs for women in manufacturing and tech sectors, aim to address traditional barriers by empowering women to take on higher-paying roles within these industries. However, the gender pay gap remains, partly due to underrepresentation in tech-intensive positions and a lower rate of female advancement in these fields (Raj, et al., 2020; Kadir, 2023). While Industry 4.0 has the potential to drive gender equality in pay, its success will depend on targeted policies that promote diversity in tech fields and facilitate equal access to digital skills training for women across industries in Malaysia and globally (Wong & Kee, 2022).

Gender Equal Pay: The Role of Industry 4.0

Industry 4.0, marked by automation, digitalization, and advanced manufacturing technologies, plays a critical role in promoting gender pay equity on a global scale. By shifting the skills demand toward digital and

technical competencies, Industry 4.0 has the potential to create high-paying opportunities in tech-intensive fields where gender-based wage disparities are traditionally less pronounced. This technological evolution allows women to access roles previously limited by physical or logistical barriers, offering flexibility and potentially reducing gender biases in pay. The expansion of remote work options further enables more women to participate in high-skill, well-compensated roles without the constraints of traditional office-based work environments (Raj, 2020).

In Malaysia, Industry 4.0 initiatives target gender disparities in sectors like manufacturing and technology by encouraging women's participation in upskilling and reskilling programs. Such efforts aim to integrate more women into high-skill, well-compensated jobs in Industry 4.0-oriented sectors. Nevertheless, Malaysia's gender pay gap persists, partly due to limited female representation in these areas and traditional barriers to career progression. Policies that enhance training access and promote gender diversity in tech and manufacturing sectors are crucial to harnessing Industry 4.0's potential to advance gender pay equity (Wong et al., 2022; Janis, 2020).

Bridging the Gap in Industry 4.0

Globally, Industry 4.0, driven by advances in automation, artificial intelligence, and digitalization, has the potential to address gender pay disparities by creating opportunities for flexible work and emphasizing skills over physical presence. A recent study highlighted that Industry 4.0 technologies are reducing traditional gender-biased hiring practices by automating recruitment processes, which emphasizes objective skills assessment and mitigates biases in candidate evaluation (Wojcik & Freeman, 2022). Automation and digitalization help to equalize pay by offering women access to high-skilled roles in tech-intensive sectors, where pay gaps are often smaller due to the demand for specialized talent. In addition, remote work options have enabled women to balance career advancement with caregiving responsibilities, which can improve long-term earning potential (Deloitte Insights, 2023). However, a persistent issue is that women remain underrepresented in the tech and manufacturing sectors, where Industry 4.0 technologies are most heavily applied. This disparity requires targeted efforts to promote female participation and retention in high-growth, high-pay sectors within Industry 4.0, as outlined by the World Economic Forum's recent gender parity report (World Economic Forum, 2023).

In Malaysia, gender pay disparities are influenced by both cultural factors and structural barriers. Industry 4.0 adoption has shown promise in addressing these gaps by providing digital upskilling and flexible work arrangements. Malaysia's gender pay gap score was 0.74 in 2023, indicating moderate progress but still revealing room for improvement (Siddartha, A., 2024). According to Janis (2020), Industry 4.0 technologies can reduce gender disparity by expanding opportunities for female workers in manufacturing through skill-based recruitment, breaking traditional biases that often limit women's upward mobility in these fields (Janis & Zulkifli, 2020). Bank Negara Malaysia highlighted in a 2024 report that while female representation in high-paying technical roles is growing, barriers remain, especially in advancing women into leadership roles within Industry 4.0 sectors (Endut, 2024). Ongoing challenges include limited access to digital literacy programs specifically tailored to women and entrenched cultural attitudes about gender roles in the workplace.

Overall, Industry 4.0 offers considerable promise for reducing gender pay gaps by emphasizing skills-based hiring and promoting flexibility, but the gap persists. Globally and in Malaysia, greater representation of women in high-tech sectors is essential to maximize these benefits. Policy interventions that support digital training, equal participation, and anti-bias measures in Industry 4.0 sectors will be crucial in bridging the gender pay gap on a broader scale.

Industry 4.0 and Equal Gender Pay

Industry 4.0 has brought forth opportunities to address gender pay gaps through advancements in automation, digitalization, and data-driven decision-making, enabling more objective and equitable employment practices. Globally, automation and digitalization have facilitated the creation of gender-neutral evaluation metrics,

thereby reducing biases that contribute to gender pay disparities. This shift allows for skill-based hiring and advancement, with recent literature underscoring how artificial intelligence (AI) in human resources can support equitable pay practices by mitigating subjective biases (Maggioli & Cunha, 2023). In the Malaysian context, the Industry 4.0 framework, particularly in the manufacturing sector, has shown promise in enhancing female workforce participation. Research highlights that the integration of digital skills and tech-based roles could reduce the gender pay gap as women access higher-paid roles in STEM fields (Janis, 2020). However, there are challenges in fully realizing this potential, as cultural and structural barriers still limit women's advancement in some sectors (Grybauskas et al., 2022).

The literature thus suggests that while Industry 4.0 can significantly contribute to reducing gender-based wage inequality, proactive policy measures and corporate commitment to training and promoting women in digital fields are necessary for sustained progress.

Challenges in Implementation of Industry 4.0

In implementing Industry 4.0, numerous financial, technological, and policy barriers hinder efforts to ensure equal gender pay. Recent literature discusses these obstacles in both global and Malaysian contexts. This study scrutinises the main challenges of Industry 4.0 as per below.

Financial Barriers

Adopting Industry 4.0 requires substantial investment in digital infrastructure, which can be a barrier for small and medium-sized enterprises (SMEs) that lack funding. This financial limitation reduces the likelihood of these enterprises implementing advanced technology that supports fair and transparent wage structures. Malaysia has seen limited digital adoption due to budget constraints in both public and private sectors, which hampers efforts to create equitable pay systems across genders (Raj et al., 2020). High investment costs for Industry 4.0 infrastructure limit equitable gender pay initiatives. Many governments face challenges in funding these changes, particularly in developing regions, where budget constraints hinder the adoption of automated systems that could support transparent wage structures. Malaysia faces similar budget constraints, which impact digital adoption efforts in smaller companies that often lack access to capital for new technologies (Elouaourti & Ibourk, 2024; Miah, et al., 2024).

Technological Barriers

Industry 4.0 technologies, such as AI and machine learning, have the potential to reduce gender bias in pay scales through unbiased data analysis. However, the lack of technical expertise and insufficient training for workers, especially women, poses a significant hurdle. Malaysia's skill development programs are still evolving, and the digital skills gap remains a barrier, limiting women's access to high-paying, tech-based roles and exacerbating existing gender pay disparities (Maggioli et al., 2023). Though advanced digital technologies, such as artificial intelligence and blockchain, can help address gender pay inequities through transparent data systems, however, the lack of skilled workers—especially women in tech roles—limits the successful implementation of these solutions. In Malaysia, the digital skill gap restricts women's access to higher-paying roles in technology, which could widen the pay disparity if not addressed. Training and educational programs are often inadequate in addressing this imbalance, further complicating the issue for policymakers (Zervoudi, 2019; Mpofu, 2024).

Policy Challenges

Globally, policies that directly address gender pay disparities within Industry 4.0 frameworks are often insufficient or inadequately enforced. In Malaysia, government efforts to promote digital inclusion and gender equality face implementation challenges, including limited regulatory enforcement and a lack of incentives for businesses to adopt gender-focused pay equity measures. Policy frameworks are still adapting to the rapid technological changes, making it difficult to monitor and ensure equal gender pay in digitalized workplaces

(Grybauskas et al., 2022). Undeniably, the evolving nature of Industry 4.0 presents challenges for existing policies, which are not always well-equipped to regulate new digital work environments effectively. Global regulatory frameworks often lack specific mandates on gender pay transparency in digital contexts, complicating enforcement. In Malaysia, although policies support digital inclusion, gaps in regulation and enforcement make it difficult to monitor fair pay practices consistently across different sectors (Mpofu, 2024).

FUTURE DIRECTIONS AND RESEARCH GAPS

Current literature on Industry 4.0 and gender pay equality reveals significant gaps, particularly in empirical studies that analyze the direct impacts of emerging technologies on wage disparities across different sectors. Most research tends to focus on technological advancements in isolation, without sufficient attention to the socio-economic factors influencing gender equality in pay. Furthermore, existing studies often lack a cross-disciplinary approach, missing the integration of gender studies, economics, and technology management that could yield a more holistic understanding of how Industry 4.0 can be leveraged to bridge gender pay gaps. This highlights the need for future research that systematically investigates the intersection of technology adoption and gender equity, potentially through case studies that examine successful implementations in various contexts (Zervoudi, 2020; Miah, 2024).

To promote effective adoption of Industry 4.0 technologies while ensuring gender equal pay, policymakers should focus on developing comprehensive strategies that encompass training programs tailored to women, incentivizing companies to invest in gender-sensitive technologies, and implementing robust pay transparency measures. Future research should explore how different countries are addressing these challenges through policy innovations, potentially offering models for other nations to follow. Emphasizing collaboration between industry, academia, and government could facilitate knowledge sharing and create environments conducive to sustainable gender equity in the workforce (Elouaourti, 2024; Zervoudi, 2020).

CONCLUSION

In conclusion, the transformative potential of Industry 4.0 presents both opportunities and challenges in addressing gender pay disparities. Key findings indicate that while advanced technologies can enhance productivity and efficiency, they may also perpetuate existing inequalities if not implemented thoughtfully. To effectively avoid gender pay disparities, organizations must prioritize gender-sensitive approaches when adopting Industry 4.0 technologies, ensuring that both women and men benefit equally from innovations such as automation and data analytics (Zervoudi, 2020; Miah, 2024).

For policymakers, it is crucial to develop targeted strategies that foster gender equality in the workforce. Recommendations include implementing policies that mandate pay transparency, promoting women's access to training in emerging technologies, and incentivizing businesses to adopt inclusive practices. Furthermore, fostering collaboration between academia, industry, and social ventures can enhance the understanding of gender dynamics in the workplace and inform policy development. A call for further research emphasizes the need for interdisciplinary studies that explore the complex relationship between technological advancements and gender equity, enabling a more informed approach to shaping a fair and equitable labour market in the age of Industry 4.0 (Elouaourti, 2024; Zervoudi, 2020).

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