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# Understanding E-bike Purchase Intentions: A Model of Environmental and Technological Determinants

Hiba Azeem [a]

**Abstract:** *The escalating need for sustainable urban mobility solutions amid concerns over climate change and fuel emissions makes the adoption of E-Bikes a critical area of study. This research investigates the psychological and cognitive factors that drive consumer Intention to Purchase E-Bikes (IPTEB), specifically examining how Environmental Awareness (EA), Consumer STEM Literacy (SL), and Perceived Technological Innovativeness (PTI) influence the perception of functional utility, operationalized as Perceived Technical Benefits (PTB). A quantitative study employing a cross-sectional design utilized Structural Equation Modeling (PLS-SEM) on data collected from 273 prospective E-Bike consumers in Multan, Pakistan. The structural model demonstrated high predictive power, explaining over 67% of the variance in the key endogenous constructs. All four hypothesized paths were supported, confirming that PTB is the overwhelming predictor of IPTEB (β= 0.820). Crucially, the antecedent variables influencing PTB ranked as follows: PTI (β= 0.373) was the strongest, closely followed by SL (β= 0.319), with EA exerting the weakest influence (β= 0.207). These findings suggest that while environmental concern provides motivation, the purchasing decision is fundamentally driven by rational, technology-based evaluations of product superiority, necessitating that manufacturers shift marketing strategy to focus on technical education and functional performance to maximize perceived value and accelerate adoption.*

**Keywords:** STEM Literacy, Environmental Awareness, Perceived Technical Benefits, E Bikes

## Introduction

In contemporary societies facing issues with climate change, resource depletion, and environmental degradation, the importance of environmental awareness becomes more critical. People's knowledge and awareness of issues pertaining to the environment positively affect their attitudes, behaviors, and decisions toward the adoption of sustainable practices (Sultana, 2025). Awareness explains how and to what extent people perceive environmental issues and conflicts and how willing they are to engage in problem-solving and to take actions that benefit the environment, including recycling, conserving energy, and sustainable consumption (Kousar et al., 2022). More recently, the integration of STEM education, communication tools, and community activities has gained attention to improve knowledge concerning issues and problems affecting the environment for the adoption of practices to benefit the environment (Al Ali & Al-Barakat, 2025; Al-Barakat et al., 2025). Environmental Concerns, lack of sustainable alternatives for transportation, and the problems associated with urban population growth have resulted in great interest in e-bikes for efficient and environmentally sustainable travel, especially in the face of traffic congestion, carbon emissions, and rising fuel prices (Ejaz et al., 2025; Pan et al., 2022; Seebauer, 2015). The use of e-bikes has the potential to environmentally improve overall transport emissions while allowing efficient travel (Flores, 2024; Flores & Jansson, 2021a). The use of e-bikes also depends on their availability, as well as on the ways in which potential users and consumers understand the technology (Flores & Jansson, 2021a). Understanding perceptions of the technology is critical to the adoption of the technology (Zhang et al., 2024). Out of all the factors, environmental awareness is most likely to influence the mobility sector (Gumasing, 2025a).

Those excelling in environmental advocacy choose technologies designed for shrinking ecological footprints and for promoting sustainable lifestyles (Shakya et al., 2025). Such customers might choose e-bikes and similar technologies more easily when their functionalities are seen as aligned with eco-friendly

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objectives (Scorrano & Rotaris, 2022). A study conducted in Henan Province, China, has also explained this phenomenon, which found that the perceived environmental benefits of e-bikes greatly increased adoption rates in urban areas (Zhang et al., 2024).

At the same time, the ability of the consumers to understand and evaluate the technology in question is also critical (Al Ali & Al-Barakat, 2025). STEM-literate individuals are equipped with the needed knowledge to understand the inner workings of a technology, its importance, and the corresponding value of its components (Al-Barakat & Ibrahim, 2025). STEM is the integration of one or more STEM disciplines with other disciplines. This integration can take place at any educational setting, including primary and secondary education, and even at the university level (Martín-Páez et al., 2019). Things such as intelligence, creativity, design, and even age are not limiting factors to this integration. STEM also helps to enhance the behaviours that support scientific problem solving (Fan & Yu, 2017). Literacy is the ability to use scientific processes and inquiry to understand the complex and often variable aspects of the natural world (Kelley & Knowles, 2016).

Users with stronger STEM literacy may better recognise the technical advantages of integrated systems such as propulsion, battery management, and digital sensors on e-bikes (Fan & Yu, 2017). Martín-Páez et al. (2019) demonstrated the positive benefits of STEM instructional approaches on attitude and understanding in environmental education. Consumers tend to associate modernity with high performance and functionality. Thus, e-bikes might arguably be viewed as a contemporary technology of personal mobility due to the integrated smart, energy-efficient, and adaptive systems (Flores & Jansson, 2021a). Increased techno-appreciation may subsequently follow. Positive relationships between innovativeness and attitude toward a product, especially a green one, are well documented, particularly among consumers familiar with green technologies (Ejaz et al., 2025; Seebauer, 2015).

The perceived technical benefits are most certainly one of the main psychological motivators of purchase intentions (Zabiulla et al., 2025). In the presence of a new technology where benefits such as ease of use, greater performance, and efficiency are abundantly evident, the likelihood of adoption is greater (Eccarius & Lu, 2020). In the sphere of sustainable mobility, perceived performance benefits are strongly predictive of intention to purchase environmentally sustainable transportation solutions (Lee & Sener, 2023). In the case of e-bikes, it is critical to analyse how and why environmental awareness, STEM literacy, and perceived innovativeness influence purchasers' perceptions and decisions about the technical benefits of e-bikes (Plazier et al., 2018). Thus, addressing this gap, the current research theoretically and empirically attempts to show how the trio of environmental awareness, STEM literacy, and perceived technological innovativeness of potential e-bike consumers positively correlate with perceived technical advantages of e-bikes, which subsequently influence the Intention to Purchase E-Bikes. This research ultimately seeks to elucidate the psychological and cognitive dynamics behind the adoption of sustainable mobility technologies.

## Literature Review

### Relationship Between Environmental Awareness and Perceived Technical Benefits

Environmental awareness is understanding the environment and the different problems and challenges the environment faces (Kousar et al., 2022). It is crucial in forecasting how people and groups will react to environmental challenges and move towards sustainability (Xie et al., 2024). It plays a crucial moderating role in the intricate relationship between green behaviour, perceived benefits, and green-buying behaviour and includes important implications for understanding how individuals make eco-friendly choices (Polas et al., 2023). Environmental awareness is of great importance in determining how individuals and groups construct their evaluation of new technologies which are sustainable (Xie et al., 2024). In regard to technologies which reduce the impacts of pollution, people's awareness encourages the valuing of such technologies. With improving awareness, e-bikes are perceived positively since they are low-emission and energy-efficient compared to other means of transport (Eccarius & Lu, 2020). People are more likely to appreciate the efficiency of e-bikes when they are aware that the benefits of the technology are numerous, as they help reduce the carbon footprint of a fuel-powered vehicle (Zabiulla et al., 2025). Perceived benefit is the positive outcomes users expect from a technology, and this is strengthened by the awareness people have of the environment (Polas et al., 2023).

Referring to green technologies, other than the functional aspects or financial improvements, one also has to consider the environmental aspects because of reduced emissions, energy savings and congestion related to pollution (Lee & Sener, 2023). For instance, a meta-analysis of the adoption of E-bikes found that benefits, assimilation, and environmental concern correlated strongly with (Gumasing, 2025b; Shakya et al., 2025) adoption intentions. In the case of eco-driving assistance systems for electric vehicles, user acceptance was positively influenced to a great degree by the perceived usefulness related to energy savings and environmental impact (Zhang et al., 2024). Hence, it can be hypothesized that

**H1:** *There exists a significant relationship between Environmental Awareness and Perceived Technical Benefits*

### Relationship Between STEM Literacy and Perceived Technical Benefits

STEM literacy allows people to understand the meaning of technical information (Fan & Yu, 2017). As new technologies emerge and become more complex, people with stronger backgrounds in STEM (science, technology, engineering and mathematics) fields are more able to make evaluations of technological features and novelties (Kelley & Knowles, 2016). E-bikes, for instance, have features such as electric motors, battery systems, torque sensors, and digital interfaces, and these features might be more easily understood by those with higher STEM literacy (Fan & Yu, 2017; Peine et al., 2017). When people have the knowledge needed to understand how such features work, they are more likely to appreciate the functionality, efficiency, and reliability of such features (Gumasing, 2025a). STEM literacy leads to a more favorable and informed perception with regard to the technical features of the e-bike systems (Flores & Jansson, 2021b). STEM literacy enhances the ability of individuals to understand the working of a technology, interpret how claims are made (energy savings and emissions reductions, for instance) and to visualise the advantages of the technology (Wahono et al., 2025). A literate person is able to appreciate the technical features of the technology with regard to its practicality and efficiency as compared to a layperson (Mambali et al., 2024). This is in line with dual process theories, where more knowledge in the area of STEM fosters analytical reasoning in the process of evaluating the effectiveness of the instrument (Fan & Yu, 2017). STEM literacies incorporate the procedural skill as well as self-efficacy with technical tasks. Hence, it can be hypothesized that

**H2:** *There exists a significant relationship between STEM Literacy and Perceived Technical Benefits*

### Relationship between Perceived Technological Innovativeness and Perceived Technical Benefits

Perceived technological innovativeness is defined by the extent to which people deem a particular technology to be new, advanced, or innovative in any way (Shetu et al., 2022). Consumers tend to be more fascinated by products and see their features as more beneficial if they believe the product contains modern innovations (Gumasing, 2025a). E-bikes may evoke strong perceptions of innovativeness because they combine electro-mechanical systems with new technology in battery management and lightweight materials, as well as smart connectivity and energy optimization (Flores, 2024; Lee & Sener, 2023). This strong innovativeness perception may lead some users to expect more powerful systems to be easier and more versatile in their functions. For this reason, these users probably expect and judge the technical benefits even more positively, reinforcing the innovativeness features of the technology (Ejaz et al., 2025). Investigations across consumer awareness, green technology, and product marketing provide evidence of this interrelationship. Relational novel studies show this to be the case with the variables of perceived complexity, familiarity, and trust. PTI may increase PTB if it is perceived as useful and familiar to a degree where users are sure that they will be able to realize any benefits (Gumasing, 2025b). An inverted-U relationship also exists whereby moderate innovativeness increases PTB (Sultana, 2025), but extreme or radical innovations may lower it, due to perceived uncertainty and a lack of supporting ecosystem. Hence, it can be hypothesized that

**H3:** *There exists a significant relationship between Perceived Technological Innovativeness and Perceived Technical Benefits*

### Relationship between Perceived Technical Benefits and Intention to Purchase E-Bikes

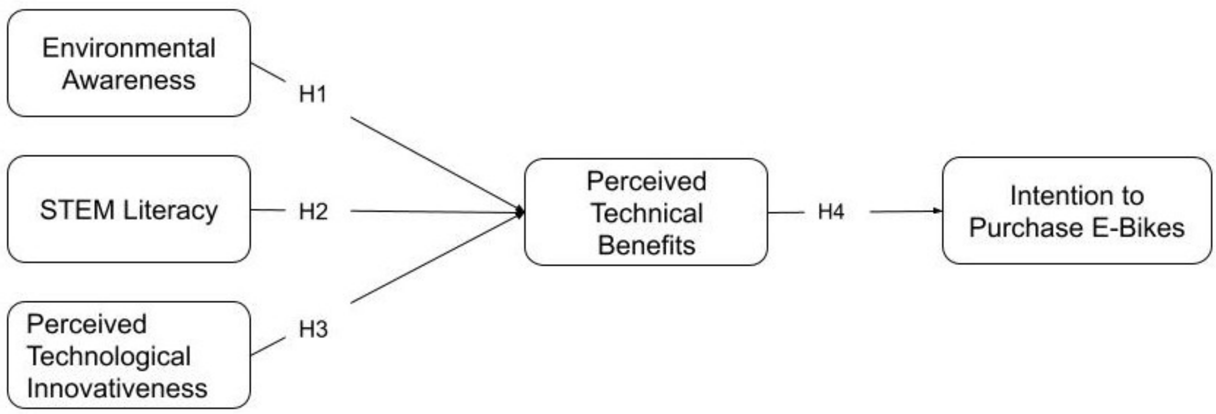
The perceived benefits of technological innovation are particularly salient when it comes to shaping the intent to purchase within the context of e-bikes and the related technologies. Products perceived to deliver sufficient value create more favorable attitudes and, as a consequence, enhanced adoption (Lee & Sener, 2023). Regarding e-bikes, technical benefits might encompass the reduction of effort required for pedalling, prolonged battery life, ease of use, incorporated digital navigation, and versatility for different forms of commuting (Gumasing, 2025a). These benefits drive consumer decision-making by lowering perceived risk, offering ease, and demonstrating a substantial value (Eccarius & Lu, 2020). If a consumer sees an e-bike as modern, upgraded, and, especially, having useful functions, the consumer likely perceives the purchase worthwhile (Zabiulla et al., 2025). In particular, enhanced battery life and rapid charge times eliminate users' anxiety regarding the distance the e-bike will effectively cover, thus bolstering confidence in the overall experience of the e-bike (Shakya et al., 2025). If customers perceive the product as technically advanced, effortless to maintain, and reliable, their intention to purchase e-bikes increases (Zhang et al., 2024). The positive correlation between the Perceived Technical Benefits and Intention to Purchase E-Bikes is extensively documented. Customers tend to have a better attitude towards e-bikes and consider buying them when they notice some strong technological benefits like superior performance, extended battery longevity, user-friendliness, advanced safety features, and robustness (Ejaz et al., 2025; Flores & Jansson, 2021a; Pan et al., 2022). Hence, it can be hypothesized that

H4: *There exists a significant relationship between Perceived Technical Benefits and Intention to Purchase E-Bikes*

### Research Framework

**Figure 1**

*Research Framework*




*Source: Authors' Work*

### Theoretical Framework

Using the Technology Adoption Model (TAM) developed by Davis et al. (1989) as a starting point provides a strong theoretical foundation for the study. TAM suggests that users' beliefs surrounding a given technology, particularly the perceptions surrounding the usefulness and ease of use, shape the attitudes and intentions towards adoption (Davis et al., 1989). TAM traditionally focuses on general perceptions of usefulness. However, TAM can also expand to include more narrowly focused evaluative beliefs surrounding specific usefulness perceptions, and Perceived Technical Benefits serve as a more narrowly tailored domain-specific extension of TAM's perceived usefulness by assessing the more practical and functional benefits of e-bike technology. While TAM describes the users' beliefs in terms of Environmental Awareness, STEM Literacy, and Perceived Technological Innovativeness as external variables, these variables also act as traits that support TAM's Integration of Characteristic Variables to describe how external factors influence the determination of use evaluation as derived from experience. TAM can support the premise that more well-informed, motivated, or oriented towards innovation users will assess technologies more favorably, and they intend to adopt them (Ejaz et al., 2025; Gumasing, 2025a). The premise of the theory can explain higher perceived benefits of e-bikes and consequently higher purchase intention in consumers who have a higher understanding of technology, value innovative solutions, and prioritise ecological sustainability. This provides further support for the use of TAM in the model, as the Technology Adoption Framework provides a well-established structure for technology acceptance.

## Methodology

### Research Technique

This research employs a quantitative methodology using deductive reasoning. The study incorporates a cross-sectional design, meaning data collection occurs at a single point in time, rather than at multiple time intervals (Payne & Wansink, 2011). This methodology is ideal for the study of the participants' actual behavior and attitudes toward e-bikes.

### Target Population and Sampling Method

For this study, the target population is defined as prospective customers who may be willing to purchase e-bikes in Multan, Pakistan. To gain access to appropriate respondents, we reached out to e-bike companies operating in Multan and obtained the contact information of customers who had most recently visited the companies' retail outlets or interacted with them online through their websites and social media platforms.

Because of its ability to help select a research participant who has particular information or experience with the subject under study, purposive sampling was employed for this study (Campbell et al., 2020; Guarte & Barrios, 2006). As a result of this sampling technique, the participants of the study were likely to have actual knowledge, interest, or experience with e-bikes.

### Data Collection

Once contact details were retrieved from e-bike dealers, a preformatted survey was sent to prospective clients using Google Forms. A total of 273 complete responses were obtained, all of which were used, as this number is ample for sample size determination for the PLS-SEM methodology. Hair et al. (2018) indicated that 100-200 is an appropriate sample for PLS-SEM. For more complex models, more responses are better. The responses obtained were analysed through Structural Equation Modelling-Partial Least Squares, SEM-PLS, which is appropriate for predictive models with multiple interrelationships among latent variables. After the suitable preliminary analyses were conducted, correlation analysis, reliability, and validity of the constructs, as well as subsequent hypotheses, were executed as per (J. F. Hair et al., 2019) protocols.

### Research Instrument and Scale Measures

A 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) was used to measure all variables (Croasmun & Ostrom, 2011; Sandiford & Ap, 2003). Environmental Awareness was assessed by three statements regarding concern about pollution, whether purchasing eco-friendly products is an integral part of a socially responsible lifestyle, and whether the consumer actively seeks information on sustainable alternatives for transportation. Perceived Technological Innovativeness (PTI) measured the product's novelty with items evaluating E-Bikes as an innovative, forward-thinking mode of personal transport that contains cutting-edge technology superior to conventional bicycles, and whether they introduce a new, modern approach to urban commuting. Finally, the four-item adapted scale for STEM Literacy (SL) focused on technical self-efficacy, asking about confidence in understanding specifications (e.g., motor torque), the ability to effectively compare performance based on technical data, recognition of how principles of physics and engineering govern efficiency, and the capacity to use technical information to weigh the long-term pros and cons of technology adoption. Perceived Technical Benefits (PTB) targeted utilitarian advantages, including whether the technology increases commute efficiency and speed, whether the specifications enhance safety and provide superior reliability, if E-Bike use reduces physical effort, making it a viable long-distance option, and if the technical performance justifies the higher cost compared to a conventional bicycle. Intention to Purchase E-Bikes (ITPEB) was captured by items assessing the consumer's temporal readiness and commitment, such as the intent to purchase within the next 12 months, the likelihood of choosing an E-Bike over alternatives soon, and the plan to make an effort to acquire one in the near future.

**Table 1**

*Measurement Instrument*

| Sr# | Variable | No. of Items | Adapted from |
|---|---|---|---|
| 1 | Environmental Awareness | 3 | (Kousar et al., 2022) |
| 2 | STEM Literacy | 4 | (Chamrat et al., 2019) |
| 3 | Perceived Technological innovation | 3 | (Shetu et al., 2022) |
| 4 | Perceived Technical Benefits | 4 | (Zheng et al., 2018) |
| 5 | Intention to Purchase E-Bikes | 3 | (Gumasing, 2025a; Shakya et al., 2025) |

## Demographic Profile of the Respondents

**Table 2**

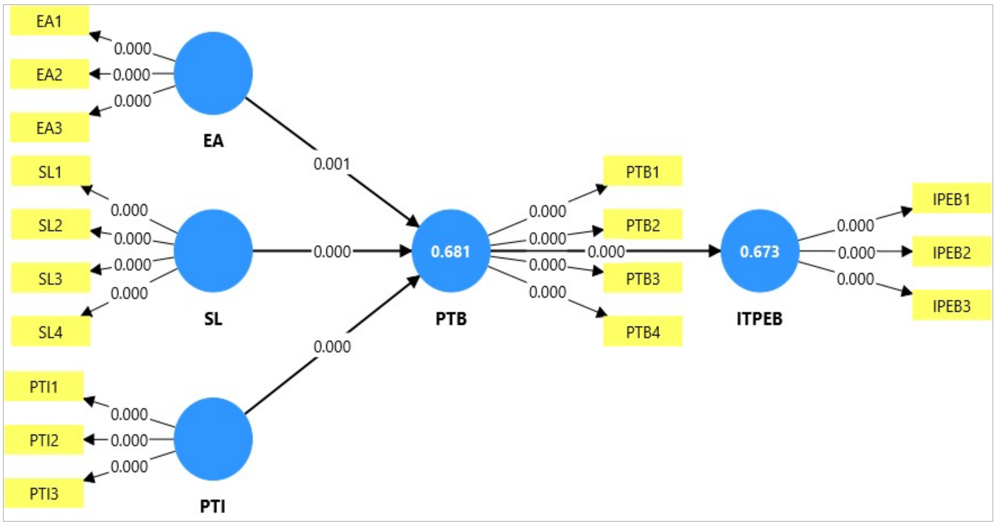
*Respondents Profile*

| Demographic Variable | Category | Frequency (N) | Percentage (%) |
|---|---|---|---|
| Gender | Male | 164 | 60.1 |
| | Female | 109 | 39.9 |
| Age Group | 18–24 | 55 | 20.1 |
| | 25–34 | 120 | 43.9 |
| | 35–44 | 78 | 28.6 |
| | 45+ | 20 | 7.3 |
| Education Level | High School/Diploma | 30 | 11.0 |
| | Bachelor's Degree | 155 | 56.8 |
| | Postgraduate Degree | 88 | 32.2 |
| Approximate Monthly Income | 50,000-60,000 PKR | 35 | 12.8 |
| | 60,000-70,000 PKR | 140 | 51.3 |
| | 70,000-80,000 PKR | 98 | 35.9 |

## SEM-PLS MODELS

**Figure 2**

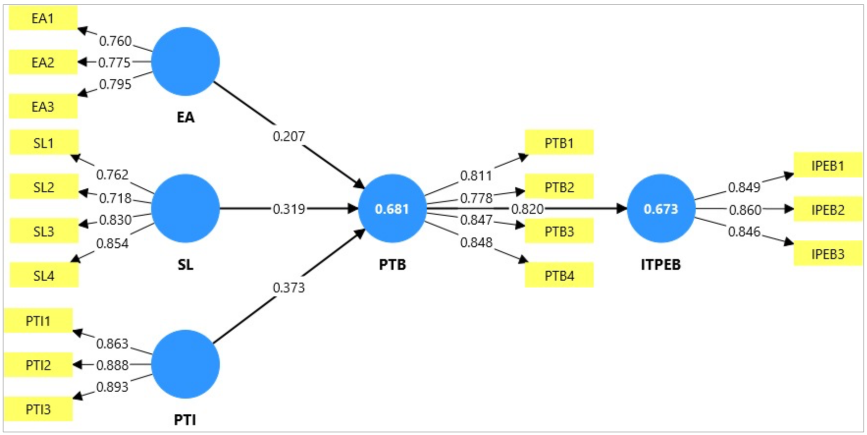
*Measurement Model*




*Source: SEM-PLS Calculation*

**Figure 3**

*Structural Model*




*Source: SEM-PLS Calculation*

## Construct Reliability & Validity

**Table 3**

*Construct Reliability & Validity*

| Constructs | No of Items | Cronbach's Alpha | Composite Reliability (rho_a) | Composite Reliability (rho_c) | Average Variance Extracted (AVE) |
|---|---|---|---|---|---|
| Environmental Awareness | 3 | 0.67 | 0.67 | 0.82 | 0.60 |
| STEM Literacy | 4 | 0.80 | 0.81 | 0.87 | 0.63 |
| Perceived Technological Innovation | 3 | 0.86 | 0.86 | 0.91 | 0.78 |
| Perceived Technical Benefits | 4 | 0.84 | 0.84 | 0.89 | 0.68 |
| Intention to Purchase E-Bikes | 3 | 0.81 | 0.81 | 0.89 | 0.73 |

*Source: SEM-PLS Calculation*

The psychometric validation of the five latent constructs, Environmental Awareness, STEM Literacy, Perceived Technological Innovativeness, Perceived Technological Benefits, and Intention to Purchase E-Bikes, shows that there is support for the fact that the measurement model is strong and can be used to test the structural hypotheses for the E-Bike adoption model. All the scales have convergent validity, and the Average Variance Extracted (AVE) is well over the 0.50 threshold with values between 0.60 and 0.78, which means that the items are able to represent the constructs (Ahmad et al., 2016). In addition to this, there are high levels of overall reliability for all the constructs, as shown by the Composite Reliability (rho_c) for the constructs, which is between 0.82 and 0.91 (Cheung et al., 2024). Environmental Awareness (0.67) is the only one that has a Cronbach's Alpha that can be considered marginal, but given that the Composite Reliability for Environmental Awareness is strong (0.82), we can be assured that there is sufficient internal consistency in the scale, and the data collected with these instruments is indeed reliable and can be used in making varied uses of predictive analytics (J. F. Hair et al., 2013).

## Discriminant Validity (Fornell-Larcker criterion)

**Table 4**

*Fornell-Larcker criterion*

| Construct | EA | SL | PTI | PTB | IPTEB |
|---|---|---|---|---|---|
| EA | 0.78 | | | | |
| SL | 0.64 | 0.85 | | | |
| PTI | 0.70 | 0.82 | 0.82 | | |
| PTB | 0.68 | 0.74 | 0.77 | 0.88 | |
| IPTEB | 0.76 | 0.79 | 0.78 | 0.80 | 0.79 |

***Acronyms:*** *EA, Environmental Awareness; SL, STEM Literacy; PTI, Perceived Technological Innovation; PTB, Perceived Technical Benefits; ITPEB, Intention to Purchase E-Bikes*
*Source: SEM-PLS Calculation*

The analysis of discriminant validity using the Fornell-Larcker criterion generally confirms that most constructs in the model are distinct, as indicated by the square root of the Average Variance Extracted (AVE), the diagonal values being greater than the correlations with all other latent variables in the respective column and row (Fornell & Larcker, 1981). For instance, Perceived Technical Benefits (PTB) demonstrates strong unique variance with a square root of AVE of 0.88, clearly exceeding its highest correlation of 0.80 with IPTEB (Alarcón et al., 2015). However, the overall model features very high inter-construct correlations, and the criterion is not strictly met for Intention to Purchase E-Bikes (ITPEB); specifically, the correlation between ITPEB and Perceived Technical Benefits (PTB) is 0.80, which is slightly greater than ITPEB's own square root of AVE (0.79), suggesting that the Intention to Purchase E-Bikes construct may not possess sufficient unique variance from the Perceived Technical Benefits construct, indicating a potential overlap or redundancy in the measurement of these two critical variables.

### Factor Loadings, Cross Loadings and Variance Inflation Factor

**Table 5**
*Factor Analysis*

| | FL | VIF | EA | IPTEB | PTB | PTI | SL |
|---|---|---|---|---|---|---|---|
| EA1 | 0.76 | 1.33 | 0.76 | 0.45 | 0.50 | 0.52 | 0.58 |
| EA2 | 0.78 | 1.26 | 0.78 | 0.50 | 0.58 | 0.53 | 0.56 |
| EA3 | 0.80 | 1.35 | 0.80 | 0.53 | 0.56 | 0.54 | 0.63 |
| IPEB1 | 0.85 | 1.78 | 0.57 | 0.85 | 0.69 | 0.61 | 0.64 |
| IPEB2 | 0.86 | 1.86 | 0.54 | 0.86 | 0.70 | 0.66 | 0.71 |
| IPEB3 | 0.85 | 1.71 | 0.52 | 0.85 | 0.71 | 0.63 | 0.66 |
| PTB1 | 0.81 | 1.71 | 0.64 | 0.70 | 0.81 | 0.72 | 0.70 |
| PTB2 | 0.78 | 1.72 | 0.51 | 0.59 | 0.78 | 0.59 | 0.56 |
| PTB3 | 0.85 | 2.12 | 0.56 | 0.65 | 0.85 | 0.56 | 0.59 |
| PTB4 | 0.85 | 1.98 | 0.59 | 0.74 | 0.85 | 0.65 | 0.68 |
| PTI1 | 0.86 | 1.92 | 0.59 | 0.69 | 0.68 | 0.86 | 0.70 |
| PTI2 | 0.89 | 2.26 | 0.63 | 0.66 | 0.69 | 0.89 | 0.74 |
| PTI3 | 0.89 | 2.36 | 0.58 | 0.62 | 0.67 | 0.89 | 0.68 |
| SL1 | 0.76 | 1.56 | 0.54 | 0.59 | 0.55 | 0.54 | 0.76 |
| SL2 | 0.72 | 1.38 | 0.62 | 0.56 | 0.56 | 0.56 | 0.72 |
| SL3 | 0.83 | 1.87 | 0.64 | 0.61 | 0.64 | 0.66 | 0.83 |
| SL4 | 0.85 | 1.97 | 0.62 | 0.72 | 0.70 | 0.75 | 0.85 |

***Acronyms:*** *EA, Environmental Awareness; SL, STEM Literacy; PTI, Perceived Technological Innovation; PTB, Perceived Technical Benefits; ITPEB, Intention to Purchase E-Bikes*
*Source: SEM-PLS Calculation*

A measurement analysis on individual items within the model confirms the strong psychometric properties, along with the model's individual features having high reliability as well as no collinearity. All Factor Loads are of the utmost quality, between 0.72 and 0.89, well above the 0.70 standard needed to confirm items as reliable measures for what they were created to measure (J. Hair et al., 2018b). Also, the VIF for the seventeen measures are all low, with the highest being 2.36, confirming that there is no multicollinearity problem with the measurement model (J. F. Hair et al., 2019). Also, the cross-loading matrix proves discriminant validity at the item level, as all items load with a substantial degree on their respective latent construct (EA1 loads 0.76 onto EA) and load less on the other constructs (EA1 loads to a maximum of 0.58 on SL), confirming the distinctiveness of the constructs being measured (J. F. Hair et al., 2011).

## Quality Assessment

**Table 6**

*Predictive Assessment*

| | R-square | R-square adjusted |
|---|---|---|
| ITPEB | 0.673 | 0.672 |
| PTB | 0.681 | 0.678 |

***Acronyms:*** *PTB, Perceived Technical Benefits; ITPEB, Intention to Purchase E-Bikes*
*Source: SEM-PLS Calculation*

The three antecedent constructs- Environmental Awareness, STEM Literacy, and Perceived Technological Innovativeness- explain about 68.1% of the variance in the Perceived Technical Benefits (PTB) construct, confirming the ability of these factors to shape consumers ' functional perceptions regarding E-Bikes. A better predictive power of the model is shown by the variance in the final dependent variable, Intention to Purchase E-Bikes (IPTEB), being 67.3%. The difference in R2 and R2 adjusted for both PTB (0.681 vs 0.678) and IPTEB (0.673 vs 0.672) being small showcases a good model fit. This gives the model more descriptive power than other models and confirms that the proposed model is valid (J. Hair et al., 2018a).

## Hypothesis Testing

*Table 7*

| Relationships | Original sample (O) | Sample mean (M) | Standard deviation (STDEV) | T statistics (\|O/STDEV\|) | P values | Pathe Coefficient | Results |
|---|---|---|---|---|---|---|---|
| EA -> PTB | 0.207 | 0.210 | 0.061 | 3.403 | 0.001 | 0.207 | Accepted |
| SL -> PTB | 0.319 | 0.321 | 0.075 | 4.284 | 0.000 | 0.319 | Accepted |
| PTI -> PTB | 0.373 | 0.370 | 0.072 | 5.157 | 0.000 | 0.373 | Accepted |
| PTB -> ITPEB | 0.820 | 0.821 | 0.021 | 38.815 | 0.000 | 0.820 | Accepted |

*Results of SEM-PLS Analysis*
***Acronyms:*** *EA, Environmental Awareness; SL, STEM Literacy; PTI, Perceived Technological Innovation; PTB, Perceived Technical Benefits; ITPEB, Intention to Purchase E-Bikes*
*Source: SEM-PLS Calculation*

The structural model analysis confirms that all four hypothesised relationships are statistically significant and supported, with all P-values being less than 0.001. The strongest relationship in the model is the direct path from Perceived Technical Benefits (PTB) to Intention to Purchase E-Bikes (IPTEB), featuring an extremely robust path coefficient of **0.820** (T-statistic = 38.815), underscoring that functional utility is the overwhelming predictor of purchase intention. This finding is in line with the existing studies (Gumasing, 2025a; Zabiulla et al., 2025; Zhang et al., 2024). Regarding the antecedents of PTB, Perceived Technological Innovativeness (PTI) exerts the greatest influence (Path Coefficient = **0.373**), confirming the results by (Shetu et al., 2022) followed by STEM Literacy (SL, Path Coefficient = **0.319**), confirming the findings by the study (Fan & Yu, 2017) while Environmental Awareness (EA) demonstrates the weakest but still significant positive effect (Path Coefficient = **0.207**), similar to the finding by (Xie et al., 2024). Collectively, all four hypotheses confirm the model's structure that cognitive and ethical drivers must successfully enhance the perception of technical superiority before a buying intention is formed.

## Discussion

This analysis has substantiated the evidence behind the model. The purchase of E-Bikes is based on functional value rather than ethical or awareness considerations. The model has predictive power, accounting for 68.1% of the variance of Perceived Technical Benefits (PTB) and 67.3% of the variance for the Intention to Purchase E-Bikes (IPTEB), all of which are based on accurate and reliable calculations

(AVE > 0.60; rho_c > 0.82). Importantly, the direct impact of PTB on IPTEB is exceptionally strong (beta = 0.820), so much so that it slightly threatens the discriminant validity of the two variables, indicating that in the mind of the consumer, technical utility and the purchase of the good are almost inseparable. Looking at the factors that fuel the driving force of this PTB construct, Perceived Technological Innovativeness (beta = 0.373) was the strongest, followed by Consumer STEM Literacy (beta = 0.319), whereby it can be deduced that consumers who view E-Bikes as innovative and who have the ability to think deeply about the technical details are the ones most likely to recognize the value that can be derived functionally.

On the other hand, with a beta of just 0.207, even though it is statistically significant, Environmental Awareness influence is the weakest of the variables. Therefore, it can be concluded that the concern about the environment may motivate a consumer. However, the purchasing decision is predominantly influenced by the consumer's perception of the technology and their ability to justify the purchase in terms of the technology.

The structural analysis supports the theoretical framework. It shows that all the assumed relationships in the model are statistically significant. The overall model is very predictive and explains a large portion of the variance in the mediating construct of Perceived Technical Benefits and the final outcome of Intention to Purchase E-Bikes. The most powerful and instructive finding is the direct impact of purchase intention on the consumer's perception of the technical advantages, which is that functional utility is the main barrier to obtaining purchase intention.

This can be attributed to the consumer perception of the E-Bike as a state-of-the-art modern solution (Perceived Technological Innovativeness), which is then influenced by the consumer's confidence and competence in the product's technical attributes (STEM Literacy). Though environmental concern strengthens the recognition of technical benefits, relative to the other three, the influence is the weakest. This shows that the rational and technology-driven values of superiority primarily weigh in on the reasoning behind the purchasing decision of the E-Bike.

## Practical and Theoretical Implications

The data is undeniable, particularly the high path coefficient between Perceived Technical Benefits (PTB) and the Intention to Purchase Electronic Bicycles (IPTEB), which presents remarkable opportunities for both academics and business practitioners. As a contribution to the theoretical agenda, PTB was presented as an essential rational driver. It is posited that ethical and cognitive predispositions must pass through a favourable utilitarian predisposition as a threshold before behavioural readiness can occur, and this strengthens and fine-tunes technology adoption theories around the inclusion of technical literacy as a cognitive filter. These results thus require manufacturers to rethink marketing strategies as an appeal to eco-consciousness is no longer sufficient. It is essential to promote technical and functional literacy as these enhance the perception of E-Bikes as more than eco-friendly options but as contemporary technological solutions. By improving functional Consumer STEM Literacy, manufacturers are able to enhance PTB, the major driver of purchase intent and thus justify the high cost of E-Bikes, thereby improving competitive advantage.

## Conclusion

The purchase intention of E-Bikes shows that technical perception is very important. The model for the current study also confirmed all four hypothesised relationships. The Model established considerable predictive quality of the Primary Endogenous Variables. While Environmental Awareness is the one that starts the motivational process, the consumer ultimately decides on the purchase based on the possession of the product's novelty and the STEM Literacy that allows the consumer to functionally determine the superiority of the product. The IPTEB and PTB relationship established the technical novelty to significantly transform cognitive and belief barriers to market activation for high commitment to green technology.

## Limitations and Future Research Direction

Despite offering valuable insights into the psychological and cognitive mechanisms driving Intention to Purchase E-Bikes (IPTEB), the present study is subject to several limitations that should be acknowledged. Data were collected exclusively from prospective E-Bike consumers in Multan, Pakistan, limiting the generalizability of the findings. Cultural, infrastructural, and socioeconomic factors in other regions may produce different outcomes and can be used for research in future. Replication in diverse geographical contexts is recommended to enhance external validity. Although the model explained a significant variance in PTB and IPTEB, it included only three antecedent variables (EA, SL, PTI). Other potentially influential factors, such as financial incentives, perceived risk, product affordability, brand trust, or infrastructure readiness, can be addressed in future research.

Even though the structural model is powerful when it comes to predictions, there may be some overlap concepts that were not accounted for, such as the close relation between Perceived Technical Benefits and Intention to Buy E-Bikes, which may suggest that these variables are either correlated too closely to be considered distinct or at the very least, redundant, with the Fornell-Larcker criterion for discriminant validity. Therefore, more studies need to be done to figure out whether these variables are only causally related to each other or if the variables are jointly defined, at least in the situation of high-investment purchases. Also, more long-term studies should be done to explain the high Technical Self-Efficacy measurement that has often been modified to prove that it is indeed a predictor focused on the actual intent that leads to strong and positive behaviours after the purchase for long-term use satisfaction, which in turn may qualify other aspects of Consumer STEM Literacy to be valid predictors of sustainable long-term adoption.

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## ANNEXURE I

| Construct | Item | Measurement Item | Source |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Intention to Purchase E-Bikes (ITPEB) | ITPEB1 | I intend to purchase an E-Bike within the next 12 months. | (Gumasing, 2025; Shakya et al., 2025) |
| | ITPEB2 | I am likely to choose an E-Bike over other transportation alternatives soon. | |
| | ITPEB3 | I plan to make an effort to acquire an E-Bike in the near future. | |
| Perceived Technical Benefits (PTB) | PTB1 | The E-Bike technology increases the efficiency and speed of my commute/travel needs. | (Zheng et al., 2018) |
| | PTB2 | The technical specifications of E-Bikes enhance safety and provide superior reliability compared to alternatives. | |
| | PTB3 | E-Bike use reduces the physical effort required for my travel, making it a viable long-distance option. | |
| | PTB4 | The technical performance of an E-Bike justifies its higher cost compared to a conventional bicycle. | |
| Environmental Awareness (EA) | EA1 | I am highly concerned about environmental problems caused by pollution and non-renewable energy use. | (Kousar et al., 2022) |
| | EA2 | Purchasing environmentally friendly products is an integral part of my socially responsible lifestyle. | |
| | EA3 | I actively seek information regarding the environmental impacts and sustainable alternatives for transportation. | |
| Perceived Technological Innovativeness (PTI) | PTI1 | E-Bikes represent an innovative and forward-thinking mode of personal transport. | (Shetu et al., 2022) |
| | PTI2 | E-Bikes contain cutting-edge technology that is superior to conventional bicycles. | |
| | PTI3 | E-Bikes introduce a new, modern approach to urban commuting. | |
| STEM Literacy (SL) | SL1 | I am confident in my understanding of the technical specifications (e.g., motor torque, battery range) of E-Bikes. | (Chamrat et al., 2019) |
| | SL2 | I can effectively compare the performance benefits of different E-Bike technologies based on their technical data. | |
| | SL3 | I recognize how principles of physics and engineering govern the efficiency and design of E-Bikes. | |
| | SL4 | I am able to use technical information to weigh the long-term pros and cons of adopting new transport technologies. | |