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# Towards sustainable energy: Factors affecting solar power system adoption by small and medium-sized businesses

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Climate change mitigation is the prime priority of businesses in the modern world, making them inclined to opt for clean energy acceptance. From the end-user perspective, acceptance of novel technologies is inevitably vital in promoting such technologies, and certain factors could play an influential role in shaping the acceptance behavior of businesses in embracing those technologies. Against this background, the purpose of this study is to determine the factors that influence the acceptance of solar panel systems (SPS) by small and medium businesses (SMBs) in Pakistan. A questionnaire survey was conducted in seven districts of Pakistan's Punjab province from December 2021 to February 2022. The data were collected using a Five-point Likert scale. Based on the questionnaire survey, the variance-based structural equation model technique is utilized. The outcomes are: 1) size of the business, ease of using SPS, and credibility of SPS are the top three driving forces. 2) The cost of SPS, and the pressure of competitors are the bottlenecks to the acceptance of SPS, while the absence of technical skills is a neutral factor. 3) According to the effect size and path coefficients, the cost of SPS, and the size of the business are found to be the most significant factors, while the absence of technical skills is found to have less significance. As it is found that economic incentives majorly affect the acceptance of SPS thus, it is concluded that lowering the cost of SPS will increase its acceptance. Based on empirical results, it is suggested to promote public awareness about the environmentally-friendly nature of solar power systems to improve its acceptability at the individual as well as firm levels.

KEYWORDS

**solar power system, SMBS, driving forces, bottlenecks, structural equation model, Pakistan**

# 1 Introduction

The ecosystems are persistently subject to anthropogenic pressures brought about by humans' persistent drive for escalated economic growth (Kapsalis et al., 2019; Ahmad and Wu, 2022b). In this regard, it has been argued that industrial and residential emissions were the root cause of air as well as water pollution (Işık et al., 2021a; Kyriakopoulos et al., 2022). As a remedy to climate change, renewable energy alternatives are revealed to be the sustainable solution to driving down the earth's temperature (Acaroğlu and Güllü, 2022). United Nations' sustainable development agenda emphasizes the transition to renewable energy economies to prevent global warming and resulting catastrophes (Işik et al., 2017). The past studies also argued about the economic viability of renewable energy solutions. For instance, (Isik et al., 2018) found economic growth supportive effects of renewable energy in the United States, China, France, Spain, Germany, and Turkey. As a countermeasure, global economies have started emphasizing the development of the renewable energy sector, involving wind, biomass, and solar power. Among these renewable energy sources, solar has been argued to be the most flexible option since the feasibility of its adoption is more incredible than wind and biomass energy (Kyriakopoulos et al., 2019; Jabeen et al., 2020). In 2019, solar energy cumulative installed capacity was noted around 627 gigawatts (GW) globally (Atchike et al., 2022; Rehman et al., 2022). It has been argued that post-2022, solar is going to report the new records for new deployments every year, with a mean increase of 125 GW of new capacity anticipated worldwide between 2021 and 2025 (IEA, 2020). Even if renewables are strongly rooted in the world's energy production sector at this stage, they hardly produce 12.9% of the total energy production (excluding the generation of hydropower) (Ahmed et al., 2021; Rehman et al., 2021; Verbič et al., 2021). In addition, fossil fuel subsidies that used to compete with hundreds of billions of US dollars per year are now being decelerated (Chandio et al., 2020). Nevertheless, despite everything, investors finance carbon power plants with tens of billions of US dollars each year (IRENA, 2019). As for access to electricity installations, approximately 1 billion people were without these installations; the vast majority belong to African countries, while around 25 million belong to Pakistan (Adedoyin et al., 2021). Solar panel systems (SPS) - a group of solar (or photovoltaic) cells that may produce energy through the photovoltaic effect—would possibly reshape the sustainable development goals (SDGs) in this case (Energy Information Administration, 2019). With this cause, various economies have generated positive anticipations for the success of the renewable energy sector (Ahmad et al., 2021c; Işık et al., 2022). The ever-increasing demand for power generation in its history is also one of the deciding relics for an economy to manage a stable prospect (Chandio et al., 2021; Ahmad and Wu, 2022a). The world's power demand is anticipated to grow to 29 per cent in the sky between 2018 and 2040. This increase is anticipated to rise by about 50 percent in Asian countries, which is notable among several other countries in the world (Ahmad et al., 2021b; Işık et al., 2021b; Satrovic et al., 2021). A horrific energy shortfall of about 9000 MW was reported in Pakistan in the middle of 2018. In the meantime, a power outage of up to 13–15 h a day was normal in rural areas, while in urban areas, 6 to more than 8 h a day (Jabeen et al., 2019). In order to overcome this power shortage, the production of SPS is anticipated to provide the solution needed, as Pakistan has enormous renewable energy potential. Despite the abundance of renewables, the use of SPS is still far below its optimum point (Fatima et al., 2019).

Although there is progress seen in the past works regarding the acceptance of renewables by small and medium businesses (SMBs), the depth of analysis and scope of factors involved in those researches remained limited. In this regard, (Acaroğlu and Baykul, 2016) conducted the economic feasibility of producing and consuming solar flat-plate systems in Eskisehir, Turkey. They concluded that though solar systems incurred huge economic costs, their potential climatic benefits could compensate for such costs. There are many shortcomings needing the attention of modern studies. 1) The existing literature, such as Qamar et al. (2022) and Rahbauer et al. (2016), focused on the factors influencing the acceptance behaviors in Pakistani and German SMBs, correspondingly. For instance, the former one considered a small sample size from a local perspective, leaving the findings with lack of generalizability. Additionally, SMBs have characteristics such as less profit margins, less revenues and a variety of customers. These characteristics may result in acceptance behavior that is different from the large businesses. Thus, including these kinds of businesses will lead to a better understanding of acceptance behavior related to SPS, which is accomplished by this study by taking SMBs into consideration. 2) The factors that are taken into consideration to analyze the acceptance of SPS in this study have never been considered by last studies as per our knowledge. Although the study of Rahbauer et al. (2018) in German SMBs considered those factors to analyze the renewable acceptance behavior but they ignored an important factor of the absence of technical skills. This study has taken this factor into consideration.

3) The factors investigated in this study were not considered by the past researchers. Again, Rahbauer et al. (2016) was the only researcher to conduct a qualitative research which was based on interviews to describe the behavior of German SMBs in regards to acceptance of renewables. Nonetheless, the difference is in the method of attainment of electric power. To investigate the acceptance of renewables by German SMBs, the company that provides the renewable energy was taken into consideration. In contrast to which, there is no study which investigated those factors in the perspective of SMBs, resulting in the decision of adopting SPS as a stand-alone photovoltaic

system rather than a company. This makes the decision of adopting renewable energy entirely different from adopting it from a company which supplies renewable energy. Hence, to fill this gap, this study investigates the acceptance behavior of SMBs in regards to acceptance and diffusion of solar photovoltaic system (SPS). It is noteworthy in a country like Pakistan which is still developing and where SMBs can get renewable energy from SPS as there are no authorized companies which supply renewable energy. In cooperation with Chinese companies, although the country has initiated some projects for renewables' development, but production of energy is still low in comparison to the demand of country (Fatima et al., 2022; Yasir et al., 2022). According to the data of 2019, the demand of power remained approximately 1,000 TWh, but the production of renewable energy was only about 6.88 TWh (Irfan et al., 2019; Jabeen et al., 2021b). So, for the smooth transition from regular energy source to a new energy source, using a using the SPS would be a better choice. 4) The relative significance of factors affecting the acceptance of SPS by SMBs was not examined in previous studies. To formulate an effective and targeted policy, it is essential to take the relative weightage of those acceptance factors into consideration. To fill this gap, this study has assigned ranks to the driving forces and bottlenecks after the identification of their importance. All these points make this study different from the existing literature.

The core aim of this work is the identification and prioritization of the factors that motivate and demotivate the acceptance of SPS by SMBs of Pakistan. Additionally, this study adds to the present knowledge by extending various contributions: 1) it recognizes the significant factors that affect the acceptance of SPS through literature review in the context of SMBs. As a further step, to get the responses of SMBs' managers/owners, the questionnaire is conducted. 2) To examine the significance of factors that motivate and also demotivate the acceptance of SPS, structural equation model technique is utilized. 3) To rank the predicted factors according to their importance, path coefficients and their effect sizes are utilized. 4) This study also formulated policy on the basis of core outcomes of the analysis.

The remaining of this research is organized as follows: Section 2 deals with the literature review and hypotheses development. Section 3 explains materials and methods. Section 4 details results and discussions. Finally, section 5 is based on conclusions.

# 2 Literature review and hypotheses formulation

A survey of the literature has been conducted on the factors that effect the acceptance of SPS by SMBs. Furthermore, to improve the semi-structured questionnaire, pilot conduction of the questionnaire was done.

## 2.1 Disposition of the SMBs

Recently, it is claimed that the employment of solar technologies by SMBs has been positively affected by the relative advantage for the environment. The study of Irfan and Ahmad (2021) in India showed that in the long run, a lot of firms gained more benefits after employing new technologies in comparison to other energy sources. Furthermore, every country should maximize its efforts to decrease pollution and SPS utilizations plays a good role in decreasing pollution rather than traditional sources of energy. Thus, in context of South Korea, the efforts to reduce pollution also affect positively on the utilization of SPS (Lee and Shepley, 2020). Ahmad et al. (2017) conducted their research in Malaysia, where a majority of SMBs' owners that used SPS were due to their own personal choice rather than government effort. An innovative work by (Kyriakopoulos, 2011b) investigated and found that the quality enhancement of the business is exhibited from the customer satisfaction. (Aravossis et al., 2019) conducted an analysis to assess the industries' environmental performance under the Holistic Performance Index for Environment. Their index included water, energy, waste, and pollution, and thus was considered a comprehensive measure of firms' environmental performance. In Pakistan, Yasmin and Grundmann (2019) performed their research regarding the acceptance of biogas by the households and concluded that they were motivated to adopt it given its health-beneficial effects. The study of Jacksohn et al. (2019) showed that utilization of SPS is affected by the social responsibility of consumers towards the environmental issues. Therefore, the consumers wanted to protect the environment which motivated them to use products that are environmentally friendly. In addition, they wanted to switch to SPS from traditional energy sources. Given this, we formulated the following hypothesized relationships:

$H_1$: Environment-related accountability is anticipated to positively affect the acceptance of SPS by SMBs.

$H_2$: Environment-related advantages are anticipated to affect the acceptance of SPS by SMBs positively.

## 2.2 Technical dimensions of SPS

Acceptance of SPS is highly influenced by the technical aspect of SPS. It was found by Azarova et al. (2019) that not having enough technical knowledge negatively influenced the acceptance of energy efficient technologies, when he researched metal manufacturing firms in Italy. The main reason was that owners of SMB lacked the knowledge and skills regarding novel technological types of equipment, impeding their acceptance of such technologies. The work of (Kyriakopoulos, 2011a) studied and revealed that the worldwide economic environment was subject to drastic changes due to human as well as non-human industrial

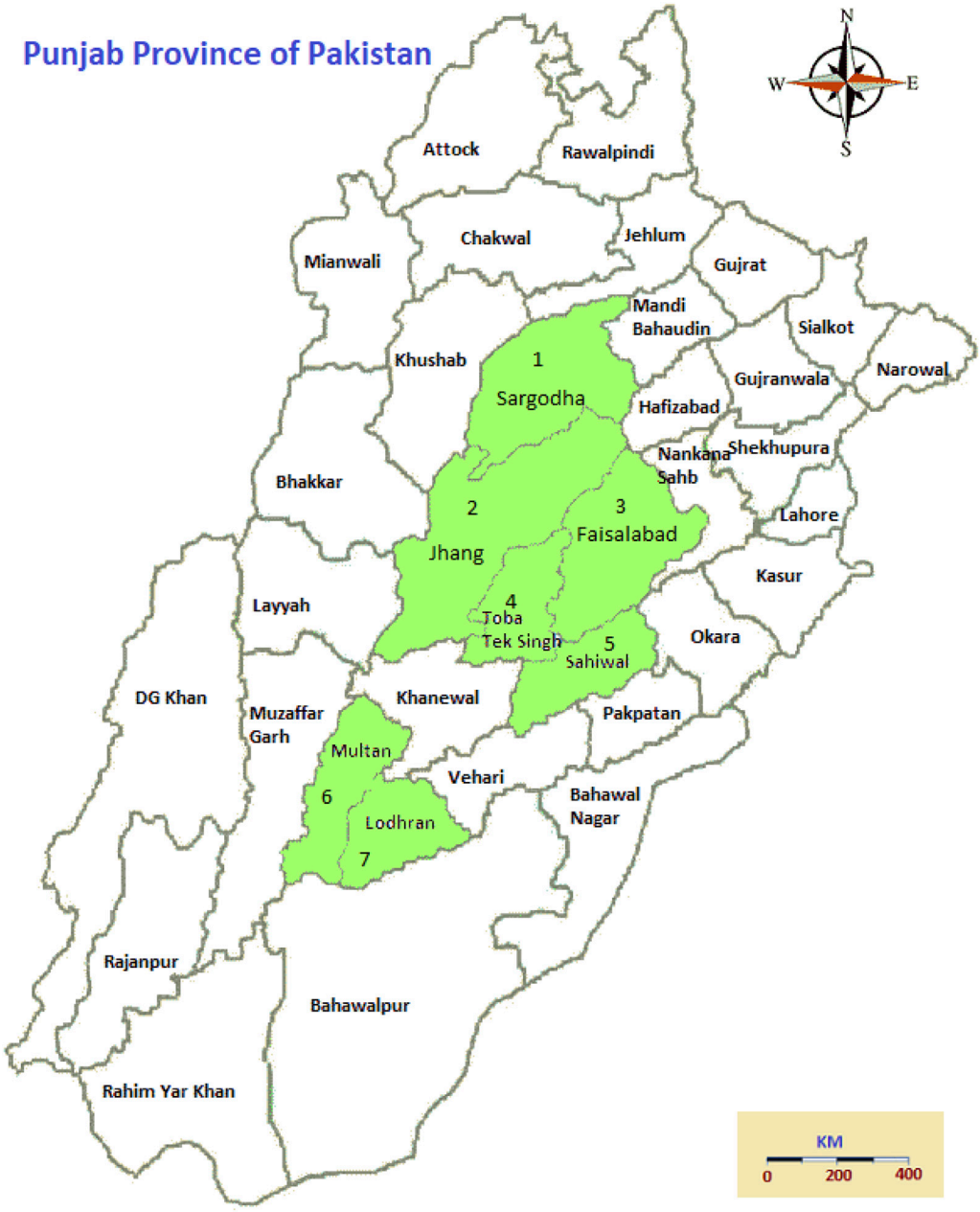


FIGURE 1
Study location.

activities. The study of Nikas et al. (2020) was based on the analysis drawn by expert opinions and it concluded that insufficient technology adversely affected the consumption of green energy. In addition to that, they found that size of firms was also a driving factor. Moreover, Hai (2019) concluded that the complexity of the system demotivated the Finnish consumers from adopting green electricity.

Dobers (2019) conducted their research on SMBs of Germany and found that consumption of green energy was negatively affected by the credibility of the system as the firms wanted to have a power supply without any interruption and they had no trust that new technology will provide them that. According to Jeslin Drusila Nesamalar et al. (2017), the credibility of system means no discrepancies between a novel and mainstream energy, which results in a negative effect on the use of new technology by SMBs. Furthermore, Balsalobre-Lorente et al. (2018) observed the acceptance of energy efficient technology in the firms of Italy. Their study shows that firms were hesitant to adopt new technology as

they found it difficult to gather the information and then to evaluate it in order to know whether it was beneficial for them to switch to new technology or not. Thus, the study concluded that complexity of system negatively influence the acceptance of advanced technology. In light of this, we formulated the following hypothesized relationships:

$H_3$: Ease of using SPS is anticipated to affect the acceptance of SPS by SMBs positively.

$H_4$: Credibility of SPS is anticipated to affect the acceptance of SPS by SMBs positively.

$H_5$: Absence of technical skills is anticipated to have an ambiguous affect on the acceptance of SPS by SMBs.

## 2.3 Economic dimensions

Regarding economic parameters, price affects the decision of adopting new technology by firms and households. Burke et al. (2019) analyzed the data of Indonesia and found that the decision of adopting SPS by households was influenced by the price. It was also found that as the cost of SPS was more than the traditional energy, it affected the decision of acceptance negatively. Whereas, Yadav et al. (2020) examined the scenario of India and Indonesia regarding the acceptance of wind energy. They concluded that although the fixed investment is much higher but the generation of electricity after that is cheaper in comparison to traditional energy, so this may affect the consumption of new energy positively. In the context of Pakistan, the study of Rauf et al. (2015) shows that clean energy is perceived as an expensive commodity by the people which results in continuous reliance by the people on conventional energy rather than adopting advanced technologies. In their study, Acaroğlu and Baykul (2018) focused on the promotion of solar energy systems at the consumer level. They guided solar adoption to show its importance for the renewable energy transition in Eskisehir, Turkey. Ali et al. (2021) studied the nexus of capital budgeting approaches and revealed that cost and risk factors moderated the financial performance of renewable energy projects.

In the context of German SMBs, there are several studies present. Shahid et al. (2020) stated that utilization of SPS by large firms was hugely affected by the competitive pressure. As the technology of SPS was used by the competitor firms, it influenced those firms who were still hesitant to the acceptance of new sources of energy. The study of Groba and Cao (2014) states that the firms with lower profit margins present in competitive markets were negatively influenced in regards to the acceptance of SPS. Whereas, Eshchanov et al. (2021) claimed that acceptance of green energy relied on the available information regarding green electricity. They further added that if it was easy to find the information or

TABLE 1 Results of measurement model.

| Constructs/items | Outer loadings | CR | CRBA | AVE |
|---|---|---|---|---|
| Environment-related accountability (ENA) | | | | |
| ENA1 | 0.762 | 0.876 | 0.848 | 0.810 |
| ENA2 | 0.716 | | | |
| ENA3 | 0.795 | | | |
| ENA4 | 0.767 | | | |
| Environment-related relative advantages (ENR) | | | | |
| ENR1 | 0.747 | 0.881 | 0.837 | 0.827 |
| ENR2 | 0.748 | | | |
| ENR3 | 0.801 | | | |
| ENR4 | 0.793 | | | |
| Ease of using SPS (EUS) | | | | |
| EUS1 | 0.783 | 0.824 | 0.813 | 0.802 |
| EUS2 | 0.727 | | | |
| EUS3 | 0.758 | | | |
| Credibility of SPS (CRS) | | | | |
| CRS1 | 0.793 | 0.820 | 0.799 | 0.797 |
| CRS2 | 0.729 | | | |
| CRS3 | 0.732 | | | |
| CRS4 | 0.784 | | | |
| Absence of technical skills (ATS) | | | | |
| ATS1 | 0.801 | 0.855 | 0.823 | 0.808 |
| ATS2 | 0.795 | | | |
| ATS3 | 0.775 | | | |
| Cost of the SPS (CTS) | | | | |
| CTS1 | 0.717 | 0.891 | 0.834 | 0.817 |
| CTS2 | 0.741 | | | |
| CTS3 | 0.773 | | | |
| Competitors' pressure (CMP) | | | | |
| CMP1 | 0.755 | 0.876 | 0.825 | 0.801 |
| CMP2 | 0.740 | | | |
| CMP3 | 0.715 | | | |
| CMP4 | 0.747 | | | |
| Size of the business (SZB) | | | | |
| SZB1 | 0.790 | 0.854 | 0.814 | 0.790 |
| SZB2 | 0.756 | | | |
| SZB3 | 0.798 | | | |
| Environment-related attitude (ERA) | | | | |
| ERA1 | 0.786 | 0.865 | 0.827 | 0.803 |
| ERA2 | 0.743 | | | |
| ERA3 | 0.734 | | | |
| ERA4 | 0.727 | | | |
| Acceptance of SPS (ASPS) | | | | |
| ASPS1 | 0.775 | 0.899 | 0.867 | 0.832 |
| ASPS2 | 0.805 | | | |
| ASPS3 | 0.812 | | | |
| ASPS4 | 0.836 | | | |
| ASPS5 | 0.794 | | | |

TABLE 2 Results of discriminant validity.

| Constructs | ERA | ENR | EUS | CRS | ATS | CTS | CMP | SZB | ERA | ASPS |
|---|---|---|---|---|---|---|---|---|---|---|
| ENA | 0.827 | | | | | | | | | |
| ENR | 0.627 | 0.772 | | | | | | | | |
| EUS | 0.502 | 0.601 | 0.859 | | | | | | | |
| CRS | 0.669 | 0.264 | 0.494 | 0.778 | | | | | | |
| ATS | 0.710 | 0.584 | 0.502 | 0.438 | 0.792 | | | | | |
| CTS | 0.473 | 0.294 | 0.573 | 0.510 | 0.473 | 0.859 | | | | |
| CMP | 0.410 | 0.573 | 0.483 | 0.489 | 0.491 | 0.781 | 0.801 | | | |
| SZB | 0.482 | 0.590 | 0.301 | 0.573 | 0.619 | 0.601 | 0.628 | 0.874 | | |
| ERA | 0.610 | 0.584 | 0.574 | 0.563 | 0.382 | 0.429 | 0.401 | 0.502 | 0.883 | |
| ASPS | 0.592 | 0.526 | 0.510 | 0.410 | 0.437 | 0.565 | 0.522 | 0.711 | 0.384 | 0.810 |

Note: CTS: perceived SET's price, SZB: size of the business, EUS: ease of using SPS, CRS: credibility of SPS, CMP: competitors' pressure, ERA: environment-related attitude, ENR: environment-related relative advantages, ENA: environment-related accountability, ATS: absence of technical skills.

gathering information related to the new technology was not costly, it would motivate the firms to accept green electricity. In view of this, we formulated the following hypothesized relationships:

H6: The cost of SPS is anticipated to have a negative effect on the acceptance of SPS by SMBs.

H7: The competitors' pressure is anticipated to have a negative effect on the acceptance of SPS by SMBs.

## 2.4 Characteristics of SMBs

Past researchers have presented studies on the significance of features of SMBs in influencing their decision of accepting SPS. Solarin et al. (2021) presented their study in the context of Nigeria and stated that consumption of renewable energy is positively influenced by the size of the firm. There is more chance of larger firms adopting renewable energy than smaller firms. Strupeit and Palm (2015) conducted their research on the firms of Germany and concluded that the size of the firm significantly affected the utilization of renewables. (Kyriakopoulos, 2012) studied the management by objectives (MBO) approach and found that the mismatch between the introductory MBO approach and its real application by the firms proved harmful to the firms' operations. Whereas, Hou et al. (2021) argued that the size of a firm negatively influenced the acceptance of green energy, as the larger the firm is, the more its energy requirement is, which leads to a higher cost of investment. Thus, making it difficult for larger firms to accept green energy. In addition, energy intensity was revealed to be an important factor in the acceptance of clean energy. As for the small firms, the consumption of energy is the main cost of production and adopting renewables can decrease their cost of production, so this influenced the acceptance of renewables positively (Oluoch et al., 2020). By conducting research on the SMB industry of India, Wang (2021) confirmed that concern towards environmental issues positively affects the consumption of renewables. After this literature review, we formulated the following hypothesized relationships:

$H_8$: Size of the business is anticipated to affect the acceptance of SPS by SMBs positively.

$H_9$: Environmental-related attitude is anticipated to affect the acceptance of SPS by SMBs positively.

# 3 Materials and methods

## 3.1 Questionnaire conduction

This research comprises a survey questionnaire which was conducted from December 2021 to February 2022 in seven districts[1] (Multan, Sahiwal, Lodhran, Faisalabad, Toba Tek Singh, Jhang, and Sargodha) of the Punjab province of Pakistan. To this end, 16 tehsils[2] were selected from the seven districts as the further administrative division. Furthermore, at least 10 union councils[3] (sub-sub) were opted for per tehsil to choose the respondents. The study location is given in Figure 1. Respondents of questionnaires were the SMBs' owners and managers and included both the adopters and non-adopters of SPS. To obtain the responses, owners/mangers were met in person and requested to fill the questionnaires. The contents of the questionnaires were explained to the respondents in detail to acquire accurate responses. On average, it took 1 h for owner or manager of SMBs to fill out the questionnaire. For the protection of data and privacy, all the respondents are kept anonymous.

1 Sub-division of province.

2 Sub-division of the district.

3 Sub-division of the tehsil.

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TABLE 3 Results of structural modeling.

| Hypothesized relationships | Structural path | Beta | Relationship | VINF | $f^2$ | $R^2$ | $Q^2$ |
|---|---|---|---|---|---|---|---|
| H1 | ENA → ASPS | 0.344** | Confirmed | 2.104 | 0.237 | 0.780 | 0.368 |
| H2 | ENR → ASPS | 0.384** | Confirmed | 2.574 | 0.265 | | |
| H3 | EUS → ASPS | 0.521* | Confirmed | 3.375 | 0.359 | | |
| H4 | CRS → ASPS | 0.481* | Confirmed | 2.382 | 0.331 | | |
| H5 | ATS → ASPS | 0.031 | Not confirmed | 3.674 | 0.021 | | |
| H6 | CTS → ASPS | -0.624* | Confirmed | 3.275 | 0.430 | | |
| H7 | CMP → ASPS | -0.456* | Confirmed | 3.281 | 0.314 | | |
| H8 | SZB → ASPS | 0.579** | Confirmed | 3.018 | 0.399 | | |
| H9 | ERA → ASPS | 0.402*** | Confirmed | 2.184 | 0.277 | | |

Note 1: *prob. < 0.10, **prob. < 0.05, ***prob. < 0.01. CTS: perceived SET's price, SZB: size of the business, EUS: ease of using SPS, CRS: credibility of SPS, CMP: competitors' pressure, ERA: environment-related attitude, ENR: environment-related relative advantages, ENA: environment-related accountability, ATS: absence of technical skills.

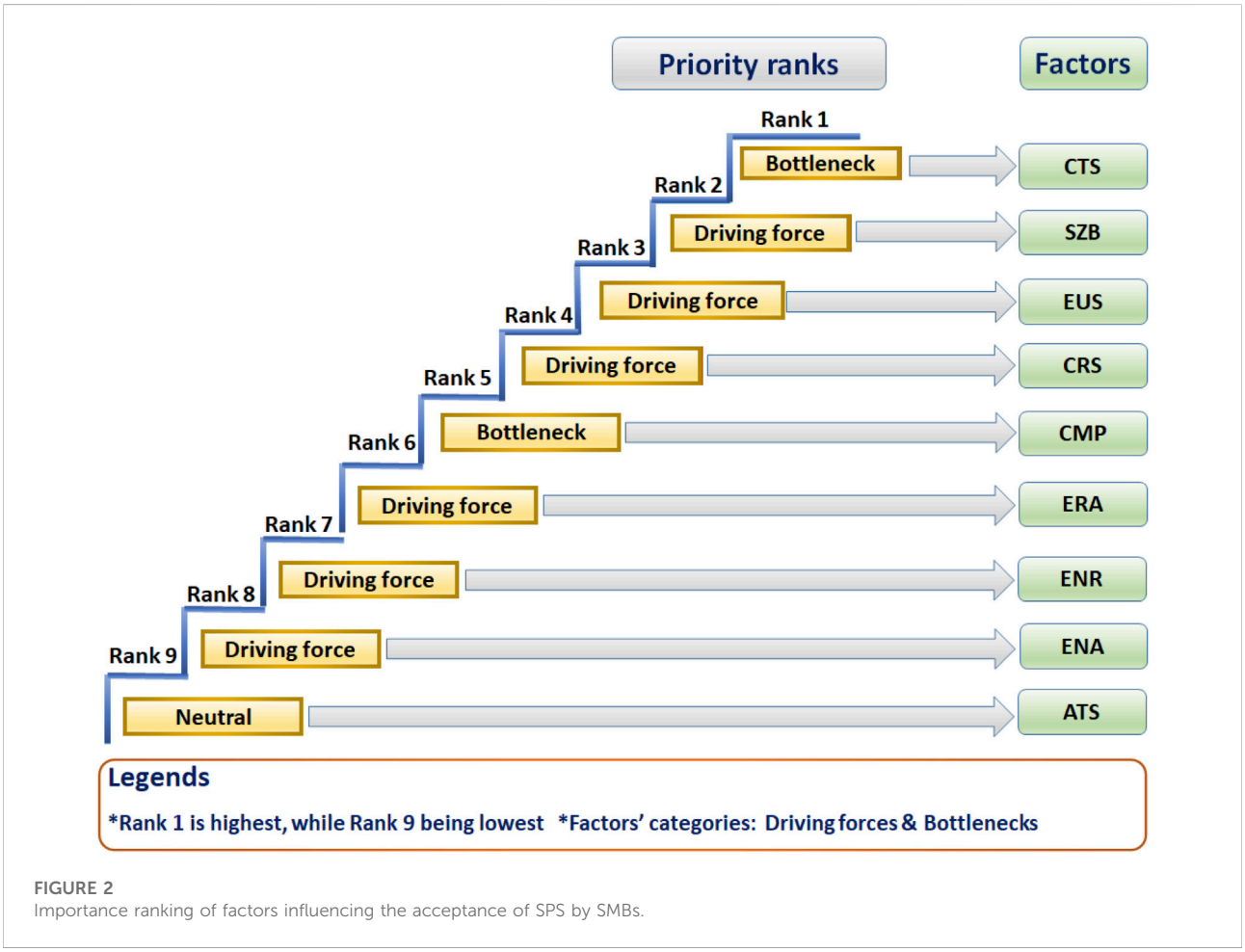


FIGURE 2
Importance ranking of factors influencing the acceptance of SPS by SMBs.

A primary questionnaire was updated after attaining the opinions of owners and managers of the firms. After the modification of the questionnaire, 845 questionnaires were filled in person by the respondents, from which accurate and properly filled questionnaires were 721. So for the analysis, 721 questionnaires were utilized. The response rate exceeded the minimum benchmark of 20% as the response rate for our questionnaire was amounted to 85.33%. Therefore, it is

appropriate for investigation (Ahmad et al., 2020). Seven key factors were used to design the questionnaire. Five point Likert scales was employed to analyze the factors of questionnaire. Respondents were requested to fill the questionnaire by choosing from "1" showing "strongly disagree" to "5" showing "strongly agree."

## 3.2 Measurement and structural model

The model consists of the validity of the constructs as well as the average-variance-extracted (AVE). The former determines the reliability amount regarding the accurateness of the constructs extracted from the questionnaire and how well they show the score of the population (Hair et al., 2016). For the validity of constructs, external loadings and cross-correlations are utilized. According to Ahmad et al. (2021a), an item having external loading above 0.70 can be used in the model, whereas an items with external loadings below 0.70 should be excluded from the model. It is shown in Table 1 that all the constructs have loading values above 0.70 which suggest that all the evaluated items had substantial construct validity. For the evaluation of how much variance is accounted by an item of the latent construct, Sarstedt et al. (2014) stated that AVE must exceed 0.70. It is analyzed in this study that AVE ranges between 0.790 and 0.832, showing that majority of the variations are captured by the construct (Sarstedt et al., 2016). Thus, the research's measurement modeling has the convergent validity.

The extent of consistency among the given components of the same latent factor is called internal consistency's credibility. To test this, Cronbach's alpha (CRBA) and Composite credibility (CR) is used by the researchers (Ketchen, 2013). A lot of inadequacies were found in CRBA, so many researchers used composite credibility for their analysis (Hair et al., 2014). The suggested values for CR and CRBA is at least 0.70, whereas it is shown in Table 1 that all the constructs exceed this value (Henseler et al., 2015). Considering CR, the value for all the constructs is from 0.820 to 0.899, while considering CRBA the value for all the constructs ranges from 0.800 to 0.875 and is higher than the value recommended by Sarstedt et al. (2016). This implies that sufficient credibility for internal consistency is proved for all the measurements.

Discriminant validity is defined as the degree to which a latent construct has contradictions with different unobserved factors, i.e., meaning that how much it is related to itself and how much to other factors (Hair and Babin, 2017). In other words, discriminant validity is utilized to evaluate the similarities among the measurements of constructs that have the potential of overlapping. In reference to Fornell-Larcker criteria, the loadings of items should exceed their own constructs in the model, and the AVE's square root value of each factor in relation with other factors should be less than its reflective correlation (Henseler et al., 2015). The findings revealed in Table 2 indicates that cross-correlations have less values than the reflective correlation values of each construct. It is presumed that each construct is defined individually from others as the overall measurement model of study demonstrate required discriminant validity.

# 4 Structural model results and discussions

## 4.1 Structural model and results

For the evaluation of hypotheses, the bootstrap process is utilized having at least 5,000 repeted sampling. For one-tailed *t*-tests, the critical values that were employed are as follow: 1.84 (level of significance = 10 percent), 1.90 (level of significance = 5 percent), and 1.98 (level of significance = 1 percent), which is confirmed by several past studies (Jabeen et al., 2021a; Fatima et al., 2021; Irfan and Ahmad, 2022). Using bootstrapping method, the path coefficient's significance revealed that except H5, all other hypotheses are relevant. Table 3 provides the path coefficients.

The analysis showed a positive and statistically significant effects of environment-related accountability (beta = 344, prob. < 0.05); environment-related relative advantages (beta = 0.384; prob. < 0.05); ease of using SPS (beta = 0.521; prob. < 0.10); credibility of SPS (beta = 0.481; prob. < 0.10); size of the business (beta = 0.579; prob. < 0.05); environment-related attitude (beta = 0.402; prob. < 0.01); on acceptance of SPS by SMBs. Considering this, acceptance of SPS by SMBs is influenced by these factors. Analysis also discovered a negative yet significant affect of cost of SPS (beta = −0.624; prob. < 0.10) and the competitors' pressure (beta = −0.456; prob. < 0.10) on acceptance of SPS by SMBs. It is proved that these factors are the bottlenecks to the acceptance of SPS by SMBs. The analysis also revealed a neutral effect of the absence of technical skills on the acceptance of SPS by SMBs. The $R^2$ (0.780) predicts 78% of the variance in acceptance of SPS by SMBs. The predictive relevance of the model is also proved as the $Q^2$ (0.368) is higher than the threshold value of 0.35. It is found that the multicollinearity between the factors does not exist as the value of variance inflation factor (VIF) is less than ten, and it is proved for all the factors. Lastly, to verify the effect size, the f-square values are calculated.

## 4.2 Discussions

To sum up, the categorized driving forces of acceptance of SPS by Pakistani SMBs included the environment-related accountability,

environment-related relative advantages, credibility of SPS, size of business, environment-related attitude, and customers' preferences. However, the cost of SPS and competitors' pressure proved to be the bottlenecks to SPS's acceptance. Finally, the absence of technical skills discovered a neutral effect on the acceptance of SPS by Pakistani SMBs. To rank the factors influencing the acceptance of SPS by SMBs, the path coefficients' magnitudes are used. Regarding this, the highest-ranked factor was found to be the cost of SPS, whereas the lowest-ranked factor was the absence of technical skills. Furthermore, the cost of SPS and the size of the business were classified as the top three factors affecting the acceptance of SPS by SMBs. Figure 2 depicts the ranking of those factors according to their importance. The environment-related attitude proved as a significant driving force of SPS acceptance. In this regard, the recent pioneering work of (Kyriakopoulos et al., 2020) manifested that though environmental behavior of business students affected environmental education, its translation into green consumption and active participation remained a bottleneck. The competitor's pressure remained the bottleneck in the acceptance of SPS by SMBs. The possible explanation is that the businesses show reluctance in bearing the cost of being green and using green technologies since they are afraid of losing their market share in the hands of those running the traditional style business. A similar idea was conveyed by (Skordoulis et al., 2022), who argued that green entrepreneurship promoted Greek firms' green process and product innovation.

To begin with, the foundation for developing hypotheses in this study was solid. The literature survey was used to extract elements influencing SMBs' decision to accept SPS, followed by a pilot questionnaire conduction with a primary structure, which was revised and changed to make the actual questionnaire carried out for the best findings. Consequently, based on the concrete context, the predicted linkages were logical and justifiable. The questionnaire respondents were chosen from SMBs that account for the majority of the region's operations. Then, because the types of businesses and local practices are more or less uniform across the province, the findings' generalizability is justified. Furthermore, it has covered a sample large enough to represent the population of SMBs in the investigated seven districts, based on district-level research. However, when considering Pakistan's other provinces, which have diverse cultures, the same problem limits generalization. As a result, the actions of SMBs' managers may differ depending on the country's cultural settings, posing a challenge to the generalization of this study's findings. Finally, this is the first study of SPS acceptance by Pakistani SMBs in a comprehensive framework that includes a variety of driving and inhibiting factors. In this vein, this study paves the way for more research in the future. More research should be done with a large sample size across the country to account for varied responses from multi-cultural respondents. It would contribute to a better understanding of SMBs' adoption decisions in developing countries like Pakistan. The findings can be duplicated in other settings.

## 5 Conclusion and policy implications

The main objective of this research is to find the factors influencing the acceptance and diffusion of SPS by SMBs in Pakistan. With the help of existing literature and a semi-structured questionnaire, the driving forces and bottlenecks were found. In addition, a structural equation model was utilized to obtain the path coefficients. This research also helps the government and policymakers to formulate a policy in order to increase the acceptance of SPS as it provides the following recommendations:

The environment-related accountability, environment-related relative advantages, credibility of SPS, size of the business, and environment-related attitude are revealed the driving forces of acceptance of SPS by SMBs in Pakistan's Punjab province. As a result, the government must pay more attention to these issues when establishing and organizing environmental legislation and incentives in order to accelerate SPS acceptability. The expense of SPS and the pressure from competitors were then identified as obstacles to SPS acceptability. SMBs, on the other hand, have lower profit margins than major corporations; as a result, even while technical advancements have greatly lowered the cost of SPS, it remains expensive for SMBs. Furthermore, the path coefficient and size of effects results showed the importance of the SPS cost and the business size in decreasing order. These findings support the government's need to take the aforementioned actions. Finally, the absence of technical skills was the least influential factor in SPS acceptability. It demonstrates a lack of customer knowledge of the importance of the SPS for the ecosystem, which is home to numerous types of living animals, including humans. Therefore, training of individuals for the technical skills regarding SPS is recommendable for the better public acceptability of such technologies.

## Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author.

## Ethics statement

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. The patients/participants provided their written informed consent to participate in this study.

## Author contributions

DA: Conceptualization, writing-original draft, variable construction, formal analysis. ZZ: Writing-review and editing, variable construction. TA: Writing-review and editing, analysis conduction. GW: Writing-review and editing, variable construction. GJ: Overall quality improvement, structure enhancement, Writing-review and editing.

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## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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