DOI: 10.6977/IJoSI.202212_7(4).0001
A. Waqas, H. Halim, N. Ahmad / Int. J. Systematic Innovation, 7(4), 1-17(2022)

# Design leadership and SMEs Sustainability; Role of Frugal Innovation and Technology Turbulence

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(Received 16 March 2022; Final version received 17 September 2022; Accepted 28 September 2022)

## Abstract

Climate change and poverty are among the emerging issues of economies around the globe. To resolve these issues, United Nations have introduced the SDGs and enforced organizations to adopt business practices that are less harmful to society. Even international organizations couldn't implement sustainability practices at a large scale and this situation is more vulnerable in the context of SMEs. Therefore, SMEs' outcomes i.e. financial, social, and environmental performance are compromised (Álvarez Jaramillo, Zartha Sossa, & Orozco Mendoza, 2019; Dey et al., 2020). Thus, this study aims to analyze the relationship between design leadership and SME sustainability through the mediating role of frugal innovation. Further, this study has also investigated the moderation of technology turbulence in the relationship between design leadership and frugal innovation. The quantitative survey was gathered through purposive sampling from 383 employees of SMEs working in the Lahore and Sialkot region with the help of SMEDA (Small and Medium Enterprise Development Authority). The data analysis was performed through SMART PLS 3. The result of this study reveals that there exists a positive significant relationship between design leadership and sustainability. Further, frugal innovation significantly mediates the relationship between design leadership and sustainability. Likewise, technology turbulence significantly moderates the relationship between design leadership and frugal innovation. This study also presents the implication and limitations along with the recommendation in a later section.

*Key Words:* Design Leadership, Frugal Innovation, Sustainability, Technology turbulence.

## 1. Introduction

The enormous damage to the climate in recent years and poverty have become major challenges for economies around the world. The growing interest of the people in climate change has caused pressure on the stakeholders of manufacturing firms to adopt pro-environmental practices (Shehzad, Zhang, Le, Jamil, & Cao, 2022). Additionally, the recent COVID-19 outbreak was a great shock and affected more than 200 countries (Worldometer, 2022). As the virus was contagious and restrictions were implemented on several businesses and other gatherings (Papadopoulos, Baltas, & Balta, 2020). These worldwide restrictions have severely affected SMEs as compared to large-scale firms. This enormous damage can be understood through the economical suffering of SMEs in several countries i.e. 41% of SMEs business in the UK(Juergensen, Guimón, & Narula, 2020), 50% of SMEs in Germany (DIHK, 2020), 70% of the SMEs in Italy (OECD, 2020), and 27% in China (Dai et al., 2021) were affected by COVID-19. While considering these emerging issues all over the world, sustainable goals provided by United Nations have gained more familiarity (Iqbal, Ahmad, Li, & Li, 2021; Smith, Discetti, Bellucci, & Acuti, 2022; Ullah, Ahmad, Rehman, & Fawad, 2021). Further, sustainability consists of three key elements i.e., economic, social, and environmental (Dima et al., 2022; Frobisher, 2021) which are helpful to mitigate emerging challenges of climate change, poverty, and other uncertain situations. Similarly, it is noted that sustainability becomes the reason for ecological and financial well-being (Dos Santos, Lampreia, & Ahmad, 2020). These benefits of sustainability encourage the organization to opt for the sustainability measures in their systems, however, SMEs are facing the enormous challenge of sustainability adoption

(Das, Rangarajan, & Dutta, 2020) because of lower resources and capabilities as compared to multinational companies(Papadopoulos et al., 2020). Previously, it is also noted that SMEs in developing countries are lacking in their focus on social and environmental issues due to inadequate support from the organization and poor implementation of the laws (Das et al., 2020).

On the contrary, SMEs' sustainability is crucial for the economic well-being of economies all over the world because it contributes majorly to the business of several economies i.e. 99.3% of the private businesses in the UK (Business, 2014), 99.8% of all the enterprises in Europe (Commission, 2019; Južnik Rotar, Kontošić Pamić, & Bojnec, 2019) and 60% of the industrial growth in China (Huang, Boateng, & Newman, 2016) is based on the SMEs. Similarly, SMEs have a major contribution to the economy of developing countries as they provide 33% of national income and 45% of total employment (iQualify, 2015; Yoshino & Taghizadeh-Hesary, 2018).

Besides this, emerging markets have gained attention internationally, as currently 17% of the revenue of multinational companies is based on emerging markets and it has a potential of US$ 30 trillion by 2025 (Ernst, Kahle, Dubiel, Prabhu, & Subramaniam, 2015). Emerging markets are comprised of two types of customers i.e., high income and low income. These emerging markets demand cost-effective products and value at lower prices which is possible through frugal innovation (Pisoni, Michelini, & Martignoni, 2018). These customers at bottom of the pyramid demand less innovative but compatible products (Cai, Ying, Liu, & Wu, 2019). Thus, frugal innovation tries to meet the needs of bottom-line customers with limited resources (Pansera & Sarkar, 2016). Precisely, resource-limitation of emerging firms encourages unique ways to innovate fundamentally which meet the requirements of the cost-sensitive customers of the emerging markets (Cai et al., 2019; Martin, Romero, & Wegner, 2019). However, a unique and innovative process is possible through design leadership which considers the future and undertakes the innovative design in the manufacturing process (Muenjohn & McMurray, 2017). For the successful adoption of innovation in organizational processes, studies show that design leadership (Muenjohn & McMurray, 2017) plays an important role. Leadership can effectively utilize such strategies which enable innovation in the overall processes of SMEs(Iqbal, Ahmad, & Halim, 2021). Therefore, design leadership can contribute to the innovation process, however, empirical evidence regarding how design leadership transforms the innovative process into sustainability is not well focused (Muenjohn & McMurray, 2017). Though, collaborative innovation and its outcomes were analyzed previously, however, it is necessary to understand the factors which contribute to the innovation process and lead the SMEs sustainable outcomes (Torfing, Cristofoli, Gloor, Meijer, & Trivellato, 2020).

Furthermore, changing nature of today's competitive environment introduces several uncertainties to businesses as the technologies obsolete rapidly and introduce challenges to organizations. The higher uncertainties in the business environment cause challenges for SMEs (Zhang, Lettice, & Pawar, 2019). Similarly, it is noted that technological turbulence influences innovation processes (Yun, Lee, & Lee, 2019). However, SMEs are not capable to innovate in such a rapidly changing environment (Zhang et al., 2019). Therefore, it is necessary to empirically understand how technological turbulence can influence SMEs' innovation process.

Previously, it is noted that organizations are striving for innovative business processes to ensure sustainability (Shibin, Dubey, Gunasekaran, Luo, Papadopoulos, Roubaud, et al., 2018). Literature has also considered the innovation capabilities and strategies of emerging market firms but lacks a comprehensive understanding of context (resource-constrained economies) based on innovative processes and their key indicators(Audretsch, Seitz, & Rouch, 2018; Cai et al., 2019; Tiwari, Kalogerakis, & Herstatt, 2016). Further, literature has considered the role of bricolage and sustainable leadership with frugal innovation (Iqbal, Ahmad, & Halim, 2021), however, technology turbulence in today's rapidly changing environment may influence the SMEs' frugal innovation process and ultimately compromise the sustainability. It is already noted that the impact of technological turbulence on ecological sustainability was overlooked (Chen, Li, Chen, & Ou, 2018). Previously, the role of external environmental factors i.e., technological turbulence was ignored among the relationships of key resource utilization strategies, design leadership, and frugal innovation. It is also noted that the relationship between leadership and strategic processes of sustainability should be empirically investigated in different contexts to bring a conclusive outcome from this relationship (Eide, Saether, & Aspelund, 2020). Furthermore, literature has documented frugal innovation in terms of products, services, processes, and characteristics (Annala, Sarin,

& Green, 2018), and marketing strategies for such products(Rosca, Arnold, & Bendul, 2017), however, strategic decisions and mechanism to pursue, and antecedents of frugal innovation were ignored (Ploeg, Knoben, Vermeulen, & van Beers, 2021). Besides this, studies have considered the strategies, and innovation processes of multinational companies, however, SMEs were ignored(Papadopoulos et al., 2020). Thus, this study investigates the role of key strategies toward the sustainability of SMEs through the mediated moderation of technological turbulence. This study will be helpful for the developing countries to overcome the sustainability issue of SMEs. Further, this study will be helpful to understand the design leadership as the key factor to produce the frugal products which might help the SMEs of developing countries to sustain in the market. It will also be helpful to understand how the external elements like technology turbulence can affect the innovation processes of the SMEs of developing countries. Beside this, it provides the empirical evidence regarding the key contributing factors of frugal innovation and its relationship with sustainability in the presence of the key hindrance factor from the external environment.

## 2. Literature Review

### 2.1. Underpinning theories

The present study framework is underpinned by the theory of Resource Base View and Contingency theory as supporting theory. RBV theory emphasizes that firms can attain a competitive advantage over their competitors through distinct resource utilization strategies (Andrews, 1971). RBV stresses that firms can utilize the bundle of resources either tangible or intangible (Barney, 1986) to attain a competitive advantage. Organizational design, environmental awareness, and technology are the key resources of any organization and they can influence sustainability(Shibin, Dubey, Gunasekaran, Luo, Papadopoulos, Roubaud, et al., 2018). Therefore, RBV theory provides us the base on which an organization can utilize its scarce resources in such a way that can help to produce more innovative products. It is noted that the customer-oriented innovative products enable the organization to achieve sustainability in the market(Shibin, Dubey, Gunasekaran, Luo, Papadopoulos, Roubaud, et al., 2018). SMEs lack the resources; design leadership can help in attaining innovatively designed products according to the need of customers. SMEs can utilize design leadership to achieve frugal products to serve their lower-income customers which will be helpful to attain business sustainability.

Furthermore, the Contingency theory explains the oscillations in business performance caused by the interaction of the firm with the environment (Lawrence, 1967; Rosenzweig, 1979). This theory stresses that firms operate in an open environment and their processes and their decisions should be environment fit (Rosenzweig, 1979). Further, organizations in the environment are exposed to various threats and it influences their profitability and innovation process (Teece, 1986). Fit between organizational strategies and its external environment can be helpful to achieve sustainable competitive advantages (Lawrence, 1967). The uncertainty in the environment due to the changing nature of technologies exhibits challenges for the organization and negatively influences the organizational innovation process (Sheng, Zhou, & Lessassy, 2013; Zhang, Wang, Zhao, & Zhang, 2017). Thus, drawing based on contingency theory, there exist several factors in the environment which can influence the performance of SMEs i.e. government policies and regulations, political situations, power dynamics, and market trends (Gunasekaran & Spalanzani, 2012). This modern era where technology is changing rapidly makes it difficult for SMEs to compete in the market due to their limitations. Therefore, in this study, RBV and Contingency theory are used as underpinning and support theories, respectively. RBV emphasizes the organizational available resources' utilization in an innovative way to sustain the market along with the insight of Contingency theory to deal with the uncertainties that exist in the organizational environment.

### 2.2. Design Leadership and Frugal Innovation

The leadership role in the design functions of the organizations has been recognized (Muenjohn & McMurray, 2017). Design leadership includes foreseeing the future, and investing in designing through establishing strategies and a design environment (Muenjohn & McMurray, 2017). Muenjohn and McMurray (2017) have empirically investigated the SMEs through an online survey of SMEs in Thailand and Vietnam and noted that design leadership keeps the employees aligned to the organization's strategic design

vision and nurtures the environment that leads the innovation (Muenjohn & McMurray, 2017). Further, organizations try to be averse to risks while disruptive innovation is due to a lack of organizational capabilities. Disruptive innovation requires innovative solutions and it stresses the need for design leadership as it can be helpful to overcome the issue of disruptive innovation (Torfing et al., 2020).

Previously, studies have discussed leadership and innovation, however, the recent developments around the world require an innovative solution that emphasizes the need for design leadership to attain market-based innovation in organizations (Torfing et al., 2020). Torfing et al. (2020) have qualitatively and comparatively reviewed the literature and found that institutional design leadership is helpful in the issues of innovation. Similarly, Rosca et al. (2017) have gone through several case studies of frugal innovation and noted that frugal innovation includes product designing which provides affordable products to low-income customers. Further, product design significantly determines sustainability (Rosca et al., 2017). Therefore, the following hypothesis can be generated from the above discussion:

H1: Design Leadership has a positive and significant relationship with frugal innovation.

## 2.3. Frugal Innovation and Sustainability

The foundation of frugality is already established in philosophy and religious studies, however, frugality concerning innovation is a recent concept (Albert, 2019; Tiwari et al., 2016). Frugal innovation is explained as more with less which increases the value by avoiding the usage of diminishing resources (Prabhu & Jain, 2015). Further, frugal innovation encompasses two elements i.e., affordable value innovation and cost innovation (Ernst et al., 2015). Frugal innovation determines the limited resource usage to produce sustainable but affordable products while targeting lower-income customers (Albert, 2019; Hossain, Levänen, & Wierenga, 2021).

It is also noted that resource slack and the pressure of cost minimization encourage organizations to produce socially valuable products to fulfill the needs of lower-end customers (Ali, Haldar, Khan, & Ullah, 2015). Albert (2019) has done a systematic review of frugal innovation and found that frugal innovation help in reducing socio-economic inequalities and solving the critical issue of resource shortage and sustainability. It is also noted that emerging markets have attracted 20,000 international corporates and around 40% of their revenue comes from China and India (Shibin, Dubey, Gunasekaran, Luo, Papadopoulos, & Roubaud, 2018). Thus, emerging economies like China and India can adopt frugal innovation to attain sustainable growth (Khan, 2016).

Previously, Levänen et al. (2016) have investigated the literature i.e. cases, reports, and articles on frugal innovation, and found that frugal innovation has a relationship with sustainability from a social, economic, and ecological perspective. Additionally, it can influence sustainable performance (Albert, 2019; Wohlfart, Bünger, Lang-Koetz, & Wagner, 2016). Further, frugal innovation is significantly associated with the social element of sustainable development(Albert, 2019). Recently, another investigation has qualitatively analyzed the cases of frugal innovation and revealed that frugal innovation can play a role as an antecedent of sustainability (Hossain, 2020).

H2: Frugal Innovation has a significant and positive relationship with Sustainability.

## 2.4. Design Leadership, Frugal Innovation and Sustainability

Sustainable development goals of the United Nations have emphasized the consideration of large-scale measures regarding economic well-being, environmental protection, reduction of poverty, and improvement in social trust (Halisçelik & Soytas, 2019). Leadership has key importance towards sustainability goals as they make the plans and encourage unique strategies which are helpful to attain sustainable performance (Tsalis, Malamateniou, Koulouriotis, & Nikolaou, 2020). In such a scenario, design leadership can be helpful to adopt frugal innovation and ultimately meet the requirements of low-income customers. Pisoni et al. (2018) have done a systematic review of the key studies which have investigated frugal innovation and revealed that frugal innovation provides sustainable solutions through the efficient utilization of scarce resources. Similarly, another study has done a systematic review of the literature on frugal innovation and its role in sustainability and found that frugal processes utilize the minimum resources and becomes the reason for a firm's profitability (Khan, 2016). Through frugal innovation, quality life can be provided to lower-income customers through affordable and value-added

products (Albert, 2019). Similarly, it has been noted that frugal innovation increases the profit ratio of organizations through cost-effective products and ser

vices. Frugal innovations include the process of recycling, minimum use of resources, and waste management which ultimately increases ecological performance (Hossain, 2020). Iqbal, Ahmad, and Halim (2021) have done a systematic review of the studies on frugal innovation and noted that frugal innovation benefits economic performance as it consumes low energy and encourages resource conservation. Further, frugal innovation helps organizations to reduce the influence of organizational processes on the environment as it motivates eco-friendly activities (Iqbal, Ahmad, & Halim, 2021). On the contrary, frugal innovation cannot be adopted directly, and it requires the strategies to utilize the resource in such a way that helps in low-cost innovation processes. It is also noted that frugal innovation is a complex process and does not independently confirm sustainability (Iqbal, Ahmad, & Halim, 2021; Leliveld & Knorringa, 2018). Therefore, design leadership is taken as the antecedent of frugal innovation to attain sustainability. From the above discussion following hypothesis is developed:

H3: Frugal Innovation mediates the relationship between design leadership and Sustainability.

## 2.5. Moderation of Technological Turbulence

Technology turbulence can be defined as the degree to which technological change occurs in any industry (Chen et al., 2018). The rapid change in technology leads to obsolescence of technology (Wu, Liu, & Zhang, 2017). In this modern era, organizations encourage the utilization of internal resources to deal with the changing requirements of technology (Jansen, Zhang, Sobel, & Chowdury, 2009). Further, technology is changing more rapidly after the 4.0 industrial revolution as it offers several alternatives to exhibit innovative and creative processes (Wu et al., 2017). Ogbeibu, Emelifeonwu, Senadjki, Gaskin, and Kaivo-oja (2020) collected the data through a time lag survey from the manufacturing firms in Malaysia and determines that technology turbulence encourages the organizations to adopt the latest technologies and increases their employee's skills (Ogbeibu et al., 2020) and it may influence their organizational strategies and innovation processes. Further, technologies are rapidly becoming obsolete, and their new replacement is more innovative and improve product quality, and increases business market share (Pandit, Joshi, Sahay, & Gupta, 2018). Previously, the influence of technology turbulence on the organization's innovative processes and their sustainable outcomes is not documented well. Further, SMEs are not capable to deal with the rapid changes in technologies and it brings a challenge for them to meet the innovative demands and ultimately affect their sustainability. It is also noted that studies have overlooked its influence on the organization's capabilities, creativity, and innovation (Ogbeibu et al., 2020).

H4: Technological turbulence moderates the relationship between Design Leadership and Frugal Innovation.

## 2.6. Theoretical Framework

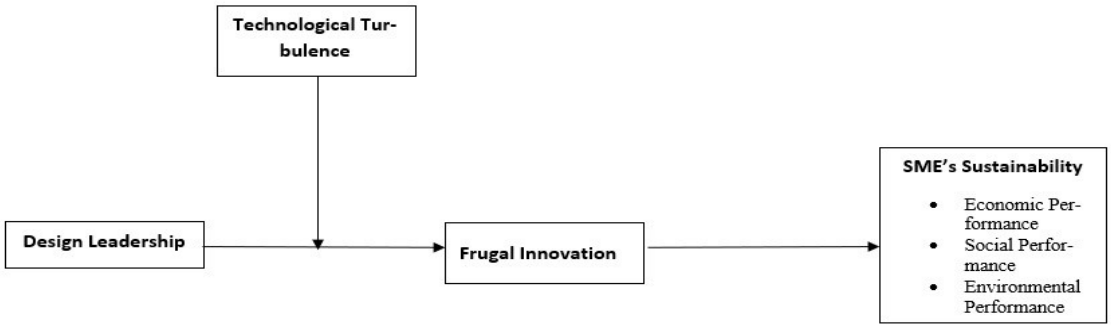


**Fig. 1.**

## 3. Methodology

### 3.1. Data collection and sampling

In this study, data were collected from the SMEs operating in Pakistan. Mainly, Lahore and Sialkot region and Karachi are the industrial areas of SMEs. However, due to the shortage of time and distance between Lahore and Karachi, SMEs of the Lahore and

the antecedents of frugal innovation and how it can transform the innovation process of SMEs into sustainability. Another study by Iqbal, Ahmad, and Halim (2020) investigated quantitatively the relationship of sustainable leadership with sustainable performance through the mediation of frugal innovation to empirically present the understating of the relationship among these constructs. Therefore, the current study is based on the survey to gather the data from the SMEs and empirically presents the evidence regarding the design leadership which can facilitate the SMEs towards frugal innovation and ultimately attain sustainability. Further, this study presents empirical evidence on how external factors like technology turbulence can influence the relationship between design leadership and frugal innovation which is not documented well previously. The major industrial portion of Pakistan is based on SMEs, likewise, SMEs significantly contribute to employment and economic development. Small and Medium Enterprises Development Authority (SMEDA) noted that SMEs contribute 90% to the overall industry of Pakistan, 80% to non-agricultural employment, and 40% to the annual GDP of Pakistan (Iqbal, Ahmad, & Halim, 2021). Additionally, frugal innovation-based products consist of the major market as the population affords low-cost products and these SMEs meet the requirements of the population with frugal innovation-based product features. We collected data from SMEs in Pakistan. These firms mainly cluster in Lahore and Karachi metropolitan industrial areas. As most SMEs are in two metropolitan cities; therefore, it serves the purpose of generalizing the findings for the country. The purposively sampling was used to collect the data from the management staff of these targeted SMEs. To measure the reasonable sample size, G*Power (3.1.9.7 version) was utilized, and the required sample size was 96. However, this study Sialkot region were selected. Previously, studies have qualitatively analyzed frugal innovation, its antecedents, and outcomes (Hossain, 2021; Levänen, Hossain, & Wierenga, 2022). Furthermore, the majority of studies have done investigations based on the literature review to understand the drivers of frugal innovation and its outcomes (Iqbal, Ahmad, & Halim, 2021; Khan, 2016; Pisoni et al., 2018). However, there is a need for practical evidence regarding

has collected data from 383, which is exceeding the required sample size. Further, this study's data is also above the minimum data requirement of PLS-SEM i.e., 100 (Reinartz, Haenlein, & Henseler, 2009).

### 3.2. Instruments

The variables of this study were measured through already developed and standardized scales. The questionnaire of this study was based on a 5-point Likert scale ranging from strongly disagree=1 to strongly agree=5. Further, design leadership was measured through 18 questions-based scales of Arham, Boucher, and Muenjohn (2013). The frugal innovation was measured through the 3-item scale of cost innovation and 2-items of affordable value innovation adopted from Zeschky, Winterhalter, and Gassmann (2014). Technology turbulence was measured through the 4-item scale of Jaworski and Kohli (1993). However, sustainability was measured through environmental, economic, and social performance. Environmental performance and economic performance were measured through 6-items and 5-items scale respectively adopted from Zhu and Sarkis (2004). Finally, social performance was measured through the 5-item scale of Sayce and Ellison (2003).

## 4. Findings

### 4.1. Data Analysis and Results

Smart PLS 3 was used to apply the PLS-SEM for data analysis as it is a recent estimation technique(Ali, Rasoolimanesh, Sarstedt, Ringle, & Ryu, 2018; Ringle, Da Silva, Bido, & Ringle, 2015). The relationship among this study variables is also explained with the

support of the theory and PLS-SEM is a useful approach to predict

these relationships (Hair Jr, Hult, Ringle, & Sarstedt, 2016; Ringle, Wende, & Will, 2005). Further, a two-stage approach of analysis was utilized to analyze the measurement model and structural model (Anderson & Gerbing, 1988). Additionally, bootstrapping was also done in PLS-SEM to check the path coefficient and significant levels.

## 4.2. Data normality

PLE-SEM does not require data normality, however, inferential statistics stresses the importance of checking the data normality before further analysis. Data normality is not required in PLS-SEM, even though it has key importance to be checked before the inferential statistics (Hair, Money, Samouel, & Page, 2007). However, to achieve the accuracy and to bring more convincing results, we have checked the data normality through SPSS 21, and the skewness and kurtosis were normally distributed between -2 to +2 which confirms the data normality.

## 4.3. Common method bias

Data was gathered single time from respondents separately and can become the reason for common method bias. So, a multi-collinearity test can be applied to check the problem of common method bias (Kock, 2015). Thus, collinearity was analyzed through VIF which assesses the common method bias. This study constructs have a VIF value lower than 3.3 which shows that this study constructs have not the issue of common method bias (Kock, 2015).

## 4.4. Demographics

Table 1 reveals the demographic details of the current study participants. The sample size of this study was 383 and table 1 shows the results that 322 (84.1%) were male and 61 (15.9%) were female. Further, of 383 participants, 185 (58.3%) were single and 198 (51.7%) were married. As well as age is concerned, 123(32.1%) of the participants were from 18-25 years, 195 (50.9%) were from 25-35 years and 63 (16.4%) were from 35-50years and 2 (0.5%) were above 50 years. Further, 95 (24.8%) of this study's participants have done bachelor's, 227(59.3%) of the participants have done master and 61(15.9%) of the participants have other qualifications. Lastly, results in table 1 show that 97 (25.3%) of the participants have experience of less than one year, 218 (56.9%) have experience of 1-5 years, 37 (9.7%) have experience of 6-10 years and only 31 (8.1%) have experience of above 10 years.

**Table 1.**

| Demographic Variables | Category | Frequency | Percentage |
|---|---|---|---|
| Gender | Male | 322 | 84.1% |
| | Female | 61 | 15.9% |
| Marital Status | Single | 185 | 48.3% |
| | Married | 198 | 51.7% |
| Age | 18-25 | 123 | 32.1% |
| | 25-35 | 195 | 50.9% |
| | 35-50 | 63 | 16.4% |
| | Above 50 | 2 | 0.5% |
| Education | Bachelors | 95 | 24.8% |
| | Master | 227 | 59.3% |
| | Others | 61 | 15.9% |
| Experience | Less than 1 year | 97 | 25.3% |
| | 1-5 year | 218 | 56.9% |
| | 6-10 year | 37 | 9.7% |
| | Above 10 years | 31 | 8.1% |

### 4.5. Measurement model assessment:

Table 2 reveals the result of convergent validity which was assessed through the loadings of items, composite reliability, and AVE (Average variance extract). Factor loading of items was majorly above 0.60 and those which were beyond the standard limit (10 items of design leadership; DL2,DL3,DL5,DL6,DL7,DL9,DL10,DL13,DL16 and DL18) were excluded because of lower loadings from the standard value. Likewise, all the constructs have shown composite reliability above 0.70 which meets the standard criteria (Ali et al., 2018). Additionally, all of this study constructs have AVE above the standard value of 0.50 (Fornell & Larcker, 1981; Hair Jr et al., 2016). However, the AVE of design leadership was 0.471 which is close to 0.5, it is acceptable to 0.4 according to the previous study and if CR is above 0.6 even then the convergent validity is fulfilled (Fornell & Larcker, 1981).

**Table 2.**

| Constructs | Items | Loading | rho-A | Alpha | CR | AVE |
|---|---|---|---|---|---|---|
| **Design Leadership** | DL1 | 0.691 | 0.844 | 0.84 | 0.876 | 0.471 |
| | DL11 | 0.653 | | | | |
| | DL12 | 0.713 | | | | |
| | DL14 | 0.734 | | | | |
| | DL15 | 0.683 | | | | |
| | DL17 | 0.629 | | | | |
| | DL4 | 0.76 | | | | |
| | DL8 | 0.612 | | | | |
| **Economic Performance** | Eco P1 | 0.943 | 0.869 | 0.777 | 0.853 | 0.553 |
| | Eco P2 | 0.525 | | | | |
| | Eco P3 | 0.598 | | | | |
| | Eco P4 | 0.599 | | | | |
| | Eco P5 | 0.939 | | | | |
| **Environmental Performance** | Env P1 | 0.761 | 0.844 | 0.841 | 0.883 | 0.56 |
| | Env P2 | 0.656 | | | | |
| | Env P3 | 0.768 | | | | |
| | Env P4 | 0.853 | | | | |
| | Env P5 | 0.713 | | | | |
| | Env P6 | 0.722 | | | | |
| **Frugal Innovation** | FI1 | 0.832 | 0.847 | 0.848 | 0.892 | 0.622 |
| | FI2 | 0.798 | | | | |
| | FI3 | 0.738 | | | | |
| | FI4 | 0.822 | | | | |
| | FI5 | 0.75 | | | | |
| **Social Performance** | Soc P1 | 0.895 | 0.931 | 0.924 | 0.943 | 0.767 |
| | Soc P2 | 0.907 | | | | |
| | Soc P3 | 0.87 | | | | |
| | Soc P4 | 0.847 | | | | |
| | Soc P5 | 0.858 | | | | |
| **Technology Turbulence** | TT1 | 0.885 | 0.855 | 0.854 | 0.911 | 0.774 |
| | TT2 | 0.873 | | | | |
| | TT4 | 0.882 | | | | |

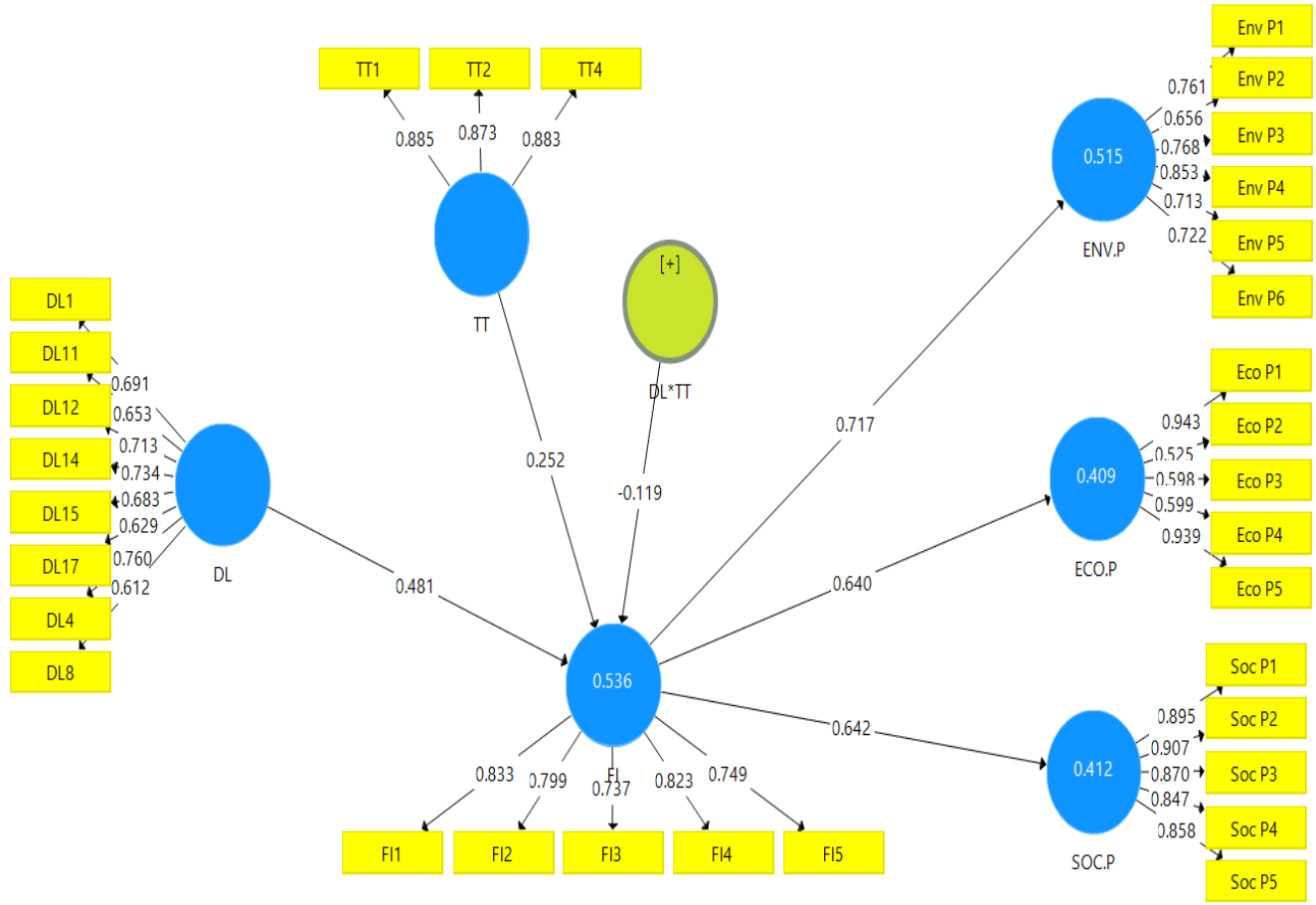


**Fig. 2 Measurement Model Assessment**

## 4.6. Discriminant validity

HTMT and Fornell-Larcker are both criteria to assess the discriminant validity of constructs, however, Fornell-Larcker cannot identify the discriminant validity effectively in a few situations (Henseler, Ringle, & Sarstedt, 2015). Thus, HTMT ratio was checked to analyze the discriminant validity of this study constructs. The results in table 3 show that HTMT value of this study's constructs is lower than the threshold value of 0.90 (Hair Jr, Sarstedt, Ringle, & Gudergan, 2017), so it fulfills the criteria of discriminant validity.

Discriminant Validity

**Table 3.**

| | DL | ECO.P | ENV.P | FI | SOC.P | TT |
|---|---|---|---|---|---|---|
| DL | | | | | | |
| ECO.P | 0.656 | | | | | |
| ENV.P | 0.764 | 0.549 | | | | |
| FI | 0.776 | 0.746 | 0.838 | | | |
| SOC.P | 0.732 | 0.514 | 0.635 | 0.716 | | |
| TT | 0.721 | 0.454 | 0.851 | 0.708 | 0.603 | |

Structural model assessment The structural model was also analyzed through bootstrapping at SMART PLS (Ringle et al., 2005). Therefore, the relationship between this study variables was investigated through path coefficients, standard errors, and t-values. Moreover, the relationships between this study constructs were also tested through empirical hypothesis which can be seen in table 4. That all of this study's hypotheses were accepted according to the standard of $P< 0.05$ and $t>1.645$ (95% confidence interval).

**Table 4. Path Analysis**

| Relationships | Beta | SD | T-value | P-value | Decision |
|---|---|---|---|---|---|
| DL -> FI | 0.469 | 0.045 | 10.506 | 0 | Supported |
| FI -> Eco P | 0.641 | 0.036 | 17.838 | 0 | Supported |
| FI -> Env P | 0.717 | 0.034 | 21.044 | 0 | Supported |
| FI -> Soc P | 0.642 | 0.036 | 17.66 | 0 | Supported |
| TT -> FI | 0.311 | 0.046 | 6.832 | 0 | Supported |
| DL -> FI -> Eco P | 0.301 | 0.035 | 8.56 | 0 | Supported |
| TT -> FI -> Eco P | 0.199 | 0.028 | 7.041 | 0 | Supported |
| DL -> FI -> Env P | 0.337 | 0.034 | 9.905 | 0 | Supported |
| TT -> FI -> Env P | 0.223 | 0.038 | 5.861 | 0 | Supported |
| DL -> FI -> Soc P | 0.301 | 0.037 | 8.08 | 0 | Supported |
| TT -> FI -> Soc P | 0.2 | 0.032 | 6.234 | 0 | Supported |
| DL*TT -> FI | -0.128 | 0.025 | 5.169 | 0 | Supported |

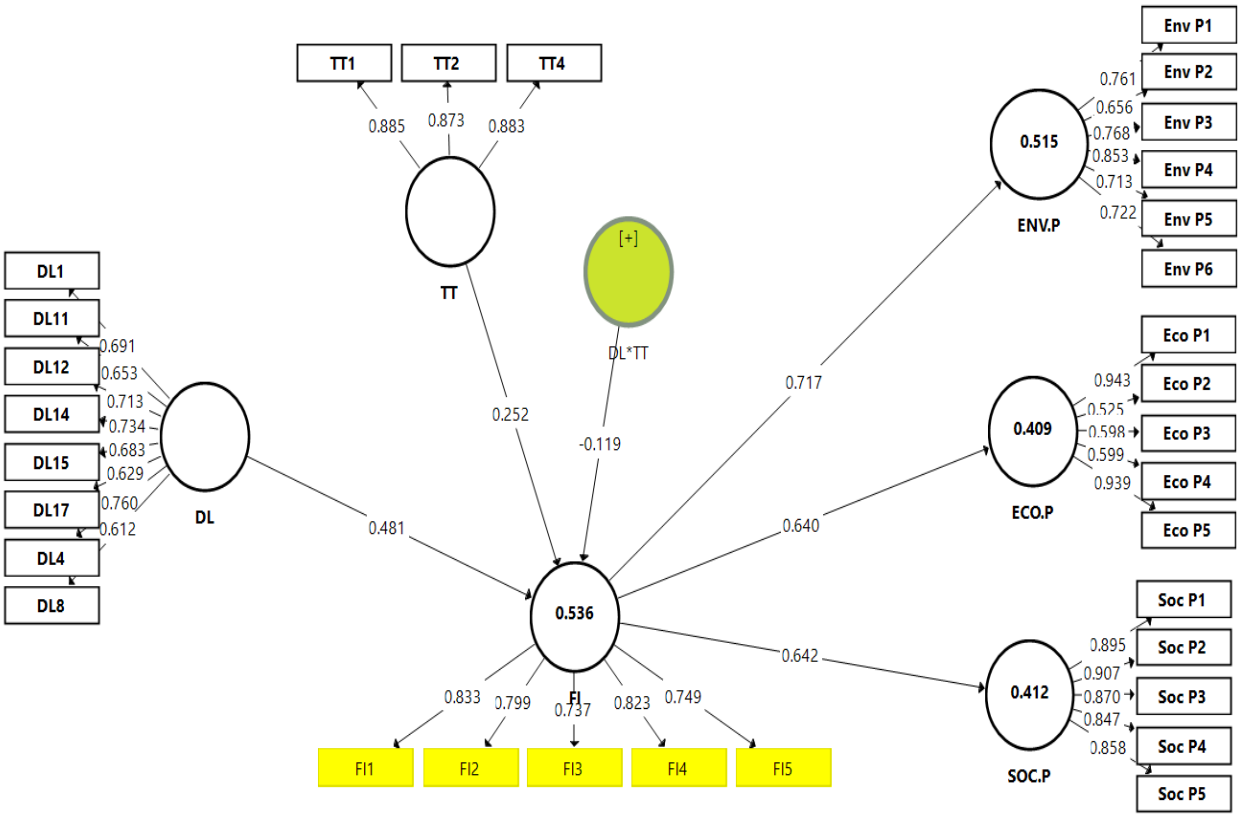


**Fig. 3. Structural Model Assessment**

## Discussion

Recently, organizations are striving for sustainability in their operations because of rising issues of environmental and climate change around the globe. Therefore, SMEs are looking for processes that meet the requirements of people and cause less damage to society and its environment. This requires innovative processes which create cost-effective solutions (Cai et al., 2019). Thus, this study aims to investigate the relationship between design leadership and SMEs' sustainability through the mediating role of frugal innovation. Further, this study has also investigated the moderating role of technology turbulence in the relationship be-

tween design leadership and frugal innovation. Previous studies lack empirical investigation of how design leadership can transform the innovation process into sustainability. This study has considered the SMEs of Pakistan and collected data from the employees of SMEs. However, lower-level labor was excluded as the SMEs in Pakistan have both kinds of employees i.e., educated, and uneducated. While considering education as the nominal level to understand the questionnaire and industry, only educated employees and their supervisors were included while distributing the survey.

The result of this study shows that design leadership significantly and positively influences sustainability. Previous studies have not empirically tested the relationship between design leadership and sustainability in the context of SMEs. However, these results are in line with the findings of previous studies in which a positive and significant relationship between design leadership and organizational innovation was revealed (Muenjohn & McMurray, 2017). furthermore, there is not any empirical investigation that has considered the relationship between design leadership with frugal innovation and SMEs sustainability. However, these results are concurrent with the finding of the previous studies in which other leadership styles were found positive and significant with organizational innovation i.e. sustainable leadership and frugal innovation (Iqbal et al., 2020), transformational leadership and innovation (Lei, Gui, & Le, 2021) and self-leadership and innovation (Marvel & Patel, 2017). Similarly, this study's results reveal that frugal innovation significantly and positively influences sustainability. This finding is also according to the results of previous studies (El-Kassar & Singh, 2019; Iqbal, Ahmad, Li, et al., 2021; Mat Dahan & Yusof, 2020). This study has also analyzed the moderating role of technological turbulence between the relationship of design leadership and frugal innovation. The results show that technology turbulence significantly moderates the relationship between design leadership and frugal innovation. Previously, the empirical testing of this relationship is missing. However, these findings are in line with the finding of previous

turbulence in the relationship between design leadership and frugal innovation as compared to the previous study (Iqbal, Ahmad, & Halim, 2021) which tested the moderating role of bricolage between sustainable leadership and frugal innovation. Methodologically, this study has measured frugal innovation through two sub-variables i.e. cost innovation and affordable value innovation as compared to the previous studies (Iqbal, Ahmad, & Halim, 2021). Previously, studies that market uncertainty and technological changes can influence the organization's innovation process i.e., frugal innovation (Iqbal, Ahmad, & Li, 2021; Rosca, Agarwal, & Brem, 2020).

## 5.1. Conclusion

This study aims to analyze the relationship between design leadership and SMEs sustainability through the mediation of frugal innovation. Further, the moderation of technology turbulence between the relationship of design leadership and frugal innovation was also tested. The results of this study reveal that design leadership has a positive and significant relationship with SMEs' sustainability. Furthermore, frugal innovation significantly mediates the relationship between design leadership and SMEs' sustainability. Similarly, technology turbulence also significantly but antagonistically moderates the relationship between design leadership and frugal innovation.

## 5.2. Theoretical Implications

This study has contributed to the literature regarding the relationship between design leadership and sustainability. This study is among the initial studies which have empirically tested the relationship between design leadership and sustainability. Further, this study has enhanced the literature on the resource-based view (RBV) and contingency theory while investigating the mediation of frugal innovation between the relationship of design leadership and sustainability through the moderation of technology turbulence. This study has analyzed the relationship between design leadership and sustainability through the mediation of frugal innovation as compared to the previous study (Iqbal, Ahmad, Li, et al., 2021) which investigated the mediation of frugal innovation between sustainable leadership and environmental performance. Further, this study has investigated the moderating role of technology

studies (Hossain, 2021; Levänen et al., 2022) have qualitatively undergone the antecedents of frugal innovation and its outcomes (Hossain, 2021; Levänen et al., 2022), however, this study provides empirical evidence among the key indicators of frugal innovation and sustainability as an outcome.

## 5.3. Practical Implications

From the angle of the practical scenario of SMEs, this study has several implications for SMEs administration, managers, and policy developers. Further, this study provides empirical evidence in light of RBV regarding how the management of SMEs can utilize design leadership to transform the innovation processes into the desired outcomes. Additionally, manufacturing firms are under great pressure to control their operations and business activities to reduce the negative effect on the environment and carbon footprints through minimum resource utilization and other renewable resources(Iqbal, Ahmad, & Halim, 2021). Thus, this study will enable the management of SMEs to utilize design leadership to innovate frugally and ultimately attain sustainability. In the same manner, this study will be helpful for SMEs to understand how technology turbulence can affect the frugal innovation process and prepare them to reduce its impact. Therefore, managers of Small and medium enterprises should focus on design leadership to produce cost-innovative and affordable value-innovative products to meet the low-end customers of emerging markets. This will not only retain their business but also the overall sustainability. Furthermore, the innovation processes of the manufacturing firms may be influenced by technological changes and SME management should be prepared to cope with these external uncertainties by enhancing their skills or innovatively designed production capability.

## 5.4. Limitations and Future directions

This study has a few shortcomings as well. This study provides empirical evidence regarding the relationship between design leadership and sustainability only from Pakistan's SMEs. Therefore, future studies should also consider the different countries to improve the generalizability. Further, this study has taken single-time data and a longitudinal survey can create a better understanding of how the design leadership and innovation strategies can be sustainable as an outcome. Future studies should consider the managerial level and CEOs and board members of the SMEs as they better understand the external environment and uncertainties. In this study, cultural context is not considered which may influence the relationship between design leadership and frugal innovation. As Pakistan is based on collectivism, it can moderate the relationship between leadership and innovation. Furthermore, future studies can also investigate the mediation of subdimensions of (cost innovation and affordable value innovation) of frugal innovation. Likewise, political pressure i.e. dysfunctional competition in developing countries can also affect the innovation process of SMEs. On the contrary, SMEs are based on the initiatives of very few people and usually have a single owner. Therefore, individual behavioral factors i.e., frugality as an individual trait can exhibit a significant effect on the organizational innovation process. Therefore, further studies should consider the frugal behaviors of SMEs' leadership as the antecedent of sustainability.

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