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Exploring the Interplay of Environmental Factors & Technological Factors in Shaping Green Purchase Behavior: A Moderated Mediation Approach

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Abstract

Purpose– Using the expanded Theory of Planned Behavior (TPB) as the foundational theoretical framework and the Technology Readiness Index (TRI) as a supporting theory, the main goal of this study is to investigate the Green Purchase Behavior (GPB) of solar technology commercial users. In particular, the study examines how Environmental Factors (EF), Green Attitude (GA), Subjective Norms (SN), Perceived Behavioral Control (PBC), and Technology Factors (TF) affect GPB. It also evaluates how Green Purchase Intention (GPI) functions as a mediating factor.

Design/methodology/approach– Snowball sampling technique was employed to collect data from 335 commercial users of solar technology. In order to ensure analytical efficiency and examine complex prediction models, the study used the Partial Least Squares Structural Equation Modeling (PLS-SEM) approach for data analysis, which was carried out using Smart PLS software. As part of a primary, quantitative research design, the study used a deductive methodological approach. Senior management leaders, including directors and CEOs of commercial businesses actively using solar technology, made up the sample, which was selected from Punjab, Pakistan's key commercial hubs.

Findings- The terms EK, GA, PBC, and SN significantly impact GPI and GPI greatly influence GPB. All the direct relations, indirect relations and mediation effect for all the relations were found significant.

Keywords: Green purchase behavior (GPB), environmental concerns (EC), environmental knowledge (EK), ecological lifestyle (EL), environmental factors (EF), green attitude (GA), subjective norms (SN), perceived behavioral control (PBC), green purchase intention (GPI), technology optimism (TO), technology innovation (TI), technological factors (TF), and structural equation modeling (SEM).

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Introduction

Bioenergy provides a sustainable substitute for fossil fuels (Rusilowati, Ngemba, Anugrah, Fitriani, & Astuti, 2024). Renewable energy is anticipated to become increasingly important as technology advances in mitigating climate change and lowering carbon emissions (Nazarov, Sulimin, & Shvedov, 2024). Oil prices also reached their highest point since 2008 which is a major source to produce the electricity. Oil crisis has intensified the volatility of oil markets (Gajdzik, Wolniak, Nagaj, Žuromskaitė-Nagaj, & Grebski, 2024). Oil is the main source of producing electricity (Wirawan, 2025). China had tremendous economic expansion over the last three decades, but energy consumption has also increased significantly. They used 446 million tons of coal in 1990; by 2017, that amount had increased to 2.8 billion tons (Zaghdoudi, Tissaoui, Hakimi, & Ben Amor, 2024). In order to prodcue electricity, both sources oil and coal are not eco-friendly (Abbas, Yaqoob, Sajjad, Ali, & Jamil, 2025).

People from western Australia have targeted to convert their energy production sector towards the solar PV technology till 2050 (Jayaraj, Klarin, & Ananthram, 2024). The stability of systems that depend more and more on renewable energy is guaranteed by this proactive management (Lee, Oh, & Pak, 2024). This emphasizes the necessity for stable energy infrastructure and energy-constrained policy solutions in order to support long-term industrial growth (Asad, 2024). Pakistan's location in the sun-passage provides it with an abundance of sunshine all year round. Building solar infrastructure may boost technical innovation, provide jobs, reduce dependence of the energy (Muhammadi et al., 2024). Pakistan's goals of attaining economical and ecologically sustainable energy production are in line with this policy. In particular, SDG 7 (Affordable and Clean Energy) is supported by Pakistan's integration of net-metering (Khan et al., 2024).

This discrepancy highlights Pakistan's need to take advantage of its plentiful solar resources in order to reduce its reliance on thermal power and increase the proportion of renewable energy in its energy mix (Muhammadi et al., 2024). However, the price of power produced by renewable energy has dropped significantly (Arshad, 2024). Pakistan benefits from year-round sunshine due to its location in the Sunny Belt, which makes solar energy a more dependable and constant source of renewable energy. Due to its high sun irradiation, the nation has great potential (Ahmed et al., 2024). People have a greater sense of responsibility to purchase green goods due to awareness about global issues like pollution, climate change, and resource depletion (Saxena, 2024).

Changing behavior of the consumer is much crucial for any business more specifically the behavior regarding the green products (Ningtyas & Falah, 2025). The deliberate choice made by customers to purchase sustainable, recyclable, or environmentally friendly goods describes GPB. Products that save resources and support long-term ecological balance, and sustainably sourced materials are considered green products (Soomro, Mirani, Sajid Ali, & Marvi, 2020). Due to intense competition and devotion-based initiatives introduced by various rivals customer retention is very difficult (Roy, Das, Lim, & Kalai, 2025; Viriri, Muranda, Chavunduka, &

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Chimwanda, 2025). Attracting and engaging consumers remains a dream (Shakeel, Juntunen, & Rajala, 2024).

Three main criteria are used by the TPB to explain why someone might want to engage in a particular behavioral attitude, SNs and PBC. Attitude is the person's overall assessment of the behavior either positive or negative. Societal pressure to engage in or refrain from engaging in a particular conduct is termed as SN. Related people in the form of society, relatives or colleagues may influence intention or behavior (Botetzagias, Grigoraki, & Kokkoris, 2024). Multiple studies advocate that GPI is positively and significantly impacted by PBC, SN, and GA (García-Salirrosas et al., 2024).

Innovative technological elements meaningfully impact GPI, and GPI strongly influences GPB (Nguyen et al., 2024). A framework called the Technology Readiness Index (TRI) is used to gauge how ready or willing people are to accept and use new technology (Saidu, Shagari, & Auwal, 2024). The distinction between GPI and GPB is subtle; while GPB measures a consumer's actual purchase behavior. Two important psychological factors named as SN and PBC have a beneficial impact on both GPI and GPB (Gustafsson & Hammarström, 2024). The GPI refers to a consumer's incentive or propensity to buy ecologically friendly products. Among the many influences on it are EF and GA (Fitriani & Warganegara, 2024).

The globe has been battling the dire effects of climate change, which are mostly the result of centuries of intensive economic activity. Think tanks, governments, and environmental groups have realized that a global transition to sustainable energy sources is necessary in response to this escalating catastrophe (Maji, Bashir, Irwin, Shenoy, & Sitaraman, 2024). Much of Europe has warmed by more than 2°C during the summer months of June through August since 1980; in some places, the warming has even exceeded 3°C in ERA5 (Schumacher et al., 2024). In South Australia, it demonstrate the significant effects of climate change, which are marked by a decline in cold extremes and hot extreme (Ferrelli, Pontrelli Albisetti, Brendel, Casoni, & Hesp, 2024). Significant growth in affected areas is anticipated under warming scenarios of 1.5°C and 2°C, highlighting the necessity of proactive risk assessment (Wei et al., 2024).

Occurrence of significant global warming events during summer season more specifically the monsoons of East Asian countries have great impact on climate change (Y. Han, Cao, Liang, Liu, & Hao, 2024). To lessen the negative effects of climate change on health, proactive steps are crucial (Bhattacharya et al., 2024). Even though Pakistan contributes less than 1% of the world’s greenhouse gas emissions, it is among the nations most impacted by climate change (Adnan et al., 2024). According to World Air Quality Report, Pakistan is the second most polluted nation in the world (M. P. Iqbal, 2024). Global climate change is greatly influenced by the transportation, industrial, and agricultural sectors, which are among the top emitters of carbon dioxide (CO_2) (Doğan, 2024).

Among Pakistan's many problems, energy scarcity and climate change are the most pressing. Pakistan is mostly an agricultural nation; hence this industry is quite important to its economy (Arslan, Imran, Tariq, Afzal, & Waseem, 2024). Energy is

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regarded as the foundation of an economy and a key factor in its expansion and advancement. It is advised that the government of Pakistan should concentrate on maximizing current energy resources and give priority to the start of efficient energy producing projects (Sarwar Khan, Hussain, Ali, & Ali). It is advised that in order to lessen income disparity and enhance the socioeconomic circumstances of low-income households, policymakers concentrate on supplying accessible and reasonably priced energy sources, especially focusing on developing areas (Hussain et al., 2024). Although there are still issues fulfilling the rising demand, these steps attempted to alleviate Pakistan's energy crisis and guarantee consistent availability to electricity (Amin et al., 2022).

In order to meet the rising demand for dependable and sustainable power sources, other nations dealing with comparable fossil fuel-based energy problems are rapidly turning to renewable energy projects (Lawani, 2024). The renewable energy sector indeed holds immense promise, with startups at the forefront of driving change through innovative solutions (Oguanobi & Joel, 2024). In order to lessen dependency on fossil fuel-based power during peak hours, distributed storage systems, such home batteries, enable extra renewable energy produced during times of low demand to be stored and used later (Skaloumpakas, Sarmas, Rachmanidis, & Marinakis, 2024).

Harnessing the energy of the sun is one of the cheapest and most eco-friendly methods. It also happens to be a renewable source of energy. It created green energy while minimizing carbon footprints (Olaleye, Oloye, Akinloye, & Akinwande, 2024). In order to make PV systems more sustainable and multipurpose, these strategies seek to balance the generation of renewable energy with ecological or agricultural purposes (Knapp & Sturchio, 2024). The government's support of these initiatives has been essential, providing subsidies and tax breaks that increase the financial viability of renewable energy for communities and businesses (Raihan, Rahman, Tanchangtya, Ridwan, & Islam, 2024).

Theoretical Framework and Hypotheses Development

Underpinning Theory: Theory of Planned Behavior (Extended)

Ajzen (1991) created the Theory of Planned Behavior (TPB), which describes how behavioral intentions and behaviors are influenced by attitudes, subjective standards, and perceived behavioral control. By incorporating behavioral control, it builds upon the previous Theory of Reasoned Action. TPB is frequently expanded with elements like environmental concern and knowledge in contemporary research, particularly on sustainability, to better understand how individual views and environmental awareness impact behavior (La Barbera & Ajzen, 2024). Three key predictors of behavioral intention: attitude, SNs, and PBC are identified in TPB theory. Attitude reflects how positively or negatively a person views a behavior. SNs involve perceived social pressure from others to perform or avoid the behavior. PBC relates to how easy or difficult the person believes the behavior is, based on past experiences and obstacles. Behavioral intention acts as a mediator between these three factors and the actual behavior (Altawalbeh & Al-Mughrabi, 2024).

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Subjective norms in TPB refer to the felt social pressure from others to engage in or refrain from a behavior. A person's confidence in their capacity to do the behavior is reflected in their perceived behavioral control. People who feel in control and supported by others have stronger intentions (J. Xu, Pan, & Li, 2024). By adding elements like ecological lifestyle, environmental awareness, and environmental concern, the extended TPB expands on the fundamental variables (attitude, SN, PBC, intention, and behavior). Since they further shape attitudes and social norms, these additions aid in the explanation of sustainability-related actions by reflecting eco-friendly ideals, environmental awareness, and an emotional commitment to environmental protection (Cao & CHEN, 2024).

Supporting Theory

A theory TRI has been used as a supporting theory in current study. It was developed by positively contribute to the adoption of new technologies. The four characteristics of the TRI model are insecurity (distrust in technology), discomfort (feeling overtaken by technology), innovativeness (early adoption tendency), and optimism (positive perspective of technology). These elements show how people view and react to technological developments (Kaufmann, 2008; WAH). These elements aid in the comprehension of how attitudes and actions toward the adoption of technologies, particularly green advances, are influenced by individual preparedness (Nigatu et al., 2024). In current study TRI is used to check the impact of TF on GPI which further impact GPB.

Variables of the Current Study

Green Purchase Behavior

The buying of goods that reduce damage to the environment is resultant of GPB. It represents consumer preferences for sustainable, eco-friendly items made from recyclable materials (Vania & Ruslim, 2023). Extensive study has identified various elements that have a major impact on GPB, such as GA, PBC, and SN (Ramadhanti, Suryandaru, & Amelia, 2024). The trend of demanding ecologically safe products has increased in last decade (Carrión-Bósquez, Ortiz-Regalado, Veas-González, Naranjo-Armijo, & Guerra-Regalado, 2024). The ultimate purpose of all the businesses has been shifted towards studying the GPB which can be achieved by studying GA, SN and PBC (La Barbera & Ajzen, 2024). Purchasing goods have little effect on the environment is known as GPB (Sharma, Aswal, & Paul, 2023). Green buying is used to purchase environment friendly products (Sharma et al., 2023).

Environmental Factors

Environmental knowledge (EK), environmental concern (EC), and ecological lifestyle (EL) are core components of environmental factors (EF) (de Oliveira Lima et al., 2024; Li, Wang, & Cui, 2022; Mettke-Hofmann, 2014). Customers with EK, EC and EL think EF are necessary to overcome the climate change (Lopes, Gomes, & Trancoso, 2024). Customers have started getting EK about the green products for sustainability and climate change (Mbokane & Modley, 2024). Green consumers are

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driven by EC which leads to purchase environment friendly goods (Kuria, 2024; Upadhyay, 2024). Although this field of study is still in its infancy, it holds great promise to impact GPB (Tao, Zhou, Bian, & Lai, 2024; Widjaja, Bimantara, & Tuwmijartssee). Consumers with high EC are more motivated to purchase eco-friendly goods (M. T. Ngo, Bui, & Tran, 2024; Suhaeni, Wulandari, Turnip, & Deliana, 2024).

Green Attitude

An individual's propensity to favor actions that lessen environmental harm is reflected in their GA. Attitudes play a crucial role in influencing cognitive factors (direct and indirect) on GPI (N. Carrión-Bósquez et al., 2024). Positive GA always influence GPI but they don't always convert actual purchase activity (Palomino Rivera & Barcellos-Paula, 2024b). Customers with EK of green products and offers of the firms influence GPI an GPB (Gading, Kuswati, Achmad, & Lestari, 2024). Attitudes are important indicators of behavioral intentions in the context of the TPB (Corboș, Bunea, Triculescu, & Mișu, 2024; Congxin Wu, Xu, Lu, & Zheng, 2024). Customers are more likely to cultivate favorable buying intentions and behaviors when they are aware of environmental benefits of green products (Corboș et al., 2024). Strong environmental attitudes correlate with a greater intention to purchase green products (Gading et al., 2024).

Subjective Norms

Social and cultural forces (views or suggestions of friends, family members and office staff etc.) that shape a person's conduct, intention or behavior is called SN (Ayieko et al., 2024). Multiple studies advocate that SN have a big impact on customers' purchase intentions. Furthermore, customers' intention to buy sustainable fashion products is strongly influenced by subjective norms, which are defined as the perceived societal influence to adopt or avoid a behavior (Fortuna, Wilson, Metta, Chandra, & Darmawan, 2025). Descriptive norm (DN) and injective norm (IN) are the two core dimensions of SN (Botetzagias et al., 2024).

People's opinions on how others usually act in a certain circumstance—what is customary—are known as descriptive norms whereas injunctive norms, which relate to what people believe should be done—what they approve or disapprove of—are distinct from descriptive norms. If consumers perceive that important others (family, friends, social circles) support or approve of buying green products, their intentions to purchase these products increase, leading to actual purchases (Liaquat, Iqbal, Munir, & Waheed, 2024).

Perceived Behavioral Control

Perceived Behavioral Control is indeed based on two key components; self-efficacy and controllability (Ajzen, 2002). Self-efficacy is a person's confidence in their capacity to carry out a certain action or task. Controllability describes how a person views outside influences that either help or hinder them from engaging in a behavior (Pilatin & Dilek, 2024). An individual's presumed control over their intended

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behavior is called PBC. Perceived behavioral control is an extra component that TPB theory has added to TRA theory. It describes how easy or difficult an activity is perceived by the individual (Liu & Madni, 2024). When examining drivers' behavior, perceived behavioral control (PBC) is essential because it measures their confidence in their capacity to carry out required driving actions and make safe choices (Kotyza et al., 2024). It is the degree to which people think they have control over how an action is performed (Omulo, Daum, Köller, & Birner, 2024).

Technological Factors

Term TF is based on four core dimensions named as technology optimism (TO), technology innovativeness (TI), discomfort and insecurity (Koch, Graczykowska, Szumiał, Rudnicka, & Marszał-Wiśniewska, 2024). People's upbeat outlook and confidence over the advantages of emerging technologies is called TO. The degree to which people are open to trying out and embracing new technologies is referred to as TI. The uneasiness, tension, or difficulty that some people feel when using new or unfamiliar technologies is called discomfort and people’s worries or anxieties around the dangers, threats, or unforeseen repercussions of new technologies is termed as insecurities (H. G. Hassan, Nassar, & Abdien, 2024).

A positive attitude based on the conviction that technology improves life by simplifying tasks and raising people's standard of living is called TO (Dangbut et al., 2024). Technology Readiness Index (TRI) theory measures people's propensity to embrace and use new technologies to accomplish their goals in their daily life and at work (Anh et al., 2024). Optimism and TRI theory gauges people's readiness to adopt new technology, are directly related (Kolar, Milfelner, & Pisnik, 2024). Technology optimism is a positive attitude toward technology in which people think it makes their life more efficient, flexible, and under control and technology optimists may feel less stressed about new technologies (Fragomeli, Annunziata, & Punzo, 2024; Köhne & Köhne, 2024). On the basis of optimism and inventiveness, new technology is embraced as innovation (Chandra, Handra, Febrianto, & Ridwan, 2024).

Green Purchase Intention

GPI describes a customer's intention or propensity to purchase eco-friendly goods. It is a significant predictor of behavior in the future since it shows how committed the consumer is to making sustainable decisions (Palomino Rivera & Barcellos-Paula, 2024a). Understanding GPI helps in predicting actual GPB (BV & Rajendran, 2024). The three fundamental dimensions of GPI are engagement, usefulness, and reliability. These components allow for a clear understanding of the notion as a mediator in green purchasing behavior (Poon, Kunchamboo, & Koay, 2024). Examining the ways in which attitudes, SN, and PBC affect the GPB with mediation of GPI (Setyarko, Noermijati, Rahayu, & Sudjatno, 2024). Consumers with high involvement are more likely to seek out information about the environmental impact of products, scrutinize certifications, and choose products based on their eco-friendly attributes (Firmansyah, Purnamasari, Farida, & Devi).

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Behavioral intentions are influenced by three key factors: attitudes toward the behavior, SN (i.e., social pressures), and PBC (i.e., the ease or difficulty of performing the behavior) (Luckho, Saulick, Gaya, & Veerapen, 2024). It is possible to enhance target consumers' intents to make green purchases by crafting messaging that specifically address their values and issues (Liang, 2024). Environmental psychology and consumer behavior the GPI and GPB are strongly influenced by GA, SN and PBC (Chao & Yu, 2024). Intention reflects their readiness to make a purchase that aligns with their environmental values (Putri & Hayu, 2024). The green purchase intention to buy green products is influenced by several key factors like GA, SN and PBC (Shang, Zhu, Liu, & Liu, 2024). Study advocates that EC, EK, GA, SN and PBC have positive impact on GPI and GPB (Pontes, Naranjo-Zolotov, & Painho, 2024). Studies suggest that GPI acts as a mediator between EF and GPB (Shafiq, Khan, & Tahir, 2024).

Hypotheses Development

Buyers who care more about the environment are more likely to encourage eco-friendly purchasing practices (Saari, Damberg, Frömbling, & Ringle, 2021). Studies reflect that higher environmental concern positively and significantly influenced individuals' intentions to buy green products (De Canio, Martinelli, & Endrighi, 2021). Environmental factors—such as EC, EK and EL—primarily influence GPB by shaping GPI, which acts as the pathway to actual behavior. (Anand & Sharma, 2023). On the basis of above discussion, we can hypothesis that:

H1: There is direct effect of EF on GPI.

The significance of attitudes as a powerful predictor of purchase intentions was emphasized by the research study. Customers who have favorable opinions on eco-friendly products, gain more attitude towards green products which ultimately influence GPI (Meliniasari & Mas'od, 2024; Palomino Rivera & Barcellos-Paula, 2024b). Another study advocates that GA strongly influence GPI and GPB (Rama & Susanto, 2024). In multiple studies it was observed that GA along with SN and PBC influence GPI which ultimately impact GPB (Kwon & Ahn, 2021; Sihombing et al., 2024). Hence, we may purpose that GA has a significant impact on GPI. On the basis of above discussion, we can hypothesis that:

H_2: There is direct effect of GA on GPI.

As a component of the TPB, subjective norms are crucial in influencing a person's intents. Social support can strengthen the intention to use public transportation (Bhagat-Conway et al., 2024). Multiple studies advocate that GA, PBC and SN significantly influence the GPI (Q.-H. Ngo, Nguyen, & Phan, 2025; Parveen & Chaudhary, 2025) (Le, Vo, Bui, & Vu, 2025; Naaman, Yeşilada, & Aghaei, 2025). It was observed that SN influences the GPI and GPB when EC and EK of green products is concerned (Soleymanpor & Norouzi, 2025). As a core component of TPB theory, PBC has influence on GPI and GPB (Barry, Haque, & Jan, 2024; S. F. Cheung & Chan, 2000; H. Han & Kim, 2010; Makamba, 2024). The results show that intentions toward engaging are significantly predicted by the three cognitive concepts

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of attitude, SN, and PBC (Su, Wan, Zhang, Teng, & Chan, 2024). On the basis of above discussion, we can hypothesis that:

H_3: There is direct effect of SN on GPI.

H4: There is direct effect of PBC on GPI.

The psychological aspects affecting the adoption of technology are the main focus of the Technology Readiness Index (TRI). It outlines four essential dimensions: insecurity (concerns about privacy and dependability), innovativeness (willingness to explore new technologies), discomfort (feeling overtaken by technology), and optimism (belief that technology improves life and productivity). Adoption is encouraged by optimism and inventiveness, but it is hampered by discomfort and insecurity (Chengzhen Wu & Lim, 2024). Technology based innovativeness and optimism are positively associated with GPI (Alhammadi, Marashdeh, & Hussain, 2023; Gopinathan, Veeraya, Raman, & Jambulingam, 2024). Technological characteristics have a favorable and considerable impact on GPI (Jarrar, Awobamise, & Sellos, 2020).

H_5:There is direct effect of TF on GPI.

The TPB is basically based on GPI and GPB. PI is used as mediator whereas GPB is used as dependent variable in basic structure of TPB (Ali, Khan, Ahmed, & Shahzad, 2011). Green purchasing behavior is influenced by green purchase intentions (Elgammal, Ghanem, & Al-Modaf, 2024). Another study conducted in Karachi reflects that EC moderates the relationship between GPI and GPB. It also reflects that GPI strongly influence GPB (A. Iqbal, Kazmi, Anwar, Ramish, & Salam, 2023). On the basis of above discussion, we may hypothesis that:

H_6: There is direct effect of GPI on GPB

Perceived behavioral control positively impact purchase behavior through mediation of PI but it also directly effects GPB (Y. Xu et al., 2022). Attitude and PBC effect green behavior through mediation of intention but PBC directly effects the GPB. Customers are more likely to acquire a strong intention to purchase eco-friendly products when they have a positive attitude about green buying. The experiments also show that PBC directly affects GPB, indicating that PBC can affect behavior on its own and is not only a function of intention (Askadilla & Krisjanti, 2017; Zdonek, Hysa, & Zdonek, 2024). Based on the above discussion, we may hypothesis that:

H_7: There is direct effect of PBC on GPB

Mediating Role of Green Purchase Intention

Research has demonstrated that environmental elements have a favorable and substantial effect on GPI (Marhadi, Sudibyo, Priatmoko, & Suyastri, 2024). Research advocates that eco-labels, a crucial tool in sustainable product marketing with EF affect GPI and GPB (M. Hassan, Mahmood, & Khakwani, 2025; Tran, Nguyen, & Nguyen, 2025; Yan, Jin, & Yew, 2024). Eco-labels in the form of EF influence GPI (Tan, Fauzi, & Harun, 2025). On the basis of above observations, we propose the following hypothesis:

H_1a: GPI mediates the relationship between EF and GPB

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People who believe that environmentally friendly products are beneficial will have a favorable attitude have a positive and significant influence on the intention which further influence GPB (Vania & Ruslim, 2023). Ultimately attitude improves GPI which further improves GPB (Imiru, 2023). As consumers grow more environmentally conscious, their positive perceptions of green items influence both GPI and GPB. On the basis of above evidences, we may hypothesis that:

H_2a: GPI mediates the relationship between GA and GPB

Subjective norms from important people influence the GPI. People are more likely to establish a greater environmental intention when they believe that significant others in their lives encourage or demand eco-friendly action (Kumar & Sinha, 2025). Students are more likely to acquire stronger EF with correlated values among SN and GPI. (Chin, Mustafa, & Nungsari, 2024). Many studies recommend that SN is a very strong predictor of GPI and GPI is the main influencer of GPB (Moazzam, Ahmad, Hussain, & Akram, 2023; Naaman et al., 2025). On the basis of the above studies we formulate the following hypothesis: -

H_3a: GPI mediates the relationship between SN and GPB.

According to the findings of the meta-analysis, GPI is positively correlated with GA, SN, PBC, and EF (Panda, Singhal, Jena, & Tripathy, 2024) and GPI has positive impact on GPB (Jana, Shandilya, & Srivastava, 2024). The findings of the study showed that among well-educated Malaysian consumers, the relationship between attitudes, SN, PBC, and GPB is mediated by GPI (M. Hassan, Mahmood, & Khakwani, 2024; Yang, Liang, Xue, yuan Zhang, & Xue, 2024; Yuan, Rasiah, Hou, & Li, 2023). According to a study in Jakarta Indonesia GPI significantly mediate the relationship between PBC and GPB (Yusuf, 2021). Hence, we may propose that GPI mediate the relationship between PBC and GPB. On the basis of above discussion, the following hypothesis is proposed; -

H_4a: GPI mediates the relationship between PBC and GPB

Technological factors in the form of TO and TI have positive and significant impact on GPI (Almaiah et al., 2022). Conclusion of this survey extracted that there was partial mediation of GPI between the relationship of inherent innovativeness and GPI (Zhang, Wen, & Shao, 2024). The purpose of the current survey was to look into how technology-based elements, particularly optimism and innovativeness, affect GPI and how that affects GPB (Álvarez-Marín, Velázquez-Iturbide, & Castillo-Vergara, 2023). On the basis of above evidences, we purpose that:

H_5a: GPI mediates the relationship between TF and GPB

Hypotheses

H_1: There is direct effect of EF on GPI.

H_1 a: GPI mediates the relationship between EF and GPB

H_2: There is direct effect of GA on GPI

H_2 a: GPI mediates the relationship between GA and GPB

H_3: There is direct effect of SN on GPI

H_3 a: GPI mediates the relationship between SN and GPB

H_4: There is direct effect of PBC on GPI

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H_4 a: GPI mediates the relationship between PBC and GPB

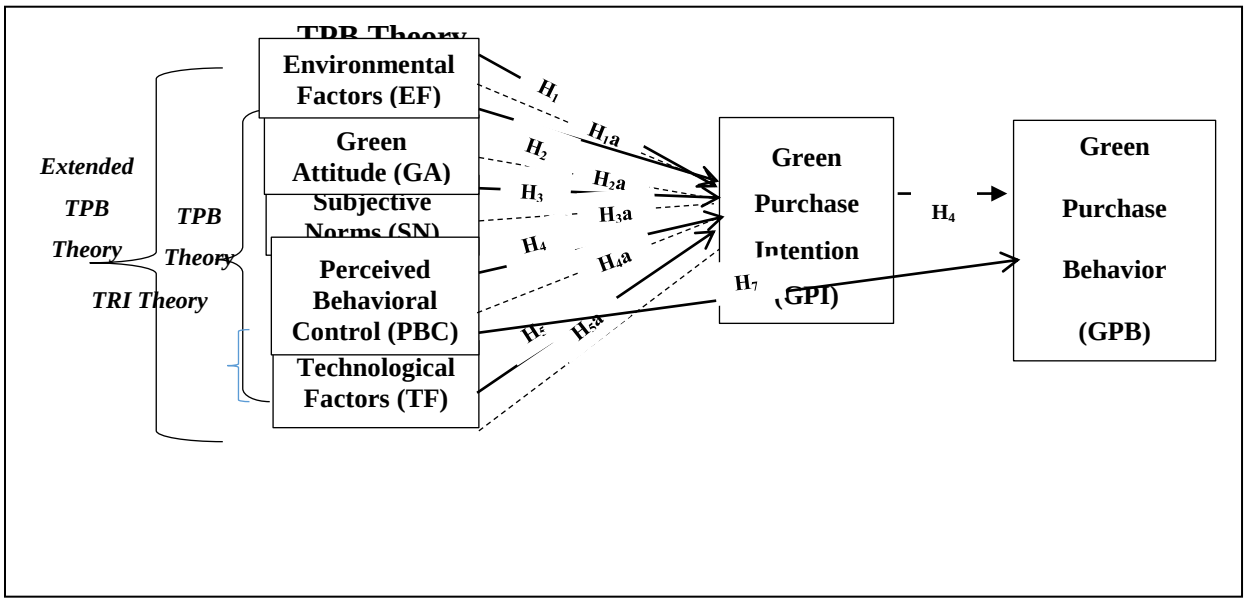
H_5: There is direct effect of TF on GPI

H_5 a: GPI mediates the relationship between TF and GPB

H_6: There is direct effect of GPI on GPB

H_7: There is direct effect of PBC on GPB

Theoretical Framework



Cochran's formula. Primary research methodology was used in order to collect firsthand knowledge from the respondents. Population for the current study was commercial users of solar technology. Top management of big organizations and owners of small businesses were the targeted population who had sound idea of solar technology-based benefits from different cities of Punjab province. PLS-SEM estimation technique was used to analyze the data because it effectively manages complicated models, which makes it perfect for research involving several interactions between components.

Measurement of the Variables

Based on the literature review a total 28 questions were developed for the questionnaire related to current study. Two major aspects were considered while developing the questions; clarity and easiness. Questions related to demographics are based on gender, age, qualification, profession, income level and geographical location. These questions were adapted from (Sun & Wang, 2020). Four (4) questions were adapted from (Rusyani, Lavuri, & Gunardi, 2021) for GPB, four (4) questions for GA are adapted from (Hua & Wang, 2019) and four (4) questions for GPI are adapted from (Sun & Wang, 2020). Four (4) questions for EF are adapted from (Hartmann & Apaolaza-Ibáñez 2012). Four (4)) questions for TF are adapted from

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(Basiago, 1994). Four (4) questions for PBC are adapted from (Alam et al. 2014) and four (4) questions for SN are adapted from (Hua & Wang, 2019).

Questionnaire Development

Variables	Items	Developed By	Used by	Past Reliability (CA)
Green Purchase Behavior	4	(Rusyani et al., 2021)	(Lavuri, 2022)	0.835
Environmental Factors	4	(Bang, Ellinger, Hadjimarcou, & Traichal, 2000)	(Asif et al., 2023)	0.910
Subjective Norms	4	(Hua & Wang, 2019)	″	0.903
Perceived Behavioral Control	4	(Alam et al. 2014) (H. Han & Kim, 2010)	(Asif et al., 2023)	0.832
Technological Factors	4	(Basiago, 1994)	(Hasheem, Wang, Ye, Farooq, & Shahid, 2022)	0.790
Green attitude	4	(Hua & Wang, 2019)	″	0.813
Green Purchase Intention	4	(Sun & Wang, 2020)	″	0.874
Total	**28**			

Table 1: Questionnaire Development

Results

This chapter is based on data analysis based on quantitative data collected through questionnaire. Smart PLS software is used to analysis data and compute graphical representation of the collected data. In this unit we have analyzed and discussed demographic data based on gender, marital status, age level, qualification and income etc. We have also explained the demographic information through graphs and tables. Computed information of demographic information has also been explained through merging different demographic components like merger of gender and qualification, gender and marital status etc. We have computed and explained the statistical tests like correlation test, regression test, discriminant validity, factor loading and normality test in this chapter.

Demographic Analysis

Demographic analysis of current study is based on gender, marital status, age level, qualifications, and income.

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Demographics of the current study has been explained below: -

Demographic Type	N	%
Gender		
Male	217	65%
Female	118	35%
Age		
≤ 30 years	122	36%
31 – 50 years	163	49%
≥ 51 years	50	15%
Qualification		
Under Graduate	123	37%
Graduate	171	51%
Post Graduate	134	12%
Marital Status		
Married	211	63%
Single	124	37%
Residence		
Urban	131	39%
Semi Urban	147	44%
Rural	57	17%

Table 2: Demographics

4.3 Factor Loading

	EF	GA	GPI	GPB	PBC	SN	TF
EF1	0.863						
EF2	0.719						
EF3	0.725						
EF4	0.766						
GA1		0.831					
GA2		0.823					
GA3		0.923					
GA4		0.881					
GPI1			0.851				
GPI2			0.942				
GPI3			0.937				
GPI4			0.917				
GPB1				0.873			
GPB2				0.851			
GPB3				0.753			
GPB4				0.769			
PBC1					0.848		
PBC2					0.820		
PBC3					0.917		

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PBC4	0.838		
SN1		0.815	
SN2		0.826	
SN3		0.805	
SN4		0.911	
TF1			0.789
TF2			0.883
TF3			0.945
TF4			0.862

Table 3: Factor loading

Journal rule of thumb for factor loading is as greater than or equal to 70% (0.7) is considered strongly valid, between 50% to 69% is considered acceptable and below 50% usually problematic (G. W. Cheung, Cooper-Thomas, Lau, & Wang, 2024). Since factor loading values for all the items in present study are more than 70%, hence considered significantly valid.

Instrument Reliability Analysis

Reliability is measured through the value of Cronbach's alpha. If it appears more than 90%, it is marked as excellent, more than 70% is considered satisfactory, between 50% to 69% is considered as tolerable, and below 50% is considered not reliable (Razali, Hamid, Alias, & Mansor, 2025). All values of current study are more than 70%, hence are reliable for analysis.

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
EF	0.797	0.799	0.867	0.621
GA	0.887	0.891	0.931	0.819
GPI	0.887	0.890	0.946	0.898
GPB	0.986	0.986	0.993	0.986
PBC	0.885	0.892	0.920	0.742
SN	0.799	0.824	0.868	0.623
TF	0.975	0.976	0.988	0.975

Table 4: Composite reliability

Correlation Analysis

Correlation analysis is measured with R-square value. R-square value less than 10% is considered inadequately correlated, between 10% to 50% is considered satisfactory and greater than 50% is considered as strongly correlated (Ozili, 2023). Since both values of r-square and adjusted r-square for the current study are more than 50%, hence are considered satisfactory for the current study.

	R-square	**R-square adjusted**

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GPB	0.609	0.604
GPI	0.701	0.700

Table 5: Correlation analysis

Discriminant Validity

HTMT table with discriminant validity has been shown in the following table: -

	EF	GA	GBK	GPB	PBC	SN	TF
EF							
GA	0.683						
GBK	0.693	0.546					
GPB	0.759	0.571	0.648				
PBC	0.845	0.691	0.860	0.873			
SN	0.764	0.854	0.624	0.668	0.793		
TF	0.534	0.604	0.483	0.522	0.591	0.879	

Table 6: HTMT Matrix

Although the correlation matrix shows associations between the constructs that are generally acceptable, certain values are noticeably high, which raises questions about discriminant validity. In particular, SN with GA (0.854), PBC with GPB (0.873) and GBK (0.860), and others surpass the typical 0.85 cutoff, indicating weak discriminant validity and possible conceptual overlap. While lesser correlations, like TF with GBK (0.483), demonstrate good separation, moderate correlations, like EF with GA (0.683) and EF with SN (0.764), stay within acceptable bounds. Researchers may need to refine constructs, combine overlapping dimensions, or provide theoretical justification for the existence of such significant associations if the square root of AVE for each construct is less than these inter-construct correlations.

Fornell-Larcker Criterion

	EF	GA	GBK	GPB	PBC	SN	TF
EF	0.788						
GA	0.582	0.905					
GBK	0.589	0.485	0.948				
GPB	0.699	0.533	0.606	0.993			
PBC	0.731	0.614	0.780	0.834	0.861		
SN	0.610	0.731	0.538	0.593	0.676	0.789	
TF	0.480	0.560	0.450	0.512	0.556	0.784	0.988

Table 7: Fornell-lacker criterion

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According to the Fornell-Larcker criterion, discriminant validity is proven when the diagonal √AVE of each construct is higher than its correlations with other constructs. EF = 0.788, GA = 0.905, GBK = 0.948, GPB = 0.993, PBC = 0.861, SN = 0.789, and TF = 0.988 are all rather high diagonal values in this table, and they are all greater than the comparable off-diagonal correlations. Discriminant validity is maintained even though some correlations are somewhat strong, such as PBC with GPB (0.834) and GA with SN (0.731), but they are still below the corresponding √AVE values of those constructs. Researchers should take note of the significant associations and make sure they are consistent with the theoretical framework, but overall, the measurement model shows satisfactory convergent and discriminant validity.

Regression Analysis

For exploratory research and predictive modeling, Smart PLS (Partial Least Squares-Structural Equation Modeling, PLS-SEM) is frequently utilized.

Total Direct Effects

Total direct effects between independent variables (IVs) and the mediator, mediator and the dependent variable (DV) and one IV and DV have been demonstrated in the following table. The structural model shows a number of important connections between the various constructions. PBC (PBC → GPI, $\beta = 0.768$, $p < 0.001$) is the most potent predictor of GPI, but EF (EF → GPI, $\beta = 0.459$, $p < 0.001$) exhibits a considerable positive influence. It's interesting to note that GA (GA → GPI, $\beta = –0.230$, $p = 0.008$) and SN (SN → GPI, $\beta = –0.127$, $p = 0.015$) have notable but adverse impacts, indicating that stronger GPI may not always follow from higher attitudes and normative demands. Intention and control are important behavioral drivers, and GPB is significantly predicted by both GPI (GPI → GPB, $\beta = 0.488$, $p < 0.001$) and PBC → GPB ($\beta = 0.469$, $p < 0.001$). Lastly, TF (TF → GPI, $\beta = 0.124$, $p = 0.013$) makes a minor but noteworthy positive contribution. All things considered, the model validates PBC's theoretical significance as the most potent predictor of GPI.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
EF -> GPI	0.459	0.451	0.086	5.306	0.000
GA -> GPI	-0.230	-0.225	0.086	2.660	0.008
GPI -> GPB	0.488	0.483	0.130	3.747	0.000
PBC -> GPB	0.469	0.474	0.129	3.625	0.000
PBC -> GPI	0.768	0.772	0.043	17.747	0.000

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SN -> GPI	-0.127	-0.124	0.052	2.444	0.015
TF -> GPI	0.124	0.122	0.050	2.488	0.013

Table 8: Total direct effects

Total Indirect Effects

Direct relationships, as used in regression analysis, describe how independent variables (predictors) affect the dependent variable in the absence of any

	Original Sample (O)	Sample mean (M)	Standard Deviation (STDEV)	T statistics (|O/STDEV|)	P values
EF -> GPB	0.224	0.218	0.075	3.001	0.003
GA -> GPB	0.112	0.106	0.048	2.352	0.019
PBC -> GPB	0.375	0.370	0.093	4.019	0.000
SN -> GPB	0.062	0.060	0.031	1.993	0.046
TF -> GPB	0.061	0.059	0.030	2.042	0.041

Table 9: Total indirect effects

The findings show that a number of factors have a major impact on GPB. The best predictor is PBC (PBC → GPB, $\beta = 0.375$, $p < 0.001$). Additionally, EF has a significant beneficial impact, demonstrating the contextual influence of environmental variables (EF → GPB, $\beta = 0.224$, $p = 0.003$). Furthermore, a minor but significant contribution is played by GA (GA → GPB, $\beta = 0.112$, $p = 0.019$), indicating that positive attitudes might influence behavior. Trust Factor (TF → GPB, $\beta = 0.061$, $p = 0.041$) and Subjective Norms (SN → GPB, $\beta = 0.062$, $p = 0.046$) both exhibit slight but substantial positive impacts, suggesting that TF and social influence offer subtly encouraging green buying. All of the results point to PBC as the main driver of GPB, with environmental and attitudinal factors supporting it. Normative and trust impacts also play a role, albeit a minor one.

Mediation Effects

In your PLS-SEM model, Green Purchase Intention (GPI) mediates the association between variables and Green Purchase Behavior (GPB). This table shows the unique indirect effects (mediation findings). The results of the mediation study reveal that GPI is a substantial mediator of the PBC–GPB relationship, with PBC exerting the highest indirect effect (PBC → GPI → GPB, $\beta = 0.375$, $p < 0.001$). GPB is also strongly influenced by EF (EF → GPI → GPB, $\beta = 0.224$, $p = 0.003$) and GA (GA → GPI → GPB, $\beta = –0.112$, $p = 0.019$) through GPI, however GA exhibits a negative indirect impact, indicating that positive attitudes do not always result in higher intentions and behavior. Similarly, TF (TF → GPI → GPB, $\beta = 0.061$, $p = 0.041$)

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contributes a minor positive effect via GPI, while SN (SN → GPI → GPB, β = –0.062, p = 0.046) indicates a tiny but substantial negative mediation channel. All things considered, these results demonstrate the major mediating role of GPI, with PBC being the most significant driver and GA and SN exhibiting detrimental mediation effects.

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P values
PBC -> GPI -> GPB	0.375	0.370	0.093	4.019	0.000
SN -> GPI -> GPB	-0.062	-0.060	0.031	1.993	0.046
TF -> GPI -> GPB	0.061	0.059	0.030	2.042	0.041
EF -> GPI -> GPB	0.224	0.218	0.075	3.001	0.003
GA -> GPI -> GPB	-0.112	-0.106	0.048	2.352	0.019

able 10: Mediation effects

Discussion

According to the findings, consumers' sense of control and capacity to make environmentally friendly decisions is the most important factor influencing sustainable consumption. The strongest driver PBC has significant influence on GPI and GPB. The EF highlights the significance of accessibility, availability, and favorable conditions for green purchasing, also have a major positive impact. In the meantime, the TF makes a minor but positive contribution, highlighting how customer trust in green claims and eco-labels reinforces GPI. The GPI was found to significantly predict GPB, supporting its mediating role between antecedents and actual behavior and in line with the TPB theory.

Conclusion

According to the study's findings, consumers' PBC has the greatest impact on determining their GPI and, eventually, their GPB. The TF and supporting EF also have a significant impact. SN and GA, on the other hand, demonstrated adverse impacts, demonstrating that social pressure or positive attitudes may not necessarily result in sustainable behavior. These findings demonstrate the ongoing attitude–behavior gap in green consumption while confirming the mediation function of GPI between predictors and GPB. Therefore, rather than depending only on attitudes or social influence, firms and politicians should concentrate on improving consumers' sense of power, developing reliable green systems, and creating enabling settings in order to promote sustainable purchasing.

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Theoretical Implications

By using the Technology Readiness Index (TRI) as a supporting theory and the expanded Theory of Planned Behavior (TPB) as the underlying theory in the context of green purchase behavior, this study adds to the body of literature. The results support the core idea of TPB since PBC was the best indicator of green buying behavior, emphasizing how crucial consumers' perceived resources and skills are in converting intentions into action. However, the lesser or even negative impacts of Subjective Norms (SN) and Attitude (GA) point to the existence of an attitude–behavior gap, suggesting that societal pressures or positive attitudes by themselves are not enough to motivate green action in the absence of enabling conditions. This goes beyond TPB by highlighting how important situational and control elements are in sustainability situations rather than just attitudes or norms. By elucidating the functions of TF and EF, which serve as external facilitators that promote confidence in adopting green practices, the integration of TRI adds even more theoretical depth. Their importance emphasizes that, contrary to what TPB implies, external institutional, social, and technological support also influences behavioral change readiness. By suggesting a more comprehensive TPB paradigm that integrates preparedness and contextual factors from TRI, the study thereby increases theoretical knowledge by bridging the gap between systemic enablers and individual cognition in predicting green buying behavior.

Practical Implications

The study's findings have a number of important real-world ramifications for companies that support eco-friendly products, legislators, and marketers. Businesses should concentrate on removing obstacles and improving consumers' ability to act by making green products more accessible, inexpensive, and easy, as PBC was the best predictor of GPB. Offering reasonable prices, guaranteeing product availability, facilitating easy access in both online and offline marketplaces, and informing customers about how small adjustments can provide long-lasting results are a few examples of how to do this.

Given the importance of EF, it is recommended that institutions and the government establish a favorable atmosphere by enacting green certifications, eco-friendly laws, subsidies, and public awareness programs that promote sustainable lifestyle choices. In a similar vein, the importance of TF emphasizes the need for businesses to gain the trust of customers by being open and fulfilling environmental pledges.

Recommendations

Businesses should increase perceived behavioral control by lowering the cost and increasing the accessibility of green products. The necessity of using digital tools like apps, e-commerce, and eco-labeling to facilitate green choices is highlighted by the role of technological elements. While leveraging subjective norms through social influence and community engagement can further enhance adoption, raising environmental awareness and green attitudes through education and campaigns can

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also promote positive behavior. When combined, these initiatives have the potential to build a positive ecosystem that encourages dependable green buying practices.

Delimitations and Limitations

This study focused on customers in a particular cultural and geographic location and was restricted to the social sciences/marketing domain of green purchasing behavior. Only important constructs like environmental factors, green attitude, perceived behavioral control, subjective norms, and technological factors were studied; the extended Theory of Planned Behavior (TPB) and Technology Readiness Index (TRI) were chosen as the theoretical frameworks to direct the model. PLS-SEM was used in the study's quantitative design, which restricted its focus to quantifiable factors and eliminated qualitative insights.

The results may not be as generalizable as they could be due to sample size, demographic variety, and geographic concentration. Social desirability effects and response bias may be introduced by relying solely on self-reported data. Moreover, the cross-sectional design limits the capacity to determine causal links across constructs over an extended period of time. In order to overcome these constraints, future studies should use mixed-method or longitudinal approaches, use larger sample sizes, and include more moderating or mediating variables to enhance comprehension.

Future Lines of the Study

Future studies should involve larger and more diverse samples to improve generalizability and adopt longitudinal designs to observe changes in green purchasing behavior over time. Researchers may also include additional constructs such as green trust, environmental knowledge, price sensitivity, and government regulations to extend the current model. Comparative studies across industries or product categories can highlight sector-specific influences. Finally, exploring the role of digital technologies, social media, and e-commerce platforms can provide deeper insights into how technological factors shape sustainable consumer behavior.

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