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The Nexus of Entrepreneurial Leadership and Entrepreneurial Success with a Mediation of Technology Management Processes: From the Perspective of the Small- and Medium-Sized Enterprises of Khyber Pakhtunkhwa, Pakistan

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Abstract: Individual leadership styles, including entrepreneurial leadership (EL), vary and encompass creative urges, risk-taking, decision-making, and a proactive mindset. This research explores how entrepreneurial leadership (EL) can positively impact entrepreneurial success (ES). It also highlights the positive influence that EL has on ES and investigates how technology management processes (TMPs) can play a mediating role. For this purpose, data were collected from employees in the SMEs sector in KP, Pakistan. The results indicate that EL has a significant relationship with ES and TMPs. Findings also reveal that TMPs partially mediate the relationship between EL and ES. Based on the findings, policy-makers and regulators can use the results of this study to design policies that encourage entrepreneurial activity and foster an environment favorable to SMEs in KP. This study's findings can help KP officials understand the elements that influence the success of SMEs and devise policies that encourage the growth of technology management systems and diverse teams in SMEs.

Keywords: entrepreneurial leadership; entrepreneurial success; technology management processes

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1. Introduction

Leadership is a crucial factor that determines the success of an organization. Effective leadership directs and regulates the organization, leading it to achieve its goals [1]. Entrepreneurial leadership (EL), in particular, significantly impacts entrepreneurial success. Entrepreneurial leadership is characterized by innovation, risk-taking, and adaptability [2]. Entrepreneurial leaders possess the vision and ability to drive their companies' capabilities, maximizing their potential for success in dynamic markets [3]. These leaders lead their teams and communicate, motivate, inspire, and teach their employees entrepreneurial abilities. Their ability to effectively communicate their vision and inspire team members is crucial in creating a shared vision and ensuring that everyone is aligned toward achieving organizational goals [2]. Therefore, the relationship between entrepreneurial leadership and entrepreneurial success is closely intertwined [3]. Entrepreneurial leadership drives entrepreneurial success [4,5]. Entrepreneurial leaders create a strong foundation for their

teams to succeed by nurturing understanding, fostering reactions, facilitating intentional focusing, cultivating instinctive responding, nurturing inclusive behaving, placing purposeful trust, and fostering relational beings [6]. In summary, the relationship between entrepreneurial leadership and entrepreneurial success is symbiotic; effective entrepreneurial leadership is essential for driving and achieving entrepreneurial success [6]. The success of an entrepreneur is highly dependent on their leadership abilities [3]. Entrepreneurial leadership [5] and perception [7] are both significantly influenced by entrepreneurial success (ES), which is considered a critical component of entrepreneurship. Research indicates that ES is further influenced by various leadership styles, although it is frequently associated with the accomplishment of a successful entrepreneurial venture (EV) [8] or personal success [5,9]. According to theoretical and empirical research [10], numerous leadership philosophies have a substantial impact on ES and business ventures. Entrepreneurial success (ES), which encompasses personal satisfaction, is widely acknowledged as a crucial element of firm sustainability. Microbusinesses require entrepreneurs to possess certain traits and capabilities to achieve success, including leadership abilities, industry knowledge, opportunity recognition, innovation skills, and technological expertise [11]. Previous research has mostly focused on how different types of entrepreneurial leadership (EL) affect organizational performance, employee behavior, creativity in the workplace, and new ideas among employees [4,12–14]. Despite calls for research on this topic [15,16], the link between EL and ES has thus far remained unexplored. Al Mamun et al. [17] note that additional research is needed to progress business studies in the domain of EL and ES due to the limited literature on the subject.

The role of technology management processes in the relationship between entrepreneurial leadership and entrepreneurial success is crucial [18]. Technology management processes are instrumental in supporting and enhancing the implementation of entrepreneurial leadership in a business [19]. They enable entrepreneurial leaders to effectively utilize technology resources to drive innovation, streamline operations, and create competitive advantages [20]. By effectively managing technology processes, entrepreneurial leaders can leverage technology to optimize efficiency, improve productivity, and stay ahead of market trends [21]. This, in turn, contributes to the overall success of the entrepreneurial venture [22].

The current study links the dynamic relationship between EL and entrepreneurial success by mediating the role of technology management practices in Pakistan's SME sector. With the evolution of technology, the importance of small businesses has also increased because of their crucial role in supporting the overall GDP of developing countries. Small and medium enterprises act as catalysts to determine the growth of national development, explicitly in developing countries such as Pakistan. According to the available statistics, Pakistan's GDP mainly depends on 3.2 million SMEs, with 40% of the overall development occurring through a contribution of 35% for goods and services, while accounting for more than 30% of country exports [23]. This study investigates the implications of entrepreneurial leadership (EL) for TMPs in the context of achieving entrepreneurial success (ES), thereby addressing the existing knowledge gaps. This study is one of the initial efforts to identify entrepreneurial leadership (EL) as a significant precursor to entrepreneurial success (ES) and to examine its predictive capacity for technology management processes (TMPs). This research enhances the understanding of TMPs, contributes to the literature, and emphasizes their critical role in advancing ES.

The remainder of this paper is organized as follows. Section 2 presents a literature review. In Section 3, we present the proposed method. Section 4 presents the results and discussion, and Section 5 presents the limitations and future directions.

2. Literature Review

2.1. Entrepreneurial Leadership

In this era of competitiveness, organizations strive to hire leaders who can seek opportunities, create a vision, and create situations [24]. They exhibit leadership behavior characterized by innovation, risk-taking, market responsiveness, and competitive advantage [25]. Such leadership is regarded as entrepreneurial leadership [5]. It is a strategic need for organizations looking to thrive in the current dynamic and uncertain business environment [26]. Entrepreneurial leadership refers to managing scarce resources to seek a competitive advantage in the market [24]. These leaders challenge the status quo, promote experimentation, inspire teams to embrace failure as a stepping stone to success, and encourage team members to think outside the box [27]. While examining the antecedents and outcomes of entrepreneurial leadership, [24] reported that it is predicted by challenge framing, entrepreneurial mindset, uncertainty absorption, ambidexterity, entrepreneurial learning, emotions, susceptibility, and work values. Studies suggest that entrepreneurial leadership brings promising outcomes for organizations, including strategic management of resources [28], wealth creation [29], innovation performance [30], new venture or start-up performance [31], employee voice [32] and creativity [14,32]. Moreover, EL can drive financial success, profitability, and competitive advantage [5].

Diverse mediating and moderating mechanisms may influence the effectiveness of entrepreneurial leadership. It fosters an innovative culture characterized by experimentation, openness, challenge acceptance, creativity [14], employee voice [32], and other organizational factors that in turn promote business success. Factors such as technology management processes may amplify the EL effectiveness of entrepreneurial leadership [33–35]. Hence, it can be argued that entrepreneurial leadership is not merely a leadership style but a strategic need to cultivate a culture of innovation, agility, and resilience that drives the organization toward long-term success. Meanwhile, tech integration brings digital tools and solutions into every part of a company's activities, from creating to selling products. Entrepreneurship has emerged as a critical factor in the modern digital age, characterized by lightning-fast technology developments and changing market dynamics, propelling innovation, economic growth, and social transformation [36].

2.2. Entrepreneurial Success

The primary objective of a business entity or start-up is to adapt, innovate, and grab opportunities to achieve sustainable business development and market leadership [37]. In other words, this organizational growth and resilience predicts entrepreneurial success [38]. Contrary to the common belief in financial performance, entrepreneurial success is a broader term encompassing an organization's short-term financial and long-term non-financial performance [39]. The extant literature suggests that entrepreneurs prefer non-monetary features of entrepreneurial activities [40]. Additionally, current theoretical and empirical studies reveal that various leadership styles influence successful business ventures and ES [10]. McKenzie and Sud [41] argued that the ultimate ES can learn from entrepreneurial failure. Baron and Henry [42] suggest that ES cannot be calculated regarding monetary growth; it is associated with knowledge and implementing different methods to attract investors to the business.

The literature has conceptualized entrepreneurial success at the entrepreneur and firm levels [37] using monetary or non-monetary criteria [43]. At the firm level, growth measured by indicators such as sales, profit, and employees predominantly conceptualizes entrepreneurial success. However, studies have reported weak correlations between growth indicators, indicating various antecedents [44]. Non-financial factors, such as environmental and sustainability goals, job creation, and the entrepreneur's satisfaction with the

performance of the firm, are also important, particularly in social entrepreneurship, where success is determined by both non-financial and financial metrics [45]. However, because social value creation is subjective, standardizing non-monetary criteria remains difficult. Entrepreneurial success is traditionally measured by personal wealth creation and income generation [46]. However, recent research has focused on non-monetary criteria, defining "subjective entrepreneurial success" as an entrepreneur's achievement assessment [47]. This emerging stream explores how non-monetary criteria influence performance outcomes and highlights the importance of understanding entrepreneurs' definitions of success [37].

2.3. Technology Management Processes

According to Nguyen et al. [12], technology management (TM) is a collection of management practices that focus on creating a competitive edge by controlling the technical aspects of a business. Strategic planning, decision-making, project frameworks, and technology roadmaps are essential components. Industries emphasize technological management more, which calls for combining technical knowledge with an entrepreneurial spirit. Technopreneurs, who focus on technology-driven initiatives, thus play an increasingly important role in today's technological landscape [48]. According to research by academics, governments and practitioners acknowledge technology as a competitive advantage in manufacturing. Gaining this edge necessitates thoroughly comprehending particular technologies and efficient management techniques; with the speed and complexity of technological innovation, it is becoming increasingly important [49]. Entrepreneurial leadership is crucial for the success and sustainability of small- and medium-sized businesses, particularly in adapting to evolving technological environments. It emphasizes creativity, proactivity, and risk-taking, which are vital for recognizing and capitalizing on opportunities in competitive marketplaces [50]. Entrepreneurial leaders cultivate a culture of innovation and flexibility, allowing firms to respond adeptly to swift technical progress and evolving client needs [51]. Additional research has emphasized that this type of leader prioritizes knowledge acquisition, employs it to integrate technology management processes, and connects technical skills with strategic objectives.

Bessant and Tidd [52] state that technology management in today's high-tech firms mainly focuses on planning, developing, implementing, and monitoring technological resources to enhance productivity and foster innovation. These processes are crucial for competition in industries characterized by frequent technological upheavals. Most business organizations, constrained by resources relative to larger organizations, depend on entrepreneurial leadership to develop cost-effective solutions that correspond with their business objectives [53]. The potential of cutting-edge technologies has increased owing to the changing technological paradigm, which has profoundly changed entrepreneurial activities [54]. Leaders frequently participate in collaborative ecosystems, including collaborations with academic institutions or technology companies, to address resource deficiencies and expedite technology adoption [55]. Entrepreneurial leadership dictates the effective implementation of digital transformation. Leaders with a strategic vision for digitization and effective technology management processes can improve an organization's resilience and customer engagement [56]. Financial limitations, insufficient technical proficiency, and resistance to change have frequently undermined the initiatives aimed at this goal. Given these obstacles, an entrepreneurial leader should adopt an organizational culture that fosters technological learning and agility [57]. Entrepreneurship has emerged as a critical factor in the modern digital age, characterized by lightning-fast technology developments and changing market dynamics, propelling innovation, economic growth, and social transformation [58] Entrepreneurs face new possibilities and threats due to the disruption of established business structures. To overcome these problems, firms must leverage strategic

innovation and integrate technology. Strategic innovation aims to generate value and obtain a competitive advantage by creating new ideas, processes, and business models [59]. Meanwhile, technology integration brings digital tools and solutions into every part of a company's activities, from building to selling products [36].

2.4. Theory and Hypotheses Development

2.4.1. Entrepreneurial Leadership and Entrepreneurial Success

The extant literature has examined the role of leadership in driving successful individual, team, and organizational outcomes [13]. Studies suggest that leaders bearing the characteristics of proactiveness, creativity, and innovation; the ability to lead diverse teams; and the ability to take risks can drive the economic growth and development of the firm [5]. These leaders are entrepreneurial leaders having a clear vision and intentions for the firm's success and the ability to manage the available resources to seek opportunities and advantages strategically [24]. While examining antecedents, outcomes, and moderators of entrepreneurial leadership, Ranjan [24] found that entrepreneurial leaders are performance-oriented, insightful, visionary, ambitious, confidence-builders, successful bargainers, inspirational, progressive, enthusiastic, and team-builders. Similarly, Hussain and Li [5] hold that entrepreneurial leaders are characterized by unique qualities such as innovation, intuition, and risk-taking. They also need to be able to inspire and guide others to collaborate successfully.

Entrepreneurial leadership has the potential to (i) inspire team members to grab opportunities in the market, (ii) challenge the status quo, and (iii) offer innovative ideas to launch entrepreneurial initiatives [12]. Furthermore, this leadership style promotes a culture of empowerment, accountability, and autonomy that empowers employees to take responsibility for their jobs and add to the company's success [26]. A firm's success encompasses both monetary and non-monetary attributes. Monetary success includes personal wealth creation and income generated [46], while the non-monetary characteristics of entrepreneurial success include environmental and sustainability goals, job creation, and the entrepreneur's satisfaction with the firm's performance [37]. Collectively, entrepreneurial leadership makes a business competitive, resilient, creative, and innovative, now capturing maximum market share [60]. Drawing upon resource-based theory [61], we argue that entrepreneurial leadership may be seen as a "managerial resource", which may prove instrumental in entrepreneurial success. Entrepreneurial leadership is a distinctive approach that emphasizes utilizing various skills to navigate creatively and resourcefully within competitive landscapes. Entrepreneurial leaders proactively foresee and tackle potential challenges by negotiating with internal and external stakeholders, securing essential resources, overcoming obstacles, and generating value. Entrepreneurial leadership drives entrepreneurial success for small and medium enterprises. Thus, we hypothesize the following:

H1: *Entrepreneurial leadership has a positive impact on entrepreneurial success.*

2.4.2. Entrepreneurial Leadership and Technology Management Processes

The prime focus of entrepreneurship research is to identify the causes and characteristics of uncertainty in entrepreneurial activities and how entrepreneurial behaviors change when faced with such challenges [56]. Many small- and medium-sized enterprises (SMEs) worldwide have shifted their focus from traditional operating procedures to technology and innovation due to the COVID-19 epidemic [12,62]. According to Jin and Cho [63], emerging countries are expected to shift from industrial to entrepreneurial societies, where entrepreneurial success largely depends on entrepreneurial leadership and technology management. Despite this, scholars have raised numerous important questions regarding the

relationship between digital technologies and entrepreneurship. These questions highlight the need to examine how the unique features of digital technologies affect entrepreneurial activities [56]. Currently, a company's adoption of cutting-edge technologies, rather than its physical assets, determines its worth. Adam and Alarifi [64] assert that technology and innovation propel small- and medium-sized enterprises (SMEs) to achieve higher performance and gain a competitive edge.

Additionally, the need for a competitive market greatly impacts an organization's performance, and technology enhances market-driven value and adds credibility to its assets [5]. The entrepreneurial leader fosters an inventive mindset personally and within the company culture, navigating through experiences while accepting trial and error as essential ideas for effectively managing the technology [65]. Entrepreneurial leadership markedly improves these processes by facilitating the strategic incorporation of technology to generate market disruption and sustained growth. Leaders play a crucial role in fostering collaboration across interdisciplinary teams, facilitating cross-functional knowledge transfer, and addressing the complexities of technological commercialization [66]. Furthermore, entrepreneurial leadership impacts technology management processes via strategic decision-making and resource distribution. Leaders that are aware of technical trends and market dynamics may guide a business to prioritize investments in research and development, collaborations, and digital transformation efforts [5,67]. We may thus hypothesize that:

H2: *Entrepreneurial leadership has a positive impact on technology management processes.*

2.4.3. Technology Management Processes and Entrepreneurial Success

The extant literature has examined the role of entrepreneurial leadership in achieving success in high-tech industries, where quick thinking, flexibility, and strategic vision are critical [68]. Entrepreneurs succeed by embracing uncertainty and fostering innovation, positioning themselves as the key drivers of modern business success. In contrast, traditional leadership often struggles to keep pace with technological changes and intense competition [69]. Over the years, breakthroughs in digital innovation have increased the demand for technological solutions, transformed business dynamics, and redefined models through IT integration. The evolving technological landscape has significantly influenced entrepreneurial success by expanding the potential of advanced tools [54]. The widespread adoption of contemporary advancements such as information and communication technology (ICT) has opened new avenues for promoting entrepreneurial success [70]. Technologies that have revolutionized sectors and opened new avenues for innovation and entrepreneurship include artificial intelligence, cloud computing, big data analytics, and the Internet of Things.

Entrepreneurs in this dynamic environment must negotiate a complicated, interwoven ecosystem in which opportunities and challenges are presented by digital disruption [36]. Entrepreneurs' endeavors are essential for a company's success. The increasing significance of venture start-ups has enhanced the commercial landscape and facilitated entrepreneurial success. Examining new venture success has attracted considerable attention, emphasizing company expansion, economic development, and value creation [71]. According to Wach et al. [72], entrepreneurship is a major factor in corporate success, especially when digital information is incorporated into company procedures. Businesses can achieve digitally centered entrepreneurial success through technological improvements and robust learning capabilities [73]. Entrepreneurs spur innovation by bringing digital product innovations into the market [74]. Technological information increases market value by creating modernized information networks, whereas ongoing digital advances produce knowledge

that enables businesses to investigate the beneficial transformations of corporate resources. We may thus hypothesize that:

H3: *Technology management processes have a positive impact on entrepreneurial success.*

2.4.4. Technology Management Processes as a Mediator of Entrepreneurial Leadership and Entrepreneurial Success

Kalko et al. [75] indicate that TMPs enhance organizational performance through higher productivity and promoting innovation culture. Similar results were reported by Xu et al. [76], who suggested that by applying TMP practices, the organization's overall performance increased in the shape of higher profit. Hussain and Li [5] indicate that EL and ES positively correlate through a mediating knowledge management mechanism. In contrast, Kalko et al. [75] suggest that TMPs enhance innovation among Ethiopian firms. Marei et al. [77] stated that technological and entrepreneurial skills improve organizational performance. Based on the experiential learning theory (ELT) approach proposed by Ferreira [78] and validated by Hussain and Li [5], this study attempts to link the relationship between the entrepreneurial leadership (EL) and entrepreneurial success (ES) of SMEs through the involvement of TMPs. Experiential learning theory shows that during the transition phase from an ordinary organizational setup to an entrepreneurial mindset, applying the latest technological innovation trends provides researchers with opportunities to understand the importance of the entrepreneurial approach.

The extant literature has examined the antecedents and outcomes of entrepreneurial leadership [24]. Studies have examined the direct effect of entrepreneurial leadership on entrepreneurial success [5,11,68] as well as the mediating mechanisms, knowledge management processes, organizational factors, and conflicts through which entrepreneurial leadership affects entrepreneurial success [5,12,33]. However, we are still unclear about the mediating mechanism of this relationship, i.e., which factors buffer or foster the effect of entrepreneurial leadership on entrepreneurial success. Hence, there is a dire need to examine the impact of entrepreneurial leadership on entrepreneurial success in SMEs in Pakistan. Furthermore, there is also a need to explore the mediating role of technology management processes (TMPs) in this relationship. The suggested mechanism enhances comprehension of how entrepreneurial leadership influences entrepreneurial success. Furthermore, the mediating function of TMPs elucidates the connection between EL and ES as TMPs signify alignment with prevailing market trends. This study aims to improve comprehension of EL, ES, and TMPs in SMEs by addressing gaps in the current literature. Drawing upon resource-based theory [61], entrepreneurial leadership is seen as a "managerial resource", which may prove instrumental in entrepreneurial success. As an organizational resource, we believe that entrepreneurial leadership strongly emphasizes human capital management. It strives to create a diversified team characterized by entrepreneurial behaviors, processes, and competencies such as risk-taking, new entry-joining, innovation, and dynamic capabilities within small firms [79,80]. Based on resource-based theory and experiential learning theory (ELT), our study examines how entrepreneurial leadership fosters entrepreneurial success. We also examine how technology management processes amplify the impact of entrepreneurial leadership on entrepreneurial success.

H4: *Technology management processes mediate the relationship between entrepreneurial leadership and entrepreneurial success.*

3. Methods

This study used a descriptive survey design and a quantitative method to examine the connection between entrepreneurial leadership (EL), entrepreneurial success (ES), and the

role of technology management processes (TMPs) in small- and medium-sized businesses in Khyber Pakhtunkhwa, Pakistan. The theoretical framework of this study is shown in Figure 1.The convenience sampling collected data from managers, supervisors, and employees of SMEs, yielding 300 valid responses from an initial sample size of 352. A standardized questionnaire adapted from prior studies measured the EL, ES, and TMP constructs. We analyzed the collected data using SPSS and Smart PLS software for structural equation modeling (SEM). This study used descriptive statistics to examine how the data were spread, Cronbach's alpha to test for reliability, and factor loadings, AVE, and discriminant validity criteria to ensure that the measurement model was correct.

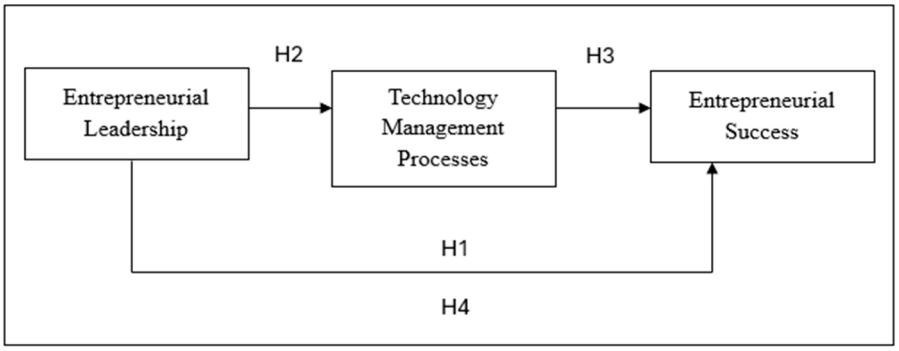


Figure 1. Theoretical framework.

3.1. Population and Sampling

This study examines the relationship between entrepreneurial leadership (EL) and entrepreneurial success (ES) in small- and medium-sized enterprises (SMEs) in Khyber Pakhtunkhwa while considering the mediating role of the technology management process. To ensure the representation of the SME industry population, data were gathered from managers, supervisors, and employees of SMEs in KP, Pakistan. Non-probability sampling techniques, specifically convenience sampling, were utilized to facilitate data collection, as suggested by prior research [4,81]. Based on the recommendations of a known population, a sample size of 352, in which 52 respondents were missing, was determined to obtain data from the target sample [82].

3.2. Measurement

Three constructs were measured to test the study's hypothesis: entrepreneurial leadership (EL), entrepreneurial success (ES), and technology management processes. A questionnaire was employed as an instrument to collect data, which is recognized as a reliable method for gathering consistent and legitimate information. The questionnaire is an objective-oriented system that uses standardized responses, ensuring that the collected data are identical and can be analyzed effectively [82,83]. Adopted scales from the studies of [5,75] were used to measure the study variables.

3.3. Data Analysis

The data from this study were examined using several statistical methods. The structural and measurement model was validated using smart PLS after fundamental descriptive statistics were utilized [84]. Measurement and structural models are crucial when using software like smart PLS for structural equation modelling (SEM). The measurement model establishes the reliability and validity of the measuring instruments used to assess constructs [85] It ensures that the observable variables appropriately reflect the underlying constructs. Subsequently, the structural model examines the constructs' relationships to illuminate plausible causal pathways. Smart PLS facilitates this procedure by enabling

researchers to assess structural models and measures at the same time. Additionally, it provides robust statistical analysis.

4. Result and Discussion

4.1. Descriptive Statistics and Reliability Analysis

Descriptive statistics are presented in Table 1, where the mean, SD, skewness, kurtosis, minimum, maximum, and Cronbach's alpha values are calculated. The average score of each variable (TMP = 4.93, ENLD = 4.65, ESC = 4.65) shows the central tendency of the responses of the three variables. The SD values (TMP = 1.18, ENLD = 1.31, and ESC = 1.36) are slightly increasing in variability. In skewness, all variables have negative skewness (TMP = −0.679, ENLD = −0.640, ESC = −0.494), which suggests that the data distribution is slightly left-skewed, with more responses being concentrated at the higher end. The kurtosis values are near zero, indicating that all variables have negative kurtosis, which is slightly flatter than the normal curve. The scores of all variables ranged from 1 to 7. All Cronbach's alpha values (TMP = 0.954, ENLD = 0.899, ESC = 0.908) were above 0.7, indicating the high reliability of the scale used to measure these constructs.

Table 1. Descriptive analysis.

Description	TMP	ENLD	ESC
Mean	4.9307	4.6513	4.6492
Std. Deviation	1.17896	1.31410	1.36620
Skewness	−0.679	−0.640	−0.494
Kurtosis	−0.109	−0.130	−0.425
Minimum	1	1	1
Maximum	7	7	7
Cronbach Alpha	0.954	0.899	0.908

TMPs = Technology management processes, ENLD = entrepreneurial leadership, ESC = entrepreneurial success.

4.2. Validity Test

As directed by Hair et al. [86], the current study tries to connect the relationship between variables through structural and measurement model analysis. First, item loading, Cronbach's alpha, and average variance extraction are used to clarify the validity and reliability of the items. Next, the HTMT ratio and the Fornell and Larcker procedure are used to validate the discriminant validity of the questions.

Factor loadings show the degree of correlation between each item and its corresponding construct. Higher numbers suggest a stronger relationship. Usually, these values range from 0 to 1. Factor loadings greater than 0.5 are generally considered acceptable; for robust measuring, values near 0.7 or higher are preferable [86]. AVE evaluates convergent validity by displaying the percentage of variance in the observed variables that can be accounted for by the core construct. AVE values range from 0 to 1, with values above 0.5 being considered acceptable for good convergent validity [87]. CR provides an alternative measure of internal consistency reliability. Like AVE, CR values range from 0 to 1, with values above 0.7 generally being considered acceptable for reliable measurement [86]. The results from Table 2 indicate that the values are in the acceptable range. Hence, validity is determined for the current model.

Table 2. Measurement model.

	Loading	**A**	**CR**	**AVE**	**Item**	**Loading**	**α**	**CR**	**AVE**
EL1	0.569	0.909	0.913	0.505	TMP1	0.764	0.954	0.957	0.502
EL10	0.724				TMP2	0.777			
EL2	0.761				TMP3	0.648			
EL3	0.713				TMP7	0.649			
EL4	0.833				TMP8	0.701			
EL5	0.815				TMP9	0.675			
EL6	0.723				TMP10	0.728			
EL7	0.760				TMP11	0.728			
EL8	0.745				TMP12	0.559			
EL9	0.777				TMP13	0.716			
ES1	0.764	0.899	0.901	0.555	TMP14	0.709			
ES2	0.777				TMP15	0.713			
ES3	0.648				TMP16	0.772			
ES4	0.674				TMP17	0.812			
ES5	0.716				TMP18	0.727			
ES6	0.816				TMP19	0.799			
ES7	0.762				TMP20	0.626			
ES8	0.786				TMP21	0.564			
ES9	0.746				TMP22	0.731			
TMP1	0.764	0.954	0.957	0.502	TMP23	0.638			

TMP = Technology management process, EL = entrepreneurial leadership, ES = entrepreneurial success.

The data in Table 3 represent discriminant validity measures between constructs using the Fornell and Larcker criterion and the heterotrait–monotrait (HTMT) ratio of correlations. The values in the diagonal represent the square root of the AVE (average variance extracted) for each construct. The off-diagonal values are the correlations between constructs. Discriminant validity is established when the square root of the AVE for each construct is more significant than its correlation with other constructs. For example, the value of 0.745 for EL represents the square root of the AVE for entrepreneurial leadership. It should be greater than the correlations between EL and other constructs (ES and TMP). The heterotrait–monotrait (HTMT) ratio compares the correlations between constructs to assess discriminant validity. Discriminant validity is established when the correlations between constructs are smaller than those between items within the same construct. For example, the value of 0.804 for EL and ES represents the correlation between entrepreneurial leadership and entrepreneurial success. The correlations between items within EL and ES should be smaller than those in EL. Overall, these measures help assess whether the constructs in the study are distinct, providing evidence of discriminant validity.

Table 3. Discriminant validity.

	Fornell and Larcker				HTMT		
	EL	**ES**	**TMP**		**EL**	**ES**	**TMP**
EL	0.745			EL			
ES	0.804	0.745		ES	0.89		
TMP	0.832	0.794	0.709	TMP	0.887	0.852	

TMP = Technology management process, EL = entrepreneurial leadership, ES = entrepreneurial success.

Figure 2 shows the measurement model analysis. Table 4 depicts the coefficients of determination (R-squared), which measure the proportion of variance in each dependent variable explained by the independent variables in the regression models. For entrepreneurial success, the independent variables account for approximately 69.7% of the variance, while for the technology management process, approximately 69.2% of the variance is explained. The adjusted R-squared values, which account for the number of predictors in the model, are also provided, indicating a slightly lower variance explanation but still substantial explanatory power in both cases.

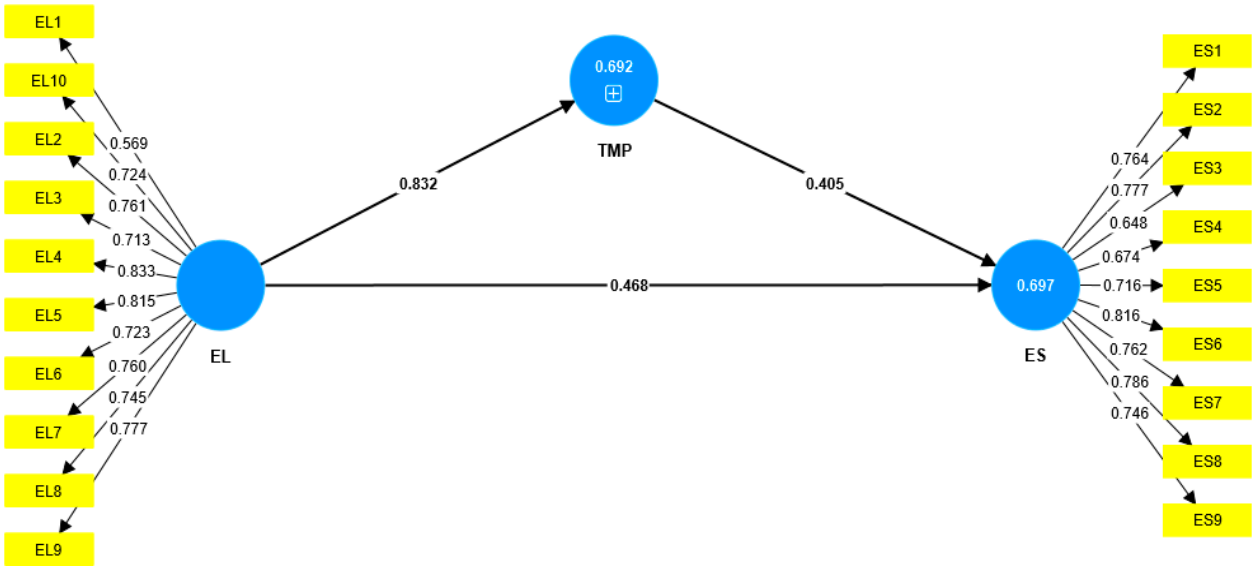


Figure 2. Measurement model analysis.

Table 4. Coefficient of determination (R^2).

	R-Square	**R-Square Adjusted**
Entrepreneurial Success	0.697	0.695
Technology Management Process	0.692	0.692

Table 5 presents the effect sizes (F-squared) of the relationships between different constructs. Effect sizes indicate the proportion of variance in the dependent variable that can be attributed to the independent variable(s). For the relationship between entrepreneurial leadership and entrepreneurial success, an F-squared value of 0.222 suggests a moderate effect size, indicating that about 22.2% of the variance in entrepreneurial success can be explained by entrepreneurial leadership. Similarly, the relationship between entrepreneurial leadership and the technology management process shows a moderate effect size with an F-squared value of 2.252, suggesting that approximately 225.2% of the variance in the technology management process can be explained by entrepreneurial leadership. In con-

trast, the effect size for the relationship between the technology management process and entrepreneurial success is weaker, with an F-squared value of 0.166, indicating that only about 16.6% of the variance in entrepreneurial success can be explained by the technology management process. Overall, these effect sizes help to quantify the strength of the relationships between the constructs, providing insights into their relative importance in explaining variations in each other.

Table 5. Result of effect size (F-square).

	F2	Description
Entrepreneurial Leadership—Entrepreneurial Success	0.222	Moderate
Entrepreneurial Leadership—Technology Management Process	2.252	Moderate
Technology Management Process—Entrepreneurial Success	0.166	Weak

Table 6 reveals the structural path analysis of the research variables. EL → ES: According to this theory, entrepreneurial success (ES) and entrepreneurial leadership (EL) are positively correlated. The link between EL and ES is moderately favorable, as the path coefficient of 0.468 indicates. The high T statistic of 6.796 provides strong support for the hypothesis, which suggests that this association is statistically significant. The information thus supports the hypothesis that more ES correlates with higher levels of EL.

Table 6. Structural path analysis.

Hypothesis	Variable Relationship	Path Coefficient	T Statistics	Results
H1	EL → ES	0.468	6.796	Accept
H2	EL → TMP	0.832	40.764	Accept
H3	TMP → ES	0.405	6.228	Accept
H4	EL → ES → TMP	0.337	6.033	Mediation

TMP = Technology management process, EL = entrepreneurial leadership, ES = entrepreneurial success.

EL → TMP: According to this hypothesis, the technology management process (TMP) and EL have a direct and beneficial link. The sizable path coefficient of 0.832 and the extraordinarily high T statistic of 40.764 show that EL and TMP have a sturdy and statistically significant positive association. The idea that strong EL has a favorable impact on an organization's TMP is thus amply supported by the evidence.

TMP → ES: This hypothesis proposes a direct positive relationship between TMP and ES. The path coefficient of 0.405 and the significant T statistic of 6.228 suggest a moderate positive relationship between TMP and ES, which is statistically supported and indicates that effective management of technology processes contributes positively to ES.

EL → ES → TMP (mediation): This hypothesis examines the indirect relationship between (EL), (ES), and (TMP), suggesting that ES partially mediates the relationship between EL and TMP. The path coefficient of 0.337 and the significant T statistic of 6.033 support this mediation effect, indicating that entrepreneurial success partially explains the relationship between entrepreneurial leadership and the technology management process. It suggests that the influence of entrepreneurial leadership on the technology management process is partially mediated by its impact on entrepreneurial success. These explanations provide insights into the direct and mediated relationships between variables, offering a comprehensive understanding of the structural dynamics within the model.

5. Discussion and Conclusions

In conclusion, the positive relationship between entrepreneurial leadership (EL) and entrepreneurial success (ES) underscores the pivotal role of effective leadership in driving business performance and achievement. Through visionary guidance, strategic decision-making, and fostering a culture of innovation and risk-taking, entrepreneurial leaders empower their teams to capitalize on opportunities, overcome challenges, and realize organizational goals. As evidenced by numerous studies, such as those by [4,5], EL cultivates an environment conducive to growth, creativity, and adaptability, ultimately leading to enhanced entrepreneurial outcomes. By leveraging their leadership skills and entrepreneurial mindset, leaders can inspire and motivate individuals, navigate uncertainties, and propel their ventures toward sustained success and competitiveness in dynamic market landscapes.

Further, we also conclude that entrepreneurial leadership (EL) has a statistically positive link with technology management practices, underscoring the critical role of effective leadership in driving technological innovation and organizational success. Through visionary guidance, strategic decision-making, and a proactive approach to technology adoption and integration, entrepreneurial leaders empower their organizations to harness the full potential of technology for competitive advantage and growth. Studies by researchers like Cuixia et al. [18] and Souza et al. [19] have demonstrated that EL fosters a culture of innovation, agility, and continuous improvement, facilitating the effective implementation of technology management practices. By leveraging their leadership skills and entrepreneurial mindset, leaders can inspire creativity, encourage collaboration between technical and non-technical teams, and drive the development and adoption of cutting-edge technologies. Ultimately, this symbiotic relationship between EL and technology management practices enables organizations to stay ahead in rapidly evolving markets, enhance operational efficiency, and achieve sustainable success in the digital age.

Similarly, the mediational role of technology management practices between entrepreneurial leadership (EL) and entrepreneurial success (ES) highlights the interconnectedness of leadership, technology, and business outcomes. Studies such as Ferreira [78] and those validated by Hussain & Li [5] and Kalko et al. [75] emphasize that effective utilization of technology management practices mediates the relationship between EL and ES. Entrepreneurial leaders prioritizing technology integration, innovation, and strategic IT decision-making create an environment conducive to organizational success. By fostering a culture of technological agility, creativity, and digital transformation, these leaders empower their teams to leverage technology as a catalyst for growth, efficiency, and competitive advantage. Moreover, technology management practices enable entrepreneurial leaders to capitalize on emerging opportunities, mitigate risks, and swiftly adapt to dynamic market conditions. This mediating role of technology management practices underscores the importance of aligning leadership strategies with technological capabilities to drive sustainable business performance. Ultimately, organizations that effectively leverage technology under visionary leadership are better positioned to achieve entrepreneurial success, navigate disruptions, and thrive in the digital era.

6. Implications

This study contributes theoretically to the literature by establishing that entrepreneurial leadership (EL) significantly impacts entrepreneurial success (ES), whereas technology management processes (TMPs) increase the probability of success. The study substantiates TMPs within the context of resource-based view (RBV) and experiential learning (EL) theories, indicating that TMPs mediate the association between EL and entrepreneurial success (ES). It provides novel insights, highlighting the emerging entrepreneurs' need

to integrate EL abilities with TMPs to achieve effective results. The results have significant consequences for professionals in the high-tech industry, small- and medium-sized enterprises, incubation centers, and researchers in entrepreneurship.

This research enhances the comprehension of both governing and non-governing entities, indicating that the implementation of TMP in entrepreneurial ventures (EVs) may diminish the failure rate. It also advises SME proprietors to promote knowledge transfer inside their firms to cultivate a robust atmosphere for attaining entrepreneurial objectives. From a managerial perspective, mentors and trainers can aid entrepreneurs in honing leadership abilities and optimizing operational efficiency under TMPs, augmenting competitiveness and ES attainment. Furthermore, mentors can underscore the significance of proficient leadership styles and specialized expertise in facilitating entrepreneurial success. Success should be seen in both the financial and non-financial dimensions.

7. Limitations and Future Direction

The current study has several limitations that need to be addressed by future researchers. First, in the current study, data were obtained once via an adopted construct, which can lead to response biases. Hence, future researchers may collect the data before and after applying TMP practices in SMEs. Secondly, in the current study, TMPs were investigated through the core and universal variable; however, future researchers can gather more detailed insights by examining the various facets of TMPs. Thirdly, future researchers may use organizational culture and team diversity to understand the dynamic relationship between EL and ES among prospective developing countries.

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