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Published in:
Journal of Open Innovation: Technology, Market, and Complexity

DOI:
10.1016/j.joitmc.2026.100772

2026

Document Version:
Publisher's PDF, also known as Version of record

Journal of Open Innovation: Technology, Market,and Complexity 12 (2026) 100772

Contents lists available at ScienceDirect

Journal of Open Innovation: Technology, Market, and Complexity

journal homepage: www.sciencedirect.com/journal/joitmc

Unveiling the key enablers of robo advisor using fuzzy-AHP approach: A decision-making framework

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ARTICLE INFO

Keywords:
Robo advisors
Financial markets
Technological innovations
Fuzzy-AHP
DPSIR Framework

ABSTRACT

Robo-Advisor is bringing a paradigm shift in the coming financial markets, changing the way individuals make investments. Based on algorithms and data, robo advisors helps in making informed financial decisions without human interventions. However, the enablers of robo advisors remain a grey area of research. Therefore, the presented study focused on exploring the enablers impacting robo advisor adoption in financial market context. The enablers explored using literature were confirmed using expert opinion, focused group discussion was conducted for the same. Also, DPSIR framework was developed, and the enablers are assessed using fuzzy-Analytic Hierarchy Process. Our results discussed that cost effectiveness financial services, technological innovations, consumer confidence, personalized decision making and reduced fatigue are key enablers. Moreover, sensitivity analysis is conducted by changing enablers weight, to check its impact on overall ranking. The results shows that final ranking of enablers remains almost same, which proves that results are reliable. The study is first of its kind to assess the enablers of adopting robo advisors in emerging economy context.

1. Introduction

Robo-advisory is revolutionizing wealth management by providing automated, affordable, and easily accessible investing options integrating artificial intelligence with financial decision-making. This Fintech platform, is quickly expanding, major force being innovation and technological sustainability in the financial services industry by enabling data-driven financial planning with little human intervention (Investopedia, 2024). Technology touches every aspect of human existence signifying advancement towards a safe, up-to-date, and healthy world. The financial sector among, others has not remained untouched with this scientific advancement, Technology, Media, and Telecommunications (TMT) leads to the accessibility of financial services within a spur of the second (Sunscrapers, 2023). The automation evolution in deliverance and usage of financial service by various stakeholders is universally termed as Financial Technology-FINTECH. Moreover, robo advisors, which is example of advanced FinTech helps to offers advice without any time or place constraints (Nourallah et al., 2026). Financial Stability Board (FSB) explains FinTech as "technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions and the provision of financial services" (RBI, 2017). A study by de Oliveira Santini et al. (2026) analyzed the role of trust, perceived privacy, security perception, perceived usefulness, and perceived ease of use in shaping attitude towards robo-advisors.

India is having the highest FinTech adoption rate with 87%, the world average being 64% (PIB, 2021). The industry is projected to reach $100 billion in enterprise value by 2030, driven by UPI with over 10,000 + fintech ventures making it the third largest, behind only the US & UK (Belgavi et al., 2024). The segments include Digital Payments, Digital Lending, InsurTech, RegTech and WealthTech (Nawka and Kedia, 2024). The WealthTech market is anticipated to hit $237 billion by 2030 (AICC, 2026). Under Wealth Tech, robo-advisory market size as of 2025 is USD 512.31 Million, which is expected to reach USD 6993.86 Million by 2034, growing at a compound annual growth rate

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https://doi.org/10.1016/j.joitmc.2026.100772
Received 27 January 2026; Received in revised form 2 April 2026; Accepted 14 April 2026
Available online 21 April 2026

(CAGR) of 33.03% (IMARC, 2026). The drivers especially in rural areas are India Stack (UPI), which facilitates digital transactions with technological innovations in AI & ML under financial inclusion initiatives such as PMJDY and Direct Benefit Transfer (Sinha, 2025).

A study by de Oliveira Santini et al. (2026)) analyzed the role of trust, perceived privacy, security perception, perceived usefulness, and perceived ease of use in shaping attitude towards robo-advisors. According to Cao et al. (2026), inadequate personal competency may prevent young, tech-savvy people from completely benefiting from robo-advice. Additionally, the authors favour a hybrid model that combines traditional advisory services with robo-advice, which may provide more advantages. Keeping in views above mentioned perspectives, the research objectives are defined as follows:

RQ1. To find out DPSIR dimension for adopting robo-advisors in emerging economy context

RQ2. To prioritize the DPSIR dimensions so as to ease robo-advisors adoption.

The remaining sections of the paper is illustrated as follows: Section 2 discusses the literature review in context of DPSIR factors for adopting robo-advisors, and research gaps. Then, next sections show research methodology followed by case illustration in the subsequent section. Second last section mentions discussion, and lastly, conclusion, limitation and scope of future work is presented.

2. Literature review

Robo-advisors, which use technology to transform investment management, is a turning point in the history of financial services in the ambit of Wealth Tech (Saleem et al., 2026). This trend started in the late 2000s, when the economy was experiencing severe financial instability and people were becoming increasingly disenchanted with conventional investing options (Bhuvan, 2024; Sumit Kochar, 2023). Robo-advisors have become a prominent Wealth Tech trend over the last two decades (Fig. 1 & Table 1), having first gained traction in the United States before going worldwide. Robo-advisors are frequently described as platforms that provide automated financial advice; however, their main function is to offer investment advice, which is a subset of financial advising (Filipsson, 2024). The global robo advisory market is valued at $7.9 billion in 2022 and is expected to reach $129.5 billion by 2032, with a CAGR of 32.5% between 2023 and 2032 (Verma et al., 2023).

India's Robo-advisory market offers three primary types of services and is governed by the SEBI (Securities and Exchange Board of India, 2023)). The law applies to traditional IAs as well with compliance of physical agreements, maintaining client records, and submitting quarterly reports on AI/ML applications, cybersecurity procedures (Ikigai Law, 2022). Risk-averse investors can consider Fund-based Robo-advisors, which concentrate on low-risk investing in specific asset class funds eg. Scripbox, Wealthy, finpeg, kuvera, fisdom etc. With equity-focused portfolios catered to individual risk profiles and goals, Robo-advisors appeal to individuals with some market understanding, like smallcase, Taura wealth etc. For individuals and families, Comprehensive Wealth Advisory offers a comprehensive strategy that includes wealth/estate planning, portfolio management, and financial planning, for example, Indwealth, Cubewealth etc. It also offers a greater selection of investment possibilities depending on risk tolerance and overall financial health (Amlegals Legal Startegists, 2022).

Investment advisors are required to register with SEBI under Regulation 3 of the SEBI(IA) Regulations. Individual advisors must have net tangible assets of Rs. 5 lakh, and companies must have a net worth of at least Rs. 50 lakh (Amlegals Legal Strategists, 2022). A professional certification accredited from NISM (National Institute of Securities Markets) or the FPA Standards (FPSB India's Certified Financial Planner) along with a minimum of five years of relevant experience, are prerequisites for advisors. Although the rules governing Robo Advisors are not stated clearly, it is believed that they must follow the same requirements for qualification (Sharma, 2016). The Table 2 summarises the top ten Robo Advisory startups in India.

2.1. Driving-force-pressure-state-impact-response (DPSIR) aspects of robo-advisors

The Driving Force-Pressure-State-Impact-Response (DPSIR) model is a fundamental tool for analyzing the causal relationship between human activities and the natural environment (Kristensen, 2004; Rasi Nezami et al., 2013). DPSIR model evolved from earlier frameworks such as the Pressure-State-Response (PSR) model developed by the Organisation for Economic Cooperation and Development (OECD) in 1993, which itself was an extension of Rapport and Friend's Stress-Response (SR) framework in 1979 (OECD, 2003). The DPSIR model builds on the pressure-state-response (PSR) model by including "Driving Forces" as the underlying causes of environmental "Pressures" and including "Impact" to account for the consequences on both the environment and socioeconomic systems (Burkhard and Müller, 2008) as shown in Fig. 2. Because of its simplicity and effectiveness, the DPSIR model is frequently used to analyze complex issues connected to resources, the environment, the economy, and society, providing a flexible and comprehensive framework for investigating the linkages between economic operations and environmental change (Pan et al., 2020). It is a popular analytical approach especially useful for assessing natural resource concerns, such as freshwater management, because it examines ecosystems' current status and implications, as well as their evolution across time (Allen, 2024).

Mandić (2020) study investigates the sustainability problems of nature-based tourism in protected regions, using the DPSIR framework to assess socioeconomic and biophysical complications. Using an inductive Grounded Theory method, it emphasizes the importance of ecosystem thinking in determining action priorities. The study further analyzed the need for strong institutional capacity, multi-layered management, monitoring, education, and community consent to ensure sustainability and resilience.

Maxim et al. (2009), Gari et al. (2015) conducted a literature assessment of the DPSIR framework, stressing its communicative strengths but limitations as an analytical tool due to its deterministic perspective. The authors contend that DPSIR oversimplifies complex environmental and socioeconomic systems, handles uncertainty and multidimensional causality. They suggest DPSIR can be redefined using a complex system which distinguishes social, environmental, economic and political segments. The Assessing Large scale environmental Risks for biodiversity with tested Methods (ALARM) project uses this improved model to conduct an integrative policy, society, economy, and

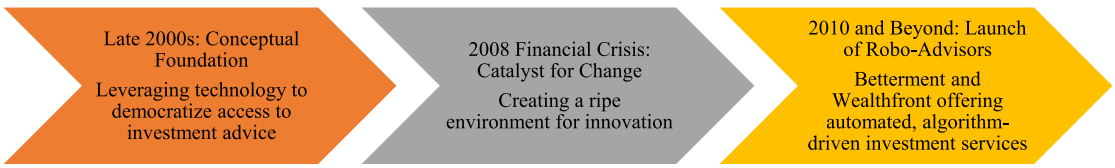

Fig. 1. Advent of robo-advisors.
(Source: Author's Own compilation).

Table 1
Emerging trends in robo-advisory services.
Source: Author's own compilation.

Characteristics	Robo-Advisors in 2010: The Pioneering Phase	Robo-Advisors in 2024: A New Era of Financial Technology
Portfolio Management	Basic portfolio management using standard algorithms	Dynamic portfolio management with advanced AI and machine learning
Personalization	Limited personalization based on basic questionnaires	Hyper-personalized strategies using big data analytics
Cost Structure	Focus on low costs	Comprehensive financial advisory services
Financial Planning Services	Basic portfolio management	Holistic financial planning, including retirement, tax, and estate planning
Integration	Standalone platforms	Integrated with broader financial ecosystems (banking, insurance)
User Interface	Basic user interfaces	Enhanced, intuitive interfaces with mobile apps and virtual assistants
Regulatory Environment	Navigating emerging regulatory frameworks	Mature regulatory frameworks, clearer guidelines, and consumer trust
Investment Options	Primarily stocks and bonds	Expanded options including alternative assets and ESG (Environment, Social & Governance) investments

Table 2
Top 10 Robo Advisory startups companies in India as on December 2025 (Source).
Source: https://tracxn.com.

Company Name	Founded Year	Location	Stage
Scripbox	2012	Bengaluru, India	Series D
INDmoney	2019	Gurgaon, India	Series D
Groww	2016	Bengaluru, India	Series E
Kuvera	2016	Bengaluru, India	Acquired
ET Money	2015	Gurgaon, India	Acquired
Fisdom	2015	Bengaluru, India	Series C
FundsIndia	2009	Chennai, India	Series C
5nance	2015	Mumbai, India	Series A
ArthaYantra	2011	Hyderabad, India	Series A
Cube Wealth	2018	Mumbai, India	Series A

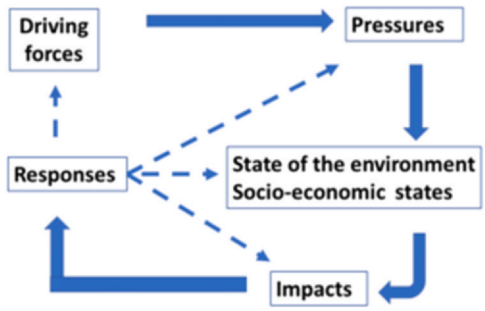

Fig. 2. DPSIR framework (Learning for sustainability, 2026).

biodiversity analysis. Yi et al. (2025) depicts how the DPSIR model successfully organizes social, environmental and economic aspects. This allows for an in-depth examination of how the green sustainable finance is contributing to rural sustainability, taking into account regional effects with moderating variables like environmental regulations and digitization.

Tscherning et al. (2012) studies the DPSIR framework as a decision-making tool by structuring indicators. Though this is helpful in bridging the science-policy gap, the framework has been criticized, particularly for its lack of stakeholder contribution and transdisciplinary research. The literature review based on the 21 studies, concludes that DPSIR is utmost effective when it mixes varied knowledge & presents decision opportunities. The participation of stakeholders and robust policymaking framework can lead to increase in its utility. Deng et al. (2025) research uses DPSIR framework in combination with applied EWM-TOPSIS method & fuzzy comprehensive assessment to study the land eco-safety in the Pearl River Delta. The study suggests how well DPSIR model complex environmental variables and accounts for dynamic interactions, resulting in a reliable method for assessing urban ecological risk.

Nyein et al. (2025) comprehensively analyzed mangrove degradation in Myanmar with the help of DPSIR framework, assessed ecological shifts and socioeconomic aspects. The authors further examined sustainability nexus and mentioned that its long-term impact is still grey area of research and needs further investigation. Mann (2025) applied DPSIR framework by taking child labour case, and concluded that it is highly useful to address social issues. Another study by Lewison et al. (2016) applied DPSIR framework in coastal setting, highlighted its capability to address scientific issues. However, the authors also stated that relatively a smaller number of research studies have used DPSIR framework as initial point for conducting quantitative and semi-quantitative investigations.

Banerjee (2025) discussed the pivotal aspects that impacts Investor's viewpoints towards robo-advisor include financial literacy and technology readiness. The authors applied structural equation modelling and concluded that technology readiness positively impacts perceived benefit and robo-advisor adoption. Steve Senteio (2024) conducted study in USA and examined the parameters which impacts customer satisfaction and trust while using robo-advisory services. The authors further discussed that lack of education is a significant deterrent towards robo-advisor adoption.

Panakaje et al. (2025) investigate the role of the snakebite effect in mediating the connection between investing decisions and the perceived value of robo-advisors. According to their research, investors' resilience and social-emotional health considerably mitigate this effect, lessening its adverse effects. To increase the efficacy of robo-advisors and investor trust, the study emphasizes the significance of combining emotional intelligence with hybrid advisory models. A dual-factor and benefit-risk model were used by Singh and Karamcheti (2025) to investigate the factors that promote and hinder the use of robo-advisors in India. Inhibitors include low-quality interactions and a lack of awareness, whereas key enablers include perceived anthropomorphism, trust, and social influence. Their results highlight the value of user-centered design and education in boosting robo-advisor market penetration and adoption.

The adoption of robo-advisors in India is examined by Fatima and Chakraborty (2024) utilizing the paradigm of technology acceptance. The authors used PLS-SEM on 445 investors responses and mentioned that behavioral intention is highly influenced by trust, anxiety, performance expectancy, and desire for human advisors. Moreover, the authors discussed the psychological and functional elements influencing investors' adoption of AI-powered financial advising systems.

Aw et al. (2023) assessed privacy and justice issues to analyze consumer opposition to robo-advisors. The adoption of robo-advisors by Indian investors is examined by Parashara et al. (2024), who place special emphasis on traditional financial preferences, trust, and technological acceptability. Through the use of regression and exploratory factor analysis, the study discovers that while traditional preferences impede adoption, trust and technology acceptance promote it.

Chandani et al. (2021) draw attention to the lack of awareness among millennials and suggest educational interventions. Also, Bhatia et al. (2020) concentrate on the potential of robo-advisors to reduce behavioral biases among individual investors. The study further highlighted the necessity of behavioral support, trust-building, and awareness-raising to improve its adoption in India. By combining the Black-Litterman portfolio model with homomorphic encryption, Ko et al. (2023) suggested a privacy-preserving robo-advisory system. In terms of privacy considerations, it provides insights into investment behavior while striking a balance between system accuracy and regulatory compliance.

Using regulatory focus theory, Chang and Wang (2023) investigate algorithm aversion in automated wealth management. Also, the authors discussed that perceived fit is the reason why prevention-focused people, who are generally conservative adopters, are less inclined to robo-advisors. The mediator of this association is perceived flexibility. Nain and Rajan (2023) use expert interviews to qualitatively analyze the state of robo-advisory in India and discussed that convenience, time efficiency, and transparency are important facilitators, and investor sentiment and low awareness are obstacles.

2.2. Research gaps

The literature which is currently available on robo-advisors identifies a number of challenges, but it does not provide a comprehensive analysis. Research like Wagner (2024) and Baker and Dellaert (2018) highlights the complexity of regulations and mentioned that there is a lack of a comprehensive framework connecting relevant factors like financial literacy, policy, & disclosure. Moreover, gaps in innovation, personalization, and hybrid models are noted by Agarwal et al. (2020), especially in the Indian setting.

Park et al. (2024) shows the potential of AI-driven models from a technological standpoint, but urge integration with more extensive data sources and comparing methodologies. The importance of trust, perceived risk, and user experience are highlighted in adoption-focused studies (Hong et al., 2023; Ashrafi and Kabir, 2023), but their causal interdependencies are not captured. Furthermore, while studies like Back et al. (2023) and Liu et al. (2023) offer behavioural insights, they do not have a formal framework for making decisions.

In order to prioritize the anticipated factors, Fuzzy AHP method is found suitable to fill a critical gap and prioritize the anticipated factors of adopting robo-advisors.

3. Research methodology

The research is conducted in two phases. In first phase, the DPSIR framework is applied for relevant dimensions. In second phase, fuzzy-AHP framework is used to prioritize these dimensions. The DPSIR framework for robo-advisors in wealth management investigates the interplay between technical improvements and regulatory needs. The growth of AI, demand for cost-effective solutions, and efforts to increase financial inclusion are among the driving forces. These pressures include SEBI compliance and the requirement for cybersecurity. The current state reflects market penetration, consumer trust, and the maturation of AI/ML technologies. Increased investor access, competition with established advisors, and regulatory supervision issues are all visible consequences. Responses include regulatory changes, industry self-regulation, and technology advancements to improve the accuracy and transparency of robo-advisory services. The DPSIR dimensions are shown in Table 3. The research methodology is illustrated in Fig. 3.

3.1. Fuzzy-AHP technique

Fuzzy-AHP technique is used to solve dynamic complex problems (Saaty, 1977). It is used in variety of research areas, for example: analysis of logistics networks (Saucedo-Martínez et al., 2024), healthcare (Alharbi et al., 2024); sustainable urban transport (Moslem et al., 2024). Although, there are various decision-making technique available in the multi-criteria decision-making analysis, but AHP is found to be superior, because of linear evaluation capability. Since human-based responses are subjected to biasness, a triangular based fuzzy scale was used to remove ambiguity as shown in Appendix-A, Table A-1. The steps of fuzzy-AHP are discussed as follows:

As per extent analysis method suggested by Chang (1996), The Fuzzy-AHP methodology involves several steps, as discussed follows:

As Chang (1996) suggested the extent analysis,

$$L^1_{gi},\ L^2_{gi},\ L^3_{gi},\ .....L^m_{gi}, \qquad i = 1,\ 2,\ 3.....n$$

where all $L^j_{gi}(j = 1,\ 2,\ 3,\ .....m)$ *represents traingular fuzzy numbers as mentioned in Table2.*

Step 1: The judgemental matrix in fuzzy form is represented as

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & .... & .... & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & .... & .... & \tilde{a}_{2n} \\ .... & .... & .... & .... & .... \\ \tilde{a}_{n1} & \tilde{a}_{n2} & .... & .... & 1 \end{bmatrix} \tag{1}$$

The judgemental matrix $\tilde{A}$ *is nxn fuzzy matrix having fuzzy number* $\tilde{a}_{ij}$(Sirisawat and Kiatcharoenpol, 2018)

$$\tilde{A}_{ij} = \begin{Bmatrix} 1 & i = j \\ 1,\ 3,\ 5,\ 7,\ 9 \ \ or..... 1^{-1},\ 2^{-1},\ 3^{-1},\ 5^{-1},\ 7^{-1},\ 9^{-1} & i \neq j \end{Bmatrix} \tag{2}$$

Step 2: Evaluate fuzzy synthetic extent with respect to ith solution using Eqs. (8)–(10) which is defined as

$$U_i = \sum_{j=1}^{m} L_{gi}{}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} L_{gi}{}^j \right] \tag{3}$$

where

$$\sum_{j=1}^{m} L_{gi}{}^j = \left(\sum_{j=1}^{m} r_{ij},\ \sum_{j=1}^{m} s_{ij},\ \sum_{j=1}^{m} t_{ij} \right) \tag{4}$$

$$\sum_{i=1}^{n} \sum_{j=1}^{m} L_{gi}{}^j = \left(\frac{1}{\sum_{n}^{i=1} \sum_{m}^{j=1} t_{ij}},\ \frac{1}{\sum_{n}^{i=1} \sum_{m}^{j=1} s_{ij}},\ \frac{1}{\sum_{n}^{i=1} \sum_{m}^{j=1} r_{ij}} \right) \tag{5}$$

where r, s and t represents lower, middle and upper limit values

Step 3: The possibility degree of $L_2 = (d_2, e_2, f_2) \geq L_1 = (d_1, e_1, f_1)$ *can be written as:*

$$V(L_2 \geq L_1) = hgt\ (L_2 \cap L_1) = \mu(d) \tag{6}$$

$$= \begin{Bmatrix} 1 & if\ s_2 \geq s_1 \\ 0 & if\ r_2 \geq t_2 \\ \frac{r_1 - t_2}{(s_2 - t_2) - (s_1 - r_1)} & otherwise \end{Bmatrix}$$

where $\mu(d)$ *represents hightest* intersection *between two fuzzy numbers* (7)

To contrast among P_1 and P_2, comparison is made between $V(L_1 \geq L_2)$ and $V(L_2 \geq L_1)$. For the probability that the convex fuzzy numbers be greater than s fuzzy numbers, P_i (i = 1,2,3,…….*e*), can be defined as:

$$V(L \geq L_1, L_2, L_3, L_4.....L_e) = V[(L \geq L_1),\ V(L \geq L_2).....V(L \geq L_e)] = minV(L \geq L_1),\ i = 1,\ 2,\ 3.....e \tag{8}$$

It is assumed that $d'(A_i) = \ \text{minV}(U_i \geq U_e)$ (9)

For $e = 1,\ 2,\ 3,\ 4,\ .....n\ (e \neq i)$, the weight vector is represented as

Table 3
DPSIR model for robo advisors.
Source: Author's own Compilation.

Particulars	Notation	Meaning	Factors	Refs.
Driving Forces	D1	Factors Leading to Adoption	Technological Innovation	Tomic et al. (2024), Zhu et al. (2024), Ku and Wang (2022),
	D2		Easy Accessibility of Investing	Ablazov et al. (2024)
	D3		Demographic Shifts	Steennot (2021), Brenner and Meyll (2020), Zhu et al. (2024), Ku and Wang (2022), Parashara et al (2024).
	D4		Mimetic Pressure from Competitors	Panda et al. (2023)
	D5		Market Uncertainty	Liu et al. (2023), Sabir et al. (2023)
Pressures	P1	Barriers and External Forces Impacting Functioning of Robo-Advisors	Compliance with SEBI Regulations	Chou et al. (2023), Yi et al. (2023), Ashrafi and Kabir (2023). Pant et al. (2024).
	P2		Cybersecurity	Piotrowski and Orzeszko (2023), Shiva et al. (2023), Han et al. (2024).
	P3		Cost Effective Financial Services	Piotrowski and Orzeszko (2023), Hong et al. (2023)
	P4		Transparency (Black Box)	Dong et al. (2022), Torno and Schildmann (2020), Zhu et al. (2023)
State	S1	Current Industry Condition	Market Penetration	Li (2023), Hong et al. (2023)
	S2		Lower Entry Barriers	
	S3		Consumer Confidence	Cardillo and Chiappini (2024), Jiang et al. (2024), Cao et al. (2026)
	S4		Technological Stability	Park et al. (2024), Yeh et al. (2023)
Impact	I1	Effects on Stakeholders	Personalized Decision Making And Reduced Fatigue	Park et al. (2024), Dong et al. (2022), Nourallah (2023), Back et al. (2023)
	I2		Improved Risk Assessment and Portfolio Optimization	Bhatnagar et al. (2024).
	I3		Enhanced Scalability (Robo-Advisors Can Serve Millions of Clients Simultaneously, Something Traditional Advisors Cannot Achieve).	Upadhyay et al. (2024).
	I4		Data-Driven Decision Making	Steennot (2021), Nain and Rajan (2023). de Oliveira Santini et al. (2026), Silber et al. (2025).
Responses	R1	Stakeholder Actions	Harmonizing Regulations Across International Borders and Within Borders	Neuwirth (2025)
	R2		Incorporating Training and Educational Programs on Fintech Innovations	Brenner and Meyll (2020), Nain and Rajan (2023), Yi et al. (2023),
	R3		Financial Literacy	Banerjee (2025). Fatima and Chakraborty (2024).
	R4		Collaboration of Financial Institutions with Fintech	Mohammed Faiz-ul-faham and Shekhar (2024), Ruhlandand Wiese (2023), Barile et al. (2025).

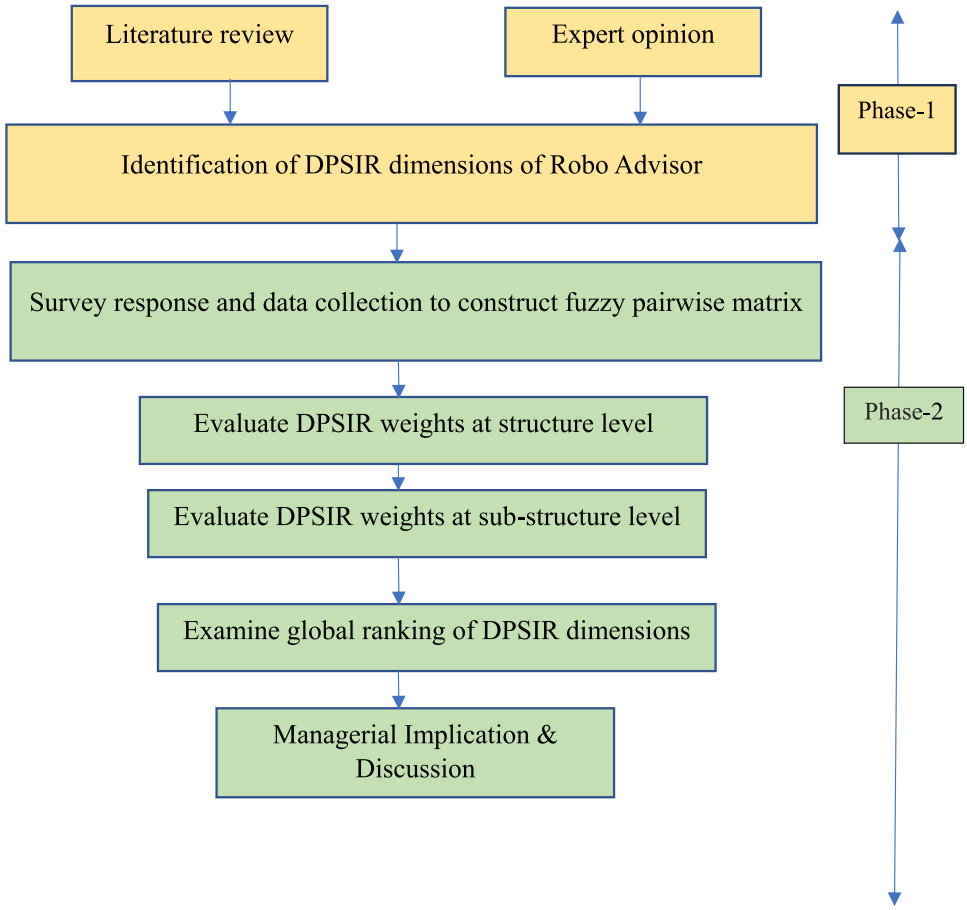

Fig. 3. Research framework.
(Source: Author's own Compilation).

$$Z' = (d'(A_1),\ d'(A_2),\ \ldots\ldots\ldots d'(A_n))^T$$
$$\text{where } A_i\ (i = 1, 2, 3, 4, 5, \ldots\ldots\ldots n)\ \text{ are } n \text{ attributes} \qquad (10)$$

where Z being non-fuzzy number

Step 4: The normalized weight vectors of solutions are evaluated as

4. Case illustration

Case industry was considered, dealing with robo-advisors. Company was pioneered in proving technological solutions for automated financial planning, investing and making crucial financial decisions. Total, 18 experts were selected, who were having vast experience of finance & investing. All the experts were holding master's degree and above forty years of age. Moreover, all the experts were having vast experience in dealing with robo-advisory services. After exploring DPSIR dimensions, the experts were asked to confirm the identified dimensions. Once the list was finalized, data was collected using personal interviews. The average time for the interview is estimated as 80 min. Before data collection, research idea and research objectives were explained to the experts. Fuzzy-comparison matrix of DPSIR dimensions is shown in Table 4. Subsequently Table 5 and Table 6 shows weights at category and sub-category level respectively.

Table 5
DPSIR weights.
(Source: Author's own Compilation).

Parameter	Weight	Rank
Driving Forces(D)	0.2307	1
Pressure(P)	0.2066	2
State(S)	0.1875	4
Impact(I)	0.2061	3
Responses(R)	0.1686	5

4.1. Sensitivity analysis

Sensitivity analysis is carried out by varying weights of DPSIR factors. Total 15 trails were conducted. In the first trial, factor1. i.e., D1

Table 4
Fuzzy-comparison matrix of DPSIR dimensions.
(Source: Author's own Compilation).

Dimensions	D	P	S	I	R
D	(1.00,1.00,1.00)	(0.25,0.57,4.00)	(1.00,5.50,9.00)	(1.00,4.39,9.00)	(0.17,2.96,9.00)
P	(0.25,1.74,4.00)	(1.00,1.00,1.00)	(1.00,2.86,9.00)	(0.25,0.41,1.00)	(0.11,0.30,6.00)
S	(0.11,0.18,1.00)	(0.11,0.35,1.00)	(1.00,1.00,1.00)	(0.11,0.52,7.00)	(0.11,0.37,6.00)
I	(0.11,0.23,1.00)	(1.00,2.44,4.00)	(0.14,1.92,9.00)	(1.00,1.00,1.00)	(0.11,0.53,6.00)
R	(0.11,0.34,6.00)	(0.17,3.30,9.00)	(0.17,2.71,9.00)	(0.17,1.89,9.00)	(1.00,1.00,1.00)

Table 6
DPSIR dimension weights.
Source: Author's own Compilation.

Particulars	Notation	Factors	Meaning	Category Ranking	Overall Rank
Driving Forces	D1	Technological Innovation	Factors leading to adoption	1	2
	D2	Easy accessibility of investing		4	13
	D3	Demographic shifts		3	17
	D4	Mimetic Pressure from competitors		2	21
	D5	Market Uncertainty		5	12
Pressures	P1	Compliance with SEBI regulations	Barriers and external forces	3	18
	P2	Cybersecurity	impacting functioning of robo-	2	19
	P3	Cost effective financial services	advisors	1	1
	P4	Transparency (Black Box)		4	15
State	S1	Market penetration	Current industry condition	4	20
	S2	Lower Entry Barriers		2	14
	S3	Consumer Confidence		1	3
	S4	Technological Stability		3	16
Impact	I1	Personalized decision making and reduced fatigue	Effects on stakeholders	1	4
	I2	Improved Risk Assessment and Portfolio Optimization		3	6
	I3	Enhanced scalability (Robo-advisors can serve millions of clients simultaneously, something traditional advisors cannot achieve).		2	5
	I4	Data-driven decision making		4	7
Responses	R1	Harmonizing regulations across international borders and within borders	Stakeholder actions	2	8
	R2	Incorporating training and educational programs on fintech innovations		1	11
	R3	Financial Literacy		4	9
	R4	Collaboration of financial institutions with fintech		3	10

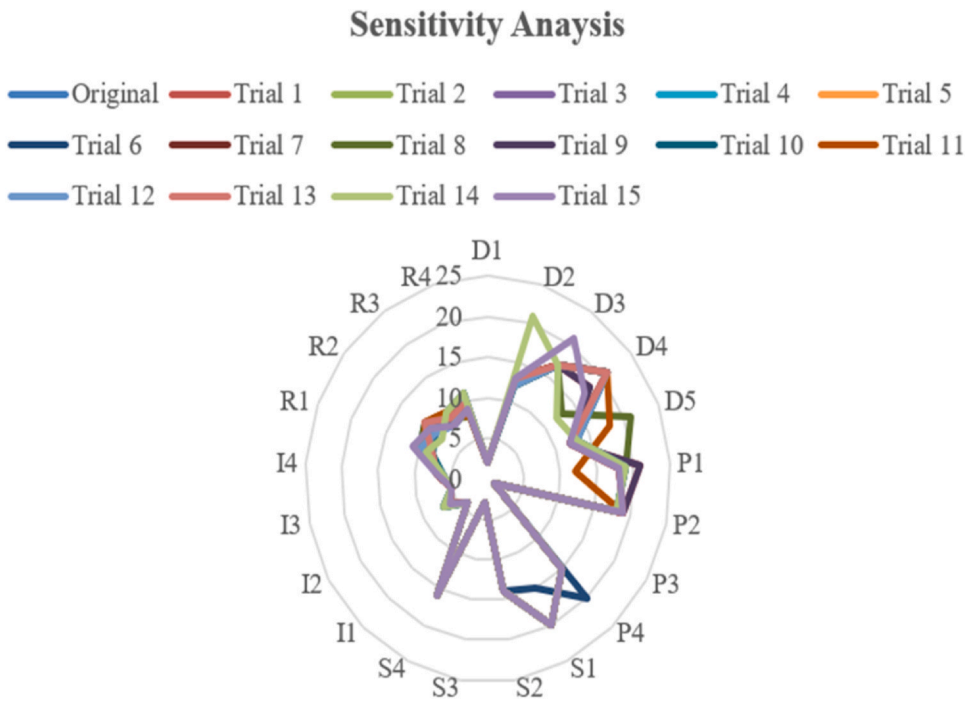

Fig. 4. Sensitivity analysis.

was assigned more weight, i.e., 0.6, and remaining twenty factors were assigned weight equal to 0.02. Likewise, in the second trail, factor D2 was assigned weight equal to 0.6, while the other remaining assigned weights as 0.02. Likewise, total fourteen trails were conducted, moreover, in the last trial, i.e., trial 15, all factors were assigned equal weight, i.e., 0.0476. It is observed that, in all these trials, ranking of factors changed a little only, which confirms the reliability & robustness of factors rankings. Sensitivity analysis results are shown in Fig. 4.

5. Results and discussion

The wealth advisory is considered a significant advancement in the current financial landscape. The DPSIR framework is a novel attempt to assess the wealth advisory with its driving force (D), pressures(P), state (S), impact (I) and response (R) that might help stakeholders understand the current situation and take relevant steps for development. Further, quantitative assessment of these DPSIR factors will help

Table 7
Future research directions.
Source: Author's own Compilation.

Parameters	Factors	Research Gap	Future Research Directions
Factors Leading to Adoption	Technological Innovation	• Paucity of studies on using technologies like blockchain and artificial intelligence (AI) to enhance robo-advisory services' efficiency, security, and personalization.	• Machine Learning & Artificial Intelligence (AI) integration in wealth technology to improve individualized investment recommendations. • Blockchain technology may revolutionize asset management and investment services.
	Easy Accessibility of Investing	• Inadequate studies on how easy accessibility translates into sustainable informed investment behaviour.	• Examine integrating accessibility with financial education to improve decision-making among new investors.
	Demographic Shifts	• Investors prefer human financial advisors as unbiased advice, concerns about conflicts of interest & potential financial frauds. • Robo-advisors may reduce the demand for financial advisors. Resistance from Investors for adapting • Unrealistic expectations by the investors • No support for financial distress at the time of market volatility.	• Analyzing how hybrid advising models strike a balance between automation and human knowledge • Future study might investigate ways to improve investor confidence in robo-advisors by addressing issues with impartial advice, conflicts of interest, and support during market volatility.
	Mimetic Pressure from Competitors	• Limited research on WealthTech's long-term impact on investor behavior, risk tolerance, and market engagement. • Huge gap in exploring challenges facing with Robo advisory regulation, trust, and competition.	• Pressure from competitors to copy in order to influence WealthTech acceptance and innovation. • FinTech companies' approaches to resolving regulatory issues. • Strategies for gaining the trust of customers and taking on established banking institutions.
	Market Uncertainty	• Less responsive to update the portfolio with less risky stocks in the financial crash, • Dependence on algorithmic decision-making, lack of adaptivity in varied market conditions	• Improving robo-advisors' ability to react to market fluctuations; • Creating dynamic algorithms for in-the-moment portfolio adjustments during financial emergencies.
Barriers And External Forces Impacting Functioning of Robo-Advisors	Compliance with SEBI Regulations	• Compliance with financial regulations to protect customer interests	• Removing psychological obstacles to increase robo-advisory services' credibility with investors. • For individualized wealth management, effective human-technology collaboration needs to be investigated. • Analyzing legal frameworks to guarantee adherence and data security in online banking
	Cybersecurity	• Concerns on vulnerability to cyber threats as use of online platforms by investors	• Investigating federated learning in WealthTech for private and secure data exchange. • Examining the merging of AI and quantum computing to increase processing capacity. • Using emerging technology to advance quantitative investment and wealth advising
	Cost Effective Financial Services	• Inability to easily integrate robo-advisors with current financial procedures and systems. • The present models of robo-advisors are not sufficiently scalable or capable of handling data.	• To develop cost-effective scalable system, integration for robo-advisory services that are affordable. • Cutting expenses for advertising and acquiring new clients. • Creating reliable methods to manage massive data sets without sacrificing functionality.
	Transparency (Black Box)	• The complexity and diversity of data sets make it impossible for robo-advisors to effectively predict risk preferences. • Insufficient interpretability and transparency erode investor confidence, impeding broad adoption.	• Enhancing risk assessment and creating interpretable AI models to increase transparency and ethical decision-making. • Simplifying the dissemination of information to improve user comprehension of robo-advisor choices.
Current Industry Condition	Market Penetration	• There has been little research on how to improve transparency and trust by integrating blockchain technology with sophisticated robo-advisor models. • Absence of empirical research on the ways in which this integration can promote market penetration and individualized investment strategies.	• Boosting the market adoption of robo-advisors by addressing cultural acceptance, financial knowledge, and user trust. • Using blockchain technology to enhance financial solutions that are more individualized, transparent, and secure.
	Lower Entry Barriers	• Limited and narrow understanding in context of entry barriers (purely financial thresholds)	• Explore multi-dimensional entry barriers • Prioritize the barriers and explore solution methodologies

(*continued on next page*)

Table 7 (*continued*)

Parameters	Factors	Research Gap	Future Research Directions
	Consumer Confidence	• Access is restricted for people who lack technology or have low incomes. • Diverse investor profiles don't fit well.	• AI facial and voice recognition for improved customer service. • Personalized guidance using cutting-edge AI technology. • Enhanced service effectiveness via AI incorporation
	Technological Stability	• Investor vigilance and risk awareness may be diminished by an over-reliance on robo-advisors. • Investigate how favorable circumstances influence the adoption of technology in asset management.	• Maintaining a balance between wealth management automation and investor participation. • Making certain that automated platforms are technically stable. • Encouraging prompt risk awareness and ongoing portfolio oversight
Effects on Stakeholders	Personalized Decision Making and Reduced Fatigue	• Insufficient customization for a range of investor objectives and intricate financial requirements. • Assumed risk aversion restricts the appropriateness of guidance, necessitating improved assistance from regulators and providers.	• Improving robo-advisors to provide tailored guidance for intricate financial situations. • Enhancing risk profiling and increasing investment possibilities to meet the specific demands of investors.
	Improved Risk Assessment and Portfolio Optimization	• Poor risk management integration of cutting-edge technology. • Tech-based portfolio optimization is not given enough attention.	• Examine the long-term impacts of robo-advisors on portfolio results and risk management. • Explore how risk frameworks and investor returns can be improved by AI and ML.
	Enhanced Scalability (Robo-Advisors Can Serve Millions of Clients Simultaneously, Something Traditional Advisors Cannot Achieve).	• Research on how the scalability of robo-advisors improves financial accessibility in emerging nations is scarce. • Studies relating scalability to adoption rates and investor satisfaction are lacking.	• Analyze how robo-advisors affect financial accessibility over the long run in emerging nations. • Examine how scalability affects user efficacy, satisfaction, and acceptance.
	Data-Driven Decision Making	• Absence of reliable, data-driven frameworks for evaluating the correctness and dependability of robo-advisory algorithms. • Not enough attention is paid to ensuring algorithmic recommendations comply with legal and investor protection requirements.	• Create sophisticated suitability analyses to match the profiles of individual investors with robo-advisory tactics. • Provide strong regulatory structures to guarantee investor safety, accountability, and algorithmic transparency.
Stakeholder Actions	Harmonizing Regulations Across International Borders and Within Borders	• How different cultural viewpoints and legal requirements affect the uptake, credibility, and long-term user experience of robo-advisory services in various markets.	• Examine the ways in which investment attitudes and cultural factors influence the uptake of robo-advisors among Indian populations. • Use long-term user experience analysis to investigate shifts in perceived risk and tech anxiety.
	Incorporating Training and Educational Programs on Fintech Innovations	• Lack of systematic educational and training programs in context of robo-advisory adoption	• Impact of robo-advisory training programs can be assessed to enhance its effectiveness. • Customized training programs can be developed to enhance engagement.
	Financial Literacy	• Insufficient financial knowledge prevents investors from using robo-advisors effectively. • Investors find it challenging to sort and apply pertinent insights due to an abundance of information.	• Research the impact of financial literacy on robo-advisor anxiety and trust. • Examine the influence of demographics in selecting automated or human guidance.
	Collaboration of Financial Institutions with Fintech	• Disruptions of financial industry due to advent of digital technologies	• Analyze how established institutions are changing and how that is affecting customer choice and competition in robo-advisory. • Examine how robo-advisors can help underprivileged communities become more financially included.

decision makers in prioritizing to the ranked DPSIR factors when formulating policies for Robo advisory management. The Fuzzy AHP analysis of DPSIR, the 'driving forces" received the highest weight of 0.2307, indicating the significance of factors leading to adoption of robo-advisory in India being technological innovation (D1), easy accessibility of investing (D2), demographic shifts (D3), mimetic pressure from competitors (D4) and market uncertainty (D5).

The category rating for D1 Innovation in Technology is the most relevant of the five assessed components, which is in line with the results of Tomic et al. (2024). D1 serves as a prerequisite for the provision of high-fidelity financial solutions, which accounts for its significance. In particular, it makes possible to implement AI-driven insights and complex algorithms that aligns with standard institutional analysis, significantly enhancing the precision and effectiveness of investment decision-making. "Easy Accessibility (D2) plays a crucial role in the broad adoption of robo-advisors, as Ku and Wang (2022) have established which suggests digital platforms successfully serve a wide range of users as they provide smooth, affordable, and simple navigation. Investor's desire to switch from traditional advisory models to automated digital solutions is significantly predicted by "Perceived Ease of

Use," which is improved by accessibility. Demographic Changes (D3) also identified by Parashara et al. (2024) as the main driver suggest, the demand for digital-first financial solutions has surged due to the growing influence of tech-savvy Gen Z and Millennial investors, who favour automated wealth platforms' efficiency, transparency, and autonomy over conventional advisory models. Additionally, financial institutions must incorporate robo-advisory services in the changing fintech ecosystem due to mimetic pressure from private fintech players (D4), identified by Fatima and Chakraborty (2024). Last but not least, robo-advisors are a desirable substitute for conventional advice models since market uncertainty(D5) has brought attention to the need for objective, data-driven investing methods (Sabir et al., 2023). All of these factors work together to propel the quick uptake and growth of robo-advisory services in India.

The DPSIR elements "pressure" and "impact" which have weights of 0.2066 and 0.2061, respectively, ranked second and third. A number of outside issues are driving forces behind the introduction of robo-advisory systems. Although it increases operational complexity, but regulatory compliance (P1) with SEBI standards guarantees investor safety. Cybersecurity issues (P2) poses a significant problem if it is compromised at any case, as reported by Shiva et al. (2023). The success of robo-advisors is directly proportional to the security features that algorithm can provide. Moreover, research and development activities help in meeting compliances with standardized rules and regulations, and providing cost-effective solutions (P3). Likewise, trust building & transparency (P4) lays the cornerstone for making crucial and secure investment and financial decisions.

On the other hand, the impact of robo-advisors is demonstrated by its capacity to offer individualized decision-making (I1), which lessens investor fatigue and enhances financial results as suggested by Nourallah (2023) also. Moreover, these platforms successfully enhance financial results by customizing tactics to distinct user profiles. The 'one size fits all' constraint of conventional advice models can be overcome in order to build trust necessary for long-term adoption. Additionally, by utilizing AI-driven methodologies, robo-advisors facilitate improved risk assessment and portfolio optimization (I2). Further, it can service millions of clients at due to scalability features (I3), something that traditional advisors find difficult to accomplish. Moreover, data-driven decision-making (I4) improves investment plans' objectivity and efficiency. Steennot (2021) also mentioned that robo-advisors offer a more dependable foundation for investor protection by leveraging standardized data and suggest better financial plans. This data-driven strategy reduces human prejudice and guarantees that financial recommendations are constantly in line with the investor's objective risk profile and market conditions.

The state (S) has a weight of 0.1875, making it the fourth most important factor affecting the adoption of robo-advisors in India. As discussed by Hong et al. (2023), the market penetration (S1) a is component, which measures how well robo-advisors have gotten traction with investors. Unlike purely theoretical drivers, this indicator assesses "value-based adoption," measuring the degree to which platforms have successfully transformed digital accessibility into financial behaviour. It acts as a yardstick for assessing whether robo-advisory has transcended to become a major player in contemporary wealth management. Reduced entry barriers (S2) facilitate adoption by increasing the accessibility of digital advisory services for both consumers and providers as concluded by Cardillo and Chiappini (2024). According to authors systematic review, these platforms improve accessibility for a wider range of consumers and make it easier for new digital service providers to join the financial ecosystem by reducing cost and complexity. Because user acceptability is directly impacted by consumer confidence (S3) in algorithm-driven financial decisions, so it is vital. Finally, technical stability (S4) boosts the uptake of robo-advisory platforms as seconded by Park et al. (2024). Their results shows that building the investor trust is required for widespread adoption in the Indian market. It requires maintaining seamless operations, strong security, and algorithmic dependability—especially during times of global economic instability.

The element that received fifth position is responses(R)with a weight of 0.1686, highlighting the role of stakeholder's actions towards robo-advisory. India is predicted to have 3.2 million robo-advisor users by 2028, fuelled by the fintech boom among young investors and rising financial literacy (Presica, 2024). A multifaceted strategy that involves regulatory harmonization, financial literacy training, education, and cooperation between fintech companies and traditional financial institutions is required for the adoption of robo-advisory services. To provide a uniform framework that promotes confidence and scalability in robo-advisory services, it is imperative to harmonize legislation across national and international borders (R1) in accordance with the study of Nain and Rajan (2023). A smoother adoption process can also be achieved by integrating training and educational initiatives (R2) on fintech developments, which can close the knowledge gap between consumers and industry professionals. Improving financial literacy (R3) is equally important since knowledgeable investors are more inclined to use and trust digital advising services. Finally, collaboration between fintech companies and financial institutions (R4) can enhance service delivery and incorporate automated solutions into the larger financial ecosystem as also suggested by Yi et al. (2023). This partnership improves the "Trust" and "Usability" impressions required for broad acceptance among the millennial generation of the twenty-first century.

According to analysis of DPSIR framework, the overall highest ranking is for the element of pressures i.e.P3-Cost effective financial services and second rank is for driving forces factor (D1) technological innovation. It is imperative to develop cost-effective robo-advisory solutions, so that its services can be availed by majority of the clients. For this, organizations must invest heavily on technological innovations, and carry out research and development activities. Under the various categories of Driving Forces, technological innovation has the highest rank among the five factors identified, the lowest being market uncertainty. As per the 'Pressures', which represents the barriers and external forces impacting functioning of robo-advisors, P3 (cost effective financial services) holds first rank, on the other hand, Transparency (Black Box) stood at last rank.

6. Conclusion, limitations & future directions

This research paper aimed to studied DPSIR framework factors impacting robo-advisors in Indian WealthTech sector which is being driven by technological innovation, regulatory adaptation, and shifting investors' expectations. The factors identified with conceptual DPSIR framework helps to gain deeper insight on how emerging technologies, accessibility to investing, demographic shifts, stakeholder's ecosystem, financial literacy impacts decision-making (Moktadir and Ren, 2023). Subsequently, the fuzzy AHP method is applied to quantitatively assess the DPSIR factors, enabling stakeholders to understand the severity of individual factors. This is a novel study to assess and prioritize various contributing factors impacting robo-advisor adoption. The uncertainty and subjectivity inherent are addressed with the fuzzy AHP method, leading to reliable and accurate decision-making. Similar findings are discussed by Mangla et al. (2015) that fuzzy logic is used to better handle uncertainty and imprecise information while capturing expert judgment.

Therefore, the fuzzy AHP approach can handle subjective data more accurately, overcoming vagueness and uncertainty in decision-making. As per category ranking, the driving force element received highest weight. Also, according to the global (overall) rank, the top five DPSIR factors were cost effectiveness of the financial services, technological innovation, consumer confidence, personalized decision making & reduced fatigue, and the enhanced scalability. These findings emphasized on leveraging advanced technologies, scalable infrastructure, and hybrid advisory models leading to cost efficiency, innovation, and personalized services. Strengthening regulatory frameworks, promoting financial literacy, and ensuring cybersecurity will lead to investor's

confidence in the wealth advisory framework and models.

There are certain limitations of the research. The results using DPSIR framework and fuzzy- AHP approach in the context of robo-advisors are not empirically validated, therefore, for future studies, empirical data can be used to validate the findings. Furthermore, the proposed study results might be country-specific, therefore future research can be conducted across different geographical locations. Robo-advisors and other advisory models could be compared in simulation-based studies to gain a better understanding of the efficacy and scalability of wealth advisory services. This would lead to improved decision-making procedures and ensure better alignment with transforming technological advancements and financial landscape. Table 7 shows the future research directions for adopting robo-advisors.

Abbreviations

EWM: Entropy Weight Method
TOPSIS: Technique for Order of Preference by Similarity to Ideal Solution
AI: Artificial Intelligence
ML: Machine Learning

CRediT authorship contribution statement

Tahseen Arshi: Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Laxmi Pandey:** Writing – review & editing, Writing – original draft, Data curation, Conceptualization. **Naveen Virmani:** Writing – review & editing, Writing – original draft, Visualization, Conceptualization. **Dimple Bhandari:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Sandeep Jagtap:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization.

Human and animal rights

This research was approved by the Research & Ethics Committee of Institute of Management Studies Ghaziabad, India via letter IMS/DR/2025/24. All research activities were conducted in accordance with institutional and national ethical guidelines.

Informed Consent and Confidentiality

The authors declare that they obtained a written informed consent from the patients and/or volunteers included in the article and that this report does not contain any personal information that could lead to their identification

Declaration of Generative AI and AI-assisted technologies in the writing process

This study did not use AI tools during manuscript preparation.

Funding Information

No funding was available for this research project.

Data Availability

Data will be made available on request.

Declaration of Competing Interest

The authors declare no conflict of interest.

Appendix

Table A-1
Linguistic variables and corresponding triangular fuzzy numbers (Coffey and Claudio, 2021).

Linguistic Term	Fuzzy Number	Triangular fuzzy number (TFN)
Equally Important	1	(1,1,1)
Weakly Important	3	(2,3,4)
Fairly Important	5	(4,5,6)
Strongly Important	7	(6,7,8)
Absolutely Important	9	(9,9,9)
Intermediate values	2	(1,2,3)
	4	(3,4,5)
	6	(5,6,7)
	8	(7,8,9)

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