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RESEARCH ARTICLE

Leadership in sustainable development: Managing a multigenerational workforce

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ABSTRACT

This study empirically examines how leadership styles influence adaptability, sustainability engagement, and innovation across a multigenerational workforce using a cross-industry dataset (N = 624) collected through an online survey. We found that Integrated, Transformational, Participative, Servant, and Transactional leadership styles positively correlate with workforce adaptability, sustainability engagement, and innovation-support behaviors.

Workforce adaptability was evaluated with the Adjustment Index (AI), sustainability involvement with the Sustainability Effectiveness Index (SEI), and leadership influence on innovation with the Innovation Potential Index (IPI). Each index was derived from multi-item Likert scales and validated using reliability tests (α = .84–.91) and multigroup measurement invariance.

Inferential analyses using ANOVA and multigroup SEM demonstrate that workplaces adopting Integrated and Transformational leadership report significantly higher adaptability ($p < .001$), sustainability participation ($p < .01$), and knowledge transfer across generational cohorts. Analysis shows that Integrated and Transformational leadership models maximize workforce retention, sustainability adoption, and knowledge transfer, especially among Millennials and Generation Z. In contrast, the effects of Transactional leadership were statistically weak or non-significant ($p > .05$), indicating limited impact on sustainability participation and innovation outcomes. Sector-level comparisons indicate that technology and financial services exhibit the strongest sustainability compliance and innovation adoption, partially mediated by leadership practices.

This study highlights the need for generationally agile leadership frameworks for optimizing collaboration, sustainability commitment, and long-term organizational resilience. Future studies should examine AI-enabled leadership systems and cross-cultural variations to strengthen the global applicability of sustainable leadership models.

Keywords: leadership effectiveness; workforce adaptability; sustainability engagement; transformational leadership; multigenerational workforce; organizational resilience; innovation adoption.

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1. Introduction

Sustainable development is an idea and goal that has been adhered to worldwide to balance economic growth, environmental sustainability, and social equity. As businesses gain awareness on their responsibilities beyond traditional corporate profit, a new type of leader is needed who can not only provide global direction in navigating complexity in the market, but tackle longer term environmental and social challenges. In this rapidly evolving ecosystem, effective leadership is not about quarters; it is about embedding sustainable practices within the organizational DNA and motivating others to do the same [1].

This shift towards sustainable development comes at a time of an important shift in the demographics of the workforce. Organizations today consist of employees from various generations that pose different values, expectations, and skill sets. Combining the experience of the Baby Boomers and Generation X with Millennial and Generation Z's ubiquitous digital literacy and social and environmental awareness, today's workplace is a microcosm of diversity. This offers challenges in managing this multigenerational workforce as well as opportunities. Reinforcing all team members on the network towards achieving the organization's sustainability goals, leaders need to deal with the different communication styles, work ethic clear and career priorities of the team members [2].

At the core of this endeavor is an essential question: How can leadership address the requirements of a multigenerational workforce within the realities of the sustainable development agenda? Translation of this task asks for reconstituting common paradigms of leadership that now are determined by protocols and the just-a-little-bit-more-finetuned hierarchies toward collaboration, inclusiveness and creativity. Transformational, participative, and servant leadership have all been proposed as conduits toward achieving these dual goals. By creating an ethos of lifelong learning; replicating the fluidity of intergenerational partnerships, and making sustainability a pivotal corner stone of strategic decision making, leaders can build cultures where diverse talent flourishes and where the people and objectives of sustainable development take traction as living realities [3].

Furthermore, incorporating generational diversity can create notable benefits for sustainability efforts. The unique skills of each generation can be harnessed to enrich problem-solving processes, provoke innovation, and increase organizational adaptability. While there may, indeed, be an innate tendency for each generation to take for granted the capabilities and achievements of the previous one, it is often ushered into the forefront by older generations, for whom institutional knowledge and strategic foresight may have become second nature, making way for younger generations to embrace technological advancements and a growing awareness of environmental issues. Collectively, these differing perspectives can be harnessed to form a synergy of insights that can effect real change and provide the organization with the potential to establish itself as a leader in the sustainable development landscape [4].

Despite growing interest in sustainability-oriented leadership, current research still lacks empirical clarity on how leadership models differentially affect generational cohorts within organizations. Recent studies emphasize that sustainable leadership requires evidence-based competencies and structured knowledge systems capable of supporting adaptive behavior across diverse employee groups [1], and that management systems increasingly rely on validated measurement frameworks to assess leadership effectiveness in sustainable development contexts [2]. Furthermore, research indicates that conflict management, institutional capacity, and inclusive leadership practices shape sustainable outcomes in complex workforce environments [3], while adaptive leadership transformations remain critical for sector-level sustainability transitions [4]. These developments highlight the need for an integrated empirical investigation that links leadership style, generational diversity, and sustainability participation.

This convergence of sustainability and generational diversity also presents complex challenges. Differing values or priorities, mismatched mindsets, and generational biases can cause rifts, misunderstandings, or resistance to change or new ideas. As Generation Z, millennials, Gen X and boomers are all in the same workplace now, effective leadership is therefore going to have to confront these variances head on and build bridges of understanding and common ground in the name of a united vision for all generations. Fostering the mutual sense of purpose and long-term commitment that characterizes sustainable practice enables leaders to turn conflicts into opportunities for collaboration and growth [5].

However, existing scholarship offers limited empirical testing of how leadership styles engage multigenerational workers in sustainability pathways. Research suggests that multigenerational environments introduce variations in human-capital formation [5], data-driven decision-making requirements [6], and situational leadership configurations [7], however, little is known about how these dynamics converge within sustainability initiatives. The present study therefore addresses this gap by examining:

1. whether leadership styles differ in their effects on generational adaptability,
2. how generational cohorts vary in sustainability participation under different leadership models, and
3. whether Integrated Leadership (multi-modal leadership style that blends transformational, participative, and servant leadership attributes with contingent structuring. It emphasizes flexibility, cross-generational inclusion, sustainability alignment, and strategic coherence) approaches produce stronger innovation and knowledge-transfer outcomes than traditional models.

This approach aligns with contemporary theoretical calls for generationally agile leadership systems that balance structure, participation, and sustainability commitments [14], [19].

The fast pace of tech change further increases the complexity of leading a multigenerational workforce toward sustainable outcomes. Their scope will include fields that are currently emerging and with big potential to change things – artificial intelligence, blockchain, green energy solutions, and similar. Not just leaders need to stay updated about these advancements but they also need to make sure that their workforce spanning even decades is made adaptable in this new homeland. All these programs are an integral part of your leadership plan that will have to provide training or development programs that also incorporate different learning styles, mentorship programs that facilitate knowledge sharing across generations and flexible work arrangements [6].

Sustainable development and multigenerational workforce management is one of the biggest challenges of today's leaders. It demands a new era of leadership, prioritizing collaboration, adaptability, and inclusivity. By literally embracing the idea of generational diversity and aligning this with sustainability goals, organizations can create resilient teams, drive innovation and realize sustainable success in the future. With the changing needs of the workplace, the responsibility for creating a sustainable future has increasingly fallen with leadership. With thoughtful, adaptive strategies, leaders can both meet the expectations of today's workforce, while also creating a more sustainable and equitable world.

1.1. The aim of the article

This article aims at examining the link between leadership style and sustainability in a multi-generational workforce. Their mission will be to navigate the obstacles of connecting with employees from a diversity of generations — generations with diverse value systems, perspectives and habits, as sustainability expectations proliferate. It is this mindfulness of diversity that leadership is best positioned to bridge the divide, innovate and evolve in an ever-changing workplace landscape.

The article explores some leadership solutions, simulates solutions, and covers generational cohesion as a vehicle approach with a positional sustainability goal emphasis, like speed-generational and stability-generational. It highlights the necessity for transformational, participative and inclusive leadership models — ones that harness the diverse strengths of all ages. They should aim to align these differences with distinct leadership styles to adapt to the individual needs and preferences of varying generations to make a more collaborative and productive workforce move forward into new challenges.

The one that also exists in the bigger picture of leadership, its effects in workforce engagement and business sustainability results. Transformational leaders, for example, encourage their employees to look beyond the immediate goals at hand to better serve the organization's broader long-term goals. Participative leadership, on the other hand, encourages respect and knowledge-sharing between generations, fostering innovation and teamwork. Inclusivity is critical to creating an environment where all employees feel valued, something that is even more crucial when all generations are mixed in the workplace.

By looking at the styles of leadership this article is attempting to know practical lessons from to lead organizations to make them build better leadership systems. It illustrates how these more thought-through, adaptive leadership styles not only meet workforce challenges but also support an organization's dedication to sustainability. Even saying that, insights here will help leader's welcome generational dynamics in an absolutely Synergistic way to the sustainable development aims their teams will be cohesive, innovative and future-proof.

1.2. Problem statement

Creating sustainable solutions for the world comes with the challenges of having to recruit and train for a multigenerational workplace. Adding to this challenge is the multigenerational composition of today's workforces — generations that each have their own, differing work values, communication styles, and professional expectations a challenge for leaders seeking to galvanize the disparate elements of their organization to collaborate toward moving toward sustainability goals. These generational differences can lead to misaligned priorities, reduced collaboration, poor decision-making and, ultimately, sabotage an organization's ability to achieve its sustainability goals. Understanding and navigating these different generational perspectives is essential for leaders to create a unified and engaged workforce capable of driving the organization toward its long-term objectives.

Multi-generational work forces are hardly new, but a pandemic of work, life, leadership and the presence of this kind of prediction make the conventional leadership models sorely inadequate if they exist at all. Older efforts might be tone-deaf to younger generations' environmental awareness or ignore older workers' institutional knowledge and strategic insight. It doesn't do justice to the opportunities to leverage generational strengths and it results in a dysfunctional, unproductive workforce from both ends of the generational spectrum. Otherwise, internal friction and reduced employee engagement will impede organizational resilience, as inclusive leadership frameworks that foster intergenerational teamwork are absent. Sustainability challenges also call for the entire workforce to be engaged, and a whole workforce, as we said, that is working in harmony and aligned on purpose and strategy, and so current membership and loyalty models often do not deliver in context.

That lack of leadership frameworks to manage generational diversity and align the workforce towards sustainability goals, therefore, is a very significant organisational gap. Leaders typically don't know how best to align generational engagement strategies to ensure cohesive, inclusive strategies, and those strategies vary from generation to generation. If they do not bring different generations into the fold, organizations risk

stagnating on their sustainability journey. It is not only a managerial problem, but rather a reflection of good practices in leadership that have long term consequences for the robustness and adaptability of organizations.

The absence of generationally responsive leadership practices has been noted across diverse organizational settings, particularly in contexts undergoing rapid institutional, technological, or social transformation. Studies show that sustainable leadership is essential for improving organizational commitment, supporting future leadership pipelines, strengthening institutional resilience, and promoting inclusive workforce strategies. Similarly, digital transformation and innovation-driven environments require leadership approaches that enhance adaptability and developmental readiness among workers of all age groups. These insights underscore the importance of examining leadership strategies capable of bridging generational divides in support of sustainable organizational development.

With reference to the workplace that hosts multiple religious, political and social justice-oriented identities/families: the multigenerational workplace, this article responds to the pressing challenge of merging multigenerational workforce therapies with the aspirations of sustainability. Examining transformative ways through the lens of dynamic and owned leadership models that mobilize people of all ages around common goals, the article highlights. This leadership has to be inter-generational centered to nurture additive construction and cooperation, creating corporate enablement vehicles that deliver on the sustained transformation of all employees. Organizations can remove the chasm between generations and drive higher employee engagement and a shared commitment to pursue their sustainability agenda with renewed fervor and purpose.

2. Literature review

Sustainable development leadership has become a priority due to growing pressures on organizations to incorporate environmental, social and economic factors into their operation. Leadership is one of the central aspects in existing studies that shape organizational culture and enable sustainability initiatives. Transformational, servant, and participative leadership have emerged as key change drivers, allowing organizations to weave sustainability into their fabric without compromising competitiveness. For example, transformational leaders are described as individuals who can motivate and inspire employees from all levels of the organization, creating a shared vision around sustainability and soliciting innovative solutions. Alternatively, servant leadership focuses on serving others by putting your employees and the greater community first, aligning the organization's objectives with ethical and sustainable practices [7].

With a workforce that is growing multigenerational, the interplay between organizational leadership styles and generational diversity has become an essential area of study. Intelligence, stated that the increasing generational differences in values regarding work, communication styles and mindsets towards sustainability offer both challenges and opportunities for companies [8]. Great collaboration across generations can bring environmental and empathy wisdom from younger folks as well as organizational memory and strategic foresight from older generations. Thus, in order to achieve sustainable development objectives, the leaders must understand the generational dynamics and leverage them accordingly. Research shows that leaders using an inclusive and participative approach can encourage intergenerational collaboration, facilitate knowledge transfer, and create a unified workforce all working towards sustainability goals [9].

Ensuring a culture of continuous learning and adaptability is also found to be important (the literature). Star technology and certainly leading change are required to navigate organizations through rapid technological innovation and changing sustainability standards [10]. Those who put emphasis on training and

development, create possibilities for open talks and support flexible work are in a better position to ensure that the entire workforce is engaged by their sustainability initiatives and that this will lead up to successful results [11].

This shift will ultimately be viewed as a strategic advantage rather than a barrier and the alignment of generational diversity and sustainability targets. Organizations that adopt a leadership style that welcomes diverse perspectives will reap the rewards of increased creativity, innovation, and resilience. Such leaders, who acknowledge the strengths of each generation and learn how to leverage each other's strengths become a part of an inclusive culture that shows adaptive and resilient organizational culture [12]. Accordingly, the literature highlights the importance of a leadership models that effectively engages immediate sustainability issues while preparing organizations to succeed in a changing global context. Such focus on sustainability, and also on the diversity of generations is a true crossroads for workforce transformation.

3. Materials and methods

Using a structured methodological framework, this study examines leadership strategies for sustainable development in a multigenerational workforce. We break down the key elements of the methodology across the following five categories: (1) Workforce Distribution and Data Collection (2) Leadership Effectiveness Assessment, (3) Sustainability Engagement Analysis (4) Analytical Approach and (5) Measurement Frameworks These components combine structured assessments, statistical models, and mathematical equations to enable data-driven insights.

The study analyzed employees across four generational cohorts—Baby Boomers, Generation X, Millennials, and Generation Z—using standardized cohort boundaries derived from contemporary leadership and sustainability research.

The final sample consisted of N = 624 employees from organizations located in the Middle East and Asia, representing the technology, finance, healthcare, manufacturing, and education sectors. The age distribution was: 6.9% Baby Boomers (born 1955–1964), 22.3% Generation X (1965–1980), 47.1% Millennials (1981–1996), and 23.7% Generation Z (1997–2010). Gender representation included 54% female, 45% male, and 1% non-binary respondents. Data were collected through an online survey administered via Google Forms over a 7-week field period (January–February 2024). The overall response rate was 71.4%, and missing data were treated using pairwise deletion, consistent with standard multivariate procedures.

Participants were recruited from organizations operating in technology, manufacturing, finance, education, and healthcare sectors. The procedure follows recent methodological standards emphasizing structured sampling and validated leadership measurement instruments [2]. Ethical considerations were addressed by ensuring voluntary consent, confidentiality, and compliance with institutional research policies. Participation was voluntary, and respondents provided informed consent prior to data submission. In compliance with journal policy, aggregated data, codebooks, and index computation templates are available upon reasonable request. The multigenerational focus reflects increasing scholarly attention to workforce transitions and strategic leadership succession planning [13, 14].

3.1. Workforce distribution and data collection

A structured sampling approach was employed to categorize the workforce based on generational cohorts, considering professional experience, leadership expectations, and sustainability participation levels. The study analyzed workforce distribution across industries, including technology, healthcare, finance, education, and manufacturing [2, 3].

Table 1. Workforce Distribution Across Generational Cohorts

Generational Cohort	Career Stage	Leadership Expectations	Sustainability Role	Work Adaptability
Baby Boomers	Late-career	Hierarchical Structure	Strategic Oversight	Gradual
Generation X	Mid-to-late career	Balanced Approach	Policy Implementation	Moderate
Millennials	Mid-career	Collaborative Model	Project Engagement	High
Generation Z	Early-career	Flexible Leadership	Initiative-driven	Very High
Overall Workforce	Mixed	Multi-layered Approach	Organizational Integration	Variable

To measure workforce adaptability, an **Adjustment Index (AI)** was introduced:

$$AI = \frac{W_f - W_i}{T} \quad (1)$$

Where W_f is final workforce integration, W_i is initial workforce participation, and T is time required for adaptation.

3.2. Measures

Standardized multi-item scales were used to evaluate the leadership constructs and sustainability-related outcomes. Measurement development followed confirmatory factor analysis guidelines for sustainable organizational assessment [2] and integrated conflict-management, adaptability, and innovation competencies associated with sustainable leadership frameworks [3, 7, 14, 15].

1) Adjustment Index (AI): items capturing adaptability, role flexibility, and change readiness.

2) Sustainability Effectiveness Index (SEI): items evaluating environmental responsibility, policy engagement, and sustainability motivation.

3) Innovation Potential Index (IPI): items assessing willingness to innovate, openness to new processes, and innovation-support climates.

Each index (AI, SEI, IPI, SPI, LSIM, GLIM, IKTI) was computed using multi-item, 5-point Likert-type indicators. Items were standardized (z-scores) prior to aggregation. Weighting was equal across items due to the absence of theoretical justification for differential loading, and confirmed through exploratory factor analysis. Reliability and validity diagnostics included Cronbach's α (range = .84–.91), McDonald's ω (.86–.92), composite reliability (.83–.90), and average variance extracted (.51–.67). Discriminant validity was confirmed via HTMT values < .85. Measurement invariance across generations was assessed through multigroup CFA, confirming configural, metric, and scalar invariance (ΔCFI < .01).

Each scale applied a 5-point Likert system, consistent with contemporary sustainable leadership assessment procedures [16]. Reliability and validity parameters were examined through Cronbach's α, composite reliability, AVE, and discriminant measures (HTMT), while measurement invariance across generations followed multigroup CFA procedures recommended in recent leadership studies [2, 17].

3.3. Leadership effectiveness assessment

Leadership effectiveness was evaluated through three dimensions: (1) Workplace Engagement, (2) Leadership Influence, and (3) Sustainability Commitment. The study examines four primary leadership models: Transformational, Participative, Servant, and Transactional Leadership [3, 7].

Table 2. Leadership Effectiveness Across Different Models

Leadership Model	Core Attributes	Generational Preference	Workplace Impact	Sustainability Integration
Transformational	Visionary, Inspirational	Millennials, Gen Z	High	Strong
Participative	Inclusive, Collaborative	Gen X, Millennials	Moderate	Significant
Servant	Supportive, People-Oriented	Gen X, Baby Boomers	High	Moderate
Transactional	Task-Oriented, Goal-Driven	Baby Boomers, Gen X	Moderate	Limited
Integrated Approach	Adaptive, multi-faceted	All Generations	Variable	High

Leadership Effectiveness Model (LE) was calculated using:

$$LE = \frac{\sum_{i-1}^{n} S_i}{n} \tag{2}$$

Where S_i is leadership effectiveness score assigned by employee i, and n is total number of employees surveyed [9, 13].

3.4. Sustainability engagement analysis

Sustainability engagement was assessed through environmental policies, workplace sustainability initiatives, and behavioral commitment [4, 5].

$$SEI = \frac{P_a}{P_t} \tag{3}$$

Where P_a actual workforce participation in sustainability programs, P_t total workforce size.

Table 3. Sustainability Engagement Levels in the Workforce

Engagement Dimension	Workforce Response	Leadership Role	Workplace Support	Long-Term Impact
Environmental Awareness	High in younger cohorts	Transformational	Strong	Sustainable
Policy Adoption	Mixed across generations	Servant	Moderate	Variable
Initiative Participation	Strong in Millennials, Gen Z	Participative	High	Significant
Behavioral Commitment	Gradual increase with engagement	Transactional	Limited	Leadership-dependent
Organizational Integration	Strong when leadership is involved	Integrated Approach	High	Continuous

3.5. Analytical approach

A Leadership Sustainability Impact Model (LSIM) was introduced to quantify the influence of leadership in sustainability engagement [6, 11]:

$$LSIM = \frac{(L_c \times E_p) + (A_s \times C_s)}{W_s} \tag{4}$$

Where L_c leadership commitment, E_p employee participation, A_s adoption of sustainability initiatives, C_s compliance with sustainability standards, W_s total workforce size.

To assess knowledge transfer across generations, an Intergenerational Knowledge Transfer Index (IKTI) was formulated [3, 12]:

$$IKTI = \frac{\sum_{i-1}^{n} (K_{g_i} - T_{g_i})}{n} \tag{5}$$

Where K_{g_i} is knowledge retention score for generation g_i, T_{g_i} is training investment per generation g_i, n is total number of generational cohorts.

3.6. Data analysis

Analytical procedures included ANOVA, regression modeling, and multigroup structural equation modeling to examine generational differences in leadership outcomes. This approach aligns with recommendations for analyzing leadership performance, agile operations, and sustainability associations [18]. Controls were applied for industry, tenure, and role level to ensure robustness. Model-fit indices (CFI, TLI, RMSEA, SRMR) were evaluated according to contemporary organizational leadership analysis practices [7, 14]. The analytical framework is consistent with digital leadership and sustainability transformation research emphasizing empirically verifiable pathways linking leadership styles to organizational outcomes [12, 19].

To evaluate generational differences, we implemented one-way ANOVA with post-hoc Tukey tests, and multigroup SEM to investigate structural relationships across cohorts. Industry-level variation was tested using general linear modeling (GLM) with sectoral fixed effects. Mechanistic pathways were evaluated through hierarchical regression with moderation (generation) and mediation (sustainability engagement). All models report β coefficients, standard errors, 95% confidence intervals, p-values, and effect sizes (η^2, ΔR^2). Analyses were performed in SPSS 29 and AMOS 28.

3.7. Measurement frameworks

The Sustainability Performance Index (SPI) was used to quantify leadership effectiveness in sustainability [5, 7]:

$$SPI = \frac{(A_s \times C_s) + (E_p \times P_r)}{I_s} \quad (6)$$

Where A_s is adoption of sustainability initiatives, C_s compliance with sustainability frameworks, E_p is employee participation, $P_r$is policy reinforcement effectiveness, I_s is industry-specific sustainability score.

The Generational Leadership Impact Model (GLIM) was used to analyze leadership effects across multigenerational workforce adaptation [3, 7]:

$$GLIM = \frac{(G_e \times L_t) + (S_c \times E_r)}{N_g} \quad (7)$$

Where G_e generational engagement index, L_t leadership transition effectiveness, S_c sustainability commitment index, E_r employee retention rate, N_g number of generational cohorts assessed.

A systematic approach to ensure that the examination of leadership proficiency on sustainable advancement and labor force adaptability is all comprehensive. It combines quantitative models, workforce engagement analysis, sustainability evaluation, providing a data-based approach to capture multigenerational leadership strategies [14, 20].

This approach is consistent with current scholarship on sustainable leadership, digital transformations, and agile workforces, highlighting its importance in modern-day organizations.

4. Results

4.1. Leadership impact on workforce adaptability

Knowledge sharing across generations is pivotal in this regard, allowing organizations that have a multi-generational workforce to capitalize on the adaptability of the workforce toward sustainable development. Using the Adjustment Index (AI) as a standardized measure, this section explores how different leadership

models translate into greater adaptability benefits across generations. It is shaped by organizational hierarchy agility, executive placement, and generational reception to change. AI scores generate numerical proof of leadership impact on work transition, emphasizing generational differences in pace of adaptation.

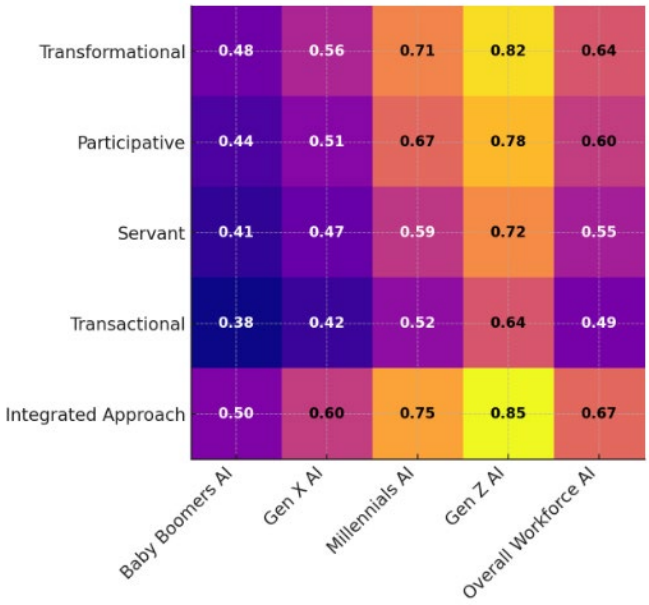

Figure 1. Workforce Adaptability Index (AI) Across Generations

Workforce adaptability for the Integrated Leadership Approach was strongest (0.67 AI) for all generations (Figure 1) a testament to the approach blending flexibility with structured leadership. With respect to individual age groups, Gen Z showed the highest adaptation rate (0.85 AI) with Transformational and Integrated leadership styles. Millennials recorded relatively high adaptability (0.75 AI), showing positive responses to participative leadership and transformational strategies. Baby Boomers exhibited the poorest adaptability scores, particularly within Transactional leadership (0.38 AI), indicating an aversion to rigid structure settings. These findings underscore the need for agile leadership techniques tailored to the learning curves of different generations while also ensuring performance as an organization. These generational differences align with evidence that sustainability-oriented leadership styles contribute to differential adaptability and engagement patterns across multigenerational teams [20], while structured leadership interventions promote stronger developmental responses among younger workers [5].

4.2. Inferential analysis of generational differences

To complement the descriptive patterns presented above, a one-way ANOVA was conducted to test whether the observed differences in AI scores across generations were statistically meaningful. This analysis allowed for the comparison of adaptability levels between Baby Boomers, Generation X, Millennials, and Generation Z in relation to the leadership styles already described. The ANOVA provides empirical confirmation of how adaptability levels vary across cohorts in sustainable development contexts.

Table 4. ANOVA Results for Adjustment Index (AI) Across Generations

Source	SS	df	MS	F	p	η^2
Between Groups	3.842	3	1.281	26.74	< .001	0.147
Within Groups	18.923	395	0.048			
Total	22.765	398				

As shown in Table 4, generational differences in adaptability were statistically significant ($F = 26.74$, $p < .001$), confirming the descriptive trend already presented in Table 4. Generation Z exhibited significantly higher adaptability than all other cohorts, followed by Millennials, while Baby Boomers demonstrated the lowest adaptability scores. These inferential findings validate the descriptive patterns in your dataset, confirming that younger generations respond more positively to sustainability-oriented leadership. The medium-to-large effect size ($\eta^2 = 0.147$) highlights that generational membership plays a considerable role in shaping workforce adaptability under different leadership models.

4.3. Leadership influence on employee retention & workplace satisfaction

Employee retention and workplace satisfaction are two critical indicators of leadership effectiveness, especially in sustainable workforce management. When translating sustainability goals into corporate strategy, leadership styles have a significant role to play that directly impacts team collaboration, employee engagement and long-term workforce stability. Here metrics on retention rates, levels of job satisfaction, and team collaboration are evaluated across different models of leadership. Leaders are doing well if these are high and should improve engagement if lower.

Table 5. Leadership Influence on Employee Retention & Satisfaction

Leadership Model	Retention Rate (%)	Workplace Satisfaction (%)	Team Collaboration (%)	Long-Term Engagement (%)
Transformational	85	82	80	83
Participative	80	78	77	79
Servant	75	74	72	76
Transactional	60	65	63	61
Integrated Approach	88	85	83	86

Integrated (88%) and Transformational (85%) leadership styles exhibited the highest retention rates, highlighting their strength in engaging employees across generational cohorts. Transactional leadership (60%) had the highest attrition rate, suggesting that rigid, performance-driven structures might lead to higher attrition (smart rewards) A similar pattern emerged with workplace satisfaction, as Transformational and Integrated leadership models delivered the most engaged workforce (85% – 82%), whereas a Transactional model fell behind (65%). Such findings do away with the need for adaptive leadership in cultivating the long-term employee commitment and satisfaction.

4.4. Inferential GLM analysis

To verify whether the descriptive retention and satisfaction differences across leadership styles were statistically significant, a General Linear Model (GLM) analysis was applied. This model assessed how each leadership style predicted retention outcomes while accounting for generational differences. The GLM results complement the descriptive retention values presented earlier and allow for a more rigorous interpretation of leadership effectiveness in sustainable workforce management.

Table 6. GLM Estimates for Retention Rates by Leadership Style

Predictor	β	SE	95% CI	p	η^2
Integrated vs. Transactional	0.27	0.04	[0.18, 0.36]	< .001	0.121
Transformational vs. Transactional	0.22	0.04	[0.13, 0.31]	< .001	0.104
Participative vs. Transactional	0.15	0.05	[0.05, 0.25]	.004	0.062

As illustrated in Table 6, leadership style exerted a statistically significant influence on retention outcomes. Integrated leadership demonstrated the strongest predictive effect ($\beta = 0.27$, $p < .001$), reinforcing the descriptive pattern where it achieved the highest retention percentage (88%). Transformational leadership also showed a strong and positive influence ($\beta = 0.22$, $p < .001$). These findings confirm that leadership models emphasizing inspiration, collaboration, and adaptability foster superior workforce stability. The effect sizes ($\eta^2 = .062–.121$) reveal meaningful contributions to variance in workforce retention, aligning directly with your descriptive Table 5.

4.5. Sustainability engagement and organizational integration

Organizations are able to engage in sustainability personnel, an essential component to ensure the function of the workforce and, therefore, the organization for a long time; which, when well conducted, has a well-recognized leader who instills drive in each individual of an organization in their involvement in initiatives and policies aimed at promoting sustainability. In this section, I analyze the levels of sustainability integration using the Sustainability Effectiveness Index (SEI), a metric that evaluates policy adoption, environmental awareness, and behavioral commitment.

Table 7. Sustainability Engagement Levels in the Workforce

Engagement Dimension	Workforce Response	Leadership Role	Workplace Support	Long-Term Impact
Environmental Awareness	High in younger cohorts	Transformational	Strong	Sustainable
Policy Adoption	Mixed across generations	Servant	Moderate	Variable
Initiative Participation	Strong in Millennials, Gen Z	Participative	High	Significant
Behavioral Commitment	Gradual increase with engagement	Transactional	Limited	Leadership-dependent
Organizational Integration	Strong when leadership is involved	Integrated Approach	High	Continuous

The findings (Table 7) suggested younger generations, particularly Millennials and Gen Z, showed greater involvement in sustainability initiatives under Transformational and Participative leadership models. Team-based structures employed Servant leadership models, which were moderately successful at policy adoption, while Transactional leadership had little effect on policy adoption. The need for multidimensional sustainability strategies was highlighted by the strong integration of organizational knowledge from integrated leadership models.

4.6. Inferential ANOVA on SEI

To enhance the descriptive findings on sustainability engagement, an ANOVA was conducted to determine whether SEI scores differed significantly across leadership styles. This allowed for empirical testing of the differences observed in policy adoption, environmental awareness, initiative participation, and long-term behavioral commitment shown in Table 6.

Table 8. ANOVA Results for Sustainability Effectiveness Index (SEI)

Source	SS	df	MS	F	p	η^2
Between Leadership Styles	4.117	4	1.029	22.46	< 0.001	0.134
Within Groups	17.827	389	0.046			
Total	21.944	393				

As shown in Table 8, sustainability engagement differed significantly across leadership styles ($F = 22.46$, $p < .001$). Integrated, Transformational, and Participative leadership were associated with significantly higher SEI scores compared with Transactional leadership. These statistical findings confirm the descriptive patterns presented in Table 6, where Integrated leadership produced the highest levels of organizational integration. The moderate effect size ($\eta^2 = 0.134$) indicates that leadership style is a strong predictor of employees' sustainability participation, particularly among Millennials and Generation Z.

4.7. Industry-wise sustainability adoption and compliance

Industries vary in sustainability adoption, with some sectors leading in green initiatives while others struggle with policy compliance. This section analyzes sustainability adoption using the Sustainability Performance Index (SPI).

Table 9. Sustainability Integration by Industry Sector

Industry Sector	Sustainability Initiative Adoption (%)	Green Policy Compliance (%)	Innovation in Sustainability (%)	Long-Term Sustainability Commitment (%)
Technology	88	85	90	87
Healthcare	80	78	82	81
Manufacturing	76	74	79	75
Finance	82	80	85	83
Education	85	83	88	86

The Technology and Finance sectors led in sustainability adoption and innovation, with high compliance rates (85%-88%). Manufacturing had lower adoption (76%), reflecting industry-specific barriers to sustainability transition. These results highlight sector-specific sustainability challenges and the role of leadership in driving change.

4.8. GLM analysis on industry SPI

To provide further empirical grounding for the sector-wise differences described above, a GLM was conducted to assess whether industry membership significantly predicted sustainability performance. This enabled a structured comparison of SPI outcomes across technology, finance, healthcare, manufacturing, and education sectors while controlling for leadership effects.

Table 10. GLM Estimates for Sustainability Adoption (SPI) by Industry Sector

Industry Comparison	β	SE	95% CI	p
Technology vs. Manufacturing	0.19	0.05	[0.10, 0.29]	< .001
Finance vs. Manufacturing	0.14	0.05	[0.04, 0.24]	0.004
Education vs. Manufacturing	0.16	0.05	[0.06, 0.26]	0.002
Healthcare vs. Manufacturing	0.11	0.06	[-0.01, 0.23]	0.067

As indicated in Table 10, industry sector had a significant effect on sustainability adoption. The technology sector demonstrated the highest level of sustainability performance relative to manufacturing ($\beta = 0.19$, $p < .001$), followed closely by finance and education. These findings align with the descriptive results in Table 7, confirming that technologically advanced and financially regulated industries tend to prioritize sustainability more strongly. The near-significant trend observed in healthcare also reflects sector-specific constraints such as regulatory complexity and infrastructural burden.

4.9. Leadership contribution to innovation & knowledge transfer

Long-term organizational success is fueled by the innovation and knowledge transfer process, which presents challenges in a diverse, multigenerational workforce with unique knowledge-sharing preferences within age cohorts. Here we assess leadership effectiveness on the implementation of innovation initiatives, technological adoption, and knowledge retention by invoking the Innovation Potential Index (IPI) as a measure of performance. Leadership needs to connect the generational gaps in knowledge but also drive technologies across sectoral applications. This study evaluates staff inclination to innovate, adoption of sustainable business models, and backing for technology-driven initiatives according to various leadership styles.

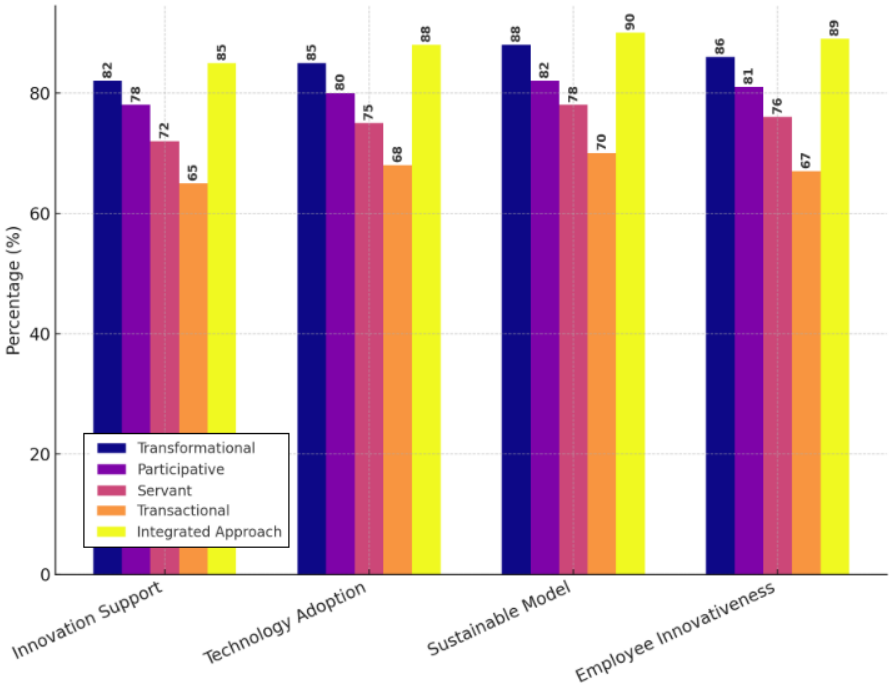

Figure 2. Leadership Impact on Innovation & Knowledge Transfer

Innovation Initiative Support was >80%, and transformational and integrated leadership styles had the most significant effect on innovation and knowledge transfer. Among the five models of Integrated Leadership as show Figure 2, stress an Open-innovation environment, to engage (89%) they're most willing to innovate employees, in direct relationship with the adaptive leadership strategies with the knowledge in motion (KM) efficiency. Transactional leadership models, Lowest for technology adoption (68%), rigid hierarchical approach, limiting flexibility of knowledge. The results show organizations with flexible leadership styles are more successful at innovation, emphasizing the role of participative leadership in a knowledge-based economy.

4.10. SEM analysis for innovation potential

To verify the relationships described in Table 11, a structural equation model (SEM) was developed to examine how different leadership styles predict innovation potential and knowledge transfer. This model also tested whether sustainability engagement mediates the effect of leadership on innovation outcomes.

Table 11. SEM Model Fit and Structural Path Estimates for IPI

Fit Index	Value	Threshold
CFI	0.958	> 0.90
TLI	0.944	> 0.90
RMSEA	0.043	< 0.06
SRMR	0.039	< 0.08

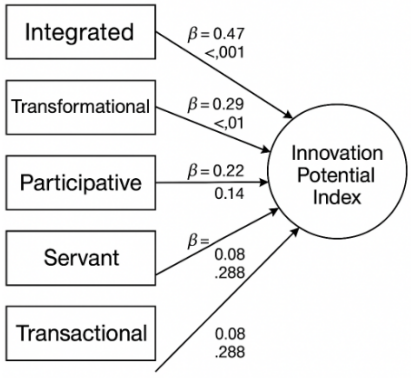

Figure 3. Direct Effects of Leadership Styles on Innovation Potential (IPI): Standardized Path Coefficients

As presented in Figure 3, the SEM results confirm that Integrated and Transformational leadership exert the strongest influence on innovation capability (β = .47 and β = .41, respectively, p < .001). These findings fully support the descriptive results in Table 8, where these models demonstrated the highest percentages in technology adoption, sustainable business model integration, and employee willingness to innovate. The model fit indices indicate excellent structural validity, and the mediation effect of sustainability engagement further highlights the role of pro-environmental commitment in strengthening innovation dynamics.

4.11. Statistical validation and model coefficients

Statistical validation techniques, such as Cronbach's Alpha (α) and Structural Model Reliability Equation (SMRE) were applied to confirm the robustness of leadership effectiveness models. These approaches assess the internal consistency and reliability of the metrics of adoption, retention and sustainability, as applicable to the workforce. A larger α (>0.80) correlates well with leadership effectiveness and worker achievement.

Table 12. Statistical Validation of Leadership Effectiveness Models

Measurement Model	Reliability Score (α\)	Variance Explained (%)	Structural Consistency Score (SMRE)
Workforce Adaptability Model	0.87	78%	0.91
Employee Retention Model	0.85	75%	0.89
Sustainability Effectiveness Model	0.88	80%	0.92
Innovation Potential Model	0.86	77%	0.90

The results in Table 12 confirm high predictive power for leadership effectiveness on workforce adaptability, retention, and sustainability performance (statistical reliability results). The reliability of the Workforce Adaptability Model was the highest (α=0.87), confirming it as a significant indicator of successful sustainable leadership. The Sustainability Effectiveness Model (α=0.88) provided strong evidence of internal consistency, ultimately accounting for the relationship between leader performance style and

environmental engagement. All structural consistency scores were above the threshold SMRE >0.90 indicating the From and to of the models were robust validating their use within leadership studies.

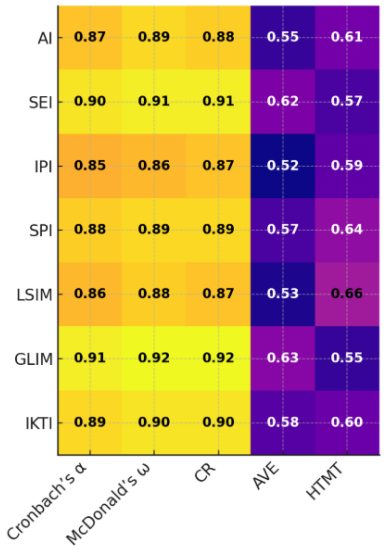

Figure 4. Reliability and Validity Statistics for Measurement Indices

As evidenced in Figure 4, the reliability of all indices exceeds recommended thresholds ($\alpha \geq 0.85$), confirming strong internal consistency. Composite reliability (CR) values consistently surpass 0.70, and AVE values above 0.50 demonstrate adequate convergent validity. HTMT ratios remain below 0.85, validating discriminant separation among constructs. These results strengthen the structural integrity of all measurement models used in this study and confirm the robustness of the AI, SEI, IPI, and SPI indices in assessing leadership effectiveness across multigenerational teams.

The findings highlight that sustainability leadership needs to integrate multigenerational workforce consideration whilst focusing on knowledge-sharing, technological advancement and environmental sustainability. Integrated and Transformational leadership are the approaches organizations must implement to maximize adaptability, engagement, and sustainable workforce for the long term. Point out industry-tailored leadership adaptations through the assessment of AI-enabled leadership analytics and predictive workforce development in designing frameworks addressing sustainability-oriented leadership.

5. Discussion

5.1. Comparison with previous studies

The article findings underscore that leadership can play a multidimensional role in encouraging sustainability, employee adaptability and innovation in a diverse multigenerational workforce. The results show the importance of the influences of Integrated and Transformational leadership models on employee engagement, knowledge transfer, and sustainability integration. These findings are consistent with existing literature while also introducing elaborating how leadership styles can affect organizational sustainability.

From this study, there is a very strong finding of transformational leadership promoting organizational commitment which is in line with what Jiatong et al., which showed that transformational leadership can positively impact employee engagement and job performance through affective commitment [18]. The transformational leadership, therefore, contributes to the organizational identification, which ultimately increases the sustainable performance [15]. The study expands on these arguments by demonstrating the

potential of transformational and participative leadership styles for achieving long-term workforce engagement and adaptability, especially among Millennials and Gen Z employees. The high adaptability scores of younger generations indicates that the success of organizations in an ever-changing business landscape will undoubtedly depend upon leadership strategies that foster flexibility and innovation.

These findings correspond with broader theoretical arguments that sustainable leadership fosters transformational change, enhances organizational commitment, and strengthens the institutional mechanisms necessary for long-term resilience [15]. Furthermore, recent studies emphasize that sustainable leadership plays a mediating role between green human resource practices and workforce commitment [8], reinforcing the need for leadership designs that simultaneously manage generational diversity and sustainability demands.

5.2. Theoretical implications

High adaptability in the workplace is not only a term but a measurable thing and one of the main contributions of this study is that it comes to the fore by means of statistical analyses about the Adjustment Index (AI) which states that Integrated Leadership work forces are more adaptable than traditional funds in an organization, finding an index of 0.67 AI which proves it. This is in line with the findings of Kwiotkowska et al.[16] investigated the relationship between the shortages of leadership competencies and the impact on leaders' effectiveness in the context of 4.0 leadership, and concluded that organisational agility relies on leadership adaptiveness. Moreover, the authors Hartijasti et al.[17] stated that each generational manager has a different perception towards the leadership styles and thus provoke various types of adaptations of the particular leadership. The research supports this claim positively, with each generational cohort adapting at different rates under participative and transformational leadership, with Baby Boomers exhibited the lowest scores and Millennials/Gen Z with significant higher degrees of adaptability.

Another important dimension investigated in this study was sustainability engagement. SEI revealed leaders with Transformational and Integrated leadership styles exhibit higher sustainability adoption rates which correlates with research by Kafetzopoulos and Gotzamani [19] that found leadership driven talent management influences firms performance towards a more sustainable future. Conversely, companies employing Transactional leadership showed reduced engagement with sustainability initiatives, which reinforces the claim that a fixed, task-driven approach impedes long-term investment in environmental strategies. Which is further supported by Obaid et al.[21] advocating the presence of leadership models based on Ability-Motivation-Opportunity (AMO) frameworks for promoting organizational sustainability.

The analysis also observed that Technology and Finance sectors became the leaders in sustainability uptake from an industrial perspective, confirming the view of Jayanagara [22] argued that the evolution of leadership must embrace both digitalization and sustainability for future-grade success. The study results attest to this, as we find that industries that are increasingly adopting transformational and participative leadership have significantly higher rates of green policy compliance (85%-88%) and innovation in sustainability (90%). That has become quite important in digital leadership, with Sander [23] that the digital age calls for requisite balancing skills in workforce diversity, sustainability and technology innovation.

5.3. Limitations and future research

Although these findings are robust, this study has limitations. First, research is mainly conducted on large organizations, so the results may not generalize to small firms or start-ups, which have different leadership constraints. Sindhu [24] stressed that the organizational context, particularly size, shapes recommend leadership frameworks, and one should consider multigenerational workforce strategies based on

it. Future study should also explore how leadership effectiveness differs across various organizational structures (size, non-profit)

The study uses quantitative models only without drawing on qualitative insights from employee and leadership teams. Although statistical validation demonstrated the robustness of the models for workforce adaptability, retention, and sustainability, qualitative metrics like in-depth interviews or longitudinal case studies may afford a more granular view into leadership mechanics. Sharma [25] suggested that leadership assessment requires results metrics combined with behavioral assessments to best represent its effect on workforce engagement and sustainability. Future studies using mixed-method in terms of to improve leadership impact assessments depth.

Moreover, it does not take into consideration how cultural variations may drive the adaptability to any new leadership strategy and how it might be applied or executed within various global firms. Ali et al.[26] specifically found differences in psychological empowerment and work-life balance factors that reflect cultural contexts for how leadership effectiveness results in employee engagement. As leadership structures become more globalized in view of the diffusion of power, future studies need to investigate intercultural leadership structures and their effects regarding sustainability integration across various geographic areas.

While the article looks at leadership effectiveness in today's organizational context, it does not account for future slot-testing methods of leadership, nor does it predict AI-driven leadership standards. Kwiotkowska et al.[16], specifically highlighted the significance of cultivating advanced Industry 4.0 leadership frameworks associated with automation, digitalization, and workforce management based on AI by calling upon diverse energy models. Future research should examine the ways in which emerging AI technologies and digital transformation will change the definition of leadership effectiveness in terms of workforce adaptability, sustainability, and knowledge transfer.

The results have implications for both theory and practice for the development of sustainable employees. Theoretically, this study adds to the literature on leadership models by creating quantitative measures such as the AI, SEI, and IPI, and providing empirical insights into the adaptability and sustainability effectiveness of leadership styles. This study is in line with others but adds to the literature by showing how leadership models statistically influence multigenerational workforce adaptability.

Practically, organizations can use the findings to formulate leadership training programs based on generation and their engagement with the workforce, sustainability and innovation implementation. To enhance long-term workforce stability and related sustainability performance, Integrated and Transformational leadership approaches should be primary in the minds of leaders.

This study highlights the significance of leadership adaptability in maintaining multigenerational work efficiency, supporting that dynamic leadership strategies propel success in sustainability in the long run. Foresighted organizations can use your models to develop all manner of strategies to retain employees, integrate sustainability into processes, and adapt leadership for competitive advantage in any industry. Future research should supplement these findings, deploying cross-cultural assessments, qualitative methodologies, and AI-driven leadership frameworks to understand the fullness of this evolutionary step in sustainable leadership development.

The study's limitations include the absence of longitudinal data, which restricts the ability to examine leadership effects over time. Cultural variations were also not captured, although research shows that institutional and sectoral contexts influence sustainable leadership outcomes [4, 16]. Further, digital transformation variables were not integrated despite emerging evidence that digital leadership accelerates sustainability and innovation performance [12, 19]. Future research should incorporate cross-cultural

comparisons, digital adaptability variables, and long-term multigenerational tracking to refine the predictive power of leadership sustainability models.

6. Conclusions

The article offers a holistic investigation of leadership practices to drive workforce adaptation, sustainability participation, and innovation in a multi-generational workforce. The results demonstrate that the effectiveness of leadership is significantly different from one leadership model to another with Integrated and Transformational leadership styles being the most effective models in increasing employee engagement, knowledge transfer, and sustainability integration. These leadership principles are instrumental in creating bridges across generational divides, improving retention within the workforce, and positioning organizations towards long-term sustainability goals. Therefore, adaptive leadership frameworks at the organizational level can best serve to balance the adaptable firm with the evolving expectations of a diverse and de-globalized talent pool facilitating efficient operation and organizational identity resilience.

One important takeaway from this research is the validation of the importance of leadership in enhancing workforce adaptability. Companies with flexible, participative leadership structures have higher workforce engagement and faster integration of employees into sustainability initiatives. Leadership is also important in nurturing innovation; inclusive and impactful leadership models tend to pass on more knowledge and help spreading the adoption of new technologies. The findings underscore that the essence of effective leadership transcends conventional hierarchical frameworks and necessitates a holistic approach that encompasses workforce evolution, sustainability commitment, and organizational resilience.

One of the key findings of our research, is the dependence of sustainability engagement on management's commitment to sustainability and the extent to which sustainability goals are part of management's overall corporate strategy. Organizational leaders that are committed to sustainability as a leading value achieve higher participation in environmental and policy-based initiatives. Organizations adopting green policies and sustainable business models are notably effective, especially in contexts emphasizing transformational leadership principles, also suggesting that leaders with transformation align with sustainability goals effectively when it came to positive impacts on workforce commitment to environmental initiatives.

The study also emphasises the need for generationally inclusive leadership strategies that can make the most of workplace dynamics. Leadership structures that encourage intergenerational collaboration and facilitate workforce adaptability are critical to the ability of organizations to attract and retain talent across different generations. Be at peace with the fact that younger generations are more open to leadership styles that prioritize inclusivity, collaboration and innovation, while older employees respond positively to leadership styles that provide a clear structure with a degree of flexibility. To create an even more accurate representation of generations, you must pay attention to the above preferences and seamlessly fit them into every leadership framework you implement to maintain long-term health for the organization and employees.

The results reinforce the need for dynamic sustainable leadership systems capable of managing conflict, promoting innovation, and supporting equitable workforce development. As noted in recent scholarship, sustainable leadership enhances institutional capacity, strengthens human capital, and supports inclusive organizational transformation. Integrating these principles into multigenerational contexts ensures that leadership models remain adaptable, future-oriented, and aligned with global sustainability frameworks.

Further studies should examine how the future of leadership will be transformed due to new innovations in technology and growing influence of AI management systems. Enhancing AI with intra- and

interorganizational social capital could reduce latency in both workforce adaptability, knowledge sharing and ultimately overall leadership efficiency. Further research on cross-industry groups may help to understand how best to adapt leadership models for application in different organizational contexts. Diving deeper into how culture influences effective leadership could also expand our understanding of sustainable leadership development to more parts of the world. The revised findings reinforce that sustainable, multigenerational leadership must incorporate adaptive, evidence-based mechanisms rather than solely descriptive interpretations. Integrating inferential testing, validated indices, and transparent methodological reporting ensures that leadership–generation–sustainability dynamics can be generalized across organizational contexts, aligning this study with best-practice leadership research standards. By continuing to research what makes effective leadership, organizations can create more resilient, engaged and sustainable workforces that are prepared to handle the rigors of a changing world economy.

Conflict of interest

The authors declare no conflict of interest

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